Environmental Review Document

Mesa H Proposal

Revision to Mesa J Iron Ore Development

Assessment No. 2121

EPBC 2017/8017

8 April 2019

Prepared by Rio Tinto with assistance from Eco Logical Australia

RTIO-HSE-0325696

Robe River Mining Co. Pty. Limited

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Invitation to make a submission

The Environmental Protection Authority (EPA) invites people to make a submission on the environmental review for this proposal.

Robe River Mining Co. Pty. Ltd is seeking to extend the life of and replace the Mesa J Iron Ore Development through development of the adjacent deposit, Mesa H, to sustain iron ore production from the Robe Valley. The Environmental Review Document (ERD) has been prepared in accordance with the EPA's ***Procedures Manual (Part IV Divisions 1 and 2)***. The ERD is the report by the proponent on their environmental review which describes this proposal and its likely effects on the environment.

The ERD is available for a public review period of two weeks from Monday 8 April 2019, closing on Wednesday 24 April 2019 (allowing an additional two days for public holidays).

Information on the proposal from the public may assist the EPA to prepare an assessment report in which it will make recommendations on the proposal to the Minister for Environment.

Why write a submission?

The EPA seeks information that will inform the EPA's consideration of the likely effect of the proposal, if implemented, on the environment. This may include relevant new information that is not in the ERD, such as alternative courses of action or approaches.

In preparing its assessment report for the Minister for Environment, the EPA will consider the information in submissions, the proponent's responses and other relevant information.

Submissions will be treated as public documents unless provided and received in confidence, subject to the requirements of the *Freedom of Information Act 1992*.

Why not join a group?

It may be worthwhile joining a group or other groups interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on information in the ERD.

When making comments on specific elements in the ERD:

- Clearly state your point of view and give reasons for your conclusions.
- Reference the source of your information, where applicable.
- Suggest alternatives to improve the outcomes on the environment.

What to include in your submission

Include the following in your submission to make it easier for the EPA to consider your submission:

- Your contact details – name and address.
- Date of your submission
- Whether you want your contact details to be confidential.
- Summary of your submission, if your submission is long.
- List points so that issues raised are clear, preferably by environmental factor.
- Refer each point to the page, section and if possible, paragraph of the ERD.
- Attach any reference material, if applicable. Make sure your information is accurate.

The closing date for public submissions is: Wednesday 24 April 2019

The EPA prefers submissions to be made electronically via the EPA's Consultation Hub at https://consultation.epa.wa.gov.au.

Alternatively, submissions can be:

- posted to: Chairman, Environmental Protection Authority, Environmental Protection Authority, Locked Bag 10, Joondalup DC, WA 6919, or
- delivered to: the Environmental Protection Authority, 8 Davidson Terrace, Joondalup, WA 6027.

If you have any questions on how to make a submission, please contact the EPA Services at the Department of Water and Environmental Regulation on 6364 7000.

Disclaimer and Limitation

This report has been prepared by Rio Tinto's Iron Ore Group (Rio Tinto), on behalf of Robe River Mining Co. Pty. Limited (the Proponent), specifically for the Mesa H Iron Ore Project. Neither the report nor its contents may be referred to without the express approval of Rio Tinto, unless the report has been released for referral and assessment of proposals.

<table>
<tr><th colspan="6">Document Status</th></tr>
<tr><th rowspan="2">Rev</th><th rowspan="2">Author</th><th rowspan="2">Reviewer/s</th><th rowspan="2">Date</th><th colspan="2">Approved for Issue</th></tr>
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ELA</td><td>C. Richards, H. Scott, K Parker</td><td>July 2018</td><td>EPA Services of the DWER</td><td>July 2018</td></tr>
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ELA</td><td>-</td><td>August 2018</td><td>EPA Services of the DWER</td><td>12 September 2018</td></tr>
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ELA</td><td>Rio Tinto Technical Specialists</td><td>February 2019</td><td>EPA Services of the DWER</td><td>7 March 2019</td></tr>
<tr><td>FINAL</td><td>M Brand
ELA</td><td></td><td>March 2019</td><td>Public Review</td><td>8 April 2019</td></tr>
</table>

CONTENTS

Tables

Figures

Appendices

Acronyms

Abbreviation	Description
AEP	Annual Exceedance Probability
AH Act	Aboriginal Heritage Act 1972
AMD	Acid and Metalliferous Drainage
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resources Management Council of Australia and New Zealand
AWT	Above Water Table
BC Act	*Biodiversity Conservation Act 2016*
BGL	Below Ground Level
BHP	BHP Billiton
BIF	Banded Iron Formation
BOM	Bureau of Meteorology
BWT	Below Water Table
CHMP	Cultural Heritage Management Plan
CID	Channel Iron Deposit
COPC	Contaminants of Potential Concern
CPI	Consumer Price Index
CWSP	Coastal Water Supply Project
DAA	Department of Aboriginal Affairs
DBCA	Department of Biodiversity, Conservation and Attractions
DEWHA	Department of the Environment, Heritage, Water and the Arts
DJTSI	Department of Jobs, Tourism, Science and Innovation
DMA	Decision Making Authorities
DMIRS	Department of Mines, Industry, Regulations and Safety
DMP	Department of Mines and Petroleum
DoE	Department of the Environment
DotEE	Department of the Environment and Energy
DoW	Department of Water
DPaW	Department of Parks and Wildlife
DPC	Department of Premier and Cabinet
DPLH	Department of Planning, Lands and Heritage
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities.

Abbreviation	Description
DWER	Department of Water and Environmental Regulations
eDNA	Environmental DNA
EIA	Environmental Impact Approval
EMP	Environmental Management Plan
EMS	Environmental Management System
EP Act	Environmental Protection Act 1986
EPA	Environmental Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
ERD	Environmental Review Document
ESD	Environmental Scoping Document
EWR	Ecological Water Requirements
FPV	Facultative Phreatophytic Vegetation
GDE	Groundwater Dependent Ecosystem
GDV	Groundwater Dependent Vegetation
GPS	Global Positioning System
GWOS	Groundwater Operating Strategy
HSECQ	Health, Safety, Environment, Communities and Quality
HTP	Hardcap Pisolite
IBRA	Interim Biogeographic Regionalisation for Australia
IUCN	International Union for Conservation of Nature
KMAC	Kurama Marthudunera Aboriginal Corporation
LIC	Local Implementation Committee
LOM	Life of Mine
MEZ	Mining Exclusion Zone
MNES	Matters of National Environmental Significance
MS	Ministerial Statement
NGER Act	National Greenhouse and Energy Reporting Act 2007
NVCP	Native Vegetation Clearing Permit
OPS	Obligate Phreatophytic Species
OPV	Obligate Phreatophytic Vegetation
PAF	Potentially Acid Forming
Parks and Wildlife	Department of Parks and Wildlife
PEC	Priority Ecological Community

Abbreviation	Description
PER	Public Environmental Review
PPV	Peak Particle Velocity
Rio Tinto	Rio Tinto Group
RIWI Act	Rights in Water and Irrigation Act 1914
RL	Relative Level
RRIA	Robe River Iron Associates
RTIO	Rio Tinto
SCARD	Spontaneous Combustion and Acid Rock Drainage
SRE	Short Range Endemic
TEC	Threatened Ecological Communities
the Fund	Pilbara Environmental Offsets Fund
the Proponent	Robe River Mining Co. Pty. Limited
TPB	Basal Pisolite
TPC	Pisolite Clay
TPH	Upper Pisolite
TPM	Mixed/Massive Pisolite
TSOP	Threatened Species Offset Plan
TSSC	Threatened Species Scientific Committee
TSF	Tailings Storage Facilities
TSOP	Threatened Species Offset Plan
TV	Trigger Values
VIA	Visual Impact Assessment
WA	Western Australia
WAM	Western Australian Museum
WFSF	Waste Fines Storage Facility

EXECUTIVE SUMMARY

Robe River Mining Co. Pty. Ltd. (the Proponent) operates the existing Mesa J Iron Ore Development located approximately 10 kilometres (km) south of Pannawonica in the Pilbara region of Western Australia (WA) (Figure ES 1). The Proponent is seeking to extend the life of and ultimately replace the existing Mesa J Iron Ore Development through the development of the Mesa H iron ore deposit, located to the west of the existing mine. This revision to the Mesa J Iron Ore Development is referred to as the Revised Proposal; with the new activities under assessment referred to as the Proposed Change.

The Development Envelope for the Revised Proposal is shown in Figure ES 2. The Proposed Change will be undertaken in the western portion of the Development Envelope (the Proposed Change Area) and will include development of above (AWT) and below water table (BWT) open cut pits at Mesa H, ore processing facilities, waste dumps, ore, topsoil and subsoil stockpiles and associated infrastructure, including water management infrastructure in the mine operations area (Figure ES 2). The Proposed Change will utilise infrastructure including processing facilities (subject to upgrades) and rail from the existing Mesa J Iron Ore Development (Figure ES 2).

Ore will be mined at the Mesa H deposit using open cut mining methods comprising conventional drill, blast, load and haul as currently used in the adjacent Mesa J Iron Ore Development. Mine pit dewatering will be required to enable mining of ore below the current water table (approximately 20% of the ore proposed for mining is below water table). Any surplus water from mine pit dewatering will be used to supply operational water demand for both Mesa J and H Operations. Where operational water storage capacity is exceeded (particularly post wet-season), surplus water will be discharged intermittently into existing Mesa J licenced discharge points (or potentially new optimised discharge points) at Jimmawurrada Creek and / or the discharge point at West Creek (both tributaries of the Robe River).

The Western Australian Environmental Protection Authority (EPA) has determined that the Proposed Change requires assessment under Part IV of the *Environmental Protection Act 1986* (EP Act), which provides for the EPA to undertake environmental impact assessment of significant proposals, strategic proposals and land use planning schemes. The Commonwealth Department of the Environment and Energy (DotEE) determined that the Proposed Change is a Controlled Action for listed threatened species and therefore requires assessment under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EPA is assessing the Proposed Change on behalf of the Commonwealth under Section 87 of this Act as an accredited assessment.

The purpose of this Environmental Review Document (ERD) is to provide a report on the environmental review for the Proposed Change to the EPA and for public review. The scope of the ERD is to present an environmental review of the principal components of the Proposed Change, including a detailed impact assessment and description of proposed environmental management measures for the key environmental factors in accordance with the Environmental Scoping Document (ESD) prepared by the EPA. This ERD has been prepared in accordance with the Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016 (EPA 2016a) to meet the requirements of section 40(2)(b) of the EP Act.

The preliminary key environmental factors relevant to the Proposed Change are (as outlined in the ESD):

- Flora and Vegetation;
- Terrestrial Fauna;
- Subterranean Fauna;

- Inland Waters (formerly Hydrological Processes and Inland Waters Environmental Quality);
- Social Surroundings; and
- Air Quality.

The ESD also identified Landforms as an 'Other factor'.

The Development Envelope for the Revised Proposal lies within the western Pilbara region, where the key landscape features are the watercourses, some with associated pools, locally significant riparian vegetation communities, and mesa landforms which host gorges, rocky hills and breakaway fauna habitats. These landscape features occur in the Development Envelope, providing shelter and foraging opportunities for fauna (including fauna that are Matters of National Environmental Significance {MNES}), and habitat for aquatic and subterranean fauna (including two troglofaunal Priority Ecological Communities (PEC) and one stygofauna PEC) and have heritage and amenity values.

The main activities of the Proposed Change that have the potential to impact significant environmental values, are land disturbance, mine pit excavation, abstraction of groundwater and discharge of surplus water. The Proponent has applied the mitigation hierarchy in the *Western Australian Environmental Offsets Guidelines* (2014) for all proposed activities to reduce the potential for significant impacts to environmental values as a result of the Proposed Change. The design of the Proposed Change has focused on avoiding potentially significant impacts to the environment, where practicable. After avoidance strategies have been considered, mitigation measures have then been investigated to reduce the remaining significant impacts to an acceptable level.

One of the key features of the Proposed Change design to achieve this outcome is the delineation of a Mining Exclusion Zone (MEZ) at Mesa H, which ensures the preservation of the mesa escarpments, through excluding mining and minimising clearing in this area while allowing mining of the internal mesa plateau i.e. maintaining the mesa façade. The existing Mesa J Iron Ore Development excludes mining from the northern escarpment of the Mesa landform, adjacent to the Robe River. This approach has been shown to be effective in the protection of environmental values and the same approach for Mesa H is expected to protect a number of key environmental, heritage and amenity values, in particular:

- Inland waters:
  - Preservation of the integrity of the river and creek flow paths, floodplains and associated semi-permanent and permanent pools
- Flora and Vegetation:
  - Limited impact on sub-regionally significant riparian vegetation in the Robe River.
  - Limited impact to vegetation analogous to the Triodia sp. Robe River PEC.
- Subterranean Fauna:
  - Retention of at least 50% by volume of pre-mining troglofauna habitat.
  - Retention of connected habitat for stygofauna.
- Terrestrial Fauna:
  - Retention of the highest value habitat for significant fauna.

- Social Surroundings:
  - o Retention of key heritage sites.
- Landforms (Other environmental factor):
  - o Preservation of the prominence, scale and structural integrity of the mesas in the landscape.

An overview of the Proposed Change, including the key proposal characteristics, is provided in Table ES 1 and Table ES 2, and a full summary of the environmental review including the potential impacts, proposed mitigation and avoidance and residual impacts for each key environmental factor is provided in Table ES 3 and for landforms (other environmental factors in Table ES 4. A brief summary of the key outcomes of the environmental review is provided below.

The highest value aspect of the Mesa H landform, the escarpments, will be retained. The only clearing within these areas will be the access cuts to the mesa plateau which account for <2% of the mesa escarpment. The design and locations of the escarpment cuts have been selected to avoid disturbance to the escarpment sections with the highest ecological and heritage values. This will largely preserve landform values and maintain the visual amenity associated with this landscape.

The Proposed Change will involve the clearing of up to 2,200 hectares (ha) of native vegetation. Direct disturbance of significant flora and vegetation values will be limited to <2 ha of riparian vegetation in the Robe River and Jimmawurrada Creek, less than 10% of the records in the Rio Tinto database of individuals of three Priority flora species, and 6 ha of vegetation analogous to the *Triodia* sp. Robe River PEC. Ongoing monitoring of key environmental values will be undertaken to ensure that no unforeseen impacts occur from dewatering and surplus water discharge, and that the significant river and creek systems within and near the Development Envelope are protected.

Direct disturbance of the most significant habitat types in the Proposed Change Area for fauna of conservation significance (including but not limited to: Northern Quoll; Pilbara Leaf-nosed Bat; Ghost Bat; Pilbara Olive Python; Short Range Endemic (SRE) species; and aquatic fauna species) will be limited to 0.5 ha of Rocky Hills, 3.4 ha of Breakaway, 0.1 ha of Gorge and 1.3 ha of Riverine fauna habitats. There will be no direct disturbance to recorded Ghost Bat roosts and Northern Quoll dens. The habitat type most affected by cumulative impacts in the Robe Valley are the Mesa Plateaus, which, accounting for cumulative impacts from reasonably foreseeable projects, will have lost 61% of their pre-European extent in this area. This impact is expected to be mitigated through retention of the highest value habitat values associated with the mesa escarpments within the broader habitat unit.

The troglofauna and stygofauna habitat present is well connected and extends beyond the proposed impact areas. The proposed mitigation strategies for the Proposed Change, including the implementation of the MEZ to preserve troglofauna habitat and the use of a thickener to reduce water abstraction demand by 30%, in addition to maintaining connected habitat, are expected to be effective in minimising the potential for significant impacts to troglobitic fauna and stygofauna respectively, including habitat for the Blind Cave Eel. These approaches should ensure the proposed mining at Mesa H can be conducted such that the ecological integrity of troglofauna and stygofauna habitat, as well as the diversity and ecological integrity of the troglofauna and stygofauna assemblages present, are unlikely to be significantly impacted.

The Project footprint has been modified to avoid impacts to two very significant Aboriginal heritage sites: Jirtiwi Thalu (ethnographic site) and the gender restricted quarry site MJ04-09, in order to preserve their ethnographic and archaeological features and values. Where there is potential for, or known impacts to other heritage sites, consent to disturb under Section 18 of the *Aboriginal Heritage Act 1972* will be obtained.

The Proponent proposes environmental offsets in the form of financial contributions to the Fund at the following specified rates for each significant residual impact. The area of Northern Quoll core habitat to be affected is an upper limit as the mine planning around minimising impact to Gorge and Breakaway habitat has been undertaken in detail. The exact location of infrastructure within the vegetation in good to excellent condition and within the extent of the PECs (which occur extensively within the Development Envelope) has not yet been determined. Therefore, the areas requiring offset outlined below and throughout this ERD are estimates only. The actual quantum of impact and offsets required will be determined through an Impact Reconciliation Procedure in accordance with EPA instructions as outlined in the Draft Conditions included in Appendix 3. The proposed offset rates for contributions to the Fund and the estimated areas are:

- $3,000 per hectare for Northern Quoll core habitat (8.6 ha). The Proponent understands that the Fund may include habitat improvement so this contribution is also expected to offset impacts to good to excellent native vegetation and riparian vegetation within that 8.6 ha.
- Provision of $1 M of funding for further research into the occurrence and range of the Blind Cave Eel.
- $1,500 per hectare for PECs and riparian vegetation (that is not MNES habitat but may also be native vegetation in good to excellent condition) (approximately 1,315 ha). This offset contribution will address significant residual impacts to the specific PECs and riparian vegetation values and to native vegetation of good to excellent condition.
- Where MNES core habitat and PECs co-occur a total of $3,000 ha will be provided to the Fund.
- $750 per hectare for native vegetation that is in good to excellent condition in the Hamersley subregion (up to 876.4 ha).

The total offset value is $3,655,600 (of which $1,025,800 is directly related to MNES impacts).

Based on the proposed avoidance of significant areas, proposed mitigation strategies and the continued implementation of existing management strategies (including offsets for the potentially significant residual impacts associated with habitat loss), the Proponent considers that the EPA objectives can be met for all environmental factors. The Proposed Change is considered environmentally acceptable and can be adequately managed through the draft Ministerial Statement (MS) conditions.

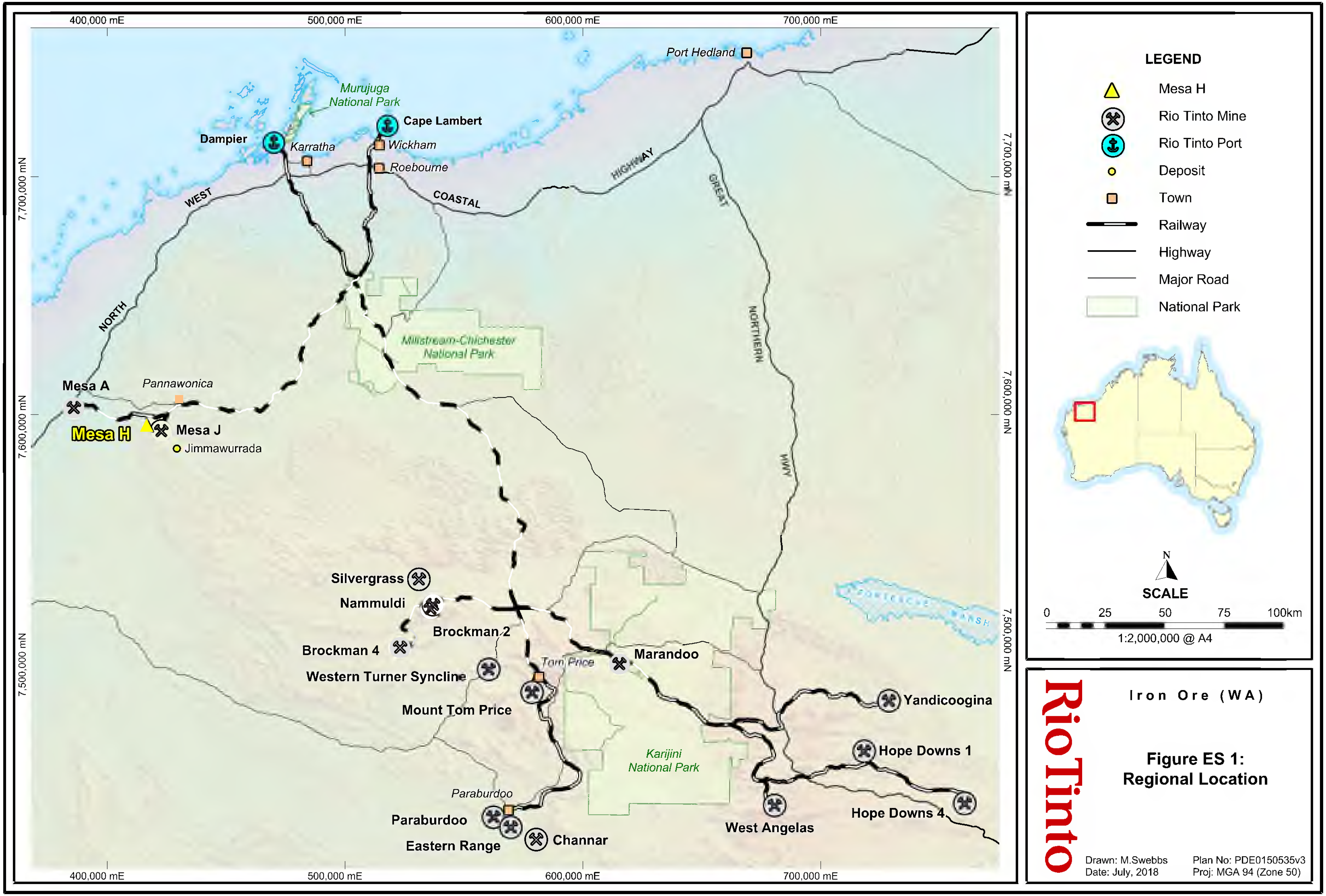
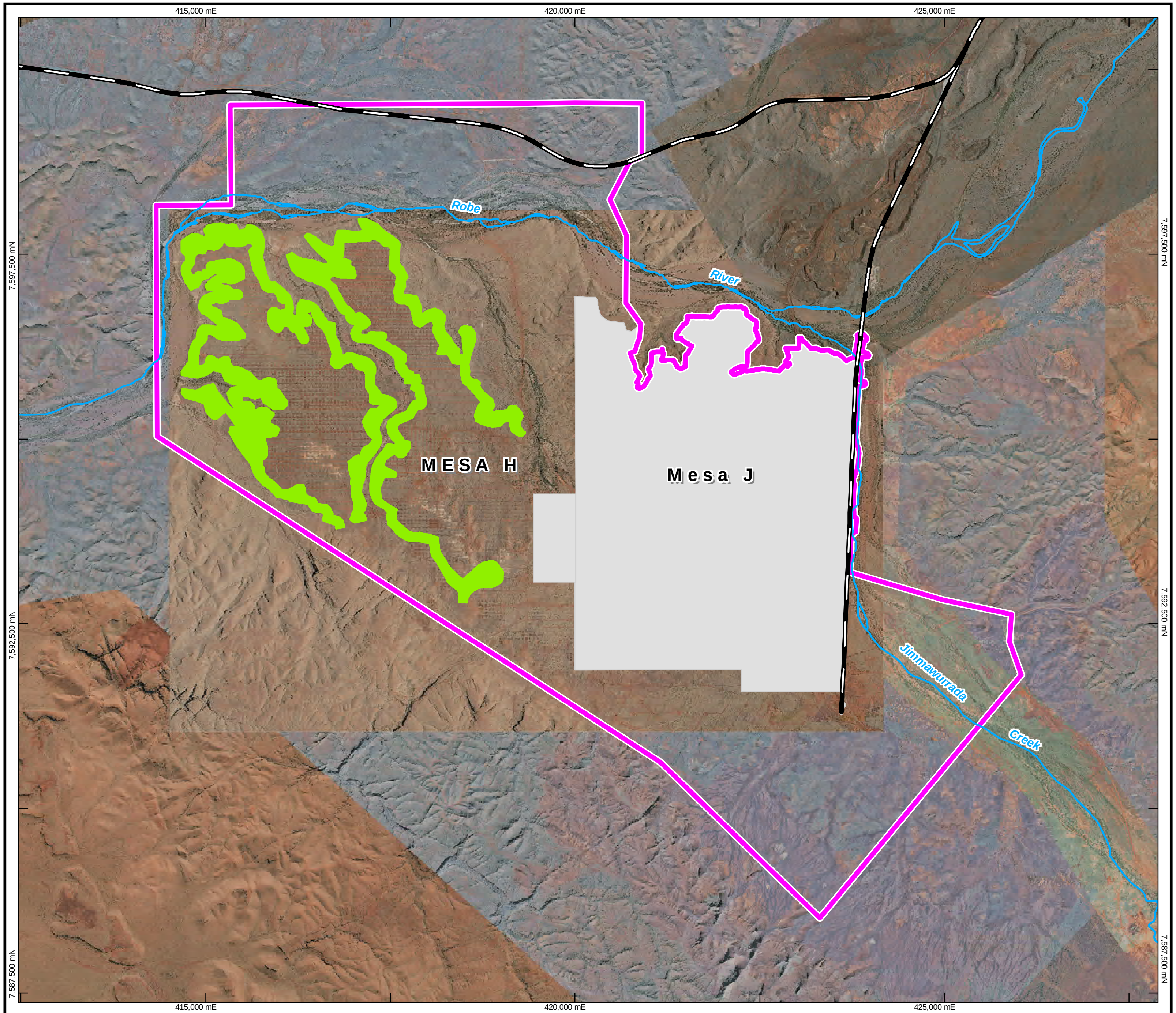


Figure ES 1: Regional Location

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Proposed Mining Exclusion Zone
- Extent of Mesa J Mine Operations Area
- Railway
- Major Watercourse

N

SCALE

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Disclaimer

Rio Tinto

Iron Ore (WA)

Figure ES2: Revised Proposal

Drawn: T.Murphy
Date: Feb, 2019

Plan No: PDE0152228v16
Proj: MGA94 Zone50

The key characteristics of the Revised Proposal (the Proposed Change and the approved Mesa J Iron Ore Development) are provided in Table ES 1 and the key characteristics of the Proposed Change are provided in Table ES 2.

Table ES 1: Summary of the Revised Proposal

Proposal title	Mesa H Proposal (Revision to the Mesa J Iron Ore Project)
Proponent name	Robe River Mining Co. Pty. Limited
Short description	The Revised Proposal is located approximately 16 km south west of Pannawonica in the Pilbara region of Western Australia. The Revised Proposal includes development of above and below water table open cut pits at Mesa J and Mesa H, ore processing facilities, waste dumps, ore, topsoil and subsoil stockpiles and associated infrastructure, including water management infrastructure. This Revised Proposal utilises infrastructure including processing facilities (subject to upgrades), waste fines storage facilities and rail from the existing Mesa J Iron Ore Development.

Table ES 2: Location and Proposed Extent of Physical and Operational Elements

Element	Location	Existing approval (Ministerial Statement/s and other regulatory approvals)	Proposed Change	Proposed extent (Revised Proposal) [total of existing approval + proposed change] [total of existing approval + proposed change]
Physical Elements				
Mine and associated infrastructure.	Figure ES 2	Total disturbance area (vegetation clearing) of up to 1,800 ha.	Clearing of up to 2,200 ha of native vegetation within the Development Envelope of 6,638 ha. Disturbance in the Mesa H Mining Exclusion Zone in accordance with the Environmental Management Plan.	Clearing of up to 4,000 ha of native vegetation within the Development Envelope of 6,638 ha. Disturbance in the Mesa J northern escarpment and Mesa H Mining Exclusion Zone in accordance with the Environmental Management Plan.
Rail	Figure ES 1	Single gauge railway line with sidings and a voice and radio data communications system with Fibre optic cable, from Cape Lambert.	N/A	Remove as not environmentally relevant.
Operational Elements				
Groundwater abstraction for water supply, ore processing and pit dewatering.	-	Not specified in MS 208 Annual water entitlement of 30 GL/a (Approved under *Rights in Water and Irrigation Act 1914* (RIWI Act) licence GWL107678(13)).	No change	Groundwater abstraction up to 30 GL/a, including from: • Water supply from Southern Cutback Borefield • Pit dewatering • Seepage interception
Surplus Water Management.	-	Not specified in MS 208. Discharge of mine dewater at designated discharge points in Jimmawurrada Creek and a tributary of Robe River (Approved under Part V Operating Licence L6820/1993/12).	No change	Controlled surface discharge to extend along Jimmawurrada Creek / West Creek and into the Robe River no further than 8 km downstream of the discharge point under natural no-flow conditions.

Table ES 3: Summary of Potential Impacts, Proposed Mitigation and Outcomes for Key Environmental Factors

Inland Waters	
EPA Objective	To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.
Policy and guidance	**EPA Policy and Guidance** • EPA Statement of Environmental Principles, Factors and Objectives (2018) • EPA Environmental Factor Guideline – Inland Waters (2018) • EPA Inland Waters of the Pilbara Western Australia (Part 1) (1989) • EPA Inland Waters of the Pilbara Western Australia (Part 2) (1989) • EPA Instructions on how to prepare an Environmental Review Document (2018) • EPA Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans (2016) • Department of Mines and Petroleum (DMP) and EPA Guidelines for Preparing Mine Closure Plans (2015). **Other policy and guidance** • WA Environmental Offsets Policy (2011) • WA Environmental Offsets Guidelines (2014) • Australian and New Zealand Environment and Conservation Council and Agriculture and Resources Management Council of Australia and New Zealand, Australian Water Quality Guidelines for Fresh and Marine Waters (2000) • Government of Western Australia, State Water Quality Management Strategy Document No. 6. Implementation Framework for Western Australia for the Australian and New Zealand Guidelines for Fresh and Marine Water Quality and Water Quality Monitoring and Reporting (2001) • Government of Western Australia, Pilbara Water in Mining Guideline. Report No 34 (2009) • Government of Western Australia, Western Australian Water in Mining Guideline. Report No 12 (2013) • Waters and Rivers Commission, Statewide Policy No 5: Environmental water provisions policy for Western Australia (2000) • Government of Western Australia, Water Quality Protection Guidelines No. 1 to 11 and Water Quality Protection Note 22 (2000; 2008) • Government of Western Australia, Strategic policy 2.09: Use of mine dewatering surplus (2013).
Potential impacts	**Direct** • Changes to groundwater levels as a result of groundwater abstraction. • Changes to the hydrological regime of Jimmawurrada Creek, West Creek and the Robe River as a result of surplus water management. • Changes to the hydrological regime of the Robe River as a result of minor surface water flow diversions. **Indirect** • Changes to surface and groundwater chemistry.
Mitigation	**Avoid**: • Diversion of surface water flows in major creeks including Jimmawurrada Creek and the Robe River will be avoided. • Mine design will avoid exposure of Potentially Acid Forming material (PAF). • The use of the existing Southern Cutback Borefield avoids the need for a new water supply borefield. **Minimise:**

	• If monitoring of water levels within the semi-permanent and permanent pools of the Robe River during active mine dewatering show declining pool water levels as a direct result of dewatering beyond that predicted in this impact assessment (i.e. up to 1 m beyond natural seasonal fluctuations), the Proponent will cease dewatering below the 120 m Relative Level (RL) water table level in the adjacent Pit 7 during dry periods and resume mining once a stream flow event occurs. • Groundwater abstraction will be minimised to that required to access the below water table resource and to meet site water requirements. • The use of a thickener is proposed to be used for the Waste Fines Storage Facilities (WFSF), specifically to optimise water recovery and reduce the overall water demand by approximately 30% from the Southern Cutback Borefield. • Monitoring of riparian vegetation and groundwater levels will continue to be undertaken along the Robe River and Jimmawurrada Creek in the vicinity of the Revised Proposal. If irreversible changes to riparian vegetation health are detected as a result of the Revised Proposal, then appropriate mitigation measures will be implemented. • Surplus water generated from mine pit dewatering will be used onsite in the first instance to supply water for operational purposes. Only surplus water exceeding the operational requirements will be discharged to local ephemeral tributaries of the Robe River. • The location of surplus discharge points will be optimised to reduce the potential for impacts to significant environmental values or areas considered to be at higher risk from the effects of groundwater drawdown, including along Jimmawurrada Creek (near the Southern Cutback Borefield) and the permanent pools of the Robe River (contingency only). • The proposed surface water diversion of small local overland catchment flows from active mine pits has been designed to redirect flows back into the Robe River, which would otherwise be captured by the Revised Proposal (and is currently captured by the Mesa J pits), to maintain the continuation of natural surface water flows into the Robe River. • Mesa J was selected as the preferred location for the WFSF rather than the alternative location of in-pit at Mesa H in order to reduce risk of seepage to the groundwater at Mesa H. • Hydrocarbon storage facilities and all associated connections will be within appropriately contained areas and storm water will be collected from these areas and treated to remove hydrocarbons prior to discharge, Hydrocarbon storage facilities and bunds will be inspected on a regular basis to identify any leaks or maintenance requirements. • The Proponent has well established management strategies for the management of PAF materials. While the likelihood of encountering significant quantities of PAF material is considered low; if PAF materials are encountered then existing management strategies within the Rio Tinto Iron Ore (WA) Mineral Waste Management Plan, and the Spontaneous Combustion and Acid Rock Drainage (SCARD) Management Plan will be implemented to ensure waste material is adequately geochemically characterised and PAF material that poses an Acid Mine Drainage risk is appropriately managed. • Water management structures such as windrows around the base of waste dumps and sediment traps will be constructed in key areas to minimise discharge of sediment-laden run-off from the site. **Rehabilitate:** • The conditions of the new MS shall require the Proponent to implement a Closure Plan in accordance with the DMP/EPA Guidelines for Preparing Mine Closure Plans. • Mine pits will be backfilled to appropriate levels to prevent the formation of pit lakes.
Outcomes	**Residual Impact:** The Revised Proposal will result in groundwater drawdown as a result of dewatering below water table resources and supplying water for processing requirements. Groundwater drawdown as a result of mine pit dewatering to enable below water table mining will result in further reduction of groundwater levels within the Mesa H Channel Iron Deposit (CID) aquifer. Groundwater recovery to pre-mining water table levels is expected to begin after groundwater abstraction activities cease upon closure, with recovery timeframes estimated in the order of ~60 years post mine closure with approximately 50% of the recovery occurring in the first 30 years.

	Dewatering of the Mesa H CID aquifer is considered unlikely to result in a significant impact to the groundwater levels in the Robe River. Groundwater levels are predicted to temporarily reduce by up to 1 m (modelled duration of less than one year). It is possible that shallow intermittent and semi-permanent pools have the potential to dry out more quickly during extended dry periods, however the effects would be seasonal and temporary, and the deeper pools and permanent pool at Yeera Bluff are expected to continue to persist without active management. Groundwater drawdown as a result of abstraction for operational water supply from the Southern Cutback Borefield will, when combined with groundwater drawdown from the existing Mesa J Iron Ore Development and from the upstream Coastal Water Supply Project (CWSP), cause a drawdown cone of depression ranging between 1 – 9 m below a 12 km section of the ephemeral Jimmawurrada Creek (resulting in a maximum depth to groundwater of 14 mbgl across a 6.5 km stretch). However, if natural recharge in Jimmawurrada Creek is reduced by 50% due to an extended period of drought, the water table levels could be lowered by almost 3 m in addition to the historical seasonal fluctuations (2 – 3 m); this would translate to localised changes in water table depths of up to 14 m from pre-mining conditions, or ~18 mbgl by 2030. Whilst the shallower outer margins of the alluvial aquifer may experience temporal loss of habitat, between 10 – 22 m of saturated alluvium is estimated to be retained within the deepest part of the channel (thalweg) if the peak groundwater drawdown coincides with a period of extreme extended dry conditions (through either climate change or an extended dry period). No permanent or semi-permanent pools have been identified in the section of Jimmawurrada Creek that would be affected by the Revised Proposal. The Revised Proposal is expected to result in ongoing but minor alteration of the natural hydrological regime of the Robe River as a result of the ongoing periodic discharge of surplus water into Jimmawurrada and West Creeks. This discharge into the Robe River will be periodic and relatively small compared to natural flood events and is similar to the current discharge regime from Mesa J. The Revised Proposal is expected to result in minor alteration of the natural catchment flows into the Robe River. However, the proposed surface water management structure will ensure the natural surface water flows to the Robe River are maintained during mining. No significant impacts to surface and groundwater quality are expected from hydrocarbons or PAF, and waste fines will be stored in existing Mesa J mined-out pits or existing Mesa J WFSF. After the mitigation hierarchy has been applied, no significant residual impact to inland waters values is anticipated and the Proponent considers that the Revised Proposal can be managed to meet the EPA's objectives for this factor. **Offset**: The Proponent considers that the Revised Proposal is unlikely to have a significant residual impact on Inland Waters and therefore offsets for these values are not proposed.
Flora and Vegetation	
EPA Objective	To protect flora and vegetation so that biological diversity and ecological integrity are maintained.
Policy and guidance	**EPA policy and guidance** • EPA Statement of Environmental Principles, Factors and Objectives (2018) • EPA Environmental Factor Guideline: Flora and Vegetation (2016) • EPA Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (2016) • EPA Cumulative environmental impacts of development in the Pilbara region: Advice of the Environmental Protection Authority to the Minister for Environment under Section 16(e) of the *Environmental Protection Act 1986* (2014) • DMP and EPA Guidelines for Preparing Mine Closure Plans (2015) • EPA Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans (2016)

	Other policy and guidance • WA Environmental Offsets Policy (2011) • WA Environmental Offsets Guidelines (2014) • Department of Water Western Australian Water in Mining Guideline (2013).
Potential impacts	**Direct impacts** • Loss of vegetation due to clearing • Loss of conservation significant flora due to clearing **Indirect impacts** • Loss or degradation of riparian vegetation as a result of groundwater drawdown • Loss or degradation of riparian vegetation as a result of surface water discharge • Degradation of vegetation due to ingress of weeds • Degradation of vegetation due to increased dust deposition.
Mitigation	**Avoid**: • The Proposed Change has been designed to avoid known locations of Priority Flora and significant vegetation (including riparian vegetation) as far as practicable. • The Proposed Change has been designed to avoid known locations of recorded range extensions of flora species. • Clearing will only occur in approved ground disturbance areas. • The Proposed Change will utilise an existing water supply borefield and therefore avoid creating a new drawdown area for groundwater supply. • Strict hygiene procedures will be implemented to prevent introduction and/or spread of Declared Weed Species into the Development Envelope. **Minimise**: • The clearing footprint has been reduced to the smallest practicable through project optimisation to reduce the extent of clearing required, particularly in relation to high value areas of vegetation and flora. • Infrastructure has been located to avoid or limit clearing within creek lines to minimise clearing of locally and sub-regionally significant riparian vegetation • Existing infrastructure and roads from the Mesa J Iron Ore Development will be utilised / optimised. • Waste-fines will be placed in-pit in the existing Mesa J Iron Ore Development footprint. • Waste and ore / topsoil stockpiles are proposed to be placed in-pit where mine schedules have allowed. • Groundwater abstraction will be minimised to that required to access the below water table resource and meet water supply requirements. • In-pit water storage management on site (e.g. Dan's Dam) also provides passive aquifer recharge and limits the requirement to draw from the Southern Cutback Borefield. • Abstracted groundwater will be used on site for processing and dust suppression to avoid discharge as far as practicable. • Surplus groundwater will be discharged at a rate which is not expected to cause bank erosion. • Annual weed control will be undertaken prior to the wet season, to minimise weed infestations in the Development Envelope. • Exposed surfaces will be reduced by minimising clearing to that required to implement the Proposed Change. • Dust controls will be implemented, including water sprays and dust suppressants within cleared areas to minimise the extent of dust deposition on vegetation. **Rehabilitate**: • Progressive rehabilitation will be undertaken to minimise the extent of cleared areas and to restore vegetation using recovered topsoil and seed of local provenance.

	• The conditions of the new MS shall require the Proponent to implement a Closure Plan in accordance with the DMP/EPA Guidelines for Preparing Mine Closure Plans. The Closure Plan includes a Closure Objective to ensure that vegetation on rehabilitated land is self-sustaining and compatible with the final land use. Indicative completion criteria include: o Seed used in rehabilitation works is of local provenance (except where seed pre-dates accurate recording of area); o Native plants within rehabilitated areas are observed to flower and / or fruit; o Recruitment of native perennial plants is observed; o Species richness of native perennial plants within rehabilitated areas is not less than reference sites; o Any weed species recorded within rehabilitation areas are present within the local area; and o Erosion from landforms does not threaten surrounding significant natural ecosystems.
Outcomes	**Residual Impact:** The Proposed Change is expected to result in the loss of up to 2,200 ha of vegetation. Disturbance of the vegetation analogous to the *Triodia* sp. Robe River Priority 3 PEC (AprTwTsr) will be limited to 6 ha, and disturbance of individuals of the three Priority flora species will be limited to 9.8%, 1% and 0.01% of records in the Rio Tinto database for *Triodia* sp. Robe River (M.E. Trudgen *et al*. Met 12367), *Rhynchosia bungarensis* and *Indigofera* sp. Bungaroo Creek, respectively. The Proposed Change involves the clearing of 2 ha of significant riparian vegetation. The Proponent considers that the residual impact from the clearing of up to 1,986 ha of native vegetation in Good to Excellent condition, including approximately 2 ha of riparian vegetation and 6 ha of vegetation analogous to the to the *Triodia* sp. Robe River PEC (AprTwTsr) is significant and warrants an offset. After the mitigation hierarchy has been applied, including avoidance and minimisation of direct impacts to key flora and vegetation values and the proposed offset, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Flora and Vegetation. The proposed loss of vegetation is not expected to cause a loss of biological diversity at the local or regional scale and the ecological integrity of the area surrounding the footprint is expected to be maintained. **Offset** The Proponent proposes the provision of an environmental offset ($750 per hectare) for the clearing of up to 1,986 ha of native vegetation in good to excellent condition, and an environmental offset at the higher offset rate ($1,500 per hectare) for the clearing of riparian vegetation and the vegetation analogous to the *Triodia* sp. Robe River PEC.
Subterranean Fauna	
EPA Objective	To protect subterranean fauna so that biological diversity and ecological integrity are maintained.
Policy and guidance	**EPA Policy and guidance** • EPA Statement of Environmental Principles, Factors and Objectives (2018) • EPA Environmental Factor Guideline: Subterranean Fauna (2016) • EPA Technical Guidance: Sampling Methods for Subterranean Fauna (2016) • EPA Technical Guidance: Subterranean Fauna Survey (2016) • DMP and EPA Guidelines for Preparing Mine Closure Plans (2015).
Troglofauna	

Potential impacts	**Direct impacts** • Reduction in troglofauna habitat due to mine pit development. • Loss of individuals and changes to assemblages due to mine pit development. **Indirect impacts** • Clearing of vegetation and placement of mineral waste potentially leading to a reduction in organic inputs into the subterranean environment. • Blasting may cause voids within the remnant mesa formations to collapse, resulting in a reduction in troglofauna habitat. • Exposure of pit faces may cause changes to the temperature and humidity in the subterranean environment, potentially leading to degradation of troglofauna habitat. • Hydrocarbon spills may result in a reduction in the quality of troglofauna habitat.
Mitigation	**Avoid:** • Single location and singleton troglofauna will be avoided as far as practicable and their ongoing avoidance will be ensured by the retention of a MEZ. • Placing waste fines in-pit at existing Mesa J WFSF avoids the need to disturb a previously undisturbed area at Mesa H. • Hydrocarbon storage and servicing and re-fuelling of plant and vehicles will not occur within the MEZ. **Minimise:** • The mine plan has been designed to retain at least 50% by volume of connected pre-mining troglofauna habitat at Mesa H by delineation of a MEZ. • Clearing within the MEZ will be minimised and limited to infrastructure such as tracks, utilities, telecommunications, monitoring stations and abandonment bunds. • The conditions of the new MS shall require the Proponent to implement an Environmental Management Plan to ensure suitable troglofauna habitat is retained. • Troglofauna sampling will be conducted in the MEZ verify persistence of troglofauna. **Rehabilitate:** • Pits will be backfilled with waste rock material where mine schedules allow and subterranean temperature and humidity at reference sites will continue to be monitored. • The conditions of the new MS shall require the Proponent to implement a Closure Plan in accordance with the DMP/EPA Guidelines for Preparing Mine Closure Plans. • The Closure Plan includes a closure objective to ensure that final landform is stable and considers ecological values and that vegetation is self-sustaining. • Progressive rehabilitation will be undertaken which will assist in re-establishing nutrient flows into the subterranean environment.
Outcomes	**Residual Impact:** The significant residual impacts on Troglofauna are: • Clearing of up to 9.2 ha and 788.1 ha of the Priority 1 PECs, the *Subterranean invertebrate community of mesas in the Robe Valley region* and the *Subterranean invertebrate community of pisolitic hills in the Pilbara*, respectively. At least 50% by volume of connected pre-mining troglofauna habitat will be retained at Mesas H by delineation of a MEZ. The mine plans for Mesa H have also been designed to avoid as many single location and singleton troglofauna as practicable and ensure their ongoing avoidance by the retention of the MEZ. The troglofauna habitat present is connected and extends beyond the proposed impact areas. Monitoring evidence also indicates that the existing MEZ at the analogous Mesa A Operations is functioning as intended, in protecting the ecological integrity of troglofauna habitat and assemblages. The proposed mitigation strategies, including the continuation of the MEZ approach, will ensure the proposed mining can be conducted such that the ecological integrity of troglofauna habitat, as well as the diversity and ecological integrity of the troglofauna assemblages present are unlikely to be impacted significantly.

	After the mitigation hierarchy has been applied, including retention of connected habitat through designation of a MEZ, the Proponent considers that the residual impact associated with the clearing of the Priority 1 PECs is significant for the Troglofauna component of the Subterranean Fauna factor and warrants an offset. Given the proposed mitigation and offset, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Subterranean Fauna. **Offset**: The Proponent proposes the provision of an environmental offset at the higher offset rate ($1,500 per hectare) for the clearing of areas with other environmental values: including PEC (i.e. the *Subterranean invertebrate community of mesas in the Robe Valley region* and the *Subterranean invertebrate community of pisolitic hills in the Pilbara*).
Stygofauna	
Potential impacts	**Direct impacts** • Reduction in stygofauna habitat due to below water table pit excavation at Mesa H (physical removal of habitat). • Reduction in stygofauna habitat due to groundwater abstraction resulting in groundwater drawdown at Mesa H and Jimmawurrada Creek. • Loss of individuals and changes to assemblages due to below water table mining at Mesa H and groundwater abstraction at Mesa H and Jimmawurrada Creek. **Indirect impacts** • Seepage from in-pit disposal of waste fines which has the potential to change groundwater chemistry and degrade stygofauna habitat. • Hydrocarbon and wastewater spills which may result in a reduction in the quality of stygofauna habitat.
Mitigation	**Avoid:** • Additional water requirements will be sourced from an extension to the existing Southern Cutback Borefield, avoiding the requirement for a new borefield impact area. • Placing waste fines in-pit at existing Mesa J WFSF avoids the need to disturb a previously undisturbed area and reduces seepage risk into stygofauna habitat at Mesa H. **Minimise:** • Groundwater abstraction will be minimised to that required to access the below water table resource and to meet site water requirements. • Water from mine dewatering will be used on site where possible to minimise the requirement for additional groundwater abstraction for operational water supply. • The Proponent will abstract groundwater within the licence limits and monitor groundwater levels to ensure impact remains within the predicted range of drawdown. If required, appropriate mitigation measures will be implemented in accordance with the Environmental Management Plan. • If monitoring of water levels within the semi-permanent and permanent pools of the Robe River during active mine dewatering show declining pool water levels as a direct result of dewatering beyond that predicted in this impact assessment (i.e. up to 1 m beyond natural seasonal fluctuations), the Proponent will cease dewatering below the 120 m RL water table level in the adjacent Pit 7 during dry periods and resume mining once a stream flow event occurs • The use of a thickener is proposed to be used for the WFSF, specifically to optimise water recovery and reduce the overall water demand by approximately 30% from the Southern Cutback Borefield, in turn reducing groundwater drawdown. • Surplus water generated from mine pit dewatering will be used onsite in the first instance to supply water for operational purposes. Only surplus water exceeding site storage capacity and operational requirements will be discharged to local ephemeral tributaries of the Robe River.

	• The location of surplus discharge points will be optimised to reduce the potential for impacts to significant environmental values or areas considered to be at higher risk from the effects of groundwater drawdown, including along Jimmawurrada Creek (near the Southern Cutback Borefield) and the permanent pools of the Robe River (contingency only). • Hydrocarbons will be handled, stored and disposed of in accordance with legal requirements. • Hydrocarbon storage will be inspected on a regular basis to identify any maintenance requirements. • Spill response procedures will be followed to contain and clean-up any hydrocarbon spills. **Rehabilitation:** • BWT pits will be backfilled enabling recovery of groundwater levels and stygofauna habitats following cessation of groundwater abstraction and to prevent the formation of pit lakes (and associated changes in water quality). • Hydrocarbon storage and handling facilities will be decommissioned at closure.
Outcomes	**Residual impact:** The significant residual impacts on Stygofauna are: • Direct removal of stygofauna habitat through groundwater drawdown of the Jimmawurrada Creek alluvial aquifer over a 12 km stretch with environmental values: the Priority 1 PEC *Stygofauna community of the Bungaroo Aquifer* and the EPBC Act listed Blind Cave Eel. The Proposed Change will result in impacts to stygofauna habitat and communities, including 3 Threatened – Vulnerable species (two Amphipods: *Nedsia hurlberti* and *Nedsia sculptilis*; and the Blind Cave Eel: *Ophisternon candidum)*; however, it is unlikely that stygofauna assemblages will be significantly impacted due to the extensive connected habitat present, extending beyond the proposed impact areas. The exception is the Blind Cave Eel which has few records so all loss of habitat within its' known range are considered significant at this point in time. Mesa H currently has approximately 20% of the CID deposit below the water table which contains potentially suitable stygofauna habitat. A proportion of available habitat will be impacted by the proposed groundwater drawdown and pit excavation. Given this habitat connects to other primary stygofauna habitat comprising the Jimmawurrada CID aquifer to the south-east, which is also in connection with the overlying Jimmawurrada Creek alluvial aquifer, it is considered that although the Proposed Change will result in the loss of individuals and reduction in habitat, it is unlikely to significantly affect the ecological integrity of the stygofauna habitat or the diversity and ecological integrity of stygofauna assemblages in the Mesa H area. At Jimmawurrada, studies indicate that the CID aquifer underlies and is connected with the Jimmawurrada Creek alluvial aquifer, and the Jimmawurrada Creek aquifer is a tributary into the Robe River alluvial aquifer. The Jimmawurrada CID aquifer is also connected to the upstream Bungaroo CID aquifer. Given the extent and connectivity with other primary habitats, such as the Robe River Alluvial Aquifer which is not expected to be significantly impacted by the Proposed Change, it is considered that although the Proposed Change will result in the localised reduction of habitat and potential loss of individuals across a 12 km section of Jimmawurrada CID and alluvial aquifers, it is unlikely to significantly affect the ecological integrity of stygofauna and their broader habitat and distribution. After the mitigation hierarchy has been applied, including the reduction of water abstraction by the use of a thickener and consideration of extensive, connected stygofauna habitat at Jimmawurrada, the Proponent considers that the residual impact associated with the clearing of the Priority 1 PEC is significant for the Stygofauna component of the Subterranean Fauna factor and warrants an offset. In addition, given the current limited status of knowledge of the Blind Cave Eel, there is uncertainty regarding the area of risk of groundwater drawdown (although the drawdowns used are likely to be an upper limit of cumulative impacts), the degree of habitat modification and the range and sensitivity of the species. Therefore, this risk is proposed to be offset to enhance further research into the understanding of the occurrence and range of this species. Given the proposed mitigation and offset, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Subterranean Fauna.

	Offset: The Proponent proposes the provision of two environmental offsets for Stygofauna. • an environmental offset at the higher offset rate ($1,500 per hectare) for the direct impact as a result of groundwater drawdown to 'Zone 3' of the Jimmawurrada Creek alluvial aquifer within areas with other environmental values: i.e. PEC (*Stygofauna community of the Bungaroo Aquifer*). • Provision of $1 M of funding for further research into the occurrence and range of the Blind Cave Eel.
Terrestrial Fauna	
EPA Objective	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.
Policy and guidance	**EPA policy and guidance** • EPA Statement of Environmental Principles, Factors and Objectives (2016) • EPA Environmental Factor Guideline: Terrestrial Fauna (2016) • EPA Technical Guidance: Sampling Methods for Terrestrial Vertebrate Fauna (2016) • EPA Technical Guidance: Terrestrial Fauna Surveys (2016) • EPA Technical Guidance: Sampling of Short Range Endemic Invertebrate Fauna (2016) • DMP and EPA Guidelines for Preparing Mine Closure Plans (2015) • EPA Instructions on how to prepare an Environmental Review Document (2016) • EPA Instruction of how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans (2016r). **Other policy and guidance** • WA Environmental Offsets Policy (2011) • WA Environmental Offsets Guidelines (2014) • Department of the Environment, Water, Heritage and the Arts (DEWHA), Survey guidelines for Australia's Threatened Bats (2010) • Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC), Survey Guidelines for Australia's Threatened Mammals (2011) • DSEWPaC, Survey guidelines for Australia's Threatened Reptiles (2011) • Threatened Species Scientific Committee (TSSC), Commonwealth Listing Advice on Northern Quoll (*Dasyurus hallucatus*) (2005) • DSEWPaC, Threat Abatement Plan to Reduce the Impacts on Northern Australia's Biodiversity by the Five Listed Grasses (2012) • DEWHA, Approved Conservation Advice on *Liasis olivaceus barroni* (Olive Python (Pilbara subspecies)) (2008) • DEWHA, Approved Conservation Advice on *Ophisternon candidum* (Blind Cave Eel) (2008) • TSSC, Conservation Advice for *Macroderma gigas* (Ghost Bat) (2016) • TSSC, Conservation Advice for *Rhinonicteris aurantia* (Pilbara form) (Pilbara Leaf-nosed Bat) (2016) • Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC and ARMCANZ), Australian Water Quality Guidelines for Fresh and Marine Waters (2000).
Potential impacts	**Direct impacts** • Loss and/or fragmentation of fauna habitat including breeding, foraging and dispersal habitat due to clearing. • Loss of individuals from increased vehicle strikes, collisions with fencing and construction activities.

	Indirect impacts • Alteration of fauna habitat due to altered hydrology arising from groundwater abstraction and increased temporal availability of surface water from discharge of surplus water. • Loss or degradation of habitat due to noise and vibration. • Degradation of habitat due to dust and light emissions. • Degradation of habitat due to altered fire regime, introduction or spread of weeds and changes to feral animal populations. • Degradation of aquatic fauna habitat due to changes to water chemistry arising from discharge of surplus water.
Mitigation	**Avoid:** • The Proposed Change has been designed to avoid disturbance to the majority of the Gorge, Breakaway and Rocky Hills fauna habitats. • The Proposed Change will avoid direct impacts to all recorded potential diurnal / maternal roost caves and nocturnal roosts for Ghost Bats; including a buffer zone of 50 m from the back of caves. • The Proposed Change will avoid direct impacts to all semi-permanent and permanent pools, and direct impacts to Riverine habitat except for <2 ha of clearing required to widen an existing road. • The Proposed Change will avoid fragmentation of habitat between the mesa escarpment and the Robe River. • The Proposed Change will utilise an existing water supply borefield and therefore avoid creating a new drawdown area for groundwater supply • The use of barbed wire will be avoided except where legislated. **Minimise:** • The total mine footprint has been minimised through the utilisation of existing Mesa J infrastructure, processing facilities and rail facilities. In addition, Mesa J mine pits will be used for disposal of waste fines rather than requiring clearing of additional habitat to develop an external WFSF. • The width of the haul road access points to the mesa have been designed to minimise disturbance to the escarpments and the locations were optimised to avoid disturbance to the highest value areas. • In the event that active dens or nests of conservation significant fauna species are identified within the proposed footprints and disturbance cannot be avoided, licensed wildlife handlers will capture and translocate individuals to suitable nearby habitat in consultation with the Department of Biodiversity, Conservation and Attractions. • Clearing will be limited to up to 2,200 ha and will retain approximately 99% of the Riverine habitat, 99% of Gorge habitat and 95% of Breakaways habitat within the Proposed Change Area. • Annual monitoring of the Ghost Bat population in the Development Envelope will be undertaken to detect any potential declining trend. In the event that populations decline as a result of implementation of the Proposed Change, the Proponent will implement mitigation measures. • Direct impacts to fauna from vehicle strikes will be minimised through the use of speed limits and strict management of access outside of the active mining area. • The Proponent will utilise surplus water from mine pit dewatering for water supply as far as practicable. The Proponent will abstract groundwater within the existing licence limits regulated under the RIWI Act and monitor groundwater levels to ensure impact remains within the predicted range of impact. The Proposed Change also capitalises on existing lowered groundwater levels as a result of the Mesa J Iron Ore Development, which reduces the volume of additional groundwater required to be abstracted and reduces surplus discharge requirements. • The impacts of groundwater drawdown on fauna habitat will be minimised through the use of the existing Southern Cutback Borefield rather than the creation of a new water supply. • Surplus water will only be discharged when dewatering supply exceeds demand, for the duration of abstraction activities only and will cease upon closure. Surplus water will be discharged at a rate unlikely to cause erosion impacts. Existing discharge infrastructure will be considered as potential discharge locations which would reduce the additional impact from new discharge sites. The footprint of the periodic surplus water discharge will overlap with areas

	subject to groundwater drawdown including along the Robe River and sections of Jimmawurrada Creek and thus may partially mitigate the potential impact from groundwater drawdown in these areas. • A Blast Management Framework will be implemented to limit vibration emissions and subsequent structural damage to bat roosts or disturbance to Ghost Bat individuals roosting. • Temporary mobile lighting will be installed in active mine pits and active operational areas, similar to the existing Mesa J Iron Ore Development. Lights will be directed inwards towards mine activities to minimise lighting effects on fauna in adjacent areas. • Dust emissions will be managed through application of dust suppression methods including water sprays, where applicable. • The Proponent has well established strategies for monitoring and management of the risk of weed ingress, feral animals and increase in fire at its Pilbara operations that will be implemented in the Development Envelope to manage these risks. **Rehabilitate:** • In the unlikely event that groundwater abstraction reduces surface water levels in Robe River pools greater than the predicted extent, groundwater may be discharged directly into the Robe River to mitigate this impact. • The conditions of the new MS shall require the Proponent to implement a Closure Plan in accordance with the DMP / EPA Guidelines for Preparing Mine Closure Plans. • The Closure Plan includes a closure objective to ensure that vegetation on rehabilitated land is self-sustaining and compatible with the final land use.
Outcomes	**Residual Impact:** The Proposed Change will result in the loss of up to 2,200 ha of fauna habitat (including habitats for conservation significant fauna species) as a result of clearing. None of the habitats recorded are restricted to the Proposed Change Area; all fauna habitats identified from the Proposed Change Area occur throughout the Robe Valley. The proposed habitat loss is treated as a permanent habitat loss due to the long duration of disturbance and the level of uncertainty regarding the timing and extent of re-establishment of habitat values following rehabilitation and closure. However, rehabilitation will be undertaken which will re-establish some fauna values following closure. The most significant habitat types in the Proposed Change Area are the Rocky Hills, Breakaway, Gorge and Riverine habitats which include habitat for Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat, Pilbara Olive Python, SREs and aquatic fauna species. Disturbance to the Rocky Hills, Gorge, Breakaway and Riverine habitats will be limited to 0.5 ha, 0.1 ha, 3.4 ha and 1.3 ha, respectively. There will be no direct disturbance to recorded Ghost Bat roosts (potential diurnal/maternal/nocturnal roosts) and recorded Northern Quoll dens. The habitat types that are most significant to conservation significant fauna (i.e. Rocky Hills, Breakaway, Gorge and Riverine habitats) will have more than 90% of their pre-European extent remaining within the Robe Valley after the cumulative impacts of all historical and reasonably foreseeably projects have been considered. The habitat type most affected by clearing in the Robe Valley are the Mesa Plateaus which have had 42.3% cleared to date and cumulative impacts from reasonably foreseeable projects will increase clearing to 61% of pre-European extent. The habitat loss within the Mesa Plateau habitat unit is predominantly of the plateau itself rather than the mesa escarpment which has the highest habitat value; particularly for bats and Northern Quolls (in addition to other environmental factor values). This impact is expected to be mitigated through retention of the highest value habitat values associated with the mesa escarpment within the broader habitat unit. Given the proposed avoidance via the creation of a MEZ and minimisation of disturbance to significant habitats and the widespread distribution and / or low value to terrestrial fauna of the other habitats, the loss of habitat is not expected to adversely affect the conservation status of species (including species of elevated conservation significance) or affect the availability or quality of significant habitat for a species. The Proponent considers that the potential for loss of individuals from increased vehicle strikes and collisions with fencing as well as all potential indirect impacts associated with construction or operations (noise, vibration, dust, light, altered fire regime, introduction or spread of weeds and changes to feral animal populations) can be managed such that they are unlikely to result in a significant impact to fauna.

	Groundwater drawdown as a result of abstraction for water supply is expected to increase groundwater drawdown below Jimmawurrada Creek. Cumulatively with the existing Mesa J abstraction and the Coastal Water Supply, this may result in localised changes to canopy cover of riparian vegetation along a 12 km section of Jimmawurrada Creek. Substantial drawdowns are expected within a 6.5 km stretch where drawdowns of up to 9 m may occur from the cumulative effects of Mesa H, Mesa J and the Coastal Water Supply; however, if an extended dry period occurs, the water table could vary by up to 14 m from pre-mining conditions. No semi-permanent of permanent pools occur in the Jimmawurrada area and the creek ecosystem function is expected to be maintained. Groundwater drawdown below the creek may locally and seasonally affect the availability and connectivity of suitable subterranean habitat for the Blind Cave Eel. Groundwater abstraction for pit dewatering may result in localised drawdown of water levels in the Robe River alluvial aquifer and associated pools. There will be no change in the permanence status of any of the Robe River pools which will maintain the ecological function of the permanent pools in the naturally variable Pilbara environment. There may be a small reduction in the length of time semi-permanent pools persist following rainfall. Potential impacts to Riverine habitat from discharge of surplus groundwater are expected to extend up to approximately 8 km from the discharge outlets in either Jimmawurrada Creek or West Creek. However, the discharge will be temporary and intermittent, lasting for the duration of discharge activities, which is anticipated to be substantially less than the life of mine. Given the temporary nature of the discharge to a system that is adapted to highly variable flow conditions, it is unlikely that there will be any significant residual impact on fauna habitat values. After the mitigation hierarchy has been applied, including avoidance of direct impacts to key habitat and key habitat features, the Proponent considers that the direct impact to core habitat for the Northern Quoll; 3.5 ha of Breakaways and Gullies habitat, 3.8 ha of habitat within 10 m of Breakaways and Gullies habitat and 1.3 ha of Riverine habitat, is considered to be a significant residual impact for the Northern Quoll and requires offsetting. Given the proposed mitigation and offset, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Terrestrial Fauna. **Offset:** The proposed offset for the significant residual impact is the contribution of $3,000 per ha of direct impacts to 8.6 ha of core habitat or an alternative but equivalent resourcing of an offset project that will provide direct benefits to Northern Quoll in the Pilbara. An offset is also proposed for the high level of uncertainty regarding the risk to the Blind Cave Eel (See Subterranean Fauna factor earlier in this table).
Social Surroundings	
EPA Objective	The EPA objective for social surroundings is to protect social surroundings from significant harm.
Policy and guidance	**EPA policy and guidance** • EPA Statement of Environmental Principles, Factors and Objectives (2018) • EPA Environmental Factor Guideline: Social Surroundings (2016) • EPA Instructions on how to prepare an Environmental Review Document (2016) • EPA Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans (2016) • DMP and EPA Guidelines for Preparing Mine Closure Plans (2015). **Other policy and guidance** • Department of Aboriginal Affairs and Department of Premier and Cabinet Due Diligence Guidelines, Version 3.0 (2013).
Potential impacts	• Disturbance of sites and places of cultural significance (via clearing, excavation and infrastructure placement) • Prevention or change to access to a site. • Indirect disturbance to sites and places of cultural significance via changes to the physical and biological attributes of the environment (via dewatering, surplus water discharge, and blast vibrations).

Mitigation	**Avoid:** • The Proposed Change has been designed to avoid direct impacts to the most significant sites, including direct disturbance to the Robe River (except for upgrading of an existing road crossing, and potential need for monitoring bores) and its associated semi-permanent and permanent pools. • The MEZ enables avoidance of all direct disturbance to recorded sites within the escarpment and supports protection of the integrity of the rockshelters. **Minimise:** • Waste dumps have been located away from prominent visual vantage points, including the Robe River and Yarramarda Law Ground, and will remain at heights which are the same level or lower than the surrounding mesas to limit visual impact. Visual impacts will be further minimised through construction of the waste dumps to be aesthetically compatible with the surrounding landscape. • Escarpment cuts are located away from the Robe River and will be largely hidden due to their location in the central (internal) gully, and south of the mesa landform. The widths required for the haul road access cuts into the mesa escarpments have been minimised as far as possible to allow safe access. • The proposed Blast Management Framework (including management of vibration and retention of escarpments via a MEZ, with an adequate width >30 m to ensure geotechnical stability), will minimise any potential impacts to the social value of the mesa escarpments, including the sites of heritage significance, comprising rockshelters present on the mesa escarpment and Jirtiwi Thalu located within the MEZ. • Where impacts to heritage sites cannot be avoided, applications will be made under Section 18 of the AH Act in consultation with the Robe River Kuruma People. • Further assessment of sites and salvaging of artefacts is expected to occur; artefact salvage will ensure the retention of artefact values ex-situ. • The Proponent has established an internal system for managing all ground disturbing activities to ensure compliance with heritage commitments and regulatory requirements. • If monitoring of water levels within the semi-permanent and permanent pools of the Robe River during active mine dewatering show declining pool water levels as a direct result of dewatering beyond that predicted in this impact assessment (i.e. up to 1 m beyond seasonal variation), the Proponent will cease dewatering below the water table in the adjacent Pit 7 during dry periods and resume mining once a stream flow event occurs. • Groundwater abstraction will be minimised to that required to access the below water table resource and to meet site water requirements. • Monitoring of riparian vegetation and groundwater levels will continue to be undertaken along the Robe River and Jimmawurrada Creek in the vicinity of the Revised Proposal. If significant changes to vegetation health are detected as a result of the Revised Proposal, then appropriate mitigation measures will be implemented. • The Proponent is committed to consulting with the Robe River Kuruma People regarding the Revised Proposal through Local Implementation Committee (LIC) meetings and heritage survey processes. **Rehabilitate:** • The Proponent has developed a Mine Closure Plan consistent with DMP and EPA Guidelines to ensure social surrounds are rehabilitated (returning cultural material back to country) post-closure. • Waste dumps will be rehabilitated, and mine pits will be backfilled to above pre-mining water table levels to prevent the formation of pit lakes.
Outcomes	**Residual Impact:** The Proposed Change has been designed to retain the Mesa H escarpments, except where cuts are required to provide access through the mesa landform, back to Mesa J Iron Ore Development. The retention of the mesa escarpments as part of the MEZ will ensure that the visual amenity of the landscape is retained and also ensures protection of identified rockshelter sites from direct impacts. The Project footprint has been further modified and buffered to avoid direct and indirect impacts to two very significant sites: Jirtiwi Thalu ethnographic site and the gender restricted quarry site MJ04-09, in order to preserve their ethnographic and archaeological features and values.

	The Proponent will continue to work in close consultation with the Robe River Kuruma People and will avoid sites where possible. However, some sites are likely to be disturbed by the Proposed Change. The Proponent will seek approval under Section 18 of the AH Act where direct disturbance to sites cannot be avoided or where there is any potential for impacts due to vibration. This is a conservative approach as all bar one of the recorded 91 rockshelter sites are located within the proposed MEZ and therefore will not be cleared, and blasts will be trimmed as blasting approaches the MEZ. Approximately nine Section 18 applications are anticipated, consisting of 74 rockshelters, 17 artefact scatters and one quarry. The Revised Proposal will result in the lowering of the groundwater table due to dewatering to enable below water table mining, which may result in a section of Jimmawurrada Creek exhibiting riparian vegetation canopy decline, stress and possible death of some individuals; and some pools of the Robe River showing lowered water levels. However, with the proposed mitigation measures, it is unlikely that the Revised Proposal will significantly impact on the continued presence of pools, riparian vegetation, and the heritage values associated with the Robe River. After the mitigation hierarchy has been applied, including avoidance of impacts to the most significant heritage sites in the Development Envelope, minimisation of disturbance to other sites, and the Proponent's commitment to continuing consultation with the Robe River Kuruma People regarding the Revised Proposal through LIC meetings and heritage survey processes; the Proponent considers that the potential impacts can be managed to meet the EPA's objective for Social Surroundings. **Offset:** The Proponent considers that the Proposed Change is unlikely to have a significant residual impact on Social Surroundings and therefore offsets for this factor are not proposed.
Air Quality	
EPA Objective	The EPA objective for air quality is to maintain air quality and minimise emissions so that environmental values are protected.
Policy and guidance	**EPA policy and guidance** • EPA Statement of Environmental Principles, Factors and Objectives (2018) • EPA Environmental Factor Guideline: Air Quality (2016). **Other policy and guidance** • WA Environmental Offsets Policy (2011) • WA Environmental Offsets Guidelines (2014).
Potential impacts	The production of greenhouse gas emissions and a reduction to air quality.
Mitigation	**Minimise:** • The Proponent is committed to an ongoing program of reporting and review to identify opportunities to further reduce energy consumption and reduce greenhouse gas emissions. • The Proponent has well established procedures for the reporting of greenhouse gas emissions at its Pilbara operations. In accordance with the *National Greenhouse and Energy Reporting Act 2007* the Proponent reports annually on energy production, energy consumption, emissions and updates on energy management projects. • The management of greenhouse gas emissions will continue to be in accordance with relevant legislation and national and state strategies relating to greenhouse gas emissions.

Outcomes	**Residual Impact:** The primary methods greenhouse gas emissions will be generated during the construction and operation of the Proposed Change is through diesel combustion by haul trucks, the clearing of native vegetation, and the use of explosives during blasting and power consumption for ore processing. This Proposal is expected to generate the following greenhouse gases emissions (primarily carbon dioxide; CO_2), on average per year: • Additional Scope 1 emissions of approximately 51,468 tonnes CO_2 equivalent • Additional Scope 2 emissions of approximately 5,806 tonnes CO_2 equivalent However, the Proposed Change is a relatively small emitter of greenhouse gases for an Iron Ore mining operation. The potential for impacts to air quality can be appropriately managed via existing legislation. **Offset:** The Proponent considers that the Proposed Change is unlikely to have a significant residual impact on Air Quality and therefore offsets for this factor are not proposed.

Table ES 4: Summary of Potential Impacts, Proposed Mitigation and Outcomes for Other Environmental Factors

Landforms	
EPA Objective	The EPA objective for landforms is to maintain the variety and integrity of distinctive physical landforms so that environmental values are protected.
Policy and guidance	**EPA policy and guidance** • EPA Environmental Factor Guideline: Landforms (2018) • EPA Statement of Environmental Principles, Factors and Objectives (2018) • DMP and EPA Guidelines for Preparing Mine Closure Plans (2015) • EPA Instructions on how to prepare an Environmental Review Document (2016) • EPA Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans (2016). **Other policy and guidance** • WA Environmental Offsets Policy (2011) • WA Environmental Offsets Guidelines (2014) • Western Australian Planning Commission, Visual Landscape Planning in Western Australia a manual for evaluation, assessment, siting and design (2007).
Potential impacts	**Direct impacts:** • Loss of variety due to removal or degradation of the mesa landforms • Loss of the integrity of the mesa landforms due to disturbance. **Indirect impacts** • Loss or degradation of the ecological values of the mesa landforms • Loss or degradation of the social values of the mesa landforms through loss of indigenous heritage and amenity values.

Mitigation	**Avoid:** • The Proposed Change has been designed with a MEZ around the perimeter of the mesa in order to ensure preservation of the mesa's most prominent feature; the mesa escarpments, effectively retaining the mesa façade (with the exception of minor access cuts to less prominent sections of the mesa where distinct escarpments are absent and ecological values are lower). • The width of the MEZ proposed for retention will be greater than 30 m (approximately 50 m) in width at the surface to ensure that the retained escarpment is geotechnically stable and to ensure cave features within the façade are maintained. • The Proposed Change has been designed to avoid all recorded Ghost Bat roosts including diurnal/potential maternal and nocturnal roosts. • Retention of the mesa escarpments will avoid impact to significant heritage sites located in the escarpments as well as reduce impacts to visual amenity of the landscape. Direct disturbance to recorded rockshelters, Jirtiwi Thalu, and the gender restricted quarry site MJ04-09 will be avoided. **Minimise:** • The access cuts for the haul roads have been designed to limit impact to the highest value habitat, areas of heritage significance and the most prominent sections of the escarpment. • The widths required for the haul road access cuts into the mesa escarpments have been minimised as far as possible to allow safe access. Escarpment cuts are located away from the Robe River, and will be largely hidden due to their location within the central (internal) gully, and south of the mesa landform. • Mine pits will be backfilled during operations to limit the volume of waste being stored in external waste dumps. • Where limited space results in the requirement for waste dumps to be placed on the margins of the mesa across sections of the MEZ, these dumps have been located in areas which avoid the highest value ecological and social (heritage and visual amenity) features and away from the Robe River. • The CID within the mesa formations provides troglofauna habitat. The Proposed Change has been designed to retain at least 50% by volume of pre-mining troglofauna habitat. • The implementation of the Blast Management Framework (including management of vibration and potential for flyrock) and retention of escarpments via a MEZ, with an adequate width >30 m to ensure geotechnical stability, will minimise any potential impacts to the ecological and social values of the mesa escarpments, including Ghost Bat roosts. • The location and layout of the mine and associated infrastructure has been designed to minimise impacts to Aboriginal heritage sites. Where impacts to heritage sites cannot be avoided, applications will be made under Section 18 of the AH Act in consultation with the Robe River Kuruma People. • Waste dumps have been located away from prominent visual vantage points, including the Robe River, and will remain at heights which are the same level or lower than the surrounding mesas to limit visual impact. **Rehabilitate:** • The conditions of the new MS shall require the Proponent to implement a Closure Plan in accordance with the DMP/EPA Guidelines for Preparing Mine Closure Plans. • The Closure Plan includes a closure objective to ensure that the final landform is stable and considers ecological and hydrological issues. • All disturbed surfaces will be rehabilitated, including pit floors, to maximise the ecological value. • Visual impacts will be further minimised through construction of the waste dumps to be aesthetically compatible with the surrounding landscape and through rehabilitation of the waste dumps.

Outcomes	**Residual Impact:** Although the Proposed Change will affect the integrity of Mesa H by removal of the interior of the landform, the highest value aspect of the landform, the escarpments, will be retained, excluding access cuts (<2% of the mesa escarpment). The design and locations of the escarpment cuts have been selected to avoid disturbance to the escarpment sections with the highest ecological and heritage values. This will largely preserve the prominence and scale of the mesas in the landscape, and therefore the Proposed Change will retain the representation or 'variety' of Robe Pisolite mesas in the Robe Valley. The existing operations at Mesas A and J, K and historical mining operations in the Robe Valley demonstrate that mesa escarpments are stable, and the structural integrity can be maintained by ensuring retention of an adequate width of escarpment. As the Proposed Change has been designed with escarpment widths that are greater than 30 m at the crest of the mesa landform, the integrity of the remaining landform is not expected to be compromised. Connected troglofauna habitat (except at the escarpment cuts) representing at least 50% of the mesa pre-mining habitat volume will be retained, and direct disturbance to all recorded rockshelter sites, the inclusion of Jirtiwi Thalu and the gender restricted quarry MJ04-09 in the MEZ will be avoided. Mineral waste has been scheduled to be backfilled in-pit as far as practical. Where ex-pit waste dumps are required, their location has been designed to avoid the highest ecological and social values of the mesa landform. After the mitigation hierarchy has been applied, including avoidance of direct disturbance to the majority of the mesa escarpments, including heritage and ecological values, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Landforms. **Offset:** The Proponent considers that the Proposed Change is unlikely to have a significant residual impact on Landforms and therefore offsets for the associated values are not proposed for this factor.

Part 1 – Overview and Proposal

1. INTRODUCTION

1.1 Purpose and Scope

Robe River Mining Co. Pty. Limited (the Proponent) operates the Robe Valley mining operations, which includes iron ore mines at Mesa J, Mesa K, Mesa A and Warramboo. The Mesa J and Mesa K mines are located approximately 10 km south of Pannawonica in the Pilbara region of Western Australia (WA) (Figure 1-1). The Proponent is seeking to extend the life of the Mesa J Iron Ore Development through development of the adjacent deposit, Mesa H, to sustain iron ore production from the Robe Valley.

The purpose of this Environmental Review Document (ERD) document is to provide a report on the environmental review for the Mesa H Proposal (*Revision to the Mesa J Iron Ore Development*) (the Revised Proposal) to the WA Environmental Protection Authority (EPA).

The scope of the ERD is to present an environmental review of the principal components of the Proposed Change, including a detailed impact assessment and description of proposed environmental management measures for the key environmental factors in accordance with the Environmental Scoping Document (ESD) prepared by the Proponent and approved by the EPA.

The ERD has been prepared by Rio Tinto and ELA on behalf of Robe River Mining Co. Pty. Ltd (the Proponent), in accordance with the Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016 and Environmental Impact Assessment (Divisions 1 and 2) Procedures Manual 2018. The referral form for this Revised Proposal is provided as Appendix 1.

The following terminology is used throughout this document:

- **Proponent** – Robe River Mining Co. Pty. Limited as manager and agent for the Robe River Iron Associates (RRIA) joint venture as set out in Section 1.2.
- **Mesa J Iron Ore Development** – The Mesa J iron ore mine and associated infrastructure (including rail) as approved under Ministerial Statement (MS) 208.
- **Mesa H deposit** – pisolite iron ore formation occurring as a partial mesa landform (also known as a Channel Iron Deposit).
- **Revised Proposal – Mesa H Proposal (Revision to the Mesa J Iron Ore Development) –** the existing Mesa J Iron Ore Development approved under MS 208 plus the Proposed Change as detailed in Section 2.
- **Proposed Change** – the new activities of the Revised Proposal associated with mining at Mesa H (i.e. the subject of this assessment).
- **Development Envelope** – the area encompassing the Revised Proposal, including the existing Mesa J Iron Ore Development and Proposed Change.
- **Proposed Change Area** – the area associated with the Proposed Change.
- **Study Area** – includes areas surveyed / studied beyond the extent of the Development Envelope.
- **Approved activities** – activities associated with the existing Mesa J Iron Ore Development.

1.2 Proponent

The Proponent for the Revised Proposal is Robe River Mining Co. Pty. Limited

ABN: 71 008 694 246

ACN: 008 694 246

GPO Box A42

Perth WA 6837

The Proponent is the manager and agent for the RRIA which is an unincorporated joint venture comprising the following participants:

- Robe River Mining Co. Pty. Limited (30% share);
- North Mining Limited (35% share);
- Mitsui Iron Ore Development Pty Ltd (20% share);
- Pannawonica Iron Associates, a partnership carried on by Nippon Steel & Sumitomo Metal Australia Pty Ltd, Nippon Steel & Sumikin Resources Australia Pty Ltd (10% share); and
- Cape Lambert Iron Associates, a partnership carried on by Nippon Steel & Sumitomo Metal Australia Pty Ltd, Nippon Steel & Sumikin Resources Australia Pty Ltd and Mitsui Iron Ore Development Pty Ltd (5% share).

The Rio Tinto Group (Rio Tinto) is managing the Environmental Impact Assessment (EIA) and approvals process on behalf of the Proponent. The Rio Tinto contact person in relation to the environmental approvals process for this Revised Proposal is:

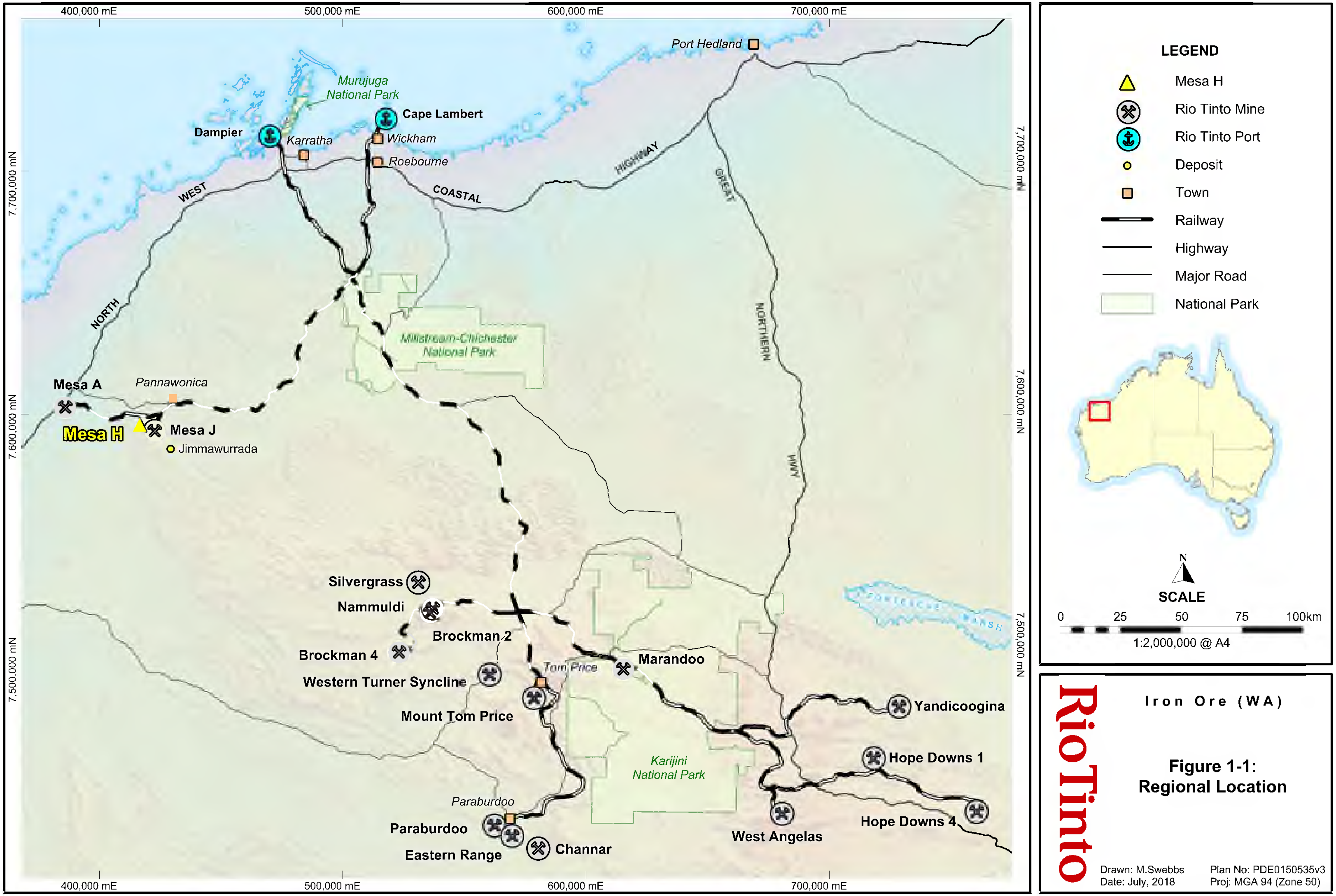
Melinda Brand

Principal Advisor Environmental Approvals

Rio Tinto

Telephone: +61 (08) 6211 6991

Email: melinda.brand@riotinto.com



RioTinto

Iron Ore (WA)

Figure 1-1: Regional Location

Drawn: M.Swebbs
Date: July, 2018

Plan No: PDE0150535v3
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping

1.3 Environmental Impact Assessment Process

The key legislative requirements relating to this Revised Proposal are:

- Part IV of the *Environmental Protection Act 1986* (EP Act) (Section 1.3.1);
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act, Section 1.3.2); and
- Iron Ore (Robe River) Agreement Act 1964.

1.3.1 Environmental Protection Act 1986 (WA)

This Revised Proposal was referred to the EPA under s38 of the EP Act on 29 June 2017. The EPA determined that the Revised Proposal required environmental assessment at the level of Public Environmental Review (PER) with a two-week public review period.

The Proponent prepared an ESD for the Revised Proposal which provides an outline of the key environmental factors, a description of the scope of the assessment of the Proposed Change associated with the Revised Proposal and an indicative timeline for the assessment process. The ESD was approved by the EPA Board on 31 October 2017 (Appendix 2).

This ERD has been prepared in accordance with the ESD, the Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures (EPA 2016a) and the Environmental Impact Assessment (Part IV Divisions 1 and 2) Procedures Manual (EPA 2018a) to meet the requirements of section 40(2)(b) of the EP Act.

Should the Revised Proposal be approved for implementation, the Proponent proposes that mining be subject to a new MS (Appendix 3).

1.3.2 Environment Protection and Biodiversity Conservation Act 1999 (Cwth)

The Commonwealth EPBC Act provides for the referral and assessment of Proposals which, if implemented, may have a significant impact on threatened species, ecological communities or heritage places listed as Matters of National Environmental Significance (MNES).

Assessment against the Significant Impact Guidelines 1.1 (Department of the Environment [DoE] 2013) indicated the requirement for referral of the Proposed Change under the EPBC Act. The Proposed Change was referred to the Department of the Environment and Energy (DotEE) under the requirements of the EPBC Act on 17 August 2017 (Appendix 4). DotEE determined that the Proposed Change is a Controlled Action on 14 October 2017 (EPBC Reference 2017/8017) and therefore it requires assessment under the EPBC Act. The EPA is assessing the Proposed Change on behalf of the Commonwealth under Section 87 of the EPBC Act as an accredited assessment. The relevant MNES for this Proposed Change are:

- Listed threatened species and communities (Sections 18 and 18A).

1.4 Other Approvals and Regulation

This Proposed Change is also subject to compliance with other relevant state legislation and regulations and is guided by relevant key over-arching state policies and strategies. In addition, there are EPA Factor Guidelines and Technical Guidance documents that have been used to determine the significance of the environmental impacts of the Proposed Change.

1.4.1 Land tenure and state agreement

The Robe Valley mining operations, including this Proposed Change, are predominantly located within the State Agreement Mineral Lease ML248SA granted pursuant to the *Iron Ore (Robe River) Agreement Act 1964*. ML248SA is held by Robe River Limited (a 100%

owned Rio Tinto entity) and sub-leased to the RRIA, pursuant to Mineral Sub-lease No. 1H/79. ML248SA is considered appropriate tenure for mining and mining related infrastructure.

Existing tenure in and near the Development Envelope is shown in Figure 1-2. The Revised Proposal pits, dumps and the majority of infrastructure are located within ML248SA (Section 104 and a portion of Section 103). A proposed powerline to the east of the Mesa J Iron Ore Development will require new tenure to be granted under the *Mining Act 1978*.

The main co-existing *Land Administration Act 1997* tenure in the Development Envelope includes the Yarraloola Pastoral Station (Lease N49500) and the Yalleen Pastoral Station (Lease N49492). These pastoral leases are held by partnerships which comprise members of the RRIA joint venture.

Additional State Agreement tenure will be required for the extension to the powerline to the Mesa J power network and grant of associated tenure as described above.

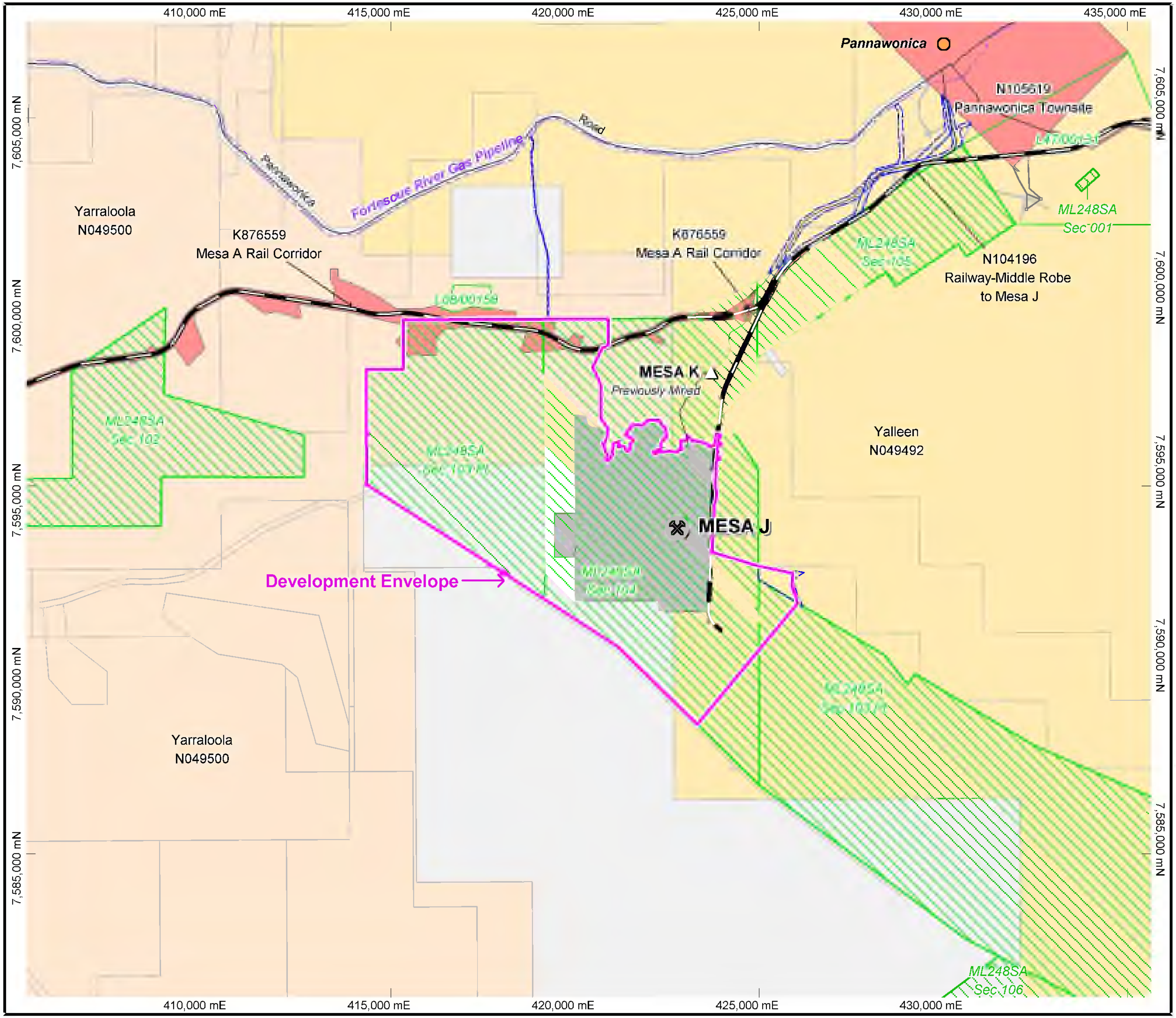
1.4.2 Native title

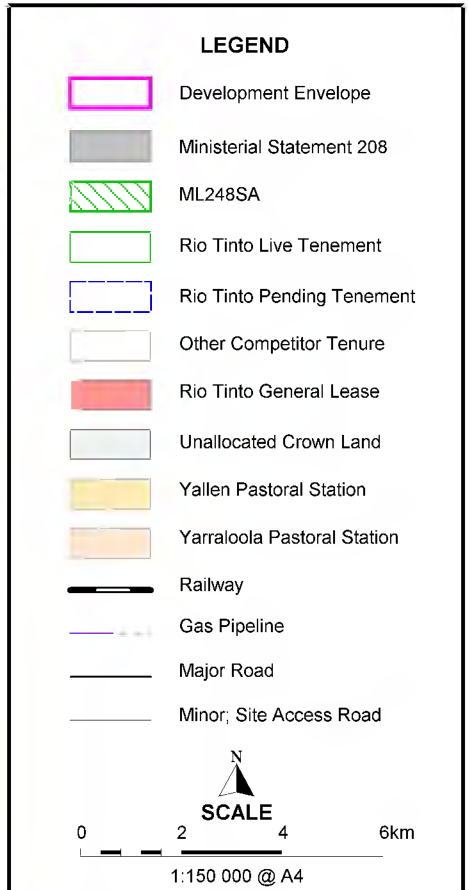
The Development Envelope lies within the determined Robe River Kuruma Native Title area (WCD2018/003) Figure 1-3. The Robe River Kuruma People were formerly known as the Kuruma Marthudunera People prior to the Native Title determination in April 2018. The Proponent has Native Title agreements with the Robe River Kuruma People that include an established consultation framework for ongoing engagement on relevant aspects of the Proponent’s operations.

The comprehensive agreements provide guidelines and requirement for communication and participation with the Robe River Kuruma People on relevant aspects of the Proponent’s operations in respect to cultural heritage management, environmental management, Life of Mine (LOM) planning, land access, employment and training, business development, and cultural awareness training in order to ensure that the Revised Proposal activities are conducted in a manner so that cultural heritage is managed appropriately.

1.4.3 Other approvals and legislation

Other approvals and legislation relevant to this Proposed Change are outlined in Table 1-1.





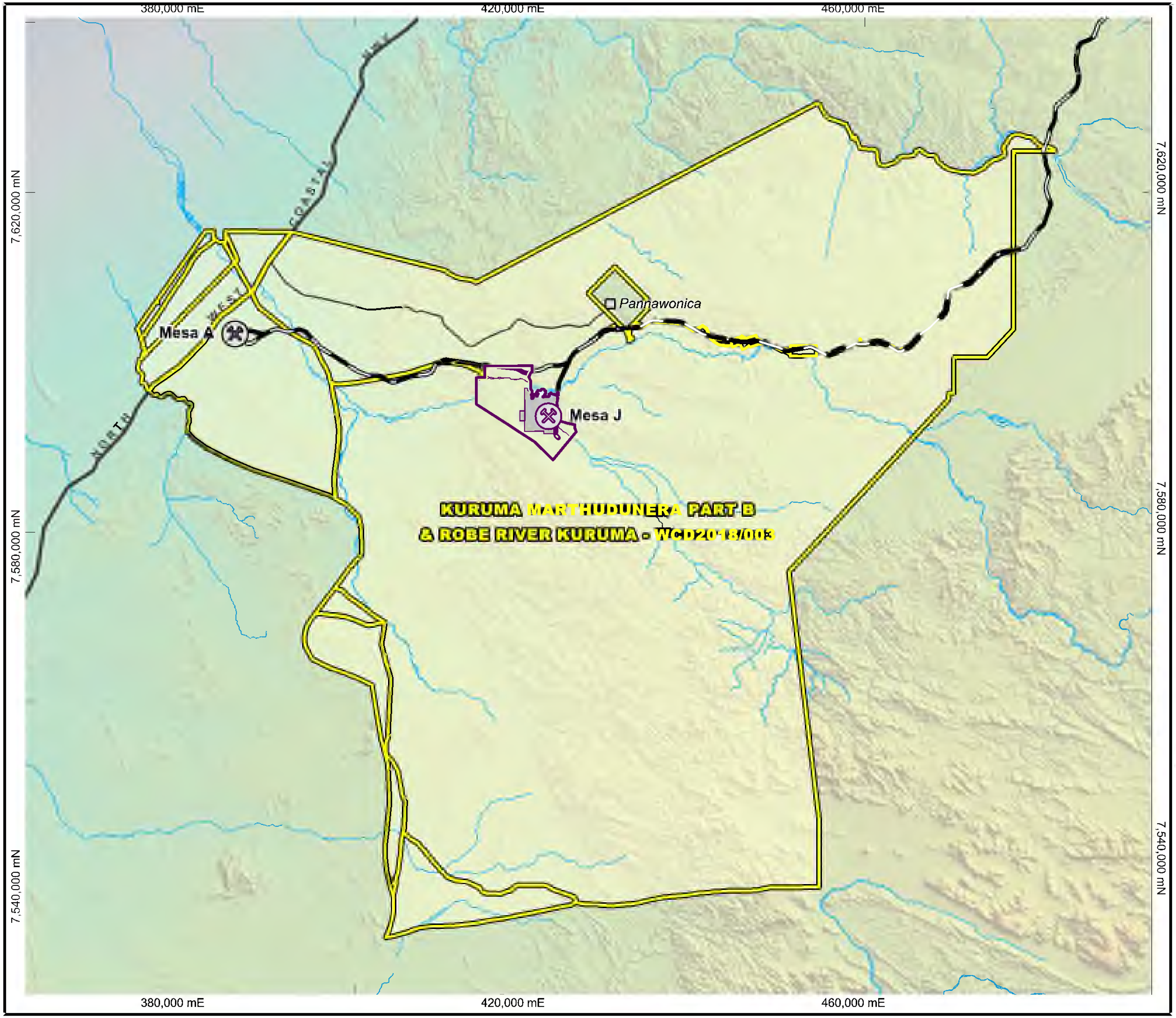
RioTinto

Iron Ore (WA)

Figure 1-2: Land use and tenure in the vicinity of the Development Envelope

Drawn: M.Swebbs
Date: Aug, 2018

Plan No: PDE0152226v4
Proj: MGA94 Zone50



LEGEND

- Development Envelope
- Ministerial Statement 208
- Kuruma Marthudunera Part B & Robe River Kuruma - Determined Area
- Mine
- Town
- Railway
- Highway
- Major Road
- Major Watercourse

N

SCALE

0 10 20 30km

1:750,000 @ A4

RioTinto

Iron Ore (WA)

Figure 1-3: Native Title Determined Boundaries

Drawn: GIS Team
Date: Aug, 2018

Plan No:PDE015437v3
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping

Table 1-1: Other Approvals and Legislation Relevant to this Proposed Change

Proposed Change activities	Land tenure/access	Type of approval	Legislation regulating the activity
Clearing of native vegetation for associated infrastructure (including power, water infrastructure and access roads) and exploration and investigative activities (e.g. mineral, geotechnical)	State Agreement (ML248SA)	Native Vegetation Clearing Permit (NVCP)	EP Act – Part V *Building Act 2011*
New infrastructure considered a prescribed activity that is not covered by an existing licence (e.g. process plant, landfill, dewatering discharge)	State Agreement (ML248SA)	Works Approval	EP Act – Part V
Operating a prescribed premise - processing of ore, dewatering (discharge), screening, power generation, sewage facility, landfill and bulk storage of chemicals.		Operating Licence	
Disturbance of a protected Heritage site	State Agreement (ML248SA)	Section 16 / section 18 consent to disturb a protected site	*Aboriginal Heritage Act 1972*
Construction of new groundwater bores	State Agreement (ML248SA)	Licence to Construct or Alter Wells	Section 26D of the *Rights in Water and Irrigation Act 1914* (RIWI Act)
Abstraction of groundwater for water supply and dewatering	State Agreement (ML248SA)	Licence to Take Groundwater	Section 5C of the RIWI Act
Interference or obstruction of significant waterways, e.g. creek crossing	State Agreement (ML248SA)	Permit to Obstruct or Interfere with Bed / Banks	Sections 11/17/21A of the RIWI Act
Extension of power line to connect to the existing Mesa J powerline network	State Agreement (ML248SA)	Miscellaneous Licence	*Mining Act 1978*
Low impact activities such as drilling programs or geotechnical investigation on Mining Act tenure	Exploration Lease	Programme of Works	*Mining Act 1978*
Construction and operation of any waste water treatment plant beyond a specified capacity	State Agreement (ML248SA)	Works Approval	*Health Act 1911* Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulation 1974 EP Act – Part V

1.4.4 Decision making authorities

The Decision-Making Authorities (DMA) identified in the ESD and their relevance to the Proposed Change are listed in Table 1-2.

Table 1-2:Decision-making Authorities

Decision-making Authority	Relevant legislation
Minister for State Development	*Iron Ore (Robe River) Agreement Act 1964*
Minister for Mines and Petroleum	*Mining Act 1978*
Minister for Environment	*Biodiversity Conservation Act 2016* (Taking of flora and fauna)
Chief Executive Officer, Department of Water and Environmental Regulation	*Environmental Protection Act 1986* (Clearing of Native Vegetation) (Part V Works Approval and Licence) *Rights in Water and Irrigation Act 1914* (Water abstraction licence)
Executive Director, Environment Department of Mines, Industry Regulation and Safety	*Mining Act 1978*
State Mining Engineer Department of Mines, Industry Regulation and Safety	*Mines Safety and Inspection Act 1994*
Chief Executive Officer: Department of Mines, Industry, Regulation and Safety	*Dangerous Goods Safety Act 2004*
Minister for Aboriginal Affairs	*Aboriginal Heritage Act 1972* (Section 18 clearance)
Chief Executive Officer: Shire of Ashburton	*Building Act 2011* *Health Act 1911* Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulation 1974
Minister for the Department of the Environment and Energy	*Environment Protection and Biodiversity Conservation Act 1999*

2. THE PROPOSED CHANGE

The Proponent is seeking to extend and replace the life of the Mesa J Iron Ore Development through development of the adjacent deposit, Mesa H, which is located 16 km south west of Pannawonica in the Pilbara region of WA. Mining of this deposit will extend the life of, and ultimately replace the existing Mesa J Iron Ore Development (approved under MS 208) (Appendix 5) in order to sustain Channel Iron Deposit (CID) ore production from the Robe Valley.

The Proposed Change includes development of an above (AWT) and below water table (BWT) CID at Mesa H, comprising: open cut pits; ore processing facilities; waste dumps, ore, topsoil and subsoil stockpiles; and associated infrastructure, including water management infrastructure.

2.1 Existing Approval

The original Mesa J Iron Ore Development was referred to the EPA under Part IV of the EP Act and was assessed at the level of Consultative Environmental Review. The EPA published its Report and Recommendations (Bulletin 574) in August 1991.

The environmental aspects (factors) considered by the EPA, as described in the EPA's Report and Recommendations (Bulletin 574), for Mesa J were:

- Riparian vegetation communities (Vegetation and Flora)
- Groundwater drawdown and surface water discharge (Inland waters)
- Rehabilitation.

The Minister approved implementation of the Mesa J Iron Ore Development, subject to the conditions of MS 208, on 16 January 1992.

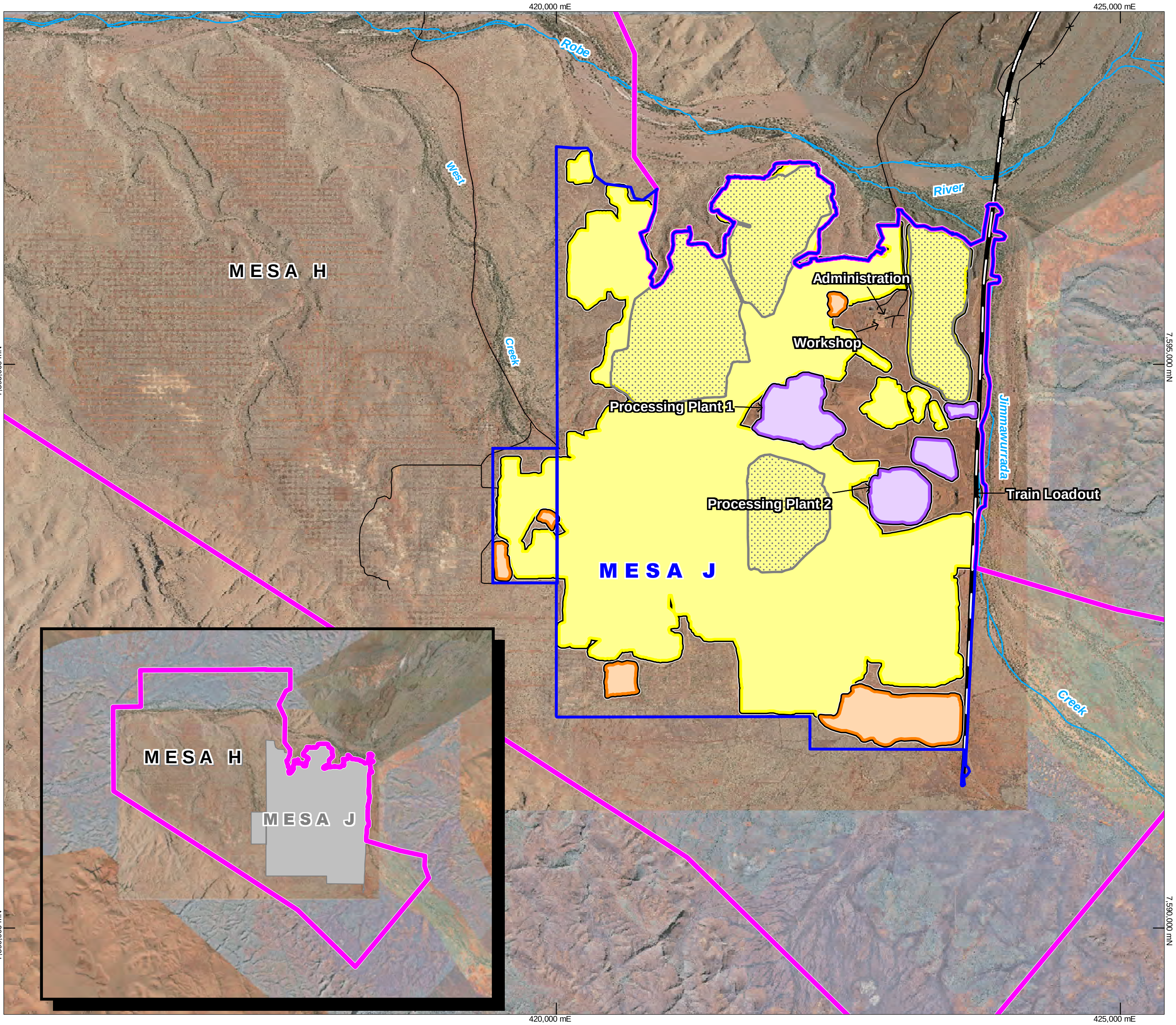
The Mesa J Iron Ore Development, as amended (see Table 2-1) and approved by MS 208, currently includes:

- Open cut, AWT and BWT mining of channel iron ore, by conventional drill, blast, and load and haul techniques.
- Ore processing in central processing facilities at approximately 35 Million tonnes per annum (Mt/a).
- Ex-pit surface waste dumps which are used in backfilling of the pits as far as practicable.
- Low grade stockpiles, topsoil, subsoil and overburden stockpiles.
- Infrastructure including:
    - dewatering and surplus water management infrastructure, including the Southern Cutback Borefield, located approximately 1 km south of the Mesa J Iron Ore Development, and discharge points on Jimmawurrada Creek and the West Creek tributary.
    - surface water management infrastructure, including diversions to direct surface water flows around the deposit.
    - landfill facility.
    - linear infrastructure, including the mine access road of approximately 35 km long which links the mine site with the Pannawonica Access road; and the rail network which transports processed ore approximately 413 km to port facilities located at Cape Lambert.

Table 2-1: Summary of Previous Changes to the Approved Mesa J Iron Ore Development

Approval Date	Ministerial Statement	Type	Change
20 December 2005	MS 208	s45C	Definition of project life, ore reserve, percentage mining BWT, total disturbance area Definition of proposal boundary
13 November 2006	MS 208	s45C	New rail siding
6 March 2007	MS 208	s45C	Installation of fibre optic cable for railway communications system (including additional clearing)
30 October 2007	MS 208	s45C	Installation of fibre optic cable for railway communications system (including additional clearing)

The existing Mesa J Iron Ore Development excludes mining from the northern escarpment of the Mesa, adjacent to the Robe River, effectively creating a 'Mining Exclusion Zone' (MEZ). This MEZ was established to protect the integrity of the mesa escarpment and landform values, including visual amenity, and heritage values. The key characteristics and authorised extent of the existing Mesa J Iron Ore Development are described in Schedule 1 of MS 208 (Appendix 5) and the existing layout is shown Figure 2-1 below.



LEGEND

- Ministerial Statement 208
- Developement Envelope (Revised Proposal)
- Pit
- Dump
- Stockpile
- Waste Fines Storage Facility
- LV Road
- Powerline
- Railway
- Major Watercourse

N

SCALE

0.5 0 0.5 1 1.5km

1:50 000 @ A4

RioTinto

Iron Ore (WA)

Figure 2-1: Existing Mesa J Iron Ore Development (MS208)

Drawn: M.Swebbs
Date: Aug, 2018

Plan No: PDE016826v3
Proj: MGA94 Zone50

Geospatial Information and Mapping

2.2 Proposed Change Description

The Proposed Change is to extend the life of and ultimately replace the adjacent operations at Mesa J. The Proposed Change includes the following key components:

- **Mine pits** - development of open cut AWT and BWT iron ore pits. Predominantly comprising three main pits and several smaller pits.
- **Processing facilities** – this Proposed Change will be supported by the existing processing facilities at Mesa J with the below modifications and may require some additional processing facilities. Ore will be transported from Mesa H to the existing dry and wet central processing facilities at the Mesa J Iron Ore Development via haul trucks. Minor modifications to the Mesa J facilities, including the provision of a new secondary sizer and associated materials handling infrastructure on the existing dry process circuit and additional screening of wet processed material via a new re-screening facility, are required.
- **Dewatering infrastructure** – including bores, pipelines, and discharge outlet(s). Approximately 20% of the Proposed Change is below the current water table and will require dewatering of up to 3 GL/a from approximately 2025 to access the BWT resource.
- **Surface water management infrastructure** – including but not limited to surface water diversion drains, levees and culverts. Surface water management structures (diversions) will be required during mining to redirect surface water flows from the Buckland Hills around the mine pits and through the central gully of Mesa H, back into the Robe River. Other surface water management infrastructure will include culverts along vehicle creek crossings / road upgrades across creek crossings (including the Robe River).
- **Support facilities** – including but not limited to workshops, power supply infrastructure, hydrocarbon storage, laydown areas, offices and waste water treatment plants.
- **Linear infrastructure** – including but not limited to heavy vehicle and light vehicle access roads and upgrades to the existing vehicle access roads, pipelines, power (including sub-stations) and communications distribution networks.
- **Mineral waste management** – including but not limited to backfilling, ex-pit waste dumps, low grade ore dumps, topsoil and sub-soil stockpiles. Topsoil will be removed prior to mining and will be stored in stockpiles for later use in rehabilitation. Waste will be transported by haul trucks to new in-pit and ex-pit waste dumps (and / or stockpiles). Backfilling of BWT pits (to prevent pit-lake formation) during operations and / or closure is proposed. Waste fines generated from wet processing will be stored in existing in-pit facilities at Mesa J.
- **Surplus water management** – including use in processing, on-site use and controlled discharge to Jimmawurrada Creek and tributaries of the Robe River. Any surplus water from mine pit dewatering, exceeding the local operational water requirement will be will be used to supply operational water demand for both Mesa J and H Operations. Where operational water storage capacity is exceeded (particularly post wet-season), surplus water will be discharged intermittently into existing Mesa J licenced discharge points (or potentially new optimised discharge points) at Jimmawurrada Creek and / or the discharge point at West Creek (both tributaries of the Robe River).

- **Process and Operational Water supply** – will utilise groundwater abstracted for dewatering, surface water that reports to pits, the existing Mesa J borefield (Southern Cutback Borefield) and additional bores, seepage recirculation from Waste Fines Storage Facilities (WFSFs) and water reservoir to adjacent pits as required for operational ancillary requirements.
- **Southern Cutback Borefield Extension** – Additional bores and associated infrastructure to support water supply for operational requirements.
- **MEZ** – area proposed for retention and avoidance of mine pit excavation (will include a portion surface clearing for installation of infrastructure such as waste dumps, tracks, utilities, telecommunications, monitoring stations and abandonment bunds).

Mined and processed ore will be railed to Rio Tinto's port operations at Cape Lambert via the existing rail network.

The exact location of the components of the Proposed Change is subject to change as part of ongoing detailed studies and engineering designs; however, the components described above will be located within the Development Envelope. The Revised Proposal Development Envelope is shown in Figure 2-2 and a conceptual mine layout is shown in Figure 2-3.

2.2.1 Key Revised Proposal characteristics

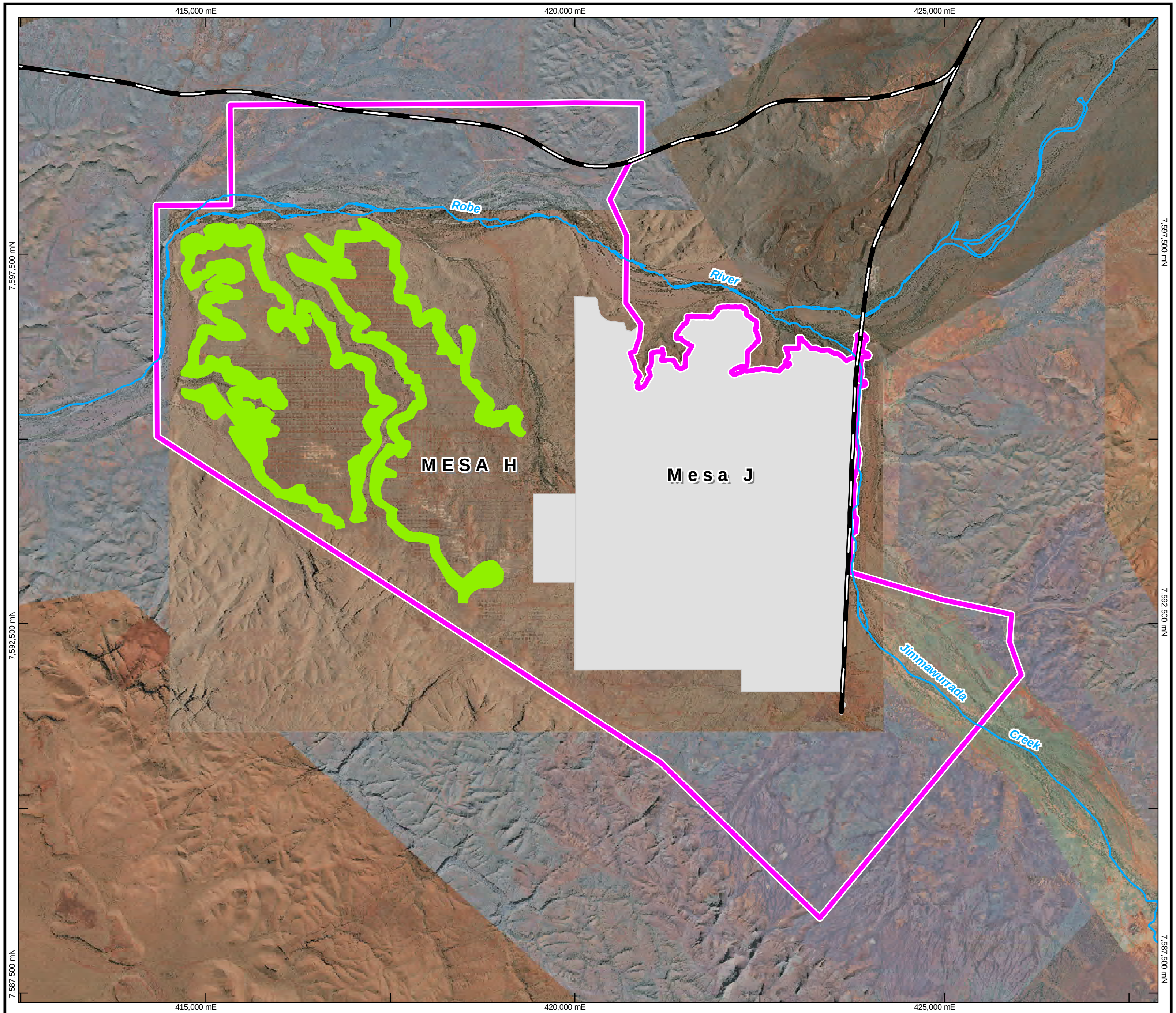
The key characteristics of the Revised Proposal (the Proposed Change and the approved Mesa J Iron Ore Development) are provided in Table 2-2 and the key characteristics of the Proposed Change only are provided in Table 2-3.

Table 2-2: Summary of the Revised Proposal

Project Title	Mesa H Proposal (Revision to the Mesa J Iron Ore Development)
Proponent Name	Robe River Mining Co. Pty. Limited
Short description	The Revised Proposal is located approximately 16 km south west of Pannawonica in the Pilbara region of WA. The Revised Proposal includes development of above and below water table open cut pits at Mesa J and Mesa H, ore processing facilities, waste dumps, ore, topsoil and subsoil stockpiles and associated infrastructure, including water management infrastructure. This Revised Proposal utilises infrastructure including processing facilities (subject to upgrades) and rail from the existing Mesa J Iron Ore Development.

Table 2-3: Location and Proposed Extent of Physical and Operational Elements

Element	Location	Existing approval (MS 208)	Proposed change	Proposed Extent (Revised Proposal)
Physical Elements				
Mine and associated infrastructure	Figure 2-2	Total disturbance area (vegetation clearing) of up to 1,800 ha	Clearing of up to 2,200 ha of native vegetation within the Development Envelope of 6,638 ha. Disturbance in the Mesa H Mining Exclusion Zone in accordance with the Environmental Management Plan.	Clearing of up to 4,000 ha of native vegetation within a Development Envelope of 6,638 ha. Disturbance in the Mesa J northern escarpment and Mesa H Mining Exclusion Zone in accordance with the Environmental Management Plan.
Rail	Figure 2-1	Single gauge railway line with sidings and a voice and radio data communications system with Fibre optic cable, from Cape Lambert.	N/A	Remove as not environmentally relevant
Operational Elements				
Groundwater abstraction (for water supply, ore processing and pit dewatering)	-	Not specified in MS 208 Annual water entitlement of 30 GL/a (Approved under RIWI licence GWL107678(13))	No change	Groundwater abstraction up to 30 GL/a, including from: • Water supply from Southern Cutback Borefield • Pit dewatering • Seepage interception.
Surplus Water Management	-	Not specified in MS 208. Discharge of mine dewater at designated discharge points in Jimmawurrada Creek and a tributary of Robe River. (Approved under Part V Operating Licence L6820/1993/12).	No change	Controlled surface discharge to extend along Jimmawurrada Creek / West Creek and into the Robe River no further than 8 km downstream of the discharge point under natural no-flow conditions.



LEGEND

- Development Envelope
- Proposed Mining Exclusion Zone
- Extent of Mesa J Mine Operations Area
- Railway
- Major Watercourse

N

SCALE

0 1 2 3km

1:75 000 @ A4

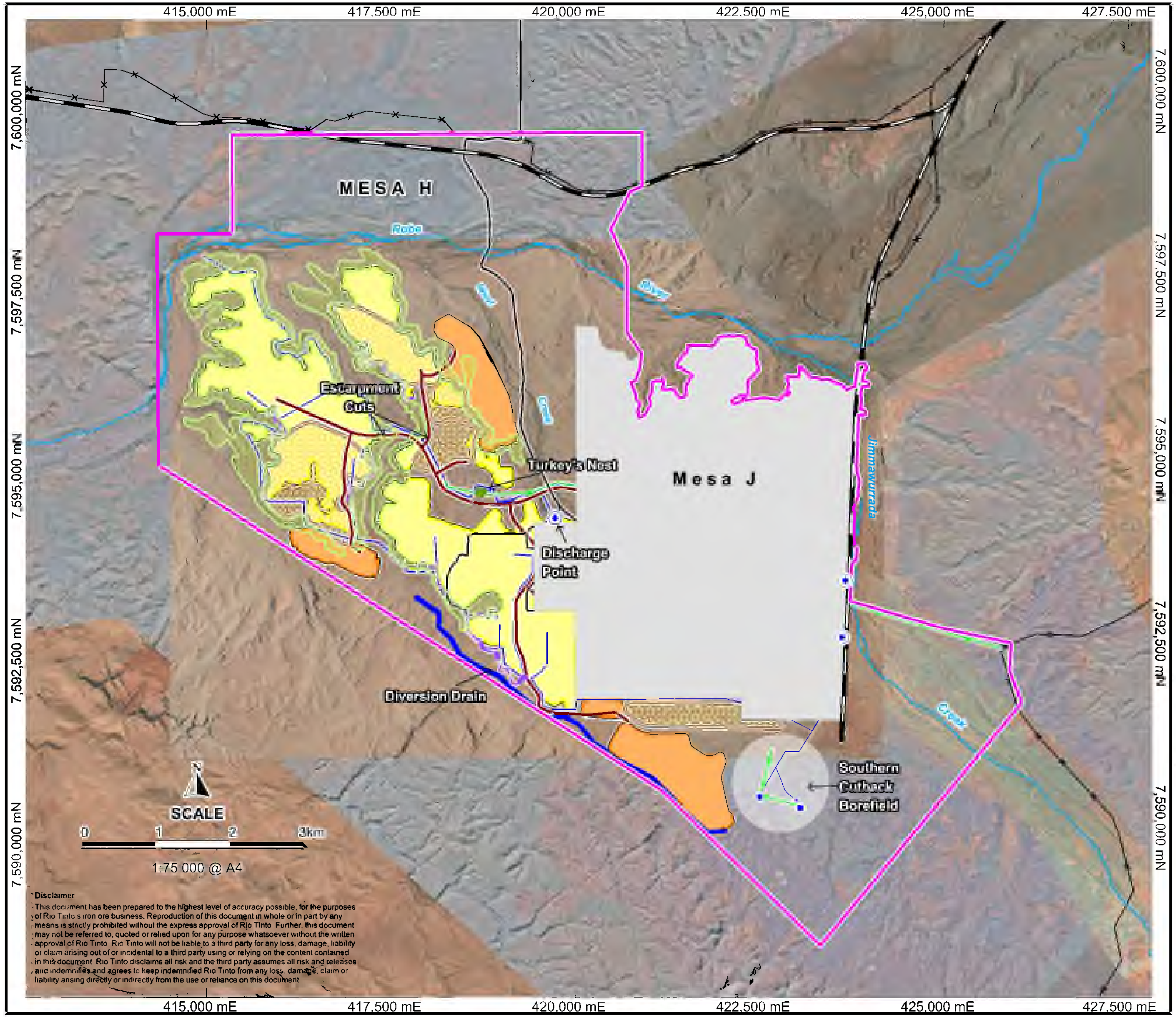
RioTinto

Iron Ore (WA)

Figure 2-2: Revised Proposal

Drawn: T.Murphy
Date: Feb, 2019

Plan No: PDE0152228v16
Proj: MGA94 Zone50



LEGEND

- Development Envelope
- Extent of Mesa J Mine Operations Area
- Mesa H Mining Exclusion Zone
- Railway
- Powerline
- LV Road
- Major Watercourse
- Existing Discharge Point

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile
- Turkey's Nest
- Diversion Drain
- Haul Road
- Discharge Pipeline
- Electrical Services
- Communicaiton Route
- Communication Tower
- Water Bore

Rio Tinto

Iron Ore (WA)

Figure 2-3: Conceptual Layout

Drawn: M.Swebbs Date: Jan, 2019

Plan No: PDE0152228v13 Proj: MGA94 Zone50

Geospatial Information and Mapping

2.2.2 Detailed Proposed Change description

2.2.2.1 Description of the resource

The Proposed Change resource comprises pisolitic iron ore, more generically referred to as a CID, which occurs as a characteristic Mesa Landform within the Robe Valley and forms the downstream continuation of the adjoining Mesa J CID.

2.2.2.2 Vegetation clearing and topsoil removal

Clearing of vegetation will occur during pre-strip and construction activities to develop the mine pits and associated infrastructure. Fill for construction purposes will be sourced from the escarpment cuts at Mesa H, borrow pits and existing waste dumps at the Mesa J Iron Ore Development.

Topsoil, subsoil and overburden will initially be removed during the bulk earthworks phase and throughout the life of the mine as each new sub-pit is developed. Topsoil is an important resource in rehabilitation as it contains a natural seed bank and typically contains significant quantities of organic material and nutrients (required for successful rehabilitation) relative to subsoil or overburden material. Topsoil layers in the Pilbara are highly variable in thickness, ranging from minimal soil development on rocky areas to approximately 300 millimetres (mm) in valley areas. Stripped topsoil, subsoil and cleared vegetation will be stored in out-of-pit stockpiles for later use in areas being rehabilitated (via existing management systems).

2.2.2.3 Mining

The Proposed Change includes development of new open cut mine pits (three main areas) at the Mesa H deposit with approximately 20% of ore proposed for mining occurring below the current water table. Mine pit dewatering will be required to enable mining of ore below the water table.

Ore will be mined using open cut mining methods comprising conventional drill, blast, load and haul as currently used in the adjacent Mesa J Iron Ore Development.

2.2.2.4 Mineral waste

The Revised Proposal mine plan has incorporated a conceptual pit sequence that enables progressive in-pit backfill of the majority of waste. Where pit sequencing and scheduling do not enable waste to be used for backfilling, ex-pit waste dumps will be utilised. Currently, three locations have been identified for ex-pit waste dumps that minimise direct impact to significant environmental and heritage areas. Both in-pit and ex-pit storage for competent material, low grade ore, subsoil and topsoil will also be required.

Wet processing of low grade ore from the Proposed Change will generate waste fines (the ultra fine clay fraction) residue. The mine plan will incorporate the use of mined-out pits within the adjacent Mesa J Iron Ore Development for in-pit WFSF over the life of the Revised Proposal, which is current practice at the Mesa J Iron Ore Development. This method for storage of inert waste fines residue in-pit is considered preferable to manage associated risks from geotechnical stability and flooding / erosion and more effective environmental management.

2.2.2.5 Ore handling, processing and transport

Haul roads will be developed to enable haulage of ore from the Proposed Change to the Mesa J Iron Ore Development for dry and wet processing. Some modifications and upgrades will be made to the existing Mesa J Iron Ore Development infrastructure, including the rail bridge. Ore will be crushed at the existing primary sizer at Mesa J and further processed using a new secondary sizer prior to being transported to the Cape Lambert port. Wet process material will be rescreened through a new wet beneficiation process (wet processing) at the existing Mesa J wet processing plants. Ore will then be transported to the Cape Lambert port by rail.

2.2.2.6 Surface water management

Surface water management will be required for the watercourses draining local catchments from the Buckland Hills south of the Proposed Change which intersect the proposed southern pits. An approximately 5.5 km drainage diversion is required along the south side of the Proposed Change, extending south of the existing Mesa J Iron Ore Development pits, to direct flow to the natural gorge watercourse through the centre of the Proposed Change Area, and subsequently direct flows back into the Robe River (refer to Figure 2-3). At this stage, the diversion is not proposed to be maintained post closure; however, pending updates to the closure plan and agreed closure outcomes, this diversion could be considered for retention in the future.

Surface water management will also be required for direct rainfall and in-pit run-off which will require in-pit pumping and discharge to the environment via licenced discharge points when in-pit water storage capacity is exceeded.

The waste dumps proposed to the south east of the Mesa J Iron Ore Development will be protected from erosion with localised drainage structures.

2.2.2.7 Pit dewatering

Approximately 20% of the ore proposed for mining at Mesa H is below the current water table, therefore dewatering to access the BWT ore is required. Dewatering will occur as required and is currently expected to commence in approximately 2025 for a period of around 12 years and will be managed via in-pit bores and sump pumping, powered by diesel generators. Groundwater abstracted for dewatering purposes will be collected in a common pipeline reporting to the Mesa J reservoir and will contribute to meeting operational demands for the Proposed Change and Mesa J Iron Ore Development, primarily wet processing. However, the timing for BWT pit dewatering and the average dewatering rate will not be sufficient to meet ore processing demands, particularly in the initial years of operation, hence an additional water supply will be required for the Proposed Change.

2.2.3 Water Supply and Management

2.2.3.1 Water supply

Water is required for:

- construction activities;
- wet processing;
- general mining activities;
- dust suppression on haul roads; and
- potable water supply.

To meet operational demands, the ongoing operation and extension of the existing water supply borefield (Southern Cutback Borefield), located immediately to the south of the Mesa J Iron Ore Development, will be required. An additional two to four new bores will be installed to meet the expected water demand.

The site water demand for the Proposed Change and continuation of the Mesa J Iron Ore Development is expected to be less than the existing Mesa J Iron Ore Development (~10GL/a) due to the addition of a thickener plant for ore processing (which will reduce water content in the waste fines) (Section 5).

2.2.3.2 Surplus water management

Limited surplus water will be generated from mine pit dewatering due to site water usage requirements, seasonal fluctuations; seepage recirculation from in-pit waste fines and the water reservoir to adjacent pits.

Despite this water balance scenario, after large rainfall events significant ponding will result in the need to discharge. See Section 5.5.1 for details on the surplus water management approach for the Proposed Change.

2.2.3.3 Surface water management and infrastructure

All mine pit and associated infrastructure are located outside the major creek lines and floodplain areas and are mainly outside associated modelled critical flood levels. Some flood protection for mine pits and ore processing facilities will be installed to minimise production loss due to water ingress or erosion. These will be designed to largely direct water past operational areas within existing natural drainage networks.

Local catchment water management will include re-direction of surface flows, currently intercepted by the Mesa J pits and proposed Mesa H mining areas via a 5.5 km diversion drain redirecting surface water into the Robe River.

2.2.4 Mine support facilities and infrastructure

Additional power supply to the Mesa J processing facilities (with a satellite facility at Mesa H) is required, comprising a powerline of approximately 2.5 km in length from the existing Coastal Water Supply Project (CWSP) powerline.

A production hub will be established for the Proposed Change comprising: truck park up; laydown; offices; ablutions; waste water treatment plant; and other facilities as required to support the operation. A power line will connect the production hub to the Mesa J power network.

A turkey’s nest will be established near the production hub to provide water for dust suppression.

Communications systems will be extended to the Proposed Change including installation of fibre optic cables.

The Proposed Change will utilise the existing Mesa J Iron Ore Development rail infrastructure.

2.2.5 Workforce

The Revised Proposal will be an extension to the existing Mesa J Iron Ore Development and will require an increase in the operational workforce. The workforce will continue as mixed residential / FIFO workforce, housed in existing accommodation in Pannawonica. Some facilities in Pannawonica will be upgraded and expanded (not part of this Proposed Change).

The construction workforce will be accommodated in a ‘dry hire’ mobile construction camp north of the Development Envelope (not part of this Revised Proposal).

2.2.6 Timing

Construction activities are planned to commence in late 2019 once all required internal and external approvals are granted.

2.2.7 Exclusions

Exclusions from the scope of the Proposed Change comprise the following:

- Activities and additional infrastructure at the Mesa J Iron Ore Development approved under MS 208.
- Low impact activities within the Development Envelope prior to Part IV approval of the Proposed Change (to be subject to relevant provisions under Part V [Land Clearing] of the EP Act), including drilling and associated activities (such as upgrades to existing roads/tracks) for the purposes of resource evaluation, geotechnical assessment and hydrogeological investigation.
- Establishment of a construction camp to support the construction phase of the Proposed Change (to be subject to relevant provisions under Part V [Land Clearing and Works Approvals / Licensing] of the EP Act).
- Establishment of temporary services (communications, water supply, power), temporary concrete batch plant, site offices, access roads, laydown areas, and borrow pits to support establishment of a construction camp (to be subject to relevant provisions under Part V [Land Clearing and Works Approval / Licensing] of the EP Act).
- Facility upgrades in Pannawonica to support the expanded workforce.
- Power network upgrades at Pannawonica, and a 9 km section of overhead power line between the Pannawonica switchyard and the Mesa A / J tee-off (to be subject to relevant provisions under Part V [Land Clearing and Works Approval / Licensing] of the EP Act).

2.3 Justification and Alternatives Considered

Consistent with the EPA's *Instructions on how to prepare an Environmental Review Document* (EPA 2018b) this section outlines the justification for this Proposed Change and summarises the alternative options considered. The intent of this section is to provide an overview of the options that have been considered by the Proponent to minimise the potential environmental impacts resulting from this Proposed Change.

2.3.1 Justification for the Proposed Change

Rio Tinto operates the world's largest integrated portfolio of iron ore assets for the supply of iron ore to meet global demand, of which the Mesa J Iron Ore Development is an important contributor to Rio Tinto's CID product. The CID is a unique iron ore product stream in Rio Tinto's portfolio as its technical properties form an important component of steel producing customers' blast furnace feedstock.

The Robe Valley CID product maintains a firm position in the market as a specific and competitive product which maintains ongoing demand. The Robe Valley currently produces around 35 Mt/a of CID ore from the combined Mesa J and Mesa A / Warramboo operations.

The Proposed Change is the only option suitable for development within the timeframe required to maintain both the type of iron ore product and efficient utilisation of the existing Mesa J Iron Ore Development infrastructure.

The Proposed Change will provide replacement tonnages for the Mesa J Iron Ore Development as it nears the end of its productive mine life and sustain the life of the existing Mesa J Iron Ore Development facilities for approximately 17 years. The Proposed Change is critical to continue the Proponent's business activities in the region.

The Proposed Change will result in economic benefits for Australia and WA through:

- Contribution to the value of mineral export.
- Royalties and taxation payments.
- Capital investment.

- Increasing direct and indirect employment opportunities in the region.
- Increasing demand for goods and services supporting the regional economy.
- The ongoing activities of the Proponent, and more broadly Rio Tinto, in the Pilbara will continue to support social and economic development projects, including:
  - Increasing the potential education, training, employment and business options for local people and local Aboriginal people.
  - Funding a range of organisations in the region, including sporting and cultural groups.

The Proposed Change will make use of the existing Mesa J infrastructure, including railway, ore processing facilities, power, communications and road networks. This will reduce the extent of new infrastructure required and result in a smaller additional disturbance footprint than would otherwise be required for a project of this scale.

2.3.2 Options assessment

This Proposed Change is located adjacent to the existing Mesa J Iron Ore Development and wherever possible, will make use of the existing central processing facilities, support facilities, integrated water management system, roads, rail network and other assets. This approach has significantly reduced the physical disturbance footprint and Greenhouse Gas emissions of the Proposed Change by optimisation of existing infrastructure and resultant energy efficiencies.

Environmental and heritage considerations have informed and shaped the Proposed Change options considered from mine planning and engineering designs through to water management and are integrated in the current design.

The following provides a summary of the key environmental criteria incorporated in the basis of the current Proposed Change design.

2.3.2.1 Evaluation of mine design

As part of the mine planning process, a number of pit designs and waste dump designs / locations were evaluated.

The pit and waste dump configurations were designed to avoid as far as practicable, the following:

- physical disturbance to ephemeral creeklines including the Robe River and Jimmawurrada Creek;
- physical disturbance to the mesa facades;
- important habitat for significant terrestrial fauna and MNES; Ghost Bat, Pilbara Leaf-nosed Bat, Pilbara Olive Python and the Northern Quoll (including mesa escarpments, caves, rivers and other key habitat features;
- significant subterranean fauna habitat;
- significant vegetation and flora communities; and
- significant ethnographic and / or archaeological sites.

See the Mitigation sections under the relevant environmental factor for further detail on avoidance strategies.

2.3.2.2 Evaluation of transport and processing options

The transport of ore from Mesa H to the existing central processing facilities at Mesa J included consideration of locations for the haul access road. The final position and associated escarpment cuts in the internal gully of Mesa H was located away from key environmental and heritage receptors.

In terms of ore processing, multiple options were assessed to increase Mesa J dry processing capacity and reduce rehandle and additional areas of ore stockpiling, which would increase the amount of ground disturbance required. The option selected includes an additional secondary sizer which will be connected via conveyors to the existing Mesa J Iron Ore Development 1500 sizer. All run of mine high grade and wet plant product will be fed to the 1500 sizer during train loading. This set-up provides enhanced processing capacity, and also eliminates the requirement for additional downstream stockpiling and rehandle.

2.3.2.3 Evaluation of dewatering / water supply options

Water supply options to meet the on-site water demand included consideration of: an extension to the current Mesa J Southern Cutback Borefield; a new borefield at Bungaroo (located approximately 15 km upstream of the current Southern Cutback Borefield); or sourcing water from Warramboo. Extension of the existing Southern Cutback Borefield has been selected as the preferred water supply option from hydrogeological studies due to its ability to satisfy ongoing site water demand and reduced requirements on other aquifers, reduced cumulative interactions with other Projects and proximity to the operations (requiring less infrastructure / pipework and associated ground disturbance), and the operational water demand will remain within the current licenced limits.

Options for reducing water demand on site for the existing Mesa J Iron Ore Development currently include surface water harvesting and storage on site in in-pit water storage facilities (which also subsequently contribute to CID aquifer recharge), and re-use of water abstracted for mine pit dewatering, interception of seepage from WFSFs and the Mesa J in-pit water reservoir. This approach is proposed to be continued for Mesa H.

2.3.2.4 Evaluation of surplus water management options

Surplus water generated from mine pit dewatering will be used to supply operational water demand for the Revised Proposal, predominantly for wet processing. On occasions, during periods of high rainfall, surplus water volumes may exceed the local operational water requirements and storage and therefore require management.

Options for the management of surplus water, aligned with the Department of Water's (DoW) water management hierarchy (outlined in the *Western Australian Water in Mining Guideline*) included evaluation of the following:

- transfer of surplus water to other users;
- storage of surplus water in mined out pit voids for infiltration / evaporation;
- reinjection of surplus water from mine pit dewatering back into an aquifer; and
- discharge of surplus water from mine pit dewatering to a local ephemeral tributary of the Robe River.

Most of the options evaluated for the management of surplus water were not considered viable, given the relatively low volume (estimated peak of 3 GL/a during dry conditions) and periodicity of discharge – mostly for wet season water management. For example, the transfer of surplus water to other users was determined not viable as significant local demand for surplus water does not currently exist, despite the activity within the local region; prospective users were not located within reasonable distances; and the infrastructure and volume demand required to transfer surplus water from mine pit dewatering to other users was prohibitive. The adjacent Bungaroo aquifer currently already supplies water to Harding Dam via an 80 km pipeline, which ultimately feeds into the Pilbara coastal towns and ports.

The preferred strategy for the management of surplus water from mine pit dewatering is to re-use on site to meet the existing operations water demand, predominantly for wet ore processing. During periods where the surplus water volume exceeds operational usage demand, surplus water will be managed via controlled discharge to Jimmawurrada Creek and / or West Creek tributaries. This strategy is described further in Section 5.5.1.

2.4 Local and Regional Context

2.4.1 Environmental and social context

The Revised Proposal is located in the Robe Valley within the western Pilbara region of WA, in the Shire of Ashburton, approximately 16 km southwest of Pannawonica (Figure 1-1). The Revised Proposal is situated within the Pilbara bioregion and the Hamersley subregion (Interim Biogeographical Regionalisation for Australia [IBRA] 2012) (Figure 2-4). The Hamersley subregion is described as *dissected bold plateaux and ranges of flat lying, moderately folded sandstone and quartzite.*

The Robe Valley is traversed by the Robe River, which is one of several major river systems in the Pilbara and flows generally westward over approximately 250 km. The Robe River intersects the Development Envelope and passes along the base of the northern and north-western margins of Mesa H (Figure 2-2). For the majority of its course, the Robe River is ephemeral with a wide, shallow floodplain. During the dry season, water is often restricted to a series of semi-permanent and permanent pools that are maintained by sub-surface flow.

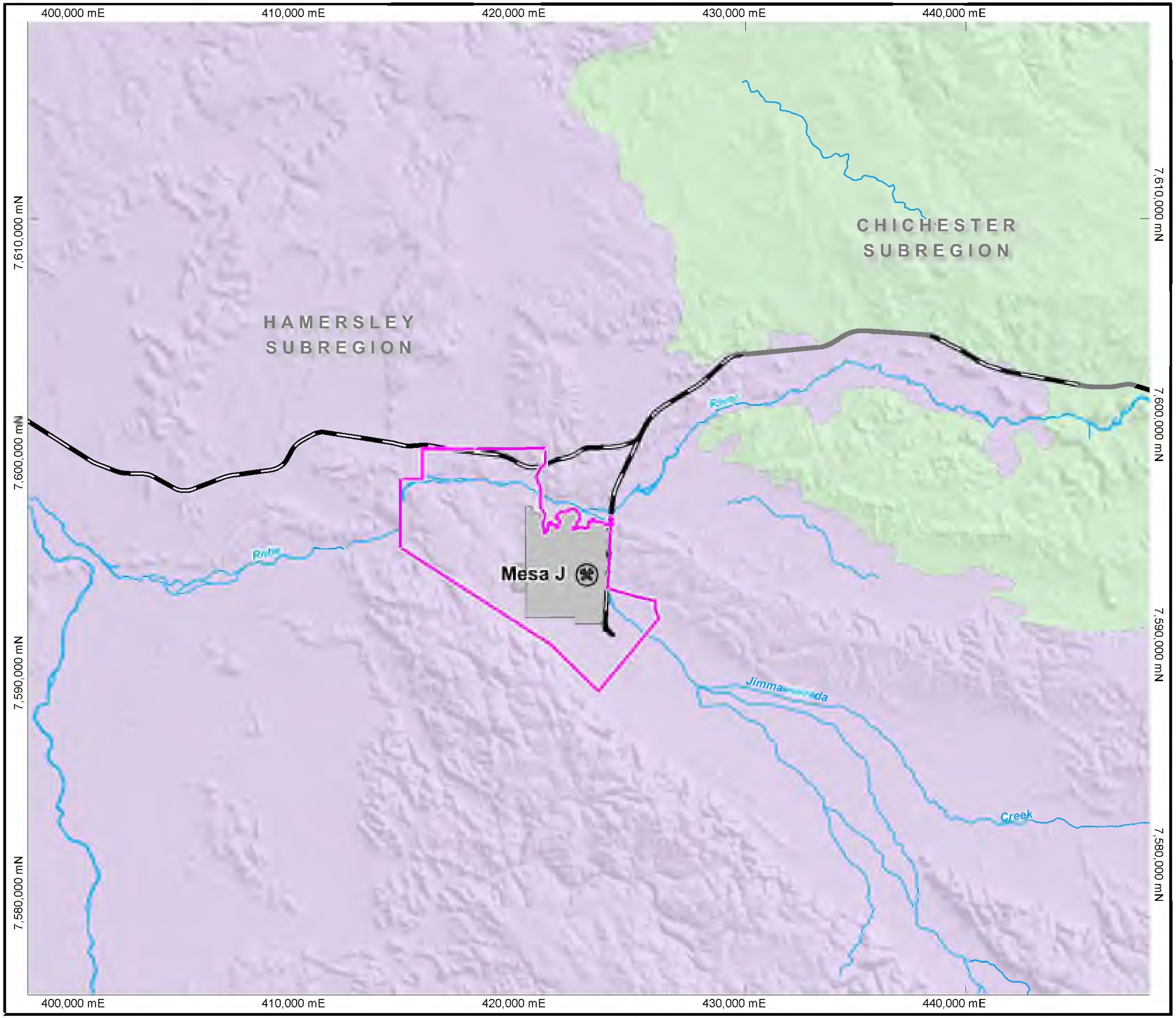
Jimmawurrada Creek also intersects the eastern margin of the Development Envelope to the east of Mesa J (Figure 2-2). Jimmawurrada Creek is also a wide shallow ephemeral creek and drains from the Bungaroo catchment to the south east, forming a tributary into the Robe River to the east of Mesa J.

The semi-permanent and permanent pools of the adjacent Robe River, together with the associated riparian vegetation of both the Robe River and its upstream tributary: Jimmawurrada Creek, represent important habitat features for terrestrial fauna. Vegetation associated with riparian habitat along the Robe River in particular is of high local to sub-regional conservation significance as it supports groundwater dependant, Obligate Phreatophytic Species (OPS), predominantly *Melaleuca Argentea*. The pools of the Robe River also have importance for both local community and local indigenous people (the Robe River Kuruma People) for cultural heritage significance and importance and for camping, fishing and hunting (Figure 2-2).

The surface and groundwater systems in the Development Envelope have been modified since the mid-1990s due to groundwater abstraction and discharge of surplus water to Jimmawurrada Creek and a tributary of the Robe River, from below water-table mining at the existing Mesa J Iron Ore Development.

The Robe Valley contains numerous mesa landforms, of which a large portion is comprised of CID. The Robe Valley mesas are remnants of the ancestral Robe River, where CID has been deposited in paleochannels. Subsequent uplift and erosion of the surrounding landscape has exposed the CID paleochannels, which have remained as elevated areas of the current landscape. Further erosion has segregated the paleochannel into a series of mesa formations, which are characterised by relatively flat tops and steep sides (escarpments), many of these escarpments contain deep gullies and/or caves. The Mesa landforms are also used by Traditional Owners as landmarks when travelling though the countryside.

Mesa H is an incised and partial-formed mesa located in the central region of the Robe Valley, within the Robe River catchment, immediately to the west and downstream of Mesa J. Mesa H is bordered on its northern and western escarpments by the ephemeral Robe River which flows in a north westerly direction. These escarpments contain deep gullies that represent important habitat features for terrestrial fauna, including threatened species such as Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat, and the Pilbara Olive Python.



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Iron Ore (WA)

Figure 2-4: Development Envelope in relation to IBRA Subregion

Drawn: M.Swebbs
Date: Aug, 2018
Plan No: PDE0159408v3
Proj: MGA94 Zone50

Geospatial Information and Mapping

2.4.2 Development context

Existing land uses in the Development Envelope include pastoral activities (Yarraloola Station and Yalleen Station), mineral exploration, mining activities, local tourism and Traditional Owner activities.

Other operations and or proposals in proximity to this Revised Proposal managed by Rio Tinto include:

- Mesa J Iron Ore Development (operating) – immediately adjacent on the eastern margin of the Proposed Change.
- Mesa K Historical and Remnant Mining Operations ~ 5 km to the northeast.
- Middle Robe Deepdale Historical Mining Operations ~ 10 km to the east.
- CWSP (operating) ~15 km to the southeast.
- Mesa A and Warramboo Operations (operating) - ~ 30 km to the northwest.
- Mesa A Hub Revised Proposal, including Mesa C and C deposits (proposed).
- Yalleen Pastoral Station – intersects the eastern side of the Development Envelope.
- Yarraloola Pastoral Station – intersects the western side of the Development Envelope.

There is also one third party proposal (approved) - Buckland Hills Iron Ore Project ~ 35 km to the southeast of Mesa H, upstream of the Bungaroo valley.

3. STAKEHOLDER ENGAGEMENT

3.1 Key Stakeholders

The Proponent identified the following government agencies and non-government organisations as key stakeholders for this Revised Proposal:

- Government agencies:
    - Department of Water and Environmental Regulation (DWER);
    - Department of Biodiversity, Conservation and Attractions (DBCA);
    - Department of Mines, Industry, Regulation and Safety (DMIRS);
    - Department of Jobs, Tourism, Science and Innovation (DJTSI);
    - Department of Planning, Lands and Heritage (DPLH); and
    - Shire of Ashburton.
- Traditional Owners:
    - Robe River Kuruma People.
- Pastoral Stations:
    - Yarraloola Station; and
    - Yalleen Station.
- Community:
    - Residents of the township of Pannawonica.

3.2 Stakeholder Engagement Process

Consultation regarding the Revised Proposal commenced in 2016 and has included discussions with a number of key stakeholders (Table 3-1).

The timing of the consultation program has enabled topics raised to be considered in the early design phase of the Proposed Change, during determination of mitigation measures and as part of the preparation of the public ERD.

The Proponent will continue to consult with relevant stakeholders during the environmental approval process and implementation of the Revised Proposal.

3.3 Stakeholder Consultation

The key themes raised during the consultation period included the following:

- Water management:
    - The importance of maintaining the pools of the Robe River.
    - Cumulative water management across the Robe Valley.
- Subterranean fauna, including management of troglofauna and stygofauna via habitat retention and presence across the Robe Valley.
- Management of heritage sites, specifically avoidance of highly significant sites.

A summary of stakeholder consultation relevant to this Proposed Change is provided in Table 3-1.

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Table 3-1: Summary of Stakeholder Consultation Relevant to this Proposed Change

Date	Issues / topics raised	Proponent response/outcome
EPA Services		
15 June 2016	Revised Proposal pre-referral meeting. The Proponent gave a presentation on the Proposed Change. Topics included regional setting / context, provisional survey area/development envelope, scope of the Proposed Change (mining, ore haulage, processing and transport, supporting infrastructure, schedule, water supply, water from mine pit dewatering, tenure and State Agreement), environmental issues (flora / vegetation, terrestrial fauna, subterranean fauna, hydrological processes, landforms, visual amenity, heritage, rehabilitation and decommissioning), EPBC Act MNES considerations, and identified likely key environmental factors Discussion items arising from the presentation included options for consolidating Mesa H, Mesa J and Mesa K conditions into the one MS and likely approach by EPA for any s18 approvals requirements and mitigation for significant heritage sites EPA Services queried what DMA consultation had been completed.	Proponent to complete studies and prepare referral documentation DMA consultation had not meaningfully commenced by 15 June 2016 but has since been initiated.
1 May 2017	The Proponent met with the Terrestrial Ecosystems Branch and provided an outline of the Proposed Change. The Proponent provided a summary of troglofauna sampling and results and presented conceptual troglofauna habitat retention areas and singleton avoidance areas for Mesa H. The EPA Services advised the Proponent to provide justification for the areas, volumes and widths selected as MEZ in terms of suitability for troglofauna. The EPA Board would like to do a site visit to see how the existing Mesa A MEZ is managed. Suggested timing is after submission of the draft ERDs.	Justification for selection of MEZs will be provided in the ERDs. The Proponent agrees an EPA Board site visit would be useful and will initiate.
EPA Board		
19 October 2017	Mesa H ESD presentation to the EPA Board. The Proponent provided an overview of the Proposed Change and the preliminary key environmental factors to be considered in the ERD. Key queries related to: • Mesa Landform and how it compared to Mesa A and broader Robe Valley. • Pools of the Robe River. • Proposed troglofauna habitat and retention of a MEZ. • Discussion of the Blind Cave Eel and habitat. • Modelled groundwater drawdown in Jimmawurrada Creek and available habitat for the Blind Cave Eel. • Greenhouse Gas Emissions – limited information in referral so considered a preliminary Key environmental factor until further information is provided.	The Mesa H ESD was updated to include 'Air Quality' as a preliminary Key environmental factor. The environmental factor: 'Landforms' was included as 'Other environmental factors or matters' to be addressed in the ERD.

Date	Issues / topics raised	Proponent response/outcome
DJTSI		
12 May 2016	Monthly DJTSI meeting. Provided a brief summary of the proposed development of the Mesa H deposit, which was at a conceptual stage. Key points included the regional setting/context for the development and an indication of timing for the State Agreement proposal. It was noted that the Mesa H pre-referral meeting with the EPA services was scheduled to be held in June 2016.	No further discussion currently anticipated with DJTSI on this development until the feasibility phase of the study and the submission of administrative letters under *the Iron Ore (Robe River) Agreement Act 1964* as required.
21 November 2017	Monthly DJTSI Meeting. Provided a brief summary of the proposed development of the Mesa H deposit and anticipated timings.	No further discussion currently anticipated with DJTSI on this development until the end of the feasibility phase of the study and the submission of administrative letters under *the Iron Ore (Robe River) Agreement Act 1964* as required.
30 January 2018	Monthly DJTSI Meeting. Provided a brief summary of the proposed development of the Mesa H deposit and the Tenure applications.	No specific response or action required from the Proponent.
1 May 2018	Monthly DJTSI Meeting. Provided a brief summary of the proposed development of the Mesa H deposit Key points included the proposed approach for the State Agreement proposals, and an overview of the proposed works.	Department supportive of approach for this project.
29 May 2018	Detailed presentation on the proposed development of the Mesa H deposit was provided.	No specific response or action required from the Proponent.
30 January 2018	Monthly meeting. Discussed ongoing tenure applications relating to the development - current and upcoming.	No specific response or action required from the Proponent.
29 May 2018	Monthly meeting. The Proponent provided a project overview presentation for Mesa H and discussed the proposed approach of Mesa H and Mesa A Hub.	No specific response or action required from the Proponent.
DBCA		
24 March 2017	The Proponent provided an outline of the scope of the Proposed Change and a status update and overview of survey results. DBCA indicated that the full flora/vegetation species context should be included in ERDs - include whole of state context, use all available data when discussing distribution (not just Rio Tinto data). DBCA suggested that confirmation should be sought soon whether the vegetation community that is analogous to the *Triodia* sp. Robe River Priority Ecological Community (PEC) is the PEC or is possibly a new PEC. Suggested reports are sent to Sandra. If the community is a PEC, then further surveys may be required to define the community more rigorously.	The Proponent agreed to provide full vegetation/species context in the ERD (refer Section 6). Confirmation of PEC 23: Technical flora and Vegetation survey reports submitted to EMB for review and confirmation if the *Triodia* sp. Robe River mapped in some areas is considered associated with the PEC. Outcomes of the review will be included in the Mesa H Revised Proposal ERD.

Date	Issues / topics raised	Proponent response/outcome
	DBCA suggested that there may be a need to assess troglofauna habitat cumulatively between Mesa J and H. DBCA concurred that it is reasonable to do additional ghost bat work (as planned) given the recent listing.	Cumulative assessment of the troglofauna habitat at Mesa H, including Mesa J context will be included in the Mesa H Revised Proposal ERD. Ghost bat roost context: Additional work is underway to assess ghost bat caves and context within the Robe Valley and to be included in the Mesa H Revised Proposal ERD and Mesa A Hub Revised Proposal ERD.
DWER (Water)		
14 February 2017	The Proponent presented a summary of the hydrogeological drilling and monitoring program in the Robe Valley and conceptual hydrogeological models for Mesa H. The DWER queried whether there were likely to be any Potentially Acid Forming (PAF) issues and whether work this year will examine the connectivity between the CID and alluvium at Mesa H, and how this may interact with the pools. Also queried current depth of water table in alluvials and CID, including thickness of the alluvial aquifer. The DWER noted that consideration of cumulative impact assessment for the lower Robe River will be expected as part of the EIA. No issues were raised regarding the proposed consultant for peer review.	No PAF issues are anticipated based on geology and mine planning / geochemical characterisation work undertaken to date. Monitoring of the water quality at the Robe River has been ongoing for over 20 years via a consultant from UWA (Streamtech), with no discernible impact to water quality detected from this work. The 2017 work will examine the connectivity between the CID and alluvium at Mesa H. However, it is not easily possible to drill in the Robe River adjacent to Mesa H (difficult for rig to access the area / maintain bores in flood events and the Kuruma Marthudunera People's concerns about disturbance in the Robe River) so multiple conceptualisations will be used to test the sensitivity of connectivity at Mesa H, in conjunction with the existing data available from the Mesa J Iron Ore Development.

Date	Issues / topics raised	Proponent response/outcome
11, 12 April 2017	The Proponent provided an outline of the Proposed Change during a site visit. Discussions were around current understanding and conceptualisation of the hydrology and hydrogeology for all of the Robe Valley existing operations and proposed developments. Items raised by the DWER included: • Discussions around the detail of hydrogeological conceptualisations, gaps in knowledge, and assumptions and how these are being addressed, including how this informs the impact assessment and approach to managing water. • Asked what fish species are found in the Robe River. • Indication that they would like to see consideration of cumulative impacts both at the local scale of the Revised Proposal and also on the broader catchment (Robe Valley) scale. • Queried if there was hydro drilling or monitoring information in the Robe River to support the hydrological predictions. • Discussed the permanent and semi-permanent pools and challenges with monitoring the semi-permanent pools since these can change over time, including their morphology after cyclonic events. • Concepts of base flow and current understanding was discussed. A site was visited to show flow in one of the small pools. • Difficulties of monitoring in the Robe River were presented due to loggers being inaccessible due to high water levels after rainfall events and also losing loggers downstream due to significant flow rates after rainfall. Hence some gaps in hydrological data. • Queries regarding what suite of hydro and environmental monitoring is currently undertaken and frequency, including subterranean fauna. • Queried if any impacts noted from the existing Mesa J Iron Ore Development in terms of water levels and water quality, including bathymetry. • Asked if there were any stygofauna impacted or restricted to Mesa H in the groundwater drawdown cone of depression. • Discussion of predicted impacts to pools and riparian vegetation and proposed options for mitigation where there is potential for uncertainty in the hydrological modelling. • Queried how much of the Robe River would be impacted by the discharge and for what duration. • Queried whether pit lakes would be left upon closure.	The queries and requests for technical information have been addressed as far as possible in this ERD. Please refer to Section 5.
4 July 2017	The Proponent provided an update on the Mesa H Part IV referral (associated hydro modelling and preliminary results) including: • Mesa H conceptual modelling results; • areas of predicted groundwater drawdown – Robe River (and pools) and Jimmawurrada; • cumulative drawdown predictions including Mesa J and Coastal Water Project; • environmental values;	<u>Robe River Pools</u>: Current environmental monitoring program has been in place for over 20 years, including water quality and levels and ecological features (riparian vegetation and aquatic fauna). No discernible impacts detected over this period, including no notable impacts from discharge of fresh water from existing Mesa J Iron Ore Development.

Date	Issues / topics raised	Proponent response/outcome
	• timeframes of the EIA; • proposed approach to Cultural values and Traditional Owner consultation; • proposed hydrogeological investigations and further environmental work; and • feedback from recent site visit. DWER asked if streamflow meters used to undertake the hydrogeological studies were the Proponent's or DWER's. Also queried the current water quality in the Robe River pools and if the Proponent had considered impacts of discharging fresh water into slightly saline downstream pools. DWER noted that semi-permanent pools can move around / change post large rainfall / cyclonic / flooding events. Discussion of challenges with monitoring and management of these pools. DWER indicated that they would like to present the information presented to their technical officers.	Challenges with monitoring and management of semi-permanent pools - work undertaken to define current extents and bathymetry. The Proponent to provide an update on the EIA component when available and include Michelle Antao. Also provide a copy of the power point presentation.
15 February 2018	The Proponent presented a hydrogeological modelling and EIA update for Mesa H. DWER had the following queries: 1. Has Proponent has consulted with Kuruma Marthudunera People on supplementary water mitigation discharge? 2. Is the Robe River Drawdown modelling based on dry/lower water table or Median water table levels? 3. Timeframe for water level recovery? 4. Are bores drilled in the alluvial aquifer? 5. Will the CWSP be moved closer to Mesa H? 6. Is the vegetation of the same significance in Jimmawurrada Creek as in the Robe River and if not, is the Proponent going to seek approval for impact?	The Proponent provided the following responses at the meeting: 1. Yes, Kuruma Marthudunera People consulted in the field on supplementary water to the Pools of the Robe River including consultation on a trial water supplementation program. 2. Drawdown was based on median pre-mining water table levels, which used over 10 years of data, including over dry periods to calculate. 3. CID groundwater recovery takes a long time - up to 60 years for the majority of the water levels to recover but the creeks / rivers are recharged after a major rainfall event. 4. Yes, there are 6 bores drilled in the alluvials. Additional bores would require approval and consent of the Kuruma Marthudunera People. 5. No, CWSP will be moved further upstream. 6. Complexity of impacts - area supports other environmental and heritage values, so will need to be managed where feasible such as optimisation of the discharge outlets to higher risk areas.

<table>
<tr><th>Date</th><th>Issues / topics raised</th><th>Proponent response/outcome</th></tr>
<tr><td colspan="3">DMIRS</td></tr>
<tr><td>30 June 2016</td><td>Presentation given on the Revised Proposal and Mesa A Hub Proposal as part of the bi-monthly meeting process.
Key topics included regional setting/context, scope of the Proposed Change (mining, processing and transport, supporting infrastructure, water from mine pit dewatering), layout and provisional development envelopes, tenure context and new tenure requirements, environmental issues (flora / vegetation, terrestrial fauna, subterranean fauna, hydrological processes, landforms, visual amenity, heritage, rehabilitation and decommissioning) and identified key environmental factors
Clarification sought on approvals schedule and timing for environmental documentation for review.
Comment that abandonment bund placement and actual installation needed to be considered early in mine planning and mine development to ensure they are not precluded from being installed at closure.
Clarification sought whether the diversion controls being considered will apply for operation only or will they remain post closure, and would pooling/damming of surface flow occur.
Confirmation sought that any new tenure to be sought would be pursuant to the Iron Ore (Robe River) Agreement Act 1964.
Clarification sought whether different or similar subterranean fauna species recorded on each mesa and whether contextual survey work for subterranean fauna and other fauna had been undertaken on remaining mesas.</td><td>Mesa H – referral scheduled for April 2017.
Acknowledged and closure plans would reflect current requirements.
Further modelling and consideration being undertaken for closure requirements, but the current design is intended for the diversion structures to allow for surface flows coming off the hills to be diverted into existing drainage into Robe River. Low risk of pools being created, and structures not designed for damming flows.
New tenure would be obtained pursuant to the Iron Ore (Robe River) Agreement Act 1964 for those new facilities as per the presentation.
Some contextual survey work for subterranean fauna has been undertaken on other mesas in the Robe Valley. Contextual fauna survey has also been undertaken for Mesa H. Fauna and subterranean fauna data recorded in the Robe Valley will be used for contextualisation for each proposal.</td></tr>
<tr><td>24 January 2017</td><td>Overview of the Mesa J Hub Closure plan that is in preparation.
DMIRS commended the fact the business was incorporating abandonment bund design and consideration during the study. DMIRS agreed that the Plan can contain some knowledge gaps as long as there is a process to close-out the gaps before the final Closure Plan for the site is submitted.</td><td>The Closure Plan will be submitted with the ERD.</td></tr>
<tr><td colspan="3">Robe River Kuruma People</td></tr>
<tr><td>4 April 2016</td><td>The Proponent provided a high level outline of the Proposed Change and a summary of results from pool monitoring.
Queries raised by Kuruma Marthudunera People on the impact of CWSP on water levels in the Robe River and in respect to tree health. Request for more information on abstraction from CWSP and water levels in the region.</td><td>Robe River Pools and Tree Health
It was highlighted by Rio Tinto (RTIO) that rainfall has been low for the last couple of years and the reduction in water levels are impacted by this
Further monitoring of the Robe Pools water levels will now occur due to installation of water loggers at a number of locations along the Robe
Rio Tinto highlighted that the Bungaroo Aquifer report would be provided when completed in May.</td></tr>
</table>

Date	Issues / topics raised	Proponent response/outcome
		Mesa H • Rio Tinto will continue to provide updates on study progress, including details of the Proposed Changes, hydrogeological outputs and Visual Impact Assessment (VIA) input. • Heritage surveys and support will continue to be requested through the normal channels.

Date	Issues / topics raised	Proponent response/outcome
25-26 May 2016	Overview of Mesa H development and key heritage issues. Mesa escarpment/facades. Retention of mesa facades along Robe River key requirement for Kuruma Marthudunera People. Preference for facades to be 50 m width rather than 30 m. Preference to retain facades along central watercourse. Jirtiwi Thalu (ethnographic) site within SE pit. Site is ~500 m from edge of pit. Significance of site and possible options discussed, including retention in-situ, trying to move the boulder associated with the site. Kuruma Marthudunera People: Very strong preference to retain in-situ but recognize location in SE pit creates challenges. Robe River and pools. Kuruma Marthudunera People: very strong preference for no impact to pools. Pools are used daily by Kuruma Marthudunera People when staying at 'the block'. Pools have cultural and ethnographic significance. Access along the Robe should be retained during mining as used by Kuruma Marthudunera People, locals and tourists. Recognized that during daily blasting access would potentially need to be restricted. Queried location of new gate on track between Mesa H and J as will restrict vehicle access to last 500 m of watercourse running parallel to track. Watercourses. Kuruma Marthudunera People: Strong preference to minimise impacts to watercourses. Visual impact. Kuruma Marthudunera People: advised proposed locations for VIA reasonable.	Mesa facades along Robe River will be retained. 50 m wide façade proposed. Central watercourse: will assess impacts to resource and discuss options further with Kuruma Marthudunera People. Jirtiwi Thalu (ethnographic) site within SE pit. In recognition of the sites significant the site has been excluded from the mine pit. Further assessment of site retained with sufficient buffer to protect from blasting flyrock and vibration, and retain access. Geotech assessment of ability to relocate boulder without damage to be undertaken. (Completed 2017). Robe River and pools. Hydrogeological investigations being undertaken to understand potential impacts of dewatering on pools. Will inform Kuruma Marthudunera People of the results of the hydrogeological studies when complete. Will investigate blasting buffer zones and how access along Robe can be managed. Gate location is to prevent public access onto Mesa H tracks that lead into Mesa J pits, and increase stand-off from the pits / operational areas at end of track. Will confirm requirement for location with mine ops. The watercourse associated with largest catchment upstream of Mesa H pit is already intersected by Pit 11 at Mesa J. The central watercourse through Mesa H drains only a small catchment. Rio Tinto will undertake drilling in 2016 to confirm extent of ore beneath central watercourse and discuss options further with Kuruma Marthudunera People. Several gullies/minor watercourses on margins of Mesa intersect substantial ore. Rio Tinto will further investigate resource in these areas and discuss options further with Kuruma Marthudunera People. Will undertake visual impact work and take photographs at locations as discussed with the Kuruma Marthadunera People and discuss results with the Kuruma Marthudunera People (Completed 2017).

Date	Issues / topics raised	Proponent response/outcome
23 August 2016	Continuing feedback from both groups about Jirtiwi Thalu as a follow up to May 25- 26 consult. The importance of Jirtiwi Thalu to the Kuruma Marthudunera People was highlighted, and concerns if the place was impacted.	The importance of Jirtiwi Thalu to the Kuruma Marthudunera People was acknowledged by RTIO, and the Heritage Sub-committee were advised that there would be further discussions to ensure protection of this significant site.
5-6 October 2016	<u>Water management</u> • Concern expressed around pools drying up in the Robe, and requested details of pumping rates from CWSP and sites. • Concerns expressed about the lack of rainfall, and discussed what would occur if there was no big rainfall event to manage water levels in the CWSP aquifer. • Kuruma Marthudunera People keen to see data from water level loggers in the Robe. • Kuruma Marthudunera People requested water report information to be provided in a user friendly format. <u>LOM Studies</u> • Kuruma Marthudunera People agreed that a blanket S18 of the Mesa B/C/H rockshelters was the logical pathway forward. • Kuruma Marthudunera People re- raised concerns over options for management of Jirtiwi Thalu.	<u>Water management</u> • Bungaroo aquifer report had been provided in May, however it is recognised that there needs to be an improved format for clearly reporting relevant data. • Groundwater Operating Strategy (GWOS) sets strategies for maintaining and running the borefield, with the final level of control being closure of the borefield. Hydros to present updates at future Kuruma Marthudunera People Local Implementation Committee (LIC) meetings. • 15 loggers have been installed and data will be reported in future LIC meetings. <u>LOM Studies</u> • Heritage to work with Kuruma Marthudunera Aboriginal Corporation (KMAC) heritage to confirm outcomes required from S16/S18 project on the rockshelters. • Rio Tinto running mine planning options which remove Jirtiwi Thalu from the mine plan / footprint.
19 December 2016	Kuruma Marthudunera People requested Rio Tinto at meeting to raise concerns relating to water in the Robe Valley, with specific focus on CWSP impacts. The initial concern raised was the lack of water in the rock hole adjacent to Old Yallen. This was seen as an indicator for general water levels in the Robe Valley and started a range of discussions about water levels, tree health, abstraction from CWSP, trigger level reporting, 6 mile well levels dropping. The key concern is about the long-term management of ecosystem health in the Robe Valley. The roles of Rio Tinto and DWER were discussed, highlighting that Rio Tinto operates and monitors the borefield on behalf of DWER, but required volumes and biological/groundwater response is governed by the GWOS in conjunction with DWER.	The Proponent discussed water drawdown from CWSP, rainfall conditions over recent years and how a combination of factors affect water levels and also provided a conceptual view of Old Yalleen and how water levels change over rainfall scenarios. The Proponent recognised that communication of water monitoring needs to be consistent and clear and will review how ground and surface water information is presented in LIC meetings etc.

Date	Issues / topics raised	Proponent response/outcome
4 April 2017	The Proponent provided an update on LOM planning and provided an overview of mine design to minimise heritage impacts. The Proponent also provided an update on the progress of environmental approvals. Kuruma Marthudunera People expressed concerned about access to pools near the Yarramarda Law ground and around the North and West of Mesa H and also about access to "the Block" during Mesa H construction. Kuruma Marthudunera People requested time to further discuss the Mesa H waste dump design and visual impact from the law ground.	Further consultation to be planned to provide detail of the construction plans, and any potential impacts on access to the pools or The Block. Consultation on the waste dump design to be conducted during upcoming ethnographic surveys in the area.
15-16 May 2017	**The Proponent discussed the following topics:** Northern waste dump options - the Proponent preferred option is to north of mesa to reduce visual impact but closer to Yarramarda law ground. Alternative dump on top of mesa has increased visual impact. The Proponent showed photomontages of both options from viewing points of law ground, the block and from road near rail underpass to N of Mesa H. Management of Yarramarda law ground during construction - proximity of construction camp, and existing road to Mesa H/J that will be used for construction access passing through the law ground. Kuruma Marthudunera People concern over unauthorised access on foot or by vehicle. Quarry site MJ04-09 and drainage diversion - discussed diversion dimensions and location in proximity to site, the Proponent showed 3D visualisation. The Proponent advised that diversions would function during operations but would not be maintained post-closure, at some point large events likely to breach diversion and drainage would report to pit. Jirtiwi Thalu and blast testing - discussed the proposed stand-offs to pit crest (~80 m) and abandonment bund (~50 m). Discussed proposed blast testing later in 2017 and requirement to glue monitors to outcropping rock at ground level (not the boulders) within the site boundary. Queried if the group of boulders to east of main boulder at site is of same significance. Noted that the rocks are highly fractured and exfoliating naturally. Access to site during operations would be restricted. **The Kuruma Marthudunera People raised the following:** Northern waste dumps - Kuruma Marthudunera People advised preference was the Proponent's preferred option. Management of Yarramarda law ground during construction – the Proponent to consult further on specific details with the Kuruma Marthudunera People. Fence along road with heritage site signage was discussed as possible approach. Quarry site MJ04-09 and drainage diversion - Kuruma Marthudunera People OK with proposed diversions. Jirtiwi Thalu and blast testing - Kuruma Marthudunera People OK with gluing monitors to outcropping rock (not the boulders). Kuruma Marthudunera People to be present during placement of monitors, and if possible during blast testing. Second group of boulders is part of site and requires blast management to same standard. Kuruma Marthudunera People queried if the site could be visited during operations with an escort.	Northern waste dumps – the Proponent will proceed with preferred option. Management of Yarramarda law ground during construction - Proponent to consult further on specific details with the Kuruma Marthudunera People. Quarry site MJ04-09 and drainage diversions - Proponent will proceed with proposed diversion. Jirtiwi Thalu and blast testing – Proponent will arrange for Kuruma Marthudunera People to be present during placement of monitors and blasting if possible and will arrange for geotechnical assessment of second group of boulders to inform blast management. Proponent to check on practicality of Kuruma Marthudunera People escort to site during operations.

Date	Issues / topics raised	Proponent response/outcome
15-17 August 2017	The Proponent provided an overview of the Mesa H development including: • Predicted effects on water levels in Robe River and Jimmawurrada Creek alluvial aquifers, due to Mesa J/H dewatering and water supply from Southern Cutback borefield. • Predicted environmental impacts of above. • Management and Monitoring of Robe Pools, especially areas of cultural significance (named pools such as Yeera Bluff, Duck Pool). • Cultural values of Robe River and Jimmawurrada Creek, discussed in detail during an on-site consultation to understand physical and biological related heritage values for the EIA. • Part IV process and when ERD will be provided for comment. • Upgrade to Robe River crossing for construction traffic (widening, installation of culverts). • Robe River discharge trial to assess aquifer response, to inform precautionary mitigation strategy. The predicted minor changes to Robe River water levels, and position of no significant environmental impact, was generally accepted by the Kuruma Marthudunera People. Kuruma Marthudunera People reinforced the cultural importance of the Robe River, and that significant impacts would not be acceptable. The significant drawdown and potential environmental impacts to riparian vegetation in Jimmawurrada Creek (e.g. potential for tree death), was of concern to the Kuruma Marthudunera People. The Proponent advised the Mesa J/H operation will continue to only abstract as much water as needed to meet operational requirements, thereby limiting environmental impacts. Kuruma Marthudunera People wish to be involved in proposed monitoring and requested an annual review on-country of monitoring results, with opportunity to assess what is happening on-ground at key sites. Kuruma Marthudunera People were concerned about access restrictions to Robe River and pools during blasting however were understanding of the requirement to ensure people's safety. Communication between the Proponent and Kuruma Marthudunera People / community will be important. <u>Access road crossing Robe River upgrade</u>: Discussed potential requirement to widen the road slightly within areas that had previously been disturbed but now had regrowth, including installation of culverts. Acknowledged a Section 18 application would be required and a specific survey to be set up from later in 2018. No major concerns raised by the Kuruma Marthudunera People except that during flow events some of the other channels also flowed so may want to look at culverts there also. Kuruma Marthudunera People suggested would be helpful if they could meet the engineers working on the Mesa H development. The Proponent advised this was being discussed internally, so good opportunity to progress later in 2018.	<u>Monitoring:</u> the Proponent will investigate increased Kuruma Marthudunera People involvement in environmental activities and identify opportunities and communicate these back to KMAC. RVS study will actively make this happen over next 18 months for baseline monitoring on Robe River (pool water levels, riparian vegetation transects, aquatic fauna monitoring). The Proponent also subsequently indicated should be able to facilitate for key operational phase monitoring, including next round of pool monitoring for Mesa J. <u>Construction access/safety</u>: the Proponent advised Kuruma Marthudunera People will continue to have access along access road and to Robe River. Kuruma Marthudunera People / the Proponent will need to communicate to discuss safety and so the Proponent knows when Kuruma Marthudunera People are likely to be there. At Block intersection with access road, Rio Tinto will look at convex mirror to improve visibility/safety. Also, will install gate and fence for ~30-50 m either side of intersection to stop people driving round if Kuruma Marthudunera People confirm that is preferred. <u>Blast exclusion on Robe River</u>: the Proponent to report back to the Kuruma Marthudunera People in Q1 2018 with more detail - based on FS schedules, work out duration of blast exclusion extending over Robe River, and confirm blasting frequency/expected time. <u>Construction personnel inductions and protection of sites/Robe River:</u> the Proponent / Kuruma Marthudunera People to discuss what the Kuruma Marthudunera People prefer in terms of fencing / signage at key sites, and whether to specifically mention in inductions. Inductions will need to emphasise importance and respect for Robe River - must be kept tidy. <u>Access road crossing Robe River upgrade:</u> the Proponent to progress Section 18 application. <u>Study/engineering team meet with Kuruma Marthudunera People:</u> the Proponent to liaise with the

Date	Issues / topics raised	Proponent response/outcome
		Kuruma Marthudunera People on a suitable date later in 2018.
17 October 2017	An update of the mine design was provided describing how the Proposed Change has been designed to avoid direct impacts to rock shelters, protect Jirtiwi Thalu, protect quarry and limit northern dump height to reduce visual impact. The Proponent stated that Section 16 and Section 18 applications will still be required for the majority of rock shelters for indirect impacts. The Proponent advised options are being assessed for water management at Mesa H and future consultation will be undertaken to provide update on Environmental Review submission, update on hydrogeological modelling, development of 3D water visualisations, schedule on-site visit with study leadership and the Kuruma Marthudunera People and discuss block access restrictions and blast restrictions. Kuruma Marthudunera People queried how many heritage sites will potentially be impacted at Mesa H.	Feedback to be provided regarding options and limitations for retaining caves and geotechnical stability of caves.
6 December 2017	The Proponent met with Kuruma Marthudunera Limited for the Annual Review and discussion of the operation. Kuruma Marthudunera People commented around keeping communication open about the interaction with Bungaroo Aquifer and would like to know about specific sites and areas and how they will be impacted by development. Kuruma Marthudunera People also asked specifically for a presentation regarding how the Proponent is protecting cultural heritage.	The Proponent will provide copies of Land Access Protocol, and the Cultural Heritage Management Plan (CHMP) to KMAC. This can also be delivered or presented at a KMAC Heritage Advisory Committee meeting.
9 May 2018	Proponent discussed with the Robe River Kuruma Heritage Advisory Committee (HAC) 14 heritage sites (rockshelters) that may be indirectly impacted by the development of the Mesa H mine. The HAC agreed that these sites should be included in a s16 submission.	Any additional comments given by the HAC were recorded and will be incorporated within the s16 submission
19 July 2018	Proponent discussed with the Robe River Kuruma Heritage Advisory Committee (HAC) 24 heritage sites (rockshelters) that may be indirectly impacted by the development of the Mesa H mine. The HAC agreed that 7 of these sites should be included in a s16 submission and that 16 of these sites are proposed to be included in a s18 submission. The outcome for 1 site was not decided on, and the HAC requested the Proponent to investigate if this site was able to be avoided	Any additional comments given by the HAC were recorded and will be incorporated within the s16 and s18 submission. The Proponent will investigate the HAC's request regarding avoiding a site
16 August 2018	Proponent discussed with the Robe River Kuruma Heritage Advisory Committee (HAC) 14 heritage sites (rockshelters) that may be indirectly impacted by the development of the Mesa H mine. The HAC agreed that 4 of these sites should be included in a s16 submission and that 9 of these sites should be included in a s18 submission. The outcome for 4 sites was not decided on and was postponed for further discussion at a future meeting. The Proponent confirmed that the 1 site queried by the HAC in the July 2018 meeting was able to be retained in-situ but would need additional blast management to do so.	Any additional comments given by the HAC were recorded and will be incorporated within the s16 and s18 submission. The Proponent confirmed that the 1 site queried by the HAC in the July 2018 meeting was able to be retained in-situ but would need additional blast management to do so. Discussion of 4 sites was postponed until next meeting

Date	Issues / topics raised	Proponent response/outcome
21 September 2018	Proponent discussed with the Robe River Kuruma Heritage Advisory Committee (HAC) 19 heritage sites that may be directly or indirectly impacted by the development of the Mesa H mine. The HAC agreed that 11 of these sites should be included in a s16 submission and that 8 of these sites should be included in a s18 submission.	Any additional comments given by the HAC were recorded and will be incorporated within the s16 and s18 submission.
4 December 2018	Proponent discussed with the Robe River Kuruma Heritage Advisory Committee (HAC) 19 heritage sites that may be directly or indirectly impacted by the development of the Mesa H mine. The HAC agreed that 2 of these sites should be included in a s16 submission and that 17 of these sites should be included in a s18 submission. Due to time constraints 5 additional sites originally on the agenda were not discussed, and will be discussed at a future meeting	Any additional comments given by the HAC were recorded and will be incorporated within the s16 and s18 submission.
KMAC		
26 July 2017	The Proponent provided an overview of the Mesa H development and discussed the following: • Predicted effects on water levels in Robe River and Jimmawurrada Creek alluvial aquifers, due to Mesa J/H dewatering and water supply from Southern Cutback borefield. • Predicted environmental impacts of above. • Management and Monitoring of Robe Pools, especially areas of cultural significance (named pools such as Yeera Bluff, Duck Pool). • Part IV process and when ERD will be provided to them for comment. • Status of CWSP aquifer (Q1) and draft of proposed quarterly report to KMAC, seeking feedback on report format. • Proposed 3D visualisation of Robe Valley hydrogeology, possible Kuruma Marthudunera People involvement in voice overs. KMAC to provide comment on draft CWSP report and if OK to get reviewed by external consultant. After discussion the Proponent agreed OK to be reviewed to improve clarity/communication of message to non-technical persons. Kuruma Marthudunera People queried a single point of contact for advice on environmental monitoring status (water levels etc.) in Robe Valley, was advised Environmental Superintendent.	The Proponent will present predicted effects on water levels or environmental impacts to a broader suite of elders and also follow up with KMAC on possible Kuruma Marthudunera People involvement in voiceovers for 3D visualisation.
15 December 2017	The Proponent presented a 3-dimensional hydrogeological visualisation program for areas in the Robe Valley.	KMAC appreciative of the program and requested the iOS and Android links.
DotEE		
18 October 2018	The Proponent provided an overview of the Mesa H development and discussed the following: • Proposed timeframes • Latest preliminary information on broader Pilbara Leaf-nosed Bat range extents • Status and direction of eDNA research being undertaken around Blind Cave Eel recorded in the vicinity of Mesa H.	The Proponent will provide any additional information to DotEE as part of the assessment process currently underway either directly or via the EPA.

Date	Issues / topics raised	Proponent response/outcome
	The Proponent will be happy to provide any additional information to DotEE as part of the assessment process currently underway either directly or via the EPA. The Proponent highlighted that for the Blind Cave Eel, in-situ habitat for this species (i.e. gravels of the alluvium) will be retained and that habitat connectivity via connected groundwater between the river systems including along the Robe River will also be maintained. The species is persisting despite approximately 30 years of the current operations at Mesa J, providing confidence that it is also likely to persist during future operations.	

Part 2 – Environmental Review

4. ENVIRONMENTAL PRINCIPLES AND FACTORS

4.1 EP Act Principles

The Proponent acknowledges the environmental protection principles of EIA listed in section 4A of the EP Act and presented in the EPA's *Statement of Environmental Principles, Factors and Objectives* (EPA 2018c). Table 4-1 describes how the Proponent has considered the EP Act principles for this Proposed Change.

4.2 Environmental Factors

The preliminary key environmental factors identified for the Proposed Change (as outlined in the ESD) are:

- Flora and Vegetation;
- Terrestrial Fauna;
- Subterranean Fauna;
- Inland Waters (formerly Hydrological Processes and Inland Waters Environmental Quality);
- Social Surroundings; and
- Air Quality.

The ESD also identified Landforms as an 'Other factor'. This other factor has been addressed in detail to ensure that all relevant information is provided to address the requirement of the recently updated EPA Landforms factor guidance which includes mesas as a key issue for impact assessment.

For ease of presenting the environmental factors in a logical sequence, the Inland Waters factor is presented first, which sets the scene and key management approaches for the remainder of the environmental factors. The Landforms chapter also provides key information but as an 'other factor' it is presented at the end of the ERD.

The following sections provide information specific to these key environmental factors, as required by the ESD and consistent with the EPA's *Instructions on how to prepare an Environmental Review Document* (EPA 2018b), including:

- a statement of the EPA objective for the environmental factors, as defined in the EPA's Statement of Environmental Principles, Factors and Objectives (2018c);
- a description of the relevant policy and guidance for the environmental factors, as defined in the EPA's Framework for Environmental Consideration in EIA (2016b);
- a summary of the existing environmental values for the environmental factors;
- a summary of the potential direct, indirect and cumulative impacts on the environmental values for the environmental factors;
- an assessment of the significance of potential direct, indirect and cumulative impacts on the environmental values for the environmental factors;
- a summary of the proposed mitigation strategies for each of the environmental factors; and
- a description of the predicted outcome against the EPA objective for the environmental factors.

4.3 Environmental Management

The Mesa J Iron Ore Development is managed via the following management plans:

- Mesa J Hub Environmental Management Plan (EMP);
- Mesa J Hub Cultural and Heritage Management Plan[1]; and
- Mesa J Hub Closure Plan.

Both management plans have been updated for this Revised Proposal (Appendix 6) and the Closure Plan has also been revised (Appendix 7).

The Mesa J Hub EMP (2012) meets the requirements of the conditions of MS 208 for the Mesa J Iron Ore Development to prepare and implement plans to manage drainage, dewatering and surface water discharge, and their potential impacts on the water levels, water quality, permanent Pools and, riparian vegetation of the Robe River – Jimmawurrada Creek environment. The EMP has been updated to include Mesa H and to address conservation significant flora and vegetation, conservation significant terrestrial fauna (including MNES) and subterranean fauna.

The Mesa J Hub Cultural and Heritage Management Plan has been prepared in consultation with the Robe River Kuruma People and has been updated to include Mesa H.

The Mesa J Hub Closure Plan (Rio Tinto 2018a) is an integrated closure plan encompassing the existing Mesa J and Mesa K operations, together with the inclusion of the Proposed Change - Mesa H, in order to optimise closure outcomes. The plan is an update to and will supersede previous closure plans for the existing Mesa J and K operations, once approved. The Closure Plan includes the mine developments and associated infrastructure contained within the Development Envelope (Mesa J and H) and within Mesa K's Development Envelope.

[1] The Cultural and Heritage Management Plan contains information sensitive to the Robe River Kuruma People and cannot be publicly released.

Table 4-1: Environmental protection principles of the EP Act

Principle	Consideration
The precautionary principle Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In application of this precautionary principle, decisions should be guided by: a) careful evaluation to avoid, where practicable, serious or irreversible damage to the environment. b) an assessment of the risk-weighted consequences of various options.	The Proponent has undertaken comprehensive baseline studies, investigations and modelling to obtain a thorough scientific understanding in order to assess potential threats of serious or irreversible damage to the surrounding environment. A precautionary approach has been taken when threats to the surrounding environment are uncertain. Where potential threats of serious or irreversible damage to the surrounding environment were identified, management strategies have been, and will continue to be, implemented to avoid or minimise those potential threats wherever possible. Examples of application of the precautionary principle to avoid, where practicable, serious or irreversible damage to the environment include the following: • The waste dumps have been redesigned to avoid and minimise risks to sites of high environmental and ethnographic and / or archaeological significance to the Robe River Kuruma People. • The Proponent has defined a MEZ, wider than the minimum geotechnical required width to avoid and minimise risk of disturbance to the mesa escarpment, which has environmental, heritage and social values. Key measures to avoid, where practicable, serious or irreversible damage to the environment are included in the application of the 'Avoid' part of the Mitigation Hierarchy in the Mitigation section under each key environmental factor.
The principle of intergenerational equity The present generation should ensure that the health, diversity and productivity of the environment is maintained and enhanced for the benefit of future generations.	The Proponents Health, Safety, Environment, Communities and Quality (HSECQ) Policy incorporates the principle of sustainable development (to ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations) and includes the following commitments: • Prioritising research and implementation programs through technology to reduce impacts to land, enhancing our contribution to biodiversity and improving our efficiency in water and energy use. • Identifying climate change improvement solutions through dedicated optimisation work programs. • Contributing to the health and well-being of local communities. The Proponent recognises the value of adaptive management mechanisms (through condition EMPs) to maintain ecological processes. In addition, the Proponent will implement mine closure and rehabilitation measures to ensure that the post-mine environment is ecologically sustainable. Further, the Proponent considers several residual impacts to be significant and warrant the application of offsets. The Proponent therefore considers that the health, diversity and productivity of the environment can be maintained and enhanced for the benefit of future generations. The Proposed Change has been developed to align with the Proponent's sustainable development principles which seek to ensure that a balance is achieved between economic, environmental and social aspects of the Proposed Change activities. These principles are consistent with the intent of the WA State Sustainability Strategy and Rio Tinto's 'The Way We Work' statement of business practice. The Revised Proposal incorporates progressive rehabilitation of disturbed areas through the Mesa J Hub Closure Plan. The aim of closure and rehabilitation is to ensure that post-mining land uses are enabled to ensure that relevant areas of the Development Envelope retain enduring value for future generations.
The principle of the conservation of biological diversity and ecological integrity	The Proponent has undertaken comprehensive baseline studies to understand and assess potential threats to biological diversity and ecological integrity. Management strategies have been, and will continue to be, implemented to avoid or minimise threats to biological diversity and ecological integrity wherever possible.

Principle	Consideration
Conservation of biological diversity and ecological integrity should be a fundamental consideration.	Examples of management strategies proposed for the conservation of biological diversity and ecological integrity include the following: • Dewatering will be managed so that there is no irreversible impact to groundwater dependant vegetation. • Discharge of excess water from mine pit dewatering will be managed so that there is no irreversible impact to the health of riparian vegetation of the Jimmawurrada and Robe River.
Principles relating to improved valuation, pricing and incentive mechanisms 1) Environmental factors should be included in the valuation of assets and services. 2) The polluter pays principles – those who generate pollution and waste should bear the cost of containment, avoidance and 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 structure, including market mechanisms, which enable those best placed to maximise benefits and / or minimise costs to develop their own solution and responses to environmental problems.	The Proponent has, and will continue to, evaluate (and implement wherever possible) opportunities to reduce impact to land, reduce waste and improve efficiencies in water and energy use during the implementation, operation and closure of Mesa H in accordance with the Proponents HSECQ Policy. The Proponent has, and will continue to operate under an operating licence, issued under Part V of the EP Act, that will ensure that pollution (when or if generated) is paid for in line with current legislation.
The principle of waste minimisation All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.	All reasonable and practicable measures have been and will continue to be undertaken by the Proponent to minimise the generation of waste at its Pilbara operations. The Proponent also has, and will continue to operate under an operating licence, issued under Part V of the EP Act, that will manage wastes.

5. INLAND WATERS

The EPA completed a review of its Guidelines and Procedures Framework in June 2018. As part of the review, the EPA amalgamated the former objectives of Hydrological Processes and Inland Waters Environmental Quality. This section addresses the requirements of the ESD for Hydrological Processes and Inland Waters Environmental Quality.

5.1 EPA Objective

The EPA applies the following objectives from the *Statement of Environmental Principles, Factors and Objectives* (2018c) in its assessment of proposals that may affect Inland Waters:

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

5.2 Policy and Guidance

The following State and Commonwealth policy and guidance have been considered in the assessment of Inland Waters with respect the above EPA objectives:

5.2.1 EPA Policy and Guidance

- EPA (2018c) Statement of Environmental Principles, Factors and Objectives;
- EPA (2018d) Environmental Factor Guideline: Inland Waters;
- EPA (2018b) Instructions on how to prepare an Environmental Review Document;
- EPA (2016c) Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans;
- EPA (1998a) Inland Waters of the Pilbara Western Australia (Part 1); and
- EPA (1989b) Inland Waters of the Pilbara Western Australia (Part 2).

5.2.2 Other Policy and Guidance

The following policies relevant to the protection of hydrological processes and inland waters environmental quality have also been considered:

- Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ) (2000) Australian Water Quality Guidelines for Fresh and Marine Waters;
- Water and Rivers Commission (2000) Statewide Policy No 5: Environmental water provisions policy for Western Australia;
- Government of Western Australia (2001) State Water Quality Management Strategy Document No.6. Implementation Framework for Western Australia for the Australian and New Zealand Guidelines for Fresh and Marine Water Quality and Water Quality Monitoring and Reporting;
- Government of Western Australia (2008) Water Quality Protection Guidelines No. 1 to 11 and Water Quality Protection Note 22;
- Government of Western Australia (2009) Report No 34 Pilbara Water in Mining Guideline;
- DoW (2013a) Report No 12 Western Australian Water in Mining Guideline;
- DoW (2013b) Strategic policy 2.09: Use of mine dewatering surplus;
- Government of Western Australia (2011) WA Environmental Offsets Policy;
- Government of Western Australia (2014b) WA Environmental Offsets Guidelines; and
- DMP and EPA (2015) Guidelines for Preparing Mine Closure Plans.

5.3 Environmental Scoping Document

Table 5-1 summarises where the requirements of the ESD are addressed in this section.

Table 5-1: Requirements of the ESD for Inland Waters

Task Number	Requirement of ESD	Section number
42	Characterise the baseline hydrology and hydrogeological regimes and water quality, both in a local and regional context, including but not limited to, water levels, water chemistry, stream flows, flood patterns, and water quantity and quality.	Section 5.4
43	Provide a detailed description of the design and location of the Proposal with the potential to impact surface water or groundwater. A figure should be provided in the ERD which depicts the predicted location of the wetting front (under natural no-flow conditions).	Section 5.5 and 5.6 and Figure 5-26
44	Provide a conceptual model of the surface and groundwater systems including the extent of connectivity between surface and groundwater systems and demonstrate that there will be no migration of seepage from infrastructure towards the Bungaroo Creek P1 Water Reserve.	Section 5.4.5, 5.5 and 5.6
45	Provide a conceptual mine water balance over the life of the Proposal to discuss the capacity to reuse surplus mine dewater.	Section 5.5.1
46	Provide a geochemical risk characterisation of the waste material to be backfilled in pit which may be exposed to groundwater.	Section 5.5 and 5.6
47	Discuss the potential environmental impacts and benefits of identified surplus water management options (i.e. discharge of excess mine dewater, reuse on site, local water supply, aquifer recharge etc.) and discuss the most appropriate water management strategy for the Proposal.	Section 5.5.1.3
48	Analyse, discuss and assess surface water and groundwater impacts, including alternatives options to water management and the feasibility of each option: • changes in groundwater levels and changes to surface water flows associated with the Proposal • •the nature, extent, and duration of impacts • cumulative impacts with other projects and referred proposals in the Robe Valley, for which relevant information is publicly available • impacts on the environmental values of significant receptors including but not limited to the Robe River catchment.	Section 5.6
49	Demonstrate application of the mitigation hierarchy to avoid and minimise impacts to Hydrological Processes and Inland Waters Environmental Quality.	Section 5.9

Task Number	Requirement of ESD	Section number
50	Prepare a Mine Closure Plan consistent with DMP and EPA *Guidelines for Preparing Mine Closure Plans* (2015) which addresses the development of completion criteria to maintain of the hydrological regimes and the quality of groundwater and surface water so that environmental values are maintained post closure. Specify whether the BWT pits will be backfilled to a level to prevent post-closure exposure of the groundwater table and the formation of permanent pit lakes.	Appendix 7
51	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Section 5.6, 5.9 and 5.10

5.4 Receiving Environment

5.4.1 Summary

The Revised Proposal is located in the Robe River subcatchment, downstream of the confluence of the Robe River and Jimmawurrada Creek (Figure 5-1), both of which are ephemeral creeks carrying a significant underflow in their alluvial beds. The Robe River in the north of the Development Envelope is the dominant drainage feature. The sub-surface flow in the alluvials maintains permanent pools in the Robe River channel.

Groundwater flow in the vicinity occurs from the southeast to northwest along the Jimmawurrada catchment and occurs predominantly within four key aquifers: Wittenoom Aquifer (Basement); CID aquifer; the Jimmawurrada Creek Alluvial Aquifer and the Robe River Alluvial Aquifer (Section 5.4.5.1).

The key water-related values in the Proposed Change Area are the ecological, social and cultural values associated with Robe River and Jimmawurrada Creek, and the value of the aquifers as a water supply.

The EPA’s assessment of the Mesa J Iron Ore Development (EPA 1991) discussed the values of the Robe River-Jimmawurrada Creek environment, including its permanent pools and riverine vegetation. The resultant conditions of MS 208 relate to the protection of the Robe River-Jimmawurrada Creek system. The permanent pool at Yeera Bluff is the only permanent pool along the Robe River in the vicinity of the Proposed Change and has important Aboriginal heritage and social value. There are no permanent or semi-permanent pools along Jimmawurrada Creek in the vicinity of the Proposed Change.

The Robe River-Jimmawurrada Creek system is an altered system as the Mesa J Iron Ore Development has been in operation since the early 1990s, with dewatering to access the BWT sections of the deposit commencing around 1995, and abstraction for water supply from the Southern Cutback Borefield commencing around 2013, resulting in lowered groundwater levels in the CID and along a small section of the Jimmawurrada Creek. Periodic discharge of surplus water into tributaries of the Robe River including West Creek and Jimmawurrada Creek (Figure 2-1) has occurred since the 1990s, and can result in channel pools occurring within these tributaries during prolonged discharge periods (not typically frequent). These pools, however, are not sustained beyond discharging events and typically do not develop during intermittent discharge regimes.

Water is also abstracted from the Bungaroo aquifer for the CWSP (15 km south-west of the Proposed Change), within the Bungaroo Creek P1 Water Reserve (Figure 5-1). The Project has been operating since 2014 and is authorised to abstract 10 GL/a, although the current and predicted abstraction from the CWSP is between 6.5 and 7.5 GL/a.

The water quality in the semi-permanent and permanent pools can be highly variable, ranging from fresh to brackish. Nutrient levels both upstream and downstream of the

Mesa J Iron Ore Development have frequently been recorded in exceedance of ANZECC/ARMCANZ Trigger Value's (TVs) for slightly to moderately disturbed systems.

The CID and Wittenoom aquifers more typically comprise much fresher water than the alluvial aquifer and the Robe River pools, and the quality of the surplus dewater discharged to creeks reflects the signature of the abstracted groundwater.

The Study Area has experienced variable annual rainfall. The long-term average is 365 mm/a, however the area experienced a wetter period from 1980 to 2011 with an average of 430 mm/a (approximately 20% higher). Rainfall in the Study Area appears to be transitioning back to long term average rainfall levels since 2011. This change is expected to be reflected in naturally lower recharge and groundwater levels within the alluvial aquifers and in the ecosystems it supports.

5.4.2 Climate

The climate of the Pilbara region of WA is classified as arid tropical with two distinct seasons: a hot, wet summer (October – April) and a mild, dry winter (May – September) (Bureau of Meteorology [BOM] 2018). Four long-term rainfall stations are still operational in the Robe Valley catchment including Yarraloola, Red Hill, Yalleen and Pannawonica stations with records dating back to 1898.

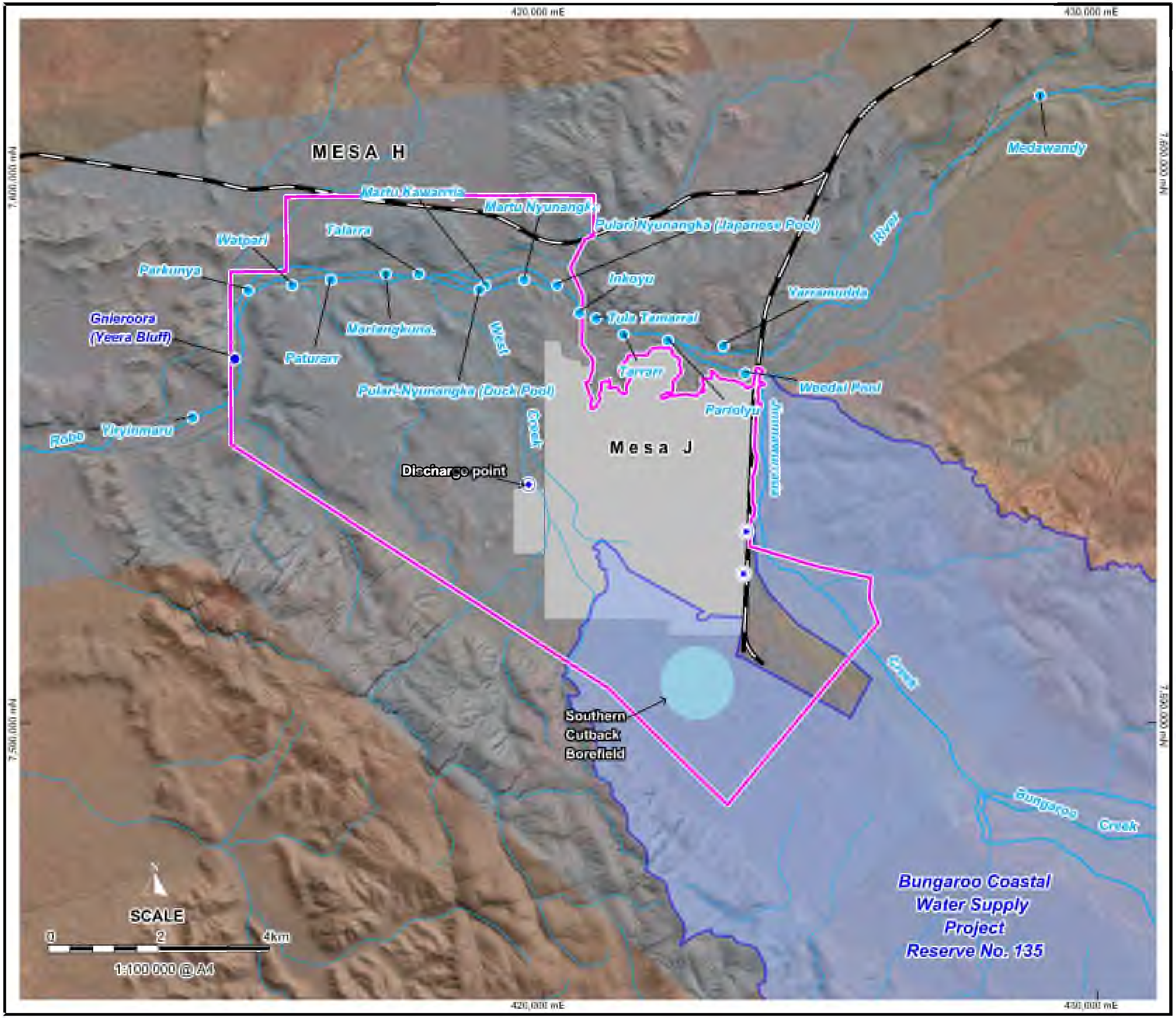
As for most parts of the Pilbara, rivers and creeks in the Robe Valley are typically dry, with rainfall runoff only occurring following significant or long duration rainfall events. Rainfall in the Pilbara is highly variable, temporally and spatially, predominantly occurring in summer, with major falls resulting from cyclones and storm events, however the Robe Valley can also receive winter (June through August) rainfall.

On average, the Study Area experiences 37 rain days per year, but daily rainfall totals larger than 50 mm are uncommon. Average rainfall experienced in the Robe Valley is 365 mm per year (from Pannawonica and Yalleen weather stations from 1930 to present), with a notable wet period from 1980 to 2011. Of these 28 wetter years, the average yearly rainfall has been 430 mm per year (~65 mm greater per year), with ~25% of these years experiencing more than double the average and ~40% of these years experiencing more than 30% higher rainfall compared to the average.

Excluding 2017, the five years following 2011 saw a return to rainfall averages of 365 mm per year, and thus a negative shift in water availability. The increased average rainfall between 1980 and 2011 is believed to have resulted in increased riverine vegetation biomass, which is reflected in aerial photography over similar periods. The last five years of complete yearly rainfall records suggests a transition back to more 'average' rainfall conditions. This change is expected to be reflected in naturally lower recharge and groundwater levels within the alluvial aquifers and subsequently reflected in the ecosystems which are supported by these alluvial aquifers e.g. riparian vegetation canopies, riparian biomass, and the distribution of aquatic vegetation formations.

5.4.3 Hydrological and hydrogeological studies

A number of hydrological, hydrogeological and geochemical studies have been undertaken to develop an understanding of the hydrological setting for the Proposed Change and to support the EIA of the Proposed Change in relation to water management. Numerous studies have also been undertaken for the existing Mesa J Iron Ore Development since 1987 and subsequently refined and calibrated based on operational data. These investigations are considered relevant to Mesa H, given the Mesa J hydrogeological setting is considered analogous. A summary of the key Mesa H supporting studies completed is outlined in Table 5-2 and the most recent survey reports are attached in Appendix 8.



LEGEND

- Development Envelope
- Ministerial Statement 208
- Major Watercourse
- Minor Watercourse
- Railway
- Pool
- Permanent Pool
- Existing Discharge Point
- Southern Cutback Borefield
- Bungaroo Creek Water Reserve

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Iron Ore (WA)

Figure 5-1: Location in relation to key hydrological features

Drawn: T.M.
Date: Dec, 2018

Plan No: PDE0162064v4
Proj: MGA94 Zone50

Geospatial Information and Mapping

Table 5-2: Summary of Supporting Hydrological Studies

Survey Report	Summary	Survey Date
Mesa J Hub H3 Hydrogeological Assessment. Rio Tinto (2019a)	Hydrogeological assessment summary report, to describe the conceptual hydrogeology of Mesa H Area, including Mesa J and immediate surrounds. The report details the numerical model calibration, predictive scenarios and impact assessment.	2018
Mesa H Groundwater Modelling. Rio Tinto (2018b)	Groundwater model development for Mesa H development to determine dewatering and water supply strategies for the Mesa J hub and assess cumulative impacts caused by mining operations and CWSP borefield (Appendix to 2019a H3 report).	2018
Mesa H Project Baseline Aquatic Ecosystem Survey Dry Season Sampling 2017. WRM (2018)	Baseline sampling program for aquatic ecosystems of Jimmawurrada Creek and the Robe River, including the semi-permanent and permanent pools of the Robe River. The program documented current ecological condition of these aquatic ecosystems, including surface water chemistry and aquatic faunal assemblages.	October 2017
Mesa H Project Baseline Aquatic Ecosystem Survey Wet Season Sampling 2016. WRM (2017)	Baseline sampling program for aquatic ecosystems of Jimmawurrada Creek and the Robe River, including the semi-permanent and permanent pools of the Robe River. The program documented current ecological condition of these aquatic ecosystems, including surface water chemistry and aquatic faunal assemblages.	April / May 2016
Surplus water discharge extent assessment: Mesa H. Rio Tinto (2017a)	A study to estimate the extent of impact of surplus water discharge along Jimmawurrada Creek and the Robe River. The study involved development of a two-dimensional model of the creek system downstream of the proposed discharge point, identification of hydraulic characteristics not accounted for by the model, estimation of maximum possible extent of discharge under steady state conditions and investigation of multiple discharge rates.	March 2017
Mesa H 2017 AMD Risk Assessment Update Summary Rio Tinto (2017b)	A review of the acid and metalliferous drainage (AMD) risk associated with mining in the Mesa H project area has been completed. The review considers recently available (July 2017) drillhole data and mine planning data.	September 2017
Mesa H Chemistry and Isotopes. Rio Tinto (2016a)	Groundwater and surface water chemical and isotope analysis aiming to assess groundwater dependency of the Robe River pools.	Quarterly sampling commenced early 2016
Mesa H 2016 Drilling and pump testing. Rio Tinto (2016b)	Drilling, installation and testing of 19 monitoring and four pump test bores completed as part of the Mesa H Study.	2016
Mesa H 2017 Drilling and pump testing. Rio Tinto (2016c)	Drilling, installation and testing of 15 monitoring and five production bores and two vibrating wire piezometers.	2017

Survey Report	Summary	Survey Date
Mesa H Bore monitoring program. Rio Tinto (2015)	Fourteen reverse circulation drill holes in the Mesa H deposit were converted to monitoring bores. The monitoring bores were designed to enable sampling of stygofauna and provide baseline groundwater level information in the vicinity of Mesa H.	2014
Mesa J Groundwater Model Report. Aqua Terra (2007)	Groundwater model development for Mesa J to determine a water supply strategy for Mesa J Iron Ore Development and assess dewatering requirements to support required infrastructure.	Based on data compilation from multiple drilling programs including in 2007

5.4.4 Hydrology

5.4.4.1 Catchment characteristics

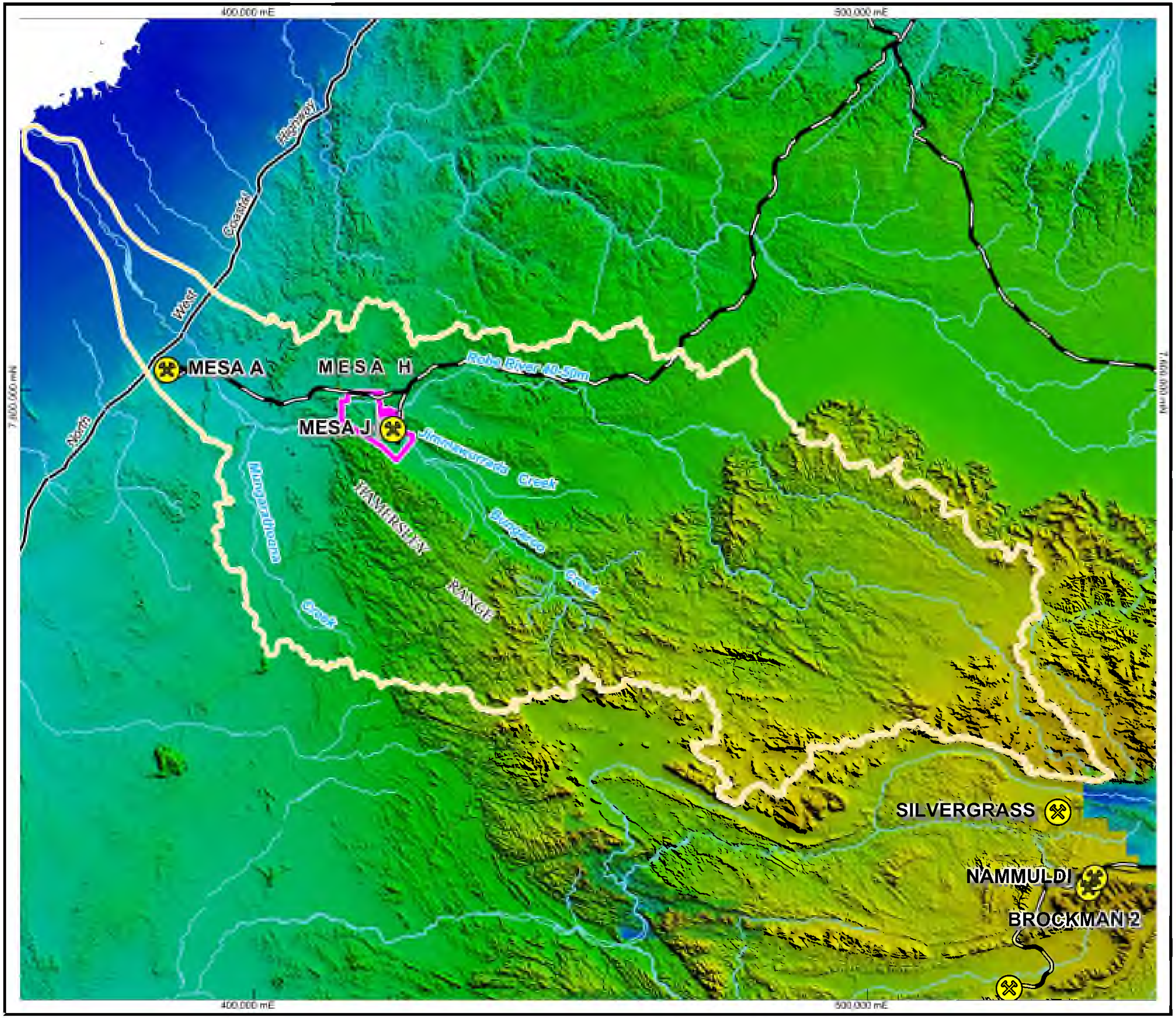
The Robe River regional catchment, in the Onslow Coast River Region, covers an area of approximately 7,500 km^2 (Figure 5-2). The major water courses in the catchment include the Robe River, Jimmawurrada Creek, Bungaroo Creek and Mungarathoona Creek, which predominantly flow from southeast to northwest through the high relief areas of the Hamersley Ranges onto the more gently sloping areas of the coastal plain, before discharging into the ocean approximately 150 km south of Dampier.

The Proposed Change is located downstream of the confluence of the Robe River and Jimmawurrada Creek, both of which are ephemeral creeks carrying a significant underflow in their alluvial beds. The alluvium found in the beds and floodplains of the local water courses is broadly permeable due to the gravelly nature of the material, with the sub-surface flow in the alluvials maintaining permanent pools in the river channel (Refer to 5.4.4.1).

The Mesa H deposit is located on elevated land immediately adjacent to the Robe River and sits, on average, 40-50 m above the Robe River channel. The deposit is bounded on the south-western boundary by the Buckland Hills which are the western-most parts of the Hamersley range (Figure 5-2).

The Proposed Change is intersected by three creeklines that drain to the Robe River between Japanese Pool and Yeera Bluff. Two creeks run from the south in a northwards direction through the Proposed Change Area with one (44 km^2) currently intersected by the Mesa J mine (Figure 5-3), and the other (9.5 km^2) running between the east and west areas of the Mesa H deposit. A third creek (11.5 km^2) is located on the western side of Mesa H and drains a number of small catchments in the Buckland Hills. A fourth set of small hillslopes and gullies drain the hills south of Mesa J that drain into Jimmawurrada Creek via flowlines that have also been intercepted by the Mesa J Iron Ore Development. The total catchment area south of the Robe River is 65 km^2 of which 43 km^2 is directly affected by the Proposed Change (Figure 5-3).

West Creek is dominated by narrow incised gorges draining 20 km^2 and 3 km^2 of steep rocky catchment incised into the Buckland Hills south of the Proposed Change. Flows from these creeks represent the primary flood management issue for both Mesa J and Mesa H pit operations. The catchment on the western edge of Mesa H bypasses active mining areas and does not directly interact with mining landscapes on top of the Mesa. Surface hydrology within the Upper Robe River Catchment is shown on Figure 5-4.



LEGEND

- Rio Tinto Mine
- Development Envelope
- Ministerial Statement 208
- Robe River Catchment
- Rio Tinto Railway
- Highway
- Major Watercourse

N

SCALE

0 15 30 45km

1:900 000 @ A4

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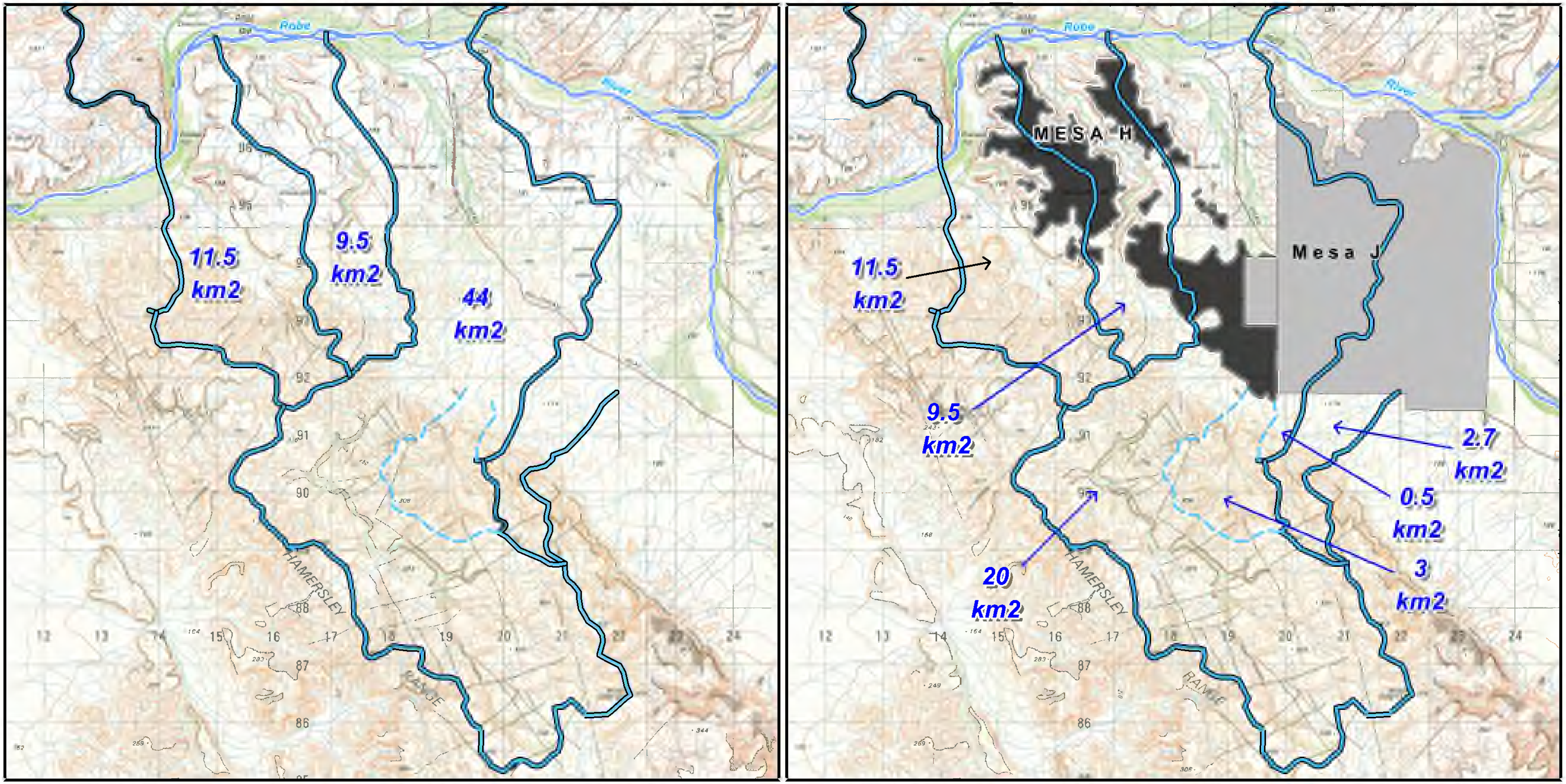
Iron Ore (WA)

Figure 5-2: Local hydrology and catchment topography

Drawn: T.M.
Date: Sept, 2018

Plan No: PDE0162065v3
Proj: MGA 94 Zone 50

Geospatial Information and Mapping



LEGEND

- Mesa H Proposed Pit
- Ministerial Statement 208
- Catchment Boundary
- River Channel

N

SCALE

1 0 1 2 3km

1:100 000 @ A4

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Figure 5-3:
Surface water catchments contributing to the Robe River between Japanese Pool and Yeera Bluff (left) and the location and effect of the revised Proposal (right)

Drawn: T.M
Date: Aug, 2018

Plan No: PDE0162751v1
Proj: MGA94 Zone50

Geospatial Information and Mapping

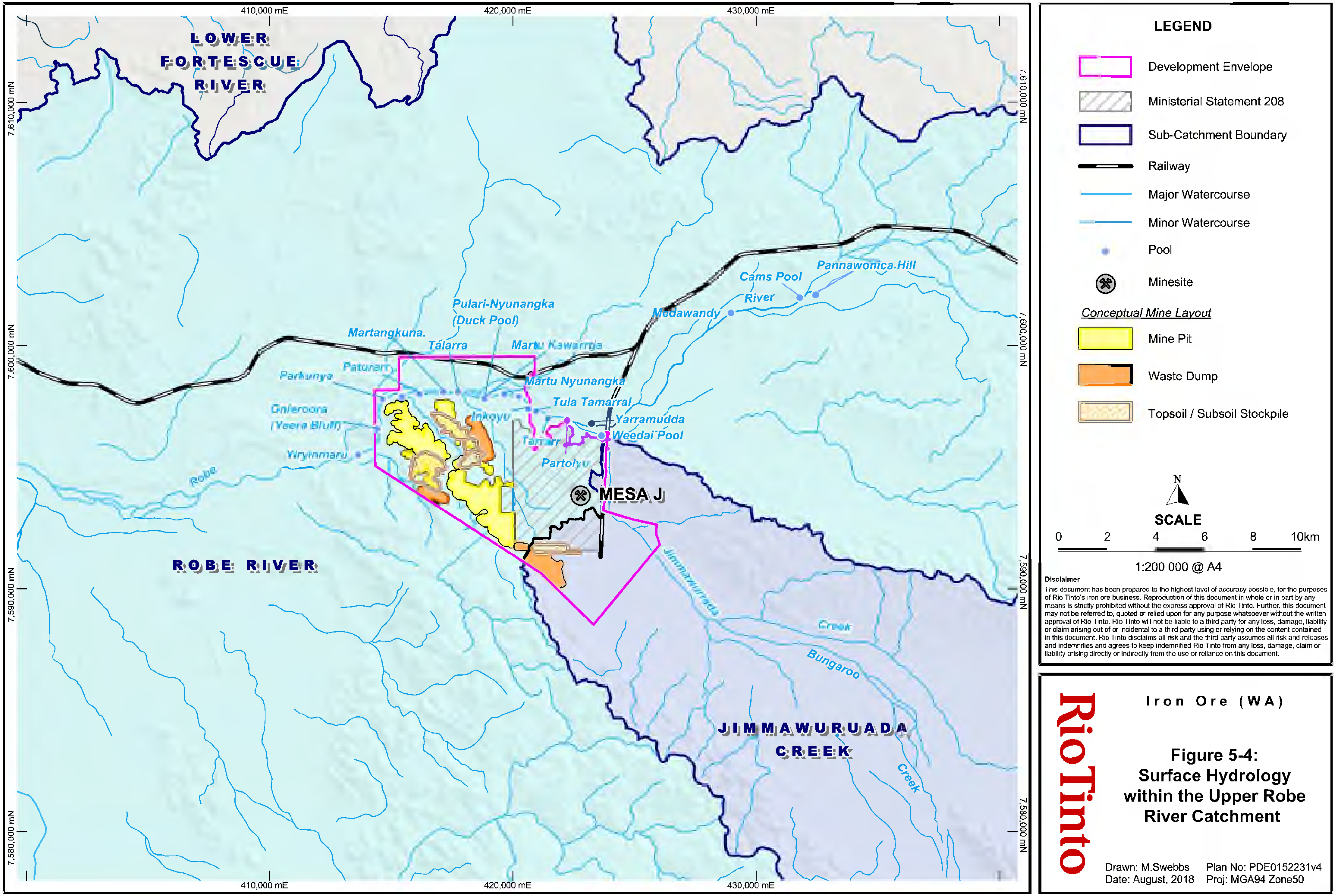

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Figure 5-4: Surface Hydrology within the Upper Robe River Catchment

Drawn: M.Swebbs
Date: August, 2018
Plan No: PDE0152231v4
Proj: MGA94 Zone50

Geospatial Information and Mapping

5.4.4.2 Streamflows and flood patterns

Surface water runoff in the region is generally only associated with high intensity rainfall events (Figure 5-5), therefore rainfall events resulting in surface water flows are uncommon. The resultant surface flow in the Robe and tributary rivers is ephemeral, typically continuing for one to two months. Low or no flow normally occurs from July to December, when most tributaries dry and the main channel is reduced to a series of isolated pools. The number and permanence of these pools is dependent on antecedent rainfall and groundwater levels (BBG 1991; Antao & Braimbridge 2010).

The Robe River has a large catchment with flood frequency measured at Yarraloola indicating 1:100 AEP (Annual Exceedance Probability) flows of 14,000 m^3/s. The largest recorded peak flow at Yarraloola is 7,100 m^3/s (2008), which corresponds to an event between 1:20 - 1:50 AEP. Based on rainfall data and flow analysis, rainfall events that result in surface flow are expected to occur 1-2 times per year, on average.

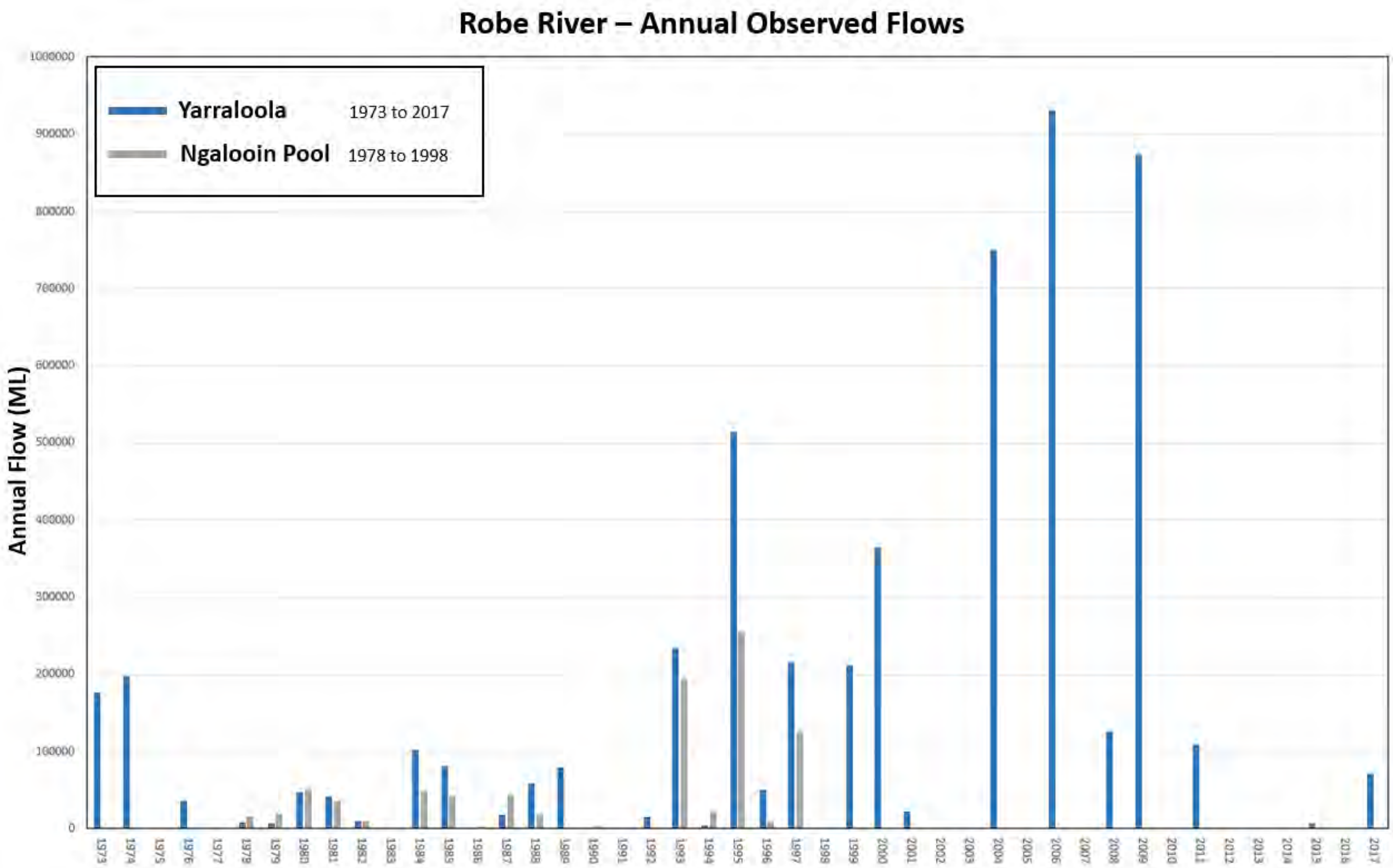


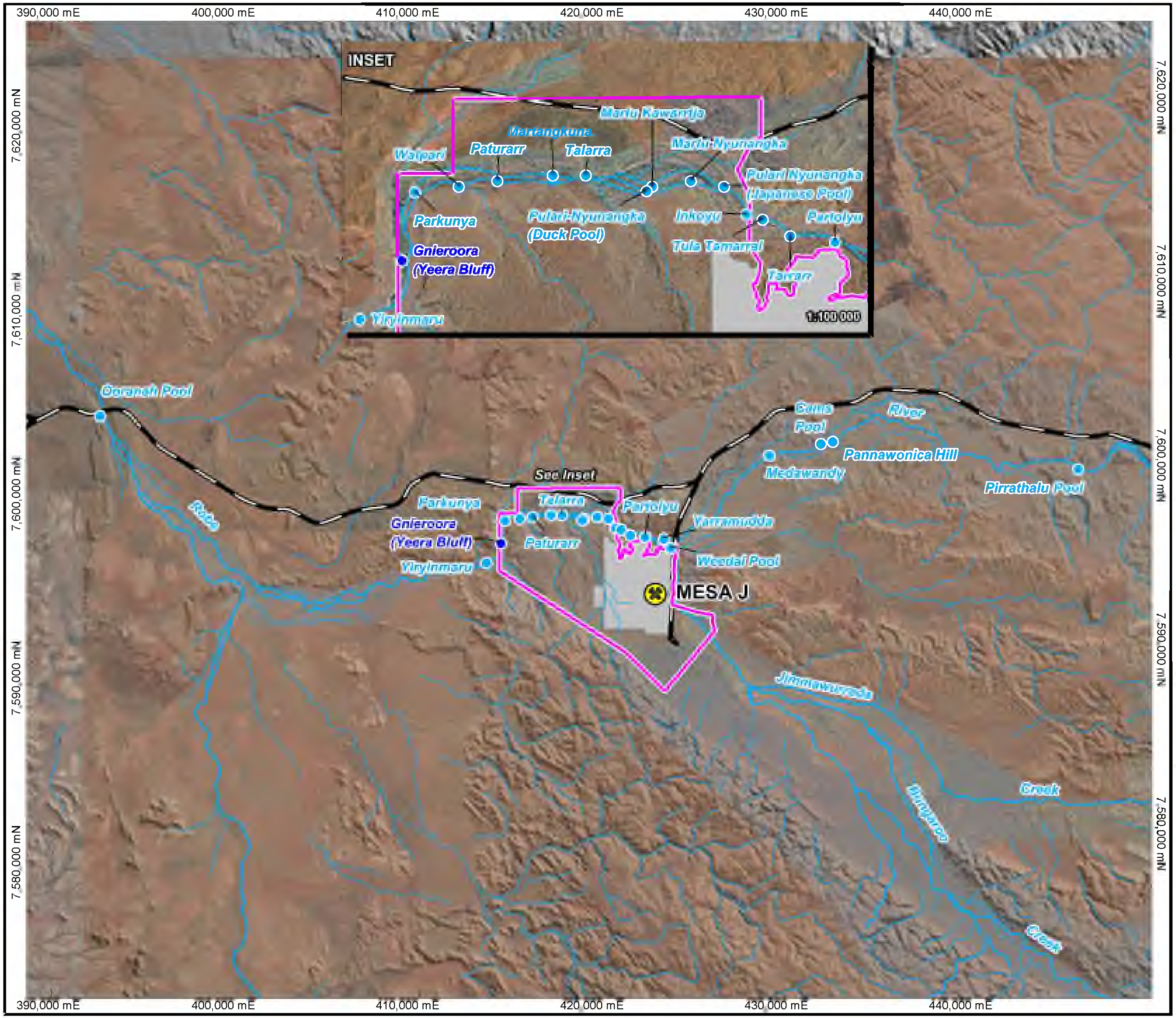
Figure 5-5: Robe River Stream Gauging Stations Annual Total Flows

5.4.4.3 Robe River pools

Permanent and semi-permanent pools exist along the Robe River due to the significant subsurface flow in the coarse channel gravels of the Robe River alluvial aquifer (Figure 5-6).

There is potentially a strong hydraulic correlation between the Robe River alluvium and the underlying aquifer, the direction of interaction changes seasonally in response to stream flow events and evapotranspiration. Streamflow events also recharge groundwater, causing the groundwater level to rise, creating large and continuous pools. After a period of no flow, the hydraulic gradient between the groundwater and the pools reverse and groundwater discharges into the pools. Ephemeral pools eventually become disconnected from intermittent pools and as surface water evaporates, these pools reduce in size or disappear.

Drought conditions and declining groundwater levels result in shallower pool depths and semi-permanent pools becoming disconnected from the groundwater. Deeper permanent pools have long-term connectivity to the groundwater and are expected to be maintained by groundwater discharge during drought periods (DoW 2010). Figure 5-7 shows a conceptual cross-section of the interdependency between ephemeral, semi-permanent and permanent pools and surface water / groundwater interaction.



LEGEND

- Development Envelope
- Ministerial Statement 208
- Minor Watercourse
- Major Watercourse
- Railway
- Pool
- Permanent Pool
- Mine

N

SCALE

0 5 10 15km

1:300 000 @ A4

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Iron Ore (WA)

Figure 5-6: Pools of the Robe River in the vicinity of the Development Envelope

Drawn: M.Swebbs
Date: August, 2018
Plan No: PDE0160791v4
Proj: MGA94 Zone50

Geospatial Information and Mapping

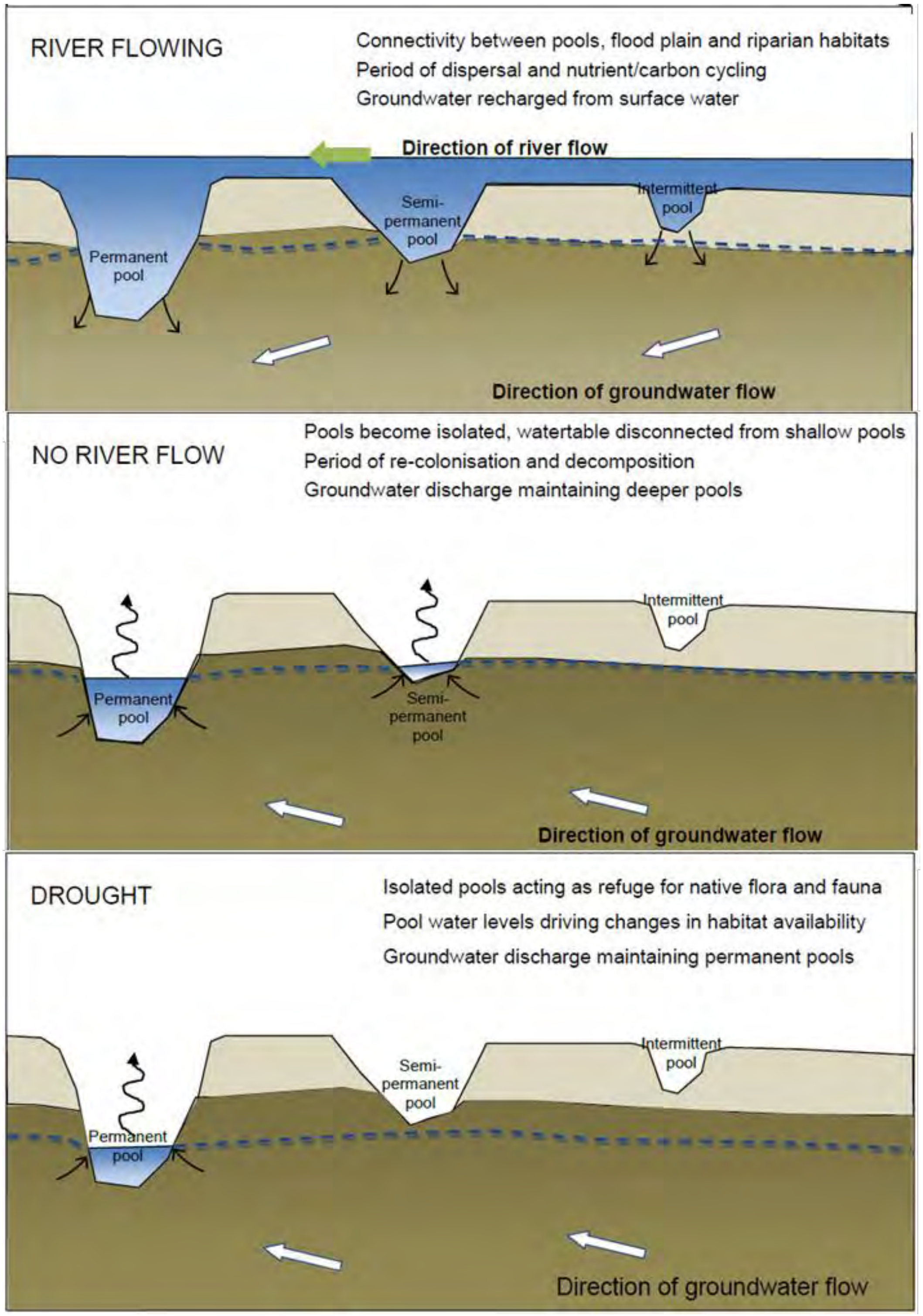


Figure 5-7: Conceptual Diagram of a Longitudinal Cross-section of the Robe River During Seasonal Climate Changes (DoW 2010)

Figure 5-8 and Figure 5-9 illustrate the spectrum of natural seasonal variability observed in the permanent pool at Yeera Bluff, at the same time of year, over a 1-year period. A survey was undertaken during 2017 to determine the bathymetry of the pools in the Robe River to support predictions relating to change in pool depth with groundwater drawdown as illustrated in Figure 5-10 and Table 5-3.

Figure 5-8: Yeera Bluff Pool (June 2016)

Figure 5-9: Yeera Bluff Pool (June 2017)

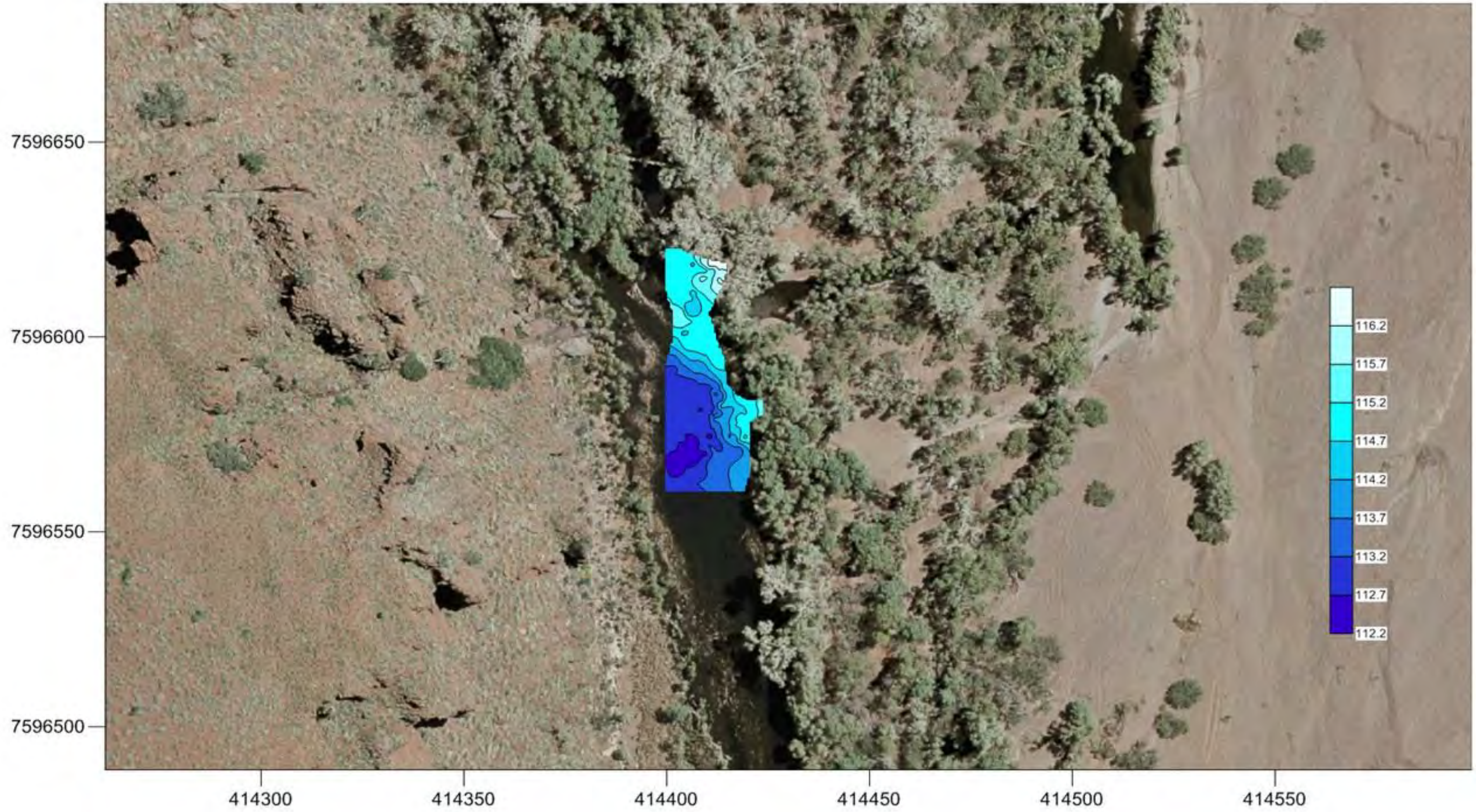


Figure 5-10: Yeera Bluff Pool Bathymetry (June 2017)

Table 5-3: Bathymetry of the Robe River Pools within the Study Area (2016 - 2017)

Pool Name(s)	Pool Type	Measured Depth (April – Oct 2016 extended dry)	Measured / Modelled depth (June 2017 – Seasonal high)
Partolyu	Semi - permanent	N/A	2.7 m (137.3 m Relative Level [RL])
Tula Tamarall	Semi - permanent	N/A	2.3 m (135.7 m RL)
Martu Nyunangka / Japanese Pool	Semi - permanent	1.5 m	2.5 m (130.5 m RL)
Duck Pool	Intermittent	Dry	N/A
Martangkuna	Semi - permanent	<0.5 m	N/A
Watpari	Semi - permanent	N/A	2.4 m (120.6 m RL)
Parkunya / New Yinta	Semi - permanent	2.4 m	3.2 m (116.3 m RL)
Nyithura / Gnieroora / Yeera Bluff pool	Permanent	3.6 m	4.1 m (112.3 m RL)
Downstream Nyithura / Gnieroora / Yeera Bluff pool	Semi - permanent	N/A	3.2 m (113.2 m RL)

The pools within the Study Area have been sampled annually since 1991 (prior to the commissioning and mining of the Mesa J Iron Ore Development) using a consistent methodology by Streamtec Pty Ltd. This monitoring has provided an integrated long-term dataset on water chemistry, channel and pool morphology, aquatic macroinvertebrates and fish, together with qualitative analysis of riparian and bank condition, weeds and water flow. The significance of this program is the duration and consistency of monitoring for nearly 30 years which has captured some long-term return frequency extreme natural events such as cyclones and prolonged dry periods, as well as pre and post mining / impact and non-impact sites.

Monitoring and analysis of the data has concluded that seasonal and annual variation in rainfall and subsequent river flows with extreme natural events are the main drivers of pool diversity and ecosystems, with deeper pools generally showing higher levels of biodiversity due to water chemistry being more stable; and shallower pools showing greater fluctuations in water temperature and dissolved oxygen, including to levels unsuitable for local fauna (Dobbs and Davies 2009). Large rainfall events such as from cyclones can change the overall morphology of both the river channel and the pools, whereby the biodiversity and predictability of biodiversity can be significantly changed and effectively 'reset' by these events.

5.4.4.4 Surface water quality

Surface water chemistry data has been monitored and collected on a quarterly basis as part of the Mesa J GWOS (required by the RIWI Act 5C licence) and the operations environmental monitoring program since 1992 (as described in Section 6). The monitoring encompasses quarterly monitoring of discharge outlets along Jimmawurrada Creek and West Creek, and annual monitoring of the semi-permanent and permanent pools of the Robe River. Further detailed sampling of surface water was undertaken biannually post wet and post dry season from 2016 – 2018 as part of the baseline aquatic fauna surveys undertaken for the Proposed Change by WRM (2019 in prep.).

A major determining factor of variability in surface water quality is pool morphology and permanence, together with cyclonic rainfall and associated stream flow events (Streamtec 2017). Hence the surface water chemistry in the semi-permanent and permanent pools can be highly variable, ranging from fresh (592 µS/cm EC) to brackish (1,700 µS/cm EC), with circum-neutral to mildly alkaline pH values (6.9 – 7.9) and dissolved oxygen from hypoxic (14.5%) to supersaturated (134.9%) (WRM 2017).

Nitrogen nutrients (total N, N_NO_x and N_NO_3) both upstream and downstream of the Mesa J Iron Ore Development have frequently been recorded in exceedance of ANZECC/ARMCANZ default 95% species protection TV's for slightly to moderately disturbed systems. Background levels of $N\text{-}NO_3$ was particularly elevated with an 80%ile value of 2.6 mg/L and a maximum of 7.4 mg/L, compared to the default TV for $N\text{-}NO_3$ of 0.03 mg/L (WRM 2017). Other naturally elevated background concentrations frequently exceeding ANZECC 80% TV's include Phosphorus (as P-total), dissolved zinc (Zn), and occasional exceedances of turbidity, dissolved boron (B) and selenium (Se).

In addition to the chemistry data collected during annual pool monitoring by Streamtec (2017), and during the detailed aquatic fauna surveys from 2016 – 2018 by WRM (2019 in prep.), the chemistry of a number of pools both up and down gradient from Mesa H were sampled on a fortnightly basis over a 12 month period (and quarterly after this period) as part of a study to assess the potential contribution of groundwater derived from local aquifers (CID and Wittenoom aquifers) to the Robe River Alluvial aquifer. Water chemistry samples, including isotopes, were collected from seven pools along the Robe River including Yeera Bluff pool and Japanese Pool within and adjacent to the Development Envelope; and Medawandy pool upstream of the Development Envelope (Figure 5-6). No semi-permanent or permanent pools occur along Jimmawurrada Creek in the vicinity of the Proposed Change and hence limited surface water chemistry data exists, with the exception of existing operational surplus water discharge outlet monitoring.

The chemistry and isotope data indicate that the pools are largely connected to the Robe River alluvial aquifer, and that the CID and Wittenoom aquifers are predominantly comprised of fresh recharge. These field results have supported the conceptual understanding that that the majority of water within the pools and alluvial gravels adjacent to Mesa J and Mesa H is derived from local runoff-recharge and river flows, and subsequently by persistent (months) post rainfall gravel baseflows that are sustained from upstream catchment alluvial aquifers. Water balance analysis suggests the basement aquifer contribution is less than 10%.

All aquifers and pools show similar cation composition while significantly differing in anion composition. This appears to be due to the increasing chloride predominance in pools, alluvial bores and some Wittenoom bores. The CID and Wittenoom aquifers more typically comprise fresher water than the alluvial aquifer and the Robe River pools. This trend is characteristically observed for waters that have undergone varying degrees of evaporation and therefore it is expected that pool concentrations will naturally fluctuate with river conditions. The quality of the surplus dewater discharged to creeks reflects the signature of the abstracted groundwater.

5.4.5 Hydrogeology

The conceptual hydrogeological model presented in this section provides detail on the overall hydrogeology; specifically on the key hydrogeological features that will determine dewatering and water supply requirements, and the potential impacts of groundwater abstraction on local and regional water resources and environments that depend on groundwater. Further details of the hydrogeological conceptualisation of the area, and the results of the groundwater numerical model can be found in Rio Tinto (2019a).

5.4.5.1 Aquifer characteristics

Groundwater within the Pilbara region originates from direct infiltration of rainfall and indirectly from surface water flows. The occurrence of groundwater within the Study Area is predominantly associated with primary porosity of creek line alluvials where saturated; primary porosity of the CID with secondary weathering induced permeability; and with secondary permeability and porosity developed as a result of weathering in the underlying basement Marra Mamba Iron and Wittenoom Formations.

Groundwater flow in the vicinity occurs from the southeast to northwest along the Jimmawurrada catchment. Groundwater occurs predominantly within four key aquifers:

- **Wittenoom Aquifer (Basement)**: consisting of *weathered* dolomite and dolomitic shale (Paraburdoo and Bee Gorge Member) and *weathered* Banded Iron Formation (BIF) (Marra Mamba Iron Formation.) with approximately 25 m thickness.
- **CID Aquifer**: consisting of CID pisolitic sediments with an average of 20 – 30 m thickness below the pre-mining water table.
- **Robe River Alluvial Aquifer**: consisting of gravelly Quaternary alluvial sediments deposited along the Robe River with an approximate 20 m thickness and average width of 400 m.
- **Jimmawurrada Creek Alluvial Aquifer**: consisting of Quaternary alluvial sediments deposited along Jimmawurrada Creek, incised up to a maximum observed thickness of 40 m in the centre of the alluvial channel (thalweg).

The basal CID unit is a 5 to 1 m thick stratigraphic unit deposited at the base of the CID Aquifer, consisting of a clay rich CID. Due to the largely impermeable physical characteristics of the unit, it is expected to function as a partial barrier to groundwater flow between the CID Aquifer and the basement Wittenoom Aquifer. Depth to groundwater in the CID is generally between 25 and 45 m below ground level (bgl).

The Wittenoom Aquifer and the CID Aquifer are bounded by Marra Mamba Iron Formation in the east and the Brockman Iron Formation in the west. The CID Aquifer is bound to the north by the Robe River, and an impermeable bedrock high is present between Mesa J and H along West Creek, and immediately to the north of Mesa J (except in the connection between Mesa J and Mesa K where a 3 – 5 m CID layer underlies the Robe River) limiting the hydraulic connection along the Robe River and Mesa J.

Based on limited data, the thickness of the CID under the Robe River, to the west of the West Creek and between the Mesa J and Mesa K bedrock high has a thickness of, on average, 5 to 10 m. The basement / CID throughflow that discharges to the Robe River alluvium has been estimated to be less than 10% of the total throughflow volume of the alluvium.

The major aquifer underlying the Robe River is contained within the gravelly alluvium which has a saturated thickness of up to 20 m adjacent to the main channel and extends laterally around 400m on average in the vicinity of the Revised Proposal and up to 5 km across the Robe River Valley closer to the coast.

Table 5-4 summarises characteristics of the four key main hydrostratigraphic units identified in or in the vicinity of the Revised Proposal.

Table 5-4: Summary of Local Key Hydrogeological Characteristics

Aquifer	Aquifer Type	Formation Name	General Lithology	Hydraulic Characteristics
Robe River Alluvium Aquifer.	Unconfined, sedimentary, vertical isotropy, regional.	Quaternary alluvium.	Shingles, conglomerates and coarse sand.	Heterogeneous, high permeability, high storage, horizontally and vertically limited.
Jimmawurrada Creek Alluvium Aquifer	Unconfined, sedimentary, vertical anisotropy, local.	Quaternary alluvium.	Conglomerates coarse to fine sand and silt / clay in the base.	Heterogeneous, low and high permeability, high storage, horizontally and vertically limited.
CID Aquifer.	Unconfined, sedimentary, vertical anisotropy, local.	Robe Pisolite.	Clay-rich basal layer, pisolite ore, and hard-capped pisolite.	Heterogeneous, high and low permeability, horizontally limited.
Basement	Confined, weathered, fractured, anisotropic, and regional.	Wittenoom Formation and Marra Mamba Iron Formation.	Dolomite, shale and BIF.	Highly heterogeneous, permeability domains associated with faults and fracturing, permeability decreases with depth.

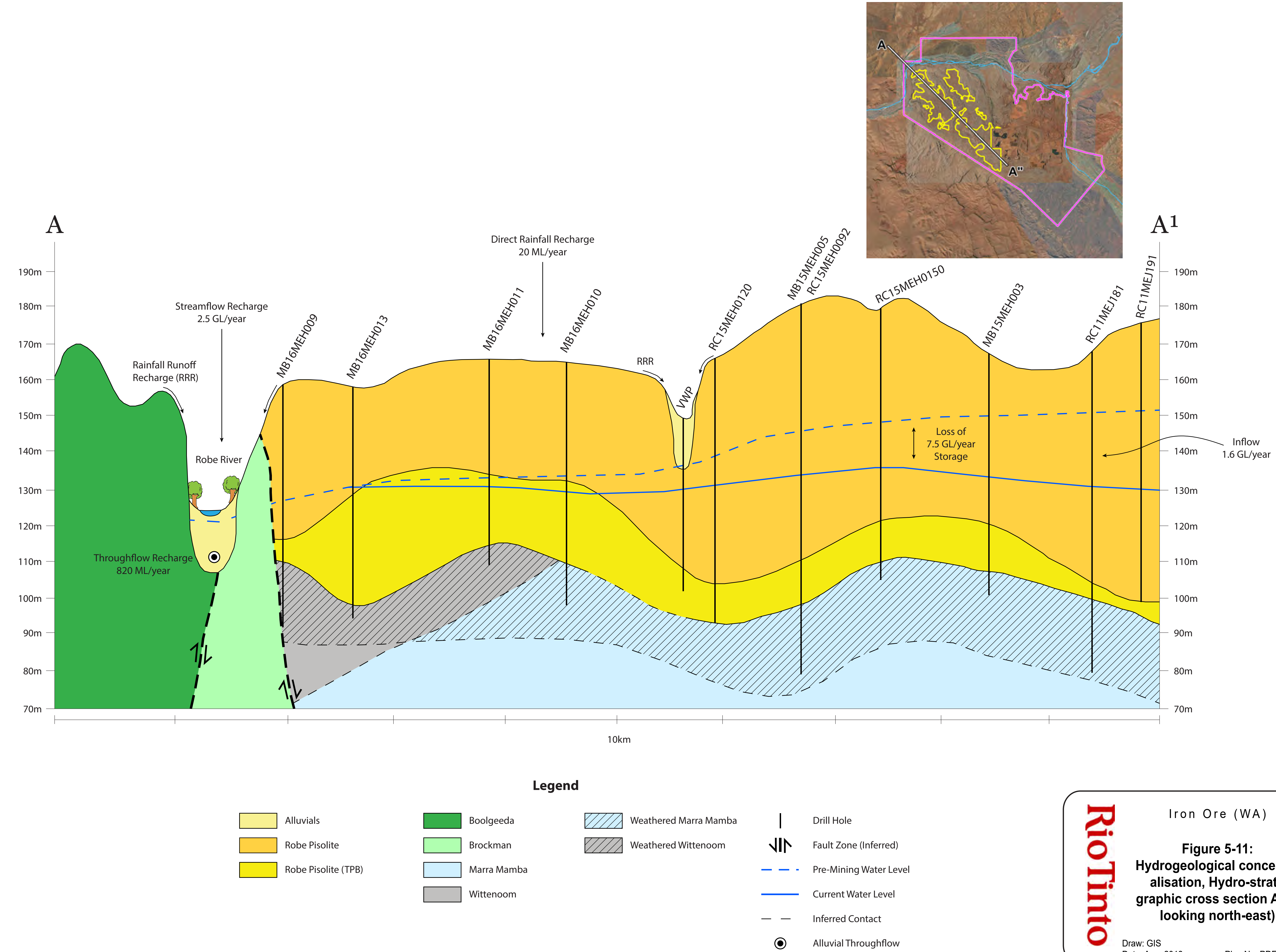
A series of cross-sections illustrating the hydrological setting and conceptualisation for the Revised Proposal are presented in Figure 5-11 to Figure 5-14.

5.4.5.2 Groundwater levels

The regional groundwater level prior to mining activity at Mesa J ranged between 150 m RL in the southern section of the deposit, transitioning to around 120 m RL in the northwest, at the confluence of Robe River, under a relatively low hydraulic gradient of 0.003.

Depth to pre-mining groundwater in the alluvial aquifer ranged from approximately 4 – 12 m bgl at Jimmawurrada (4 – 6 mbgl in the vicinity of the Development Envelope), and approximately 2 – 5 mbgl along the Robe River in the vicinity of Mesa H. These groundwater levels fluctuate by up to 3 m seasonally depending on climatic variability and rainfall patterns. Pre-mining and current groundwater levels measured in RL at Mesa H and Mesa J are shown in Figure 5-16 and Figure 5-17.

The water levels between the CID and the basement formation is broadly the same, however hydrogeological pump testing completed across bores slotted against each of these units shows a much higher drawdown in the basement formation than in the CID, suggesting the confinement of the weathered Wittenoom and Marra Mamba Iron Formations in areas of limited vertical extension (Rio Tinto 2019a).



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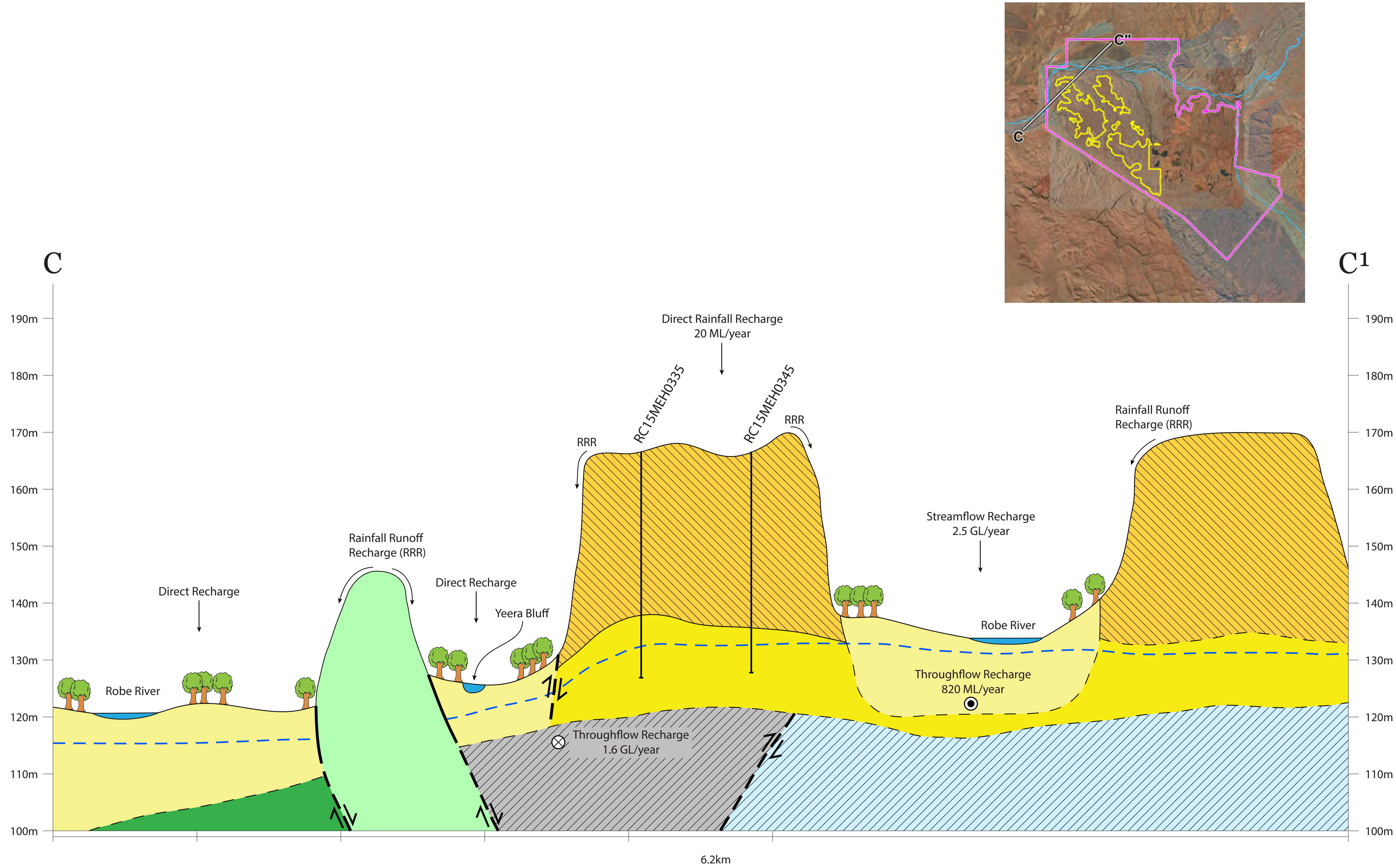
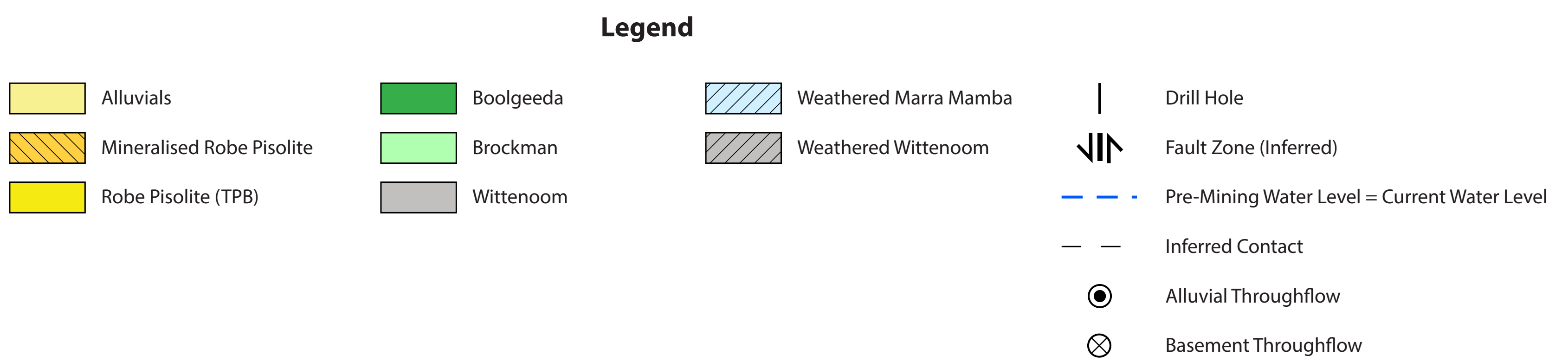
Iron Ore (WA)

Figure 5-11: Hydrogeological conceptualisation, Hydro-stratigraphic cross section A-A" looking north-east)

Draw: GIS
Date: Aug, 2018
Plan No: PDE0147573v3





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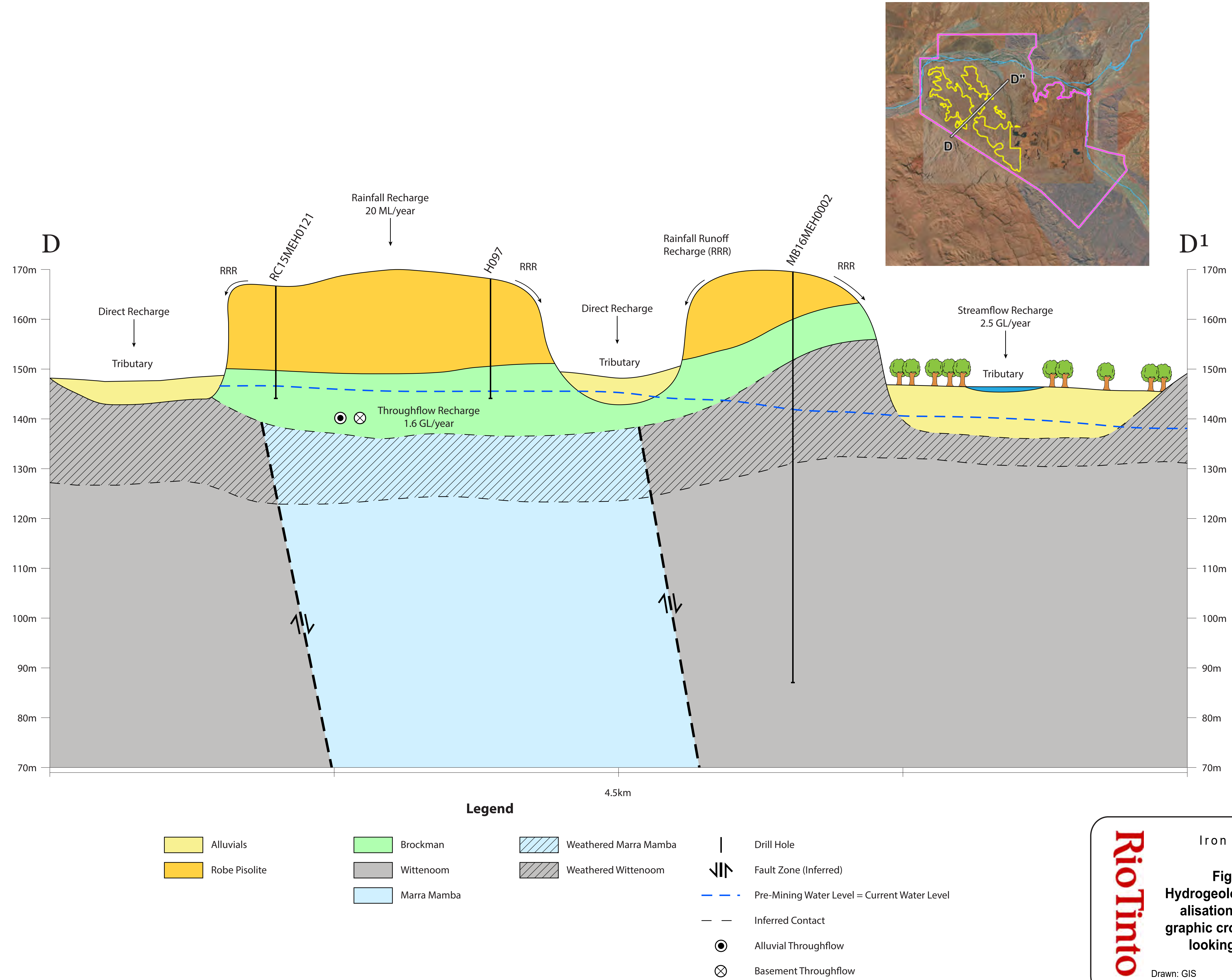
Iron Ore (WA)

Figure 5-12: Hydrogeological conceptu-alisation, Hydro-strati-graphic cross section C-C" looking north-west)

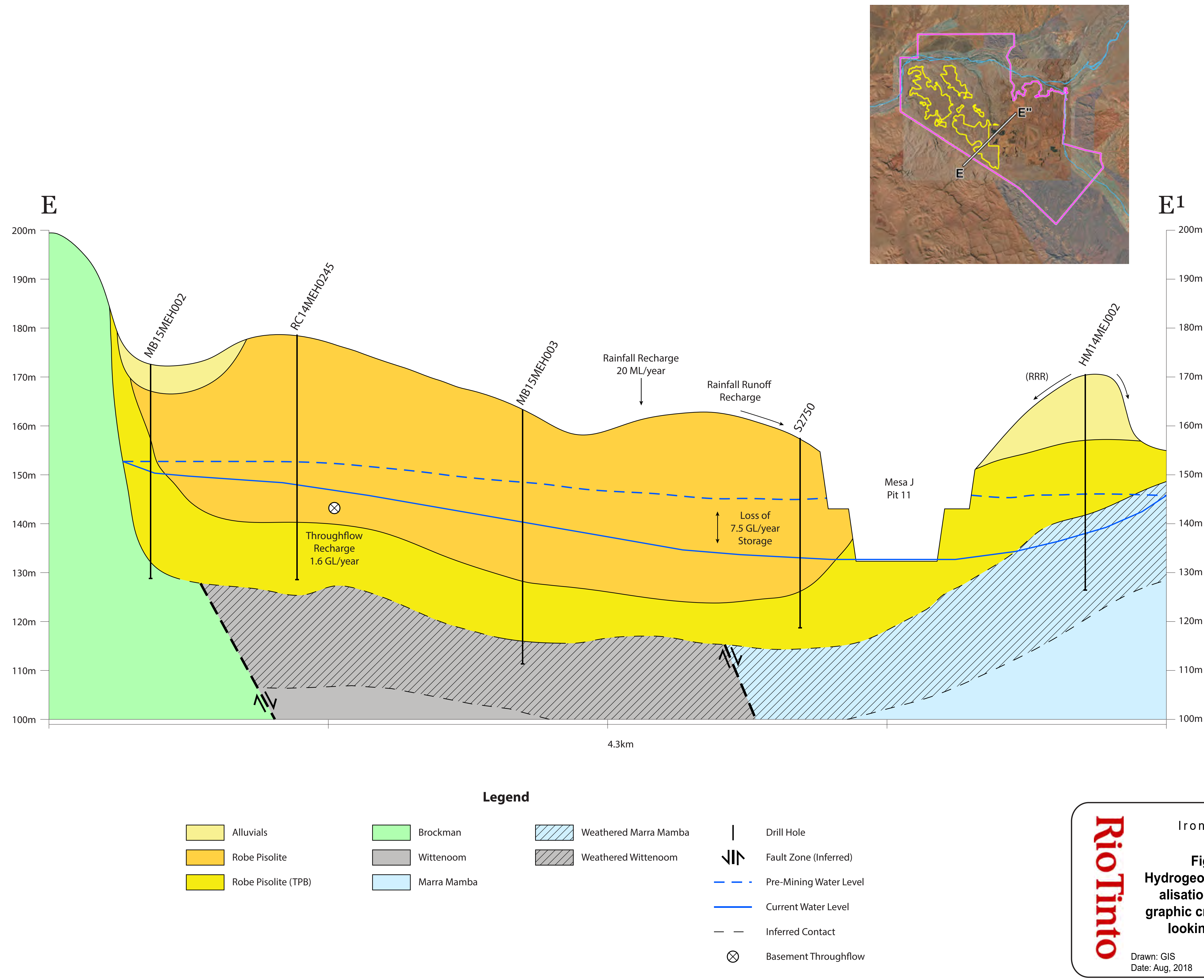
Drawn: GIS
Date: Aug, 2018
Plan No: PDE0147573v3



Iron Ore (WA)

Figure 5-13: Hydrogeological conceptualisation, Hydro-stratigraphic cross section D-D" looking north-west)

Drawn: GIS
Date: Aug, 2018
Plan No: PDE0147573v3



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Iron Ore (WA)

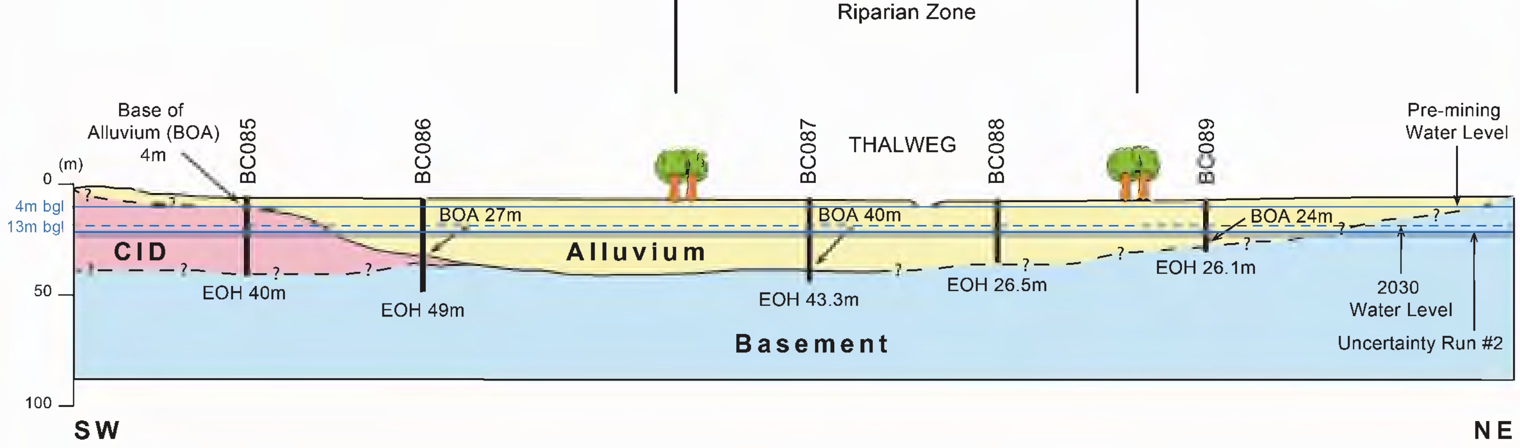
Figure 5-14: Hydrogeological conceptualisation, Hydro-stratigraphic cross section E-E" looking north-west)

Drawn: GIS
Date: Aug, 2018
Plan No: PDE0147573v3

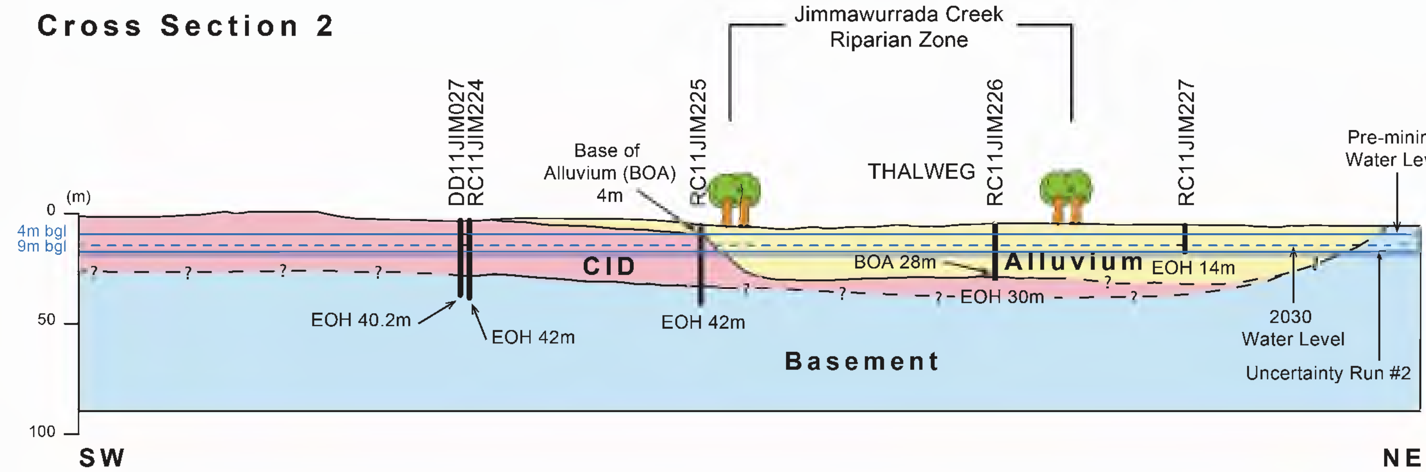
Rio Tinto

Figure 5-15: Jimmawurrada Creek cross sections (x2 vertical exaggeration)

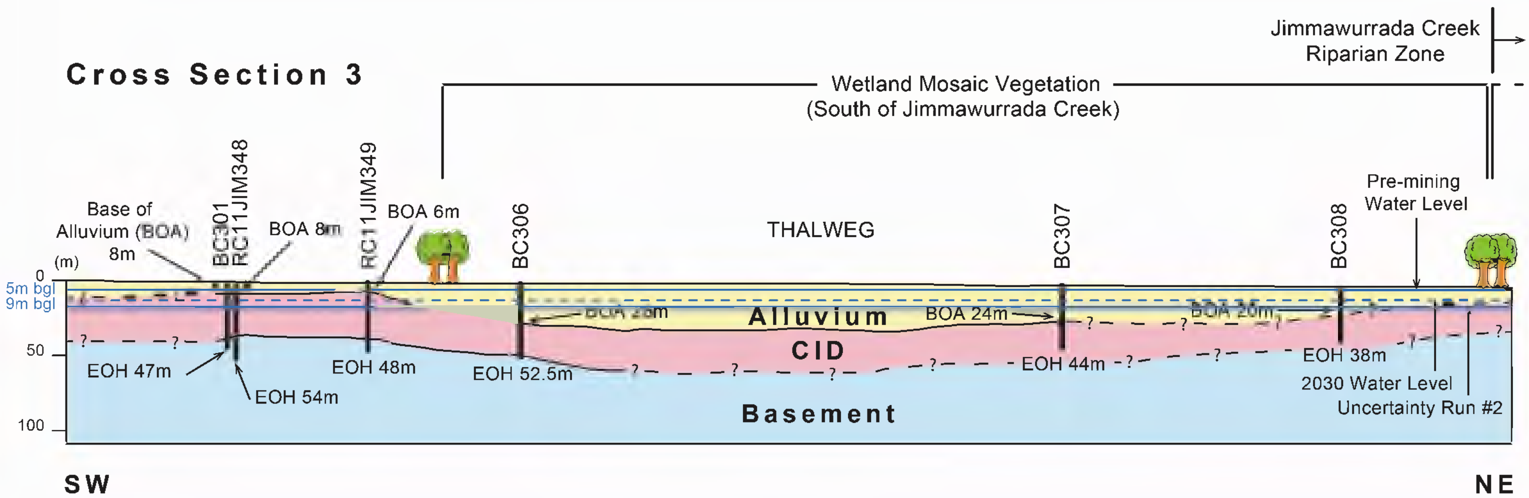
Cross Section 1

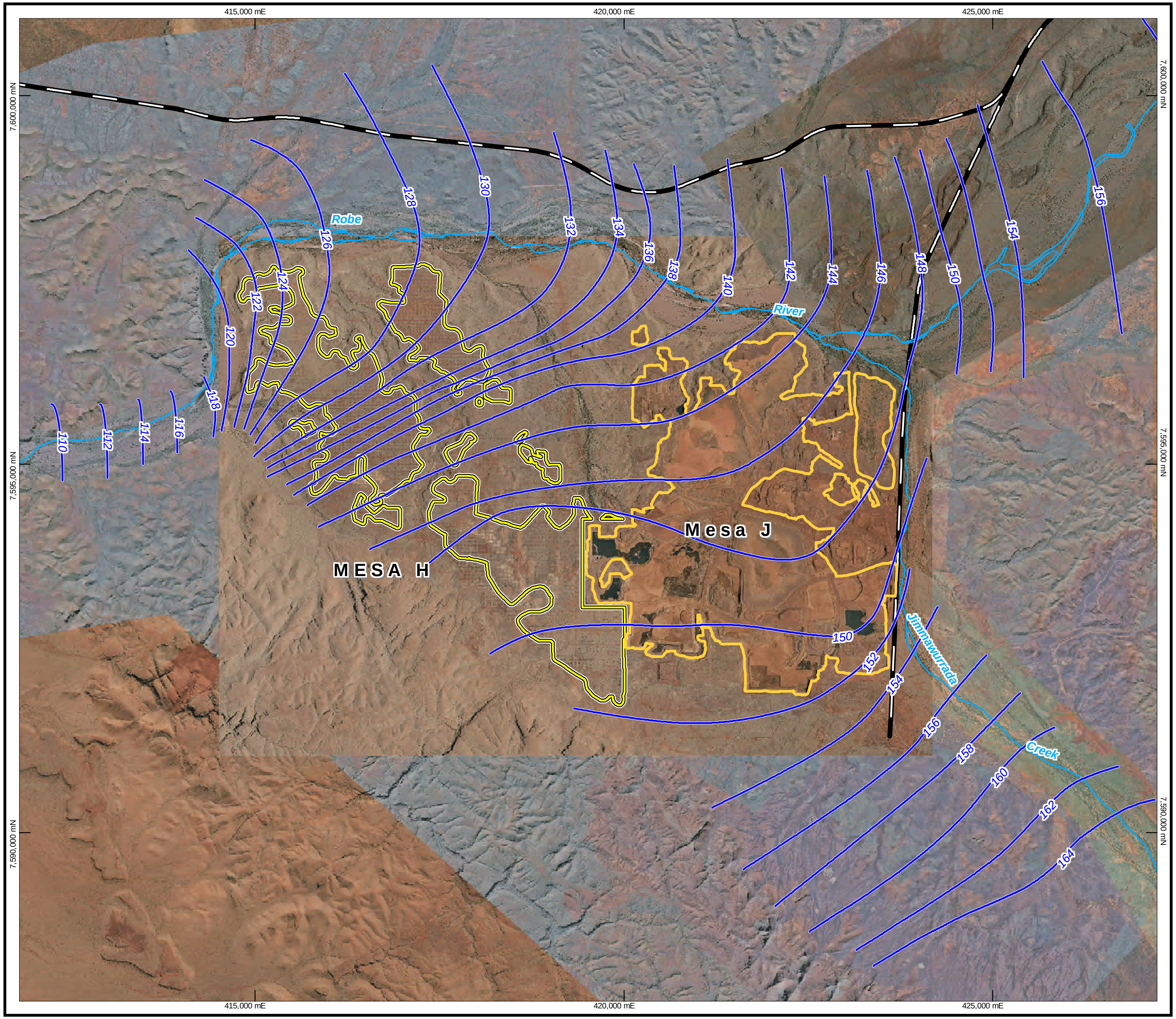


Cross Section 2



Cross Section 3





LEGEND

- Water table contour (RL)
- Mesa H proposed pit
- Mesa J Pit
- Railway
- Major Watercourse

N

SCALE

1 0 1 2 3km

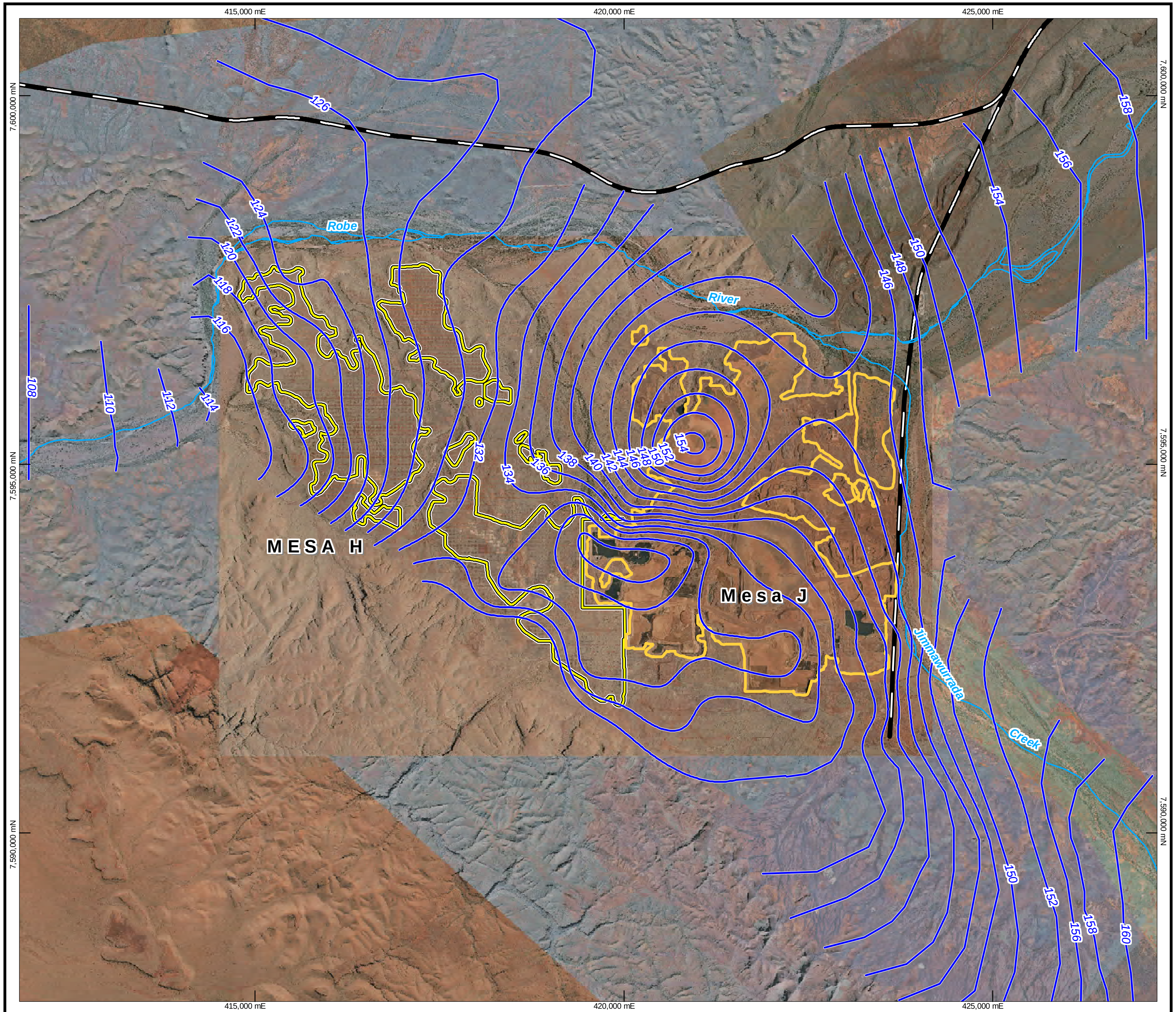
1:75 000 @ A4

RioTinto

Iron Ore (WA)

Figure 5-16: Estimated pre-mining water table contours

Drawn: T.M
Date: February, 2019
Plan No: PDE0165754v2
Proj: MGA94 Zone50



LEGEND

- Water table contour (RL)
- Mesa H proposed pit
- Mesa J Pit
- Railway
- Major Watercourse

N

SCALE

1 0 1 2 3km

1:75 000 @ A4

Iron Ore (WA)

Figure 5-17: Current water table contours

Drawn: T.M
Date: February, 2019

Plan No: PDE0165755v2
Proj: MGA94 Zone50

5.4.5.3 Groundwater quality

Monitoring of groundwater chemistry has been undertaken for the Mesa J Iron Ore Development since the early 1990's, including major ions, dissolved metals, nutrients, biological and physical parameters. The groundwater within the local catchment is described as fresh, with recorded salinities typically around 64 mg/L, though readings up to 2,800 mg/L have been recorded; and circum-neutral pH between 6 – 8 (Rio Tinto 2019a). The CID and Wittenoom aquifers generally comprise fresher water than the alluvial aquifer and the Robe River pools.

An analysis of the groundwater chemistry from Mesa H bores was found to be similar to Mesa J groundwater, however nitrate levels in the Mesa J bores were typically higher.

5.4.6 Existing water management scheme at Mesa J

5.4.6.1 Groundwater abstraction

The Proponent is authorised to abstract groundwater up to 30 GL/a at the Mesa J Iron Ore Development (RIWI Act 5C licence GWL 107678-13) for activities including dewatering, dust suppression, earthworks and construction, and for on-site potable use.

Groundwater is abstracted from:

- Mesa J Borefield (comprising production bores and in-pit sumps), which includes water from:
  - mine pit dewatering;
  - interception of seepage to the CID aquifer from in-pit water reservoirs and WSFSs;
  - surface water harvesting (direct rainfall and surface runoff management); and
  - decant water recovery.
- Southern Cutback water supply borefield production bores.

The scheme is complex, with abstraction derived from a combination of the production bores and in-pit sumps at the mine site, and production bores at the Southern Cutback water supply borefield. Water abstracted from the in-pit sumps includes surface water harvesting which is highly variable depending on the magnitude of rainfall/cyclone events. The scheme provides for operation flexibility to allow for variable operational water requirements and variable rainfall. The existing Mesa J Iron Ore Development borefield was originally commissioned in 1993.

At Mesa J, one of the mined-out pits, (known as Dan's Dam), is used to store water from the in-pit sumps and the Southern Cutback Borefield production bores (excluding potable bores). These storage facilities are used to provide operational flexibility for managing water demand to the processing plants and for dust suppression and to maintain a constant head near Jimmawurrada Creek to offset potential drawdown to the creek. Based on recent water balance studies of the mine site, a substantial proportion of the water stored at mined out pits (Dan's Dam combined with water in the WFSFs) seeps back into the CID.

To meet water demand for the process plant water supply, the Mesa J Iron Ore Development also harvests surface run-off from the Mesa H central catchment drainage, which runs in a north-easterly direction, terminating in the Mesa J pits. The Southern Cutback Borefield is located south-east of Mesa H (south of Mesa J) and approximately 2 km west of Jimmawurrada Creek (Figure 2-3). The borefield was commissioned in 2013 to replace old bores and provide a secure water supply for the mine site, comprising eight production bores ranging between 70 and 110 m deep, slotted against the CID and the Basement aquifers; of these, only five bores are currently operational.

Current groundwater abstraction at Mesa J from dewatering, water supply bores and surface water harvesting (rainfall runoff management) is between 10 – 14 GL/a.

The GWOS (Rio Tinto 2016d) provides details on the Mesa J water scheme and Table 5-5 in Section 5.5.1.1 provides Mesa J water balance details.

5.4.6.2 Surplus water management

Surplus water from Mesa J mine pit dewatering is primarily used to meet the process water demands of the Mesa J mining operations. Mesa J Iron Ore Development currently uses surplus water derived from mine pit dewatering for wet ore processing and dust suppression. Process water from the existing WFSFs is also recycled, with approximately 50% of the slurry wet volume (decant water) being recovered and recycled.

Based on this approach, the existing Mesa J site is effectively considered a water *neutral* site, however during wet season or significant rainfall events when storage capacity is exceeded, surplus water is required to be discharged.

Surplus water is discharged from the east of the mine into Jimmawurrada Creek and into a drainage line west of Mesa J (West Creek, a tributary of the Robe River) (Figure 2-3), in accordance with requirements under the EP Act Part V licence L6820/1993/12. Discharge from these outlets are sporadic and occur only during periods where surplus water exceeds operational requirements such as during high rainfall periods.

5.4.7 Current altered hydrological regime

Surface water and groundwater in the Development Envelope has been modified and managed for several decades as a result of mining activities in the area.

The Mesa J mine has been in operation since the early 1990s, with dewatering to access the BWT sections of the deposit commencing around 1995. The groundwater level within the CID at Mesa J has been altered by the combination of pit dewatering and water supply for the operations, with groundwater levels lowered in the CID by between 4 and 20 m since this time, extending up to 3 km laterally into the adjacent Mesa H deposit (Figure 5-18).

Depth to water in the adjacent Robe River alluvial aquifer ranges between 2 and 5 mbgl, whilst along the entire length of Jimmawurrada Creek it varies between 4 and 12 mbgl, with a seasonal variation of 3 m.

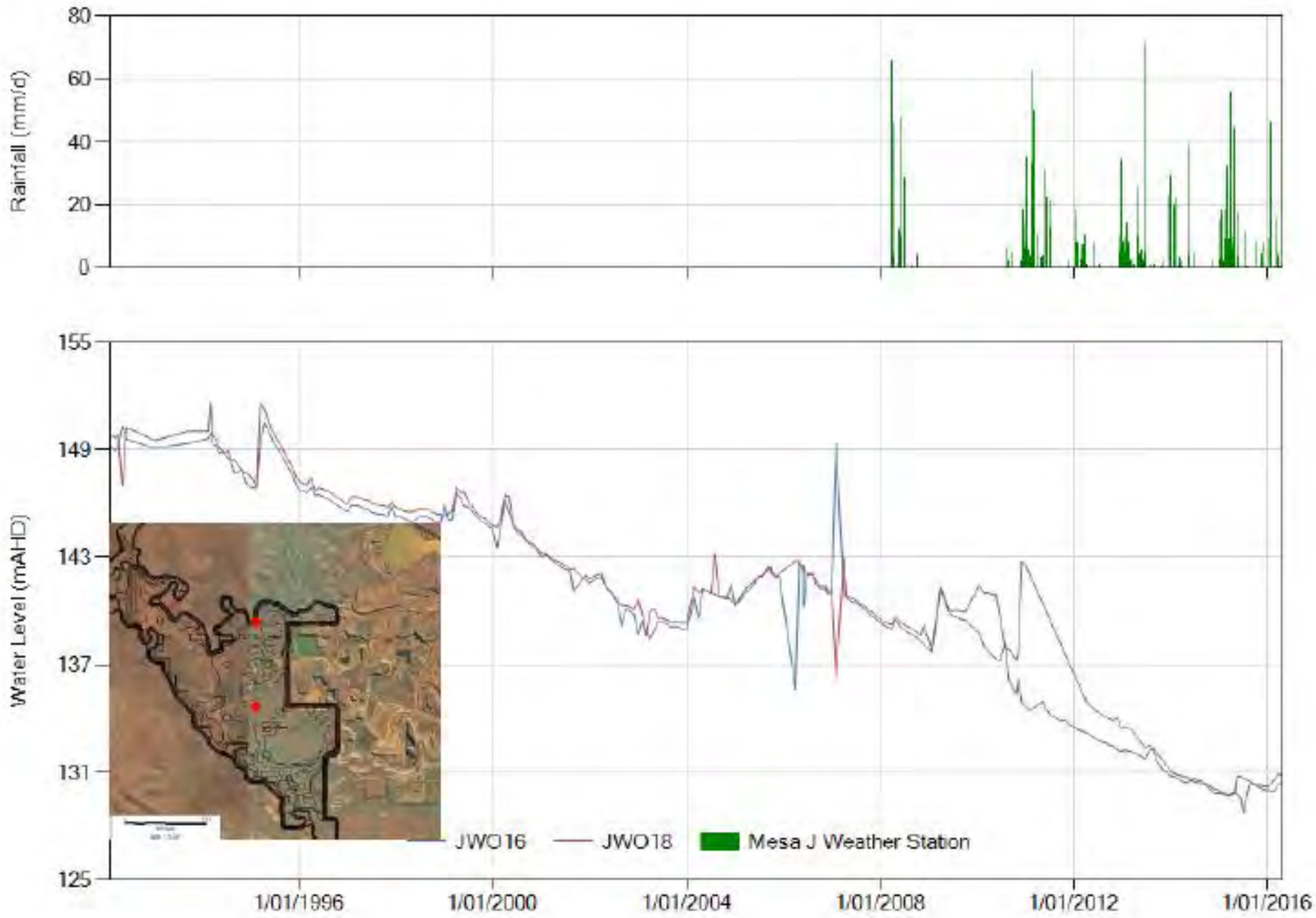


Figure 5-18: Mesa H monitoring bore hydrographs indicating existing groundwater drawdown due to Mesa J's dewatering and recorded rainfall

The six monitoring bores located to the east of the Southern Cutback Borefield, close to Jimmawurrada Creek, indicates a continuous decline in the water level since 2010 (Figure 5-18), possibly attributed to a combination of factors including lower rainfall since 2011, Mesa J dewatering, water supply from the Southern Cutback Borefield and the aquifer throughflow reduction due to the CWSP.

Aquifer recharge resulting from leakage of the WFSF and water reservoirs appear to play an important role in limiting the extent of the dewatering cone of depression from mine dewatering to the north towards the Robe River and east towards the Jimmawurrada Creek, based on site monitoring observations, including in groundwater monitoring bores and water levels measured in the pools of the Robe River.

Most of the surplus water from Mesa J is discharged to Jimmawurrada Creek, east of Mesa J. This water is observed to reach confluence with the Robe River (3.8 km) where it recharges a semi-permanent pool (Yarramudda) (Figure 5-1) and partially recharges into the Robe River gravels. Although theoretical modelling suggests the discharge may extend up to 8 km downstream the observed influence will rarely extend beyond the densely vegetated areas adjacent to the Mesa J access causeway (5 km).

5.4.8 Potable water supply

The Pannawonica town borefield abstracts groundwater from two buried alluvial channels located in the Robe River floodplain. The channel alluvium comprises about 20 m of river gravels, overlying fractured basalt. Groundwater flow in the aquifer is to the southwest towards the Robe River valley and is intermittently recharged by stream-aquifer interaction with the adjacent ephemeral Robe River, which is in hydraulic connection with the alluvial aquifer. The Pannawonica town borefield is more than 10 km from the Development Envelope and is not expected to interact with the impacts of the Proposed Change.

The Pannawonica town borefield has been operating since 1981 and provides water for potable water supply and dust suppression. The current Pannawonica licence (GWL 107677-7) has a water allocation of 700,000 kL/a (0.7 GL/a) and the bores operate on a rotational basis to allow sufficient recovery of the aquifer. Potable groundwater abstraction will continue to be managed under the existing Groundwater Licence and associated GWOS, and any amendments as required.

5.5 Potential Impacts

The key potential impacts to Inland Waters identified for the Revised Proposal on the basis of hydrological surveys and assessments are described in Sections 5.5.2 and 5.5.3.

The key potential direct impacts of the Revised Proposal on the key water-related values of Jimmawurrada Creek and the Robe River are:

- Changes to groundwater levels along the Robe River and Jimmawurrada Creek as a result of groundwater abstraction
- Changes to the hydrological regime of Jimmawurrada Creek and the Robe River as a result of surplus water discharge
- Changes to Robe River flows as a result of surface water infrastructure.

The key potential indirect impact of the Revised Proposal on Inland Waters is:

- Changes to surface and groundwater quality.

The Revised Proposal also has the potential to contribute to cumulative hydrological impacts to the Robe River Catchment.

The potential indirect impacts from abstraction and surplus discharge on other factors are addressed under the relevant factor, e.g. impacts on riparian vegetation in Flora and Vegetation (Section 6.6) and impacts on Subterranean Fauna habitat (Section 7.5).

5.5.1 Proposed water management scheme

The Proponent proposes to continue to manage groundwater and surplus dewater for mining at Mesa H according to the existing water management scheme in place for the Mesa J Iron Ore Development, and within the existing authorisations under the RIWI Act and EP Act Part V. As water management at Mesa H will be integrated with water management at Mesa J, it is difficult to separate out the contribution from the Proposed Change, therefore discussion of potential impacts in this section refers to the impact of the Revised Proposal (i.e. including both the Proposed Change and the Mesa J Iron Ore Development).

This section discusses the key changes to the water balance as a result of the Revised Proposal and discusses water demand, water supply and surplus water management options considered during the Proposed Change design to minimise the potential impacts of the water balance components (as discussed in Sections 5.5.1 to 5.5.3).

5.5.1.1 Conceptual water balance

Due to the integrated nature of water management for the Revised Proposal, a combined Mesa J and Mesa H water balance forecast was generated shown in Figure 5-19. The water balance estimate incorporates abstraction for the Proposed Change and the existing Mesa J Iron Ore Development.

As discussed in Section 5.4.6, groundwater currently abstracted from the Mesa J mine and Southern Cutback Borefield is stored in a water reservoir (currently Dan's Dam). Groundwater abstraction is metered at this point, so the components of groundwater abstraction and demand in Table 5-5 are estimates only. Also, as discussed, the components of the water balance will vary over time due to variable operational water requirements and variable rainfall, so a range of volumes is presented. The peak estimates presented in the table are not directly additive because the relative contribution of the components towards the total groundwater abstraction will change. For example, if the volume of mine pit dewatering is high, the volume required from the Southern Cutback water supply borefield will be less. Figure 5-19 shows the water balance forecast over the life of the operations including Mesa J and Mesa H.

A maximum of 15 GL/a is likely to be abstracted for the Revised Proposal. Volumes exceeding on site water storage will be periodically discharged, with an estimated peak of 7 GL/a. See the *Mesa H – H3 Hydrogeological Level Assessment Report* (Rio Tinto 2019a, Appendix 8) for further details. The conceptualisation was peer reviewed by Independent Groundwater Consultants, and the numerical models were peer reviewed by RPS / Aquaterra (Appendix 8).

Table 5-5: Combined Operations Water Balance Forecast

Component	Current Mesa J (GL/a) Peak (Range)	[1]Revised Proposal (Mesas J and H) (GL/a) Peak (Range)	Comment
Groundwater abstraction			
Dewatering	10 (7 – 10)	8 (3 – 8)	Assumes inclusion of a Thickener Plant
Southern Cutback Borefield water supply	3 (1 – 3)	5 (1 – 5)	
Surface water harvesting Seepage interception from water reservoir and WFSFs Decant water recovery	7 (3 – 7)	7 (3 – 7)	Based on observed data (not included in groundwater model)
[2]Maximum total abstraction	**14**	**15**	**Peak abstraction estimated to be 15 GL/a for the Revised Proposal**
Peak Demand			
Wet Plant Demand	10 (9 - 10)	7 (3 – 7)	
Dust Suppression Non-processing infrastructure Evaporation	1	1.5 (1 – 1.5)	
Maximum total demand	11	8.5	
Surplus (after demand met)			
Discharge	7 (1 – 7)	7 (1– 7)	Excludes discharge from major cyclonic events

[1] Source: From Mesa H: Hydrogeological H3 Level Assessment (Rio Tinto 2019a)

[2] Maximum total abstraction is not additive from peak volumes from rows above

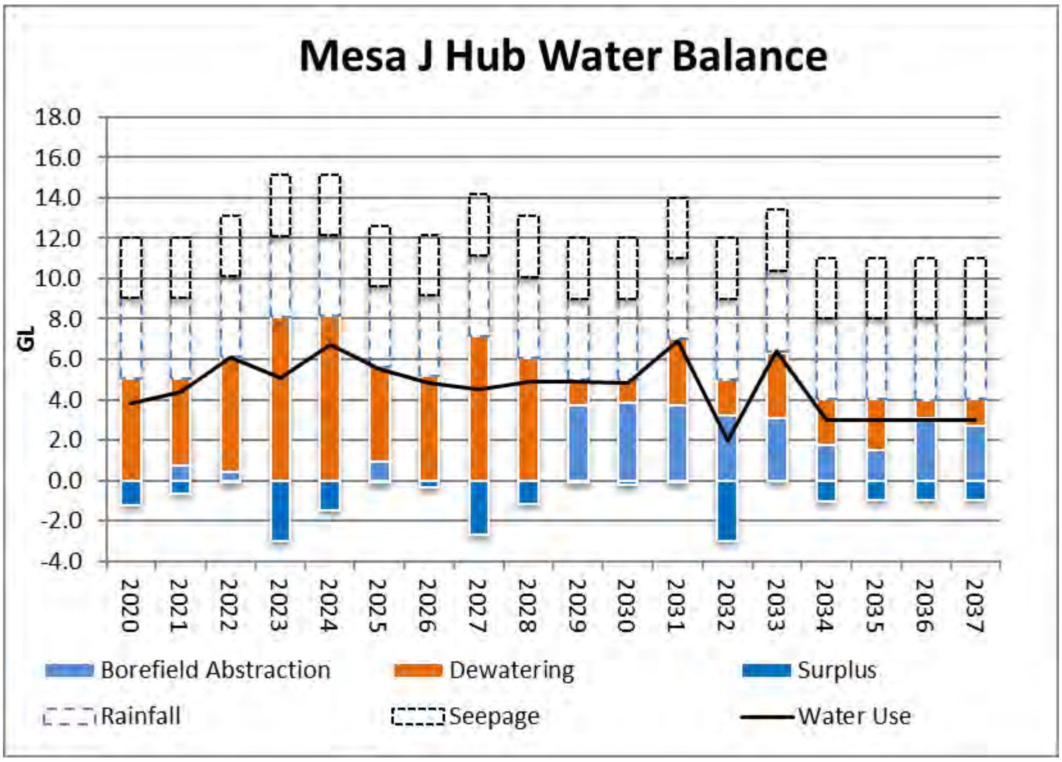


Figure 5-19: Revised Mesa J Iron Ore Development Water Balance

5.5.1.2 Water demand and water supply options

The initial proposed wet ore processing for the Proposed Change was modelled to have increased current site water demand, requiring additional water supply beyond the current supply for Mesa J. Water supply options to meet the on-site water demand, other than an extension to the current Southern Cutback Borefield, were considered because initial modelling predicted large drawdown increases (and associated impacts) along Jimmawurrada Creek. The options considered were; a new borefield at Bungaroo (located approximately 15 km upstream of the current Southern Cutback Borefield); or sourcing water from Warramboo.

The Proponent also reviewed a number of options to reduce water demand for the Revised Proposal (Mesa J and Mesa H). The most effective option considered viable was to include a thickener plant to increase reclaimed water volumes from the WFSFs and reduce cumulative groundwater drawdown along the Jimmawurrada Creek. The inclusion of a thickener has been included in mine planning and will reduce the groundwater demand by 30% (approximately 50 GL) during the LOM (Rio Tinto 2019a, Appendix 8). Given this water demand reduction strategy, an extension of the existing Southern Cutback Borefield was selected as the preferred water supply option due to its ability to satisfy the forecast increased water supply requirements (Table 5-5), avoid impacts to other aquifers or new footprint areas, minimise cumulative interactions with other Projects and its proximity to the Revised Proposal operations (requiring less infrastructure / pipework and associated ground disturbance).

5.5.1.3 Surplus water management options

Groundwater dewatering and associated surplus water generation from Mesa H is only anticipated to occur during the period when the BWT ore is required to be accessed, currently scheduled to commence around 2025. Discharge of surplus water is predominantly required during and directly post wet season for surface water management purposes.

Although most surplus water is proposed to be used on site, a number of management options were considered for the management of surplus water for the Revised Proposal, consistent with the *Pilbara Water in Mining Guideline* (DoW 2009), including:

- Efficient on-site use, including mitigation of any impacts.
- Use for fit-for-purpose activities (such as processing and dust suppression). It must be demonstrated that the water is of suitable quality for the end use.
- Transferred to meet other demand including other proponents in the area.
- Injection back into the aquifer at designated sites determined by the proponent and agreed by DWER.
- Controlled release to the environment where the surplus water is allowed to flow into a designated water course.

The outcomes of the water management options assessment are summarised in Table 5-6.

Table 5-6: Summary of Assessment of Surplus Water Management Options

Option	Outcome
On site use / mitigation of impacts.	**Feasible and proposed.** Currently approved / implemented for the existing Mesa J Iron Ore Development - surplus water partially meets demand. Surplus water generated via Mesa H mine pit dewatering (scheduled from 2025) is proposed to be fed directly back into the combined Mesa J and H operations to support wet processing and thus reduce the water demand from the Southern Cutback Borefield. An option of localised water supplementation into the permanent pool of Yeera Bluff in the Robe River may be implemented as a mitigation measure to maintain water levels to protect both cultural and environmental values. This approach would be based on monitoring results indicating a variation of water levels beyond natural climatic variability and reference monitoring sites.
Transfer to the third party user.	**Not considered feasible.** Most of the mine pit water from mine pit dewatering will be required to meet operational water demand for the Revised Proposal, predominantly for wet ore processing. The adjacent CWSP currently supplies water to Harding Dam for distribution to Pilbara Coastal towns and ports. Building infrastructure to enable relatively small and intermittent contributions to CWSP is not considered environmentally or economically feasible. In addition, the surplus water would generally only be available following wet conditions when demand is low.
Supply Pannawonica town and industrial area.	**Not considered feasible.** Pannawonica town water supply requirement of approximately 2 ML/day is currently met by a local bore field which is more than 10 km from the Development Envelope. The Pannawonica town water demand is significantly less than the volume to be dewatered from Mesa H. A significant increase in the Pannawonica water supply requirement is unlikely.
Passive recharge via a mined-out pit.	**Feasible and proposed.** Currently approved / implemented for the existing Mesa J Iron Ore Development. Whilst this option is feasible, water recharged to the aquifer may re-circulate to nearby dewatering bores during operations and would need to be managed in relation to proximity to active mine pits.
Re-injection into the CID	**Not considered feasible.**

Option	Outcome
	Based on previous Managed Aquifer Recharge trials within the Central Pilbara at Marandoo, Karijini National Park, Southern Fortescue, Yandicoogina and Nammuldi, the feasibility for injection as a water management option requires the target aquifer to have adequate storage and the prevention or minimisation of the recirculation of water back into the mine. To meet this requirement certain criteria have to be met: • Permeable aquifer where each injection bore can inject at a rate greater than 1 ML/day • Adequate storage available in the aquifer • Sufficient depth to water of greater than 40 m to ensure water levels do not rise above acceptable levels, this prevents the establishment of dependant shallow rooted vegetation • Aquifer that is down gradient or disconnected from the mining area to prevent recirculation of water back into the mine • Outside the mine abstraction borefield's cone of depression to prevent recirculation of water back into the mine. These criteria are not met within the Development Envelope.
Re-injection into Jimmawurrada Creek alluvial aquifer.	**Not considered feasible.** Limited surplus water available to consistently recharge the system during dry season when water in the creeklines would be most required and sourcing additional groundwater from CID aquifers to top up alluvial aquifers may potentially increase the drawdown-related impacts. In addition, it is likely re-injection infrastructure would be damaged by flood events resulting in significant cost and operational delays. Due to the permeable nature of the alluvial aquifer, recharge is expected to occur as a result of surface water discharge.
Re-injection into the Robe River alluvial aquifer.	**Not considered feasible.** Uncertainty related to aquifer storage and dimensions. It is likely re-injection infrastructure would be damaged by flood events resulting in significant cost and operational delays. However, localised water supplementation into the permanent pool of Yeera Bluff in the Robe River may be implemented as a mitigation measure to maintain water levels to protect both cultural and environmental values. This would result in some localised recharge of the Robe River alluvial aquifer.
Discharge to Jimmawurrada Creek and / or West Creek.	**Feasible and proposed.** Currently approved / implemented for the existing Mesa J Iron Ore Development. Feasible for the Revised Proposal. Discharge will be periodic and may at times result in intermittent surface water expression up to 8 km downstream of the discharge point and may alter the water chemistry in Jimmawurrada Creek and the Robe River to groundwater signatures. Discharge outlet locations may be optimised to focus delivery of discharge water to areas along Jimmawurrada Creek, upgradient of the Southern Cutback Borefield, to reduce potential drawdown impacts predicted for this area.
Discharge to the Robe River.	**Feasible but not proposed.** Discharge of water directly into the Robe River is not proposed except as a contingency measure if pool water levels drop more than expected. .

5.5.2 Potential direct and cumulative impacts

5.5.2.1 Groundwater drawdown along the Robe River as a result of mine pit dewatering

Approximately 20% of the CID at Mesa H occurs below the current water table and hence pit dewatering will be required to allow for mining of these lower sections of the orebody.

As part of the 2016 dewatering and impact assessment of the Revised Proposal, a new groundwater model was developed which incorporates the Proposed Change, the existing Mesa J Iron Ore Development, and the adjacent upstream CWSP. Results from this model were peer reviewed by RPS Aquaterra (Appendix 8).

Active dewatering of the Mesa H Pits to enable BWT mining is currently estimated to commence from around 2025 (Figure 5-20). Peak groundwater abstraction from Mesa H only is estimated several years later in the mine life (current estimate around 2033 – 2034) of approximately 3 GL/a (~7.1 ML/day), with a total of ~15 GL to be dewatered during the life of the operations. The peak dewatering abstraction for the Revised Proposal is predicted to decrease from the current peak of 10 GL/a at the Mesa J Iron Ore Development to 8 GL/a for the Revised Proposal (excluding surface water management and seepage inflows).

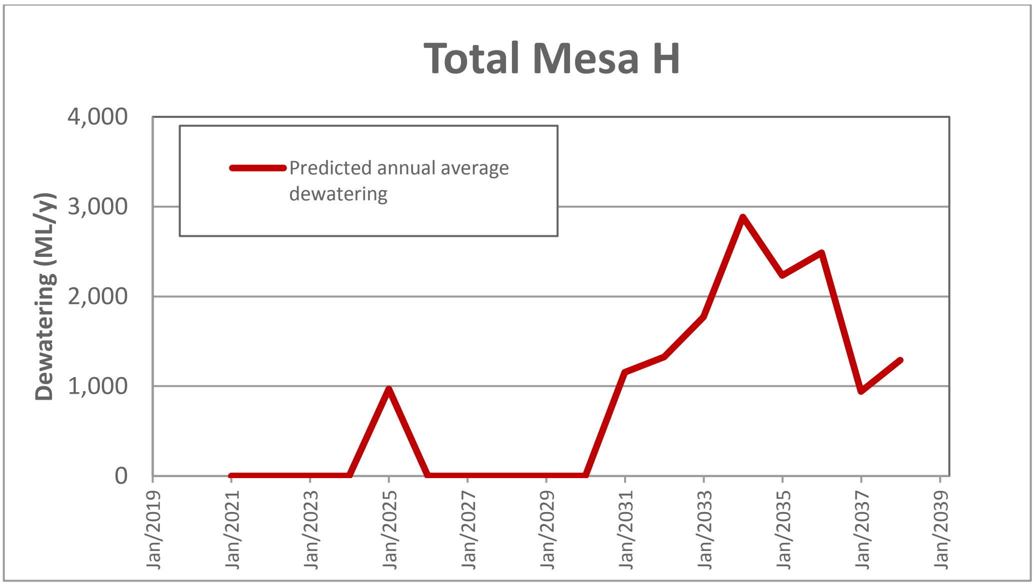


Figure 5-20: Mesa H Predicted Dewatering Rates and Cumulative Volumes

Based on the predicted dewatering volumes, dewatering will lower the current groundwater level by a further approximately 20 m (24 – 40 mbgl total) in the CID aquifer, which has limited but some connectivity to the Robe River Alluvial aquifer and associated pools.

During the development of the hydrogeological conceptualisation of the Development Envelope, a series of uncertainties were recognised which could potentially affect the Robe River pools. Based on the unknowns, four conceptualisations were used (one base case and three conceptual uncertainty runs / predictions) to test the numerical model sensitivity and calibration for each major uncertainty.

Based on the conceptual groundwater model, a numerical groundwater model was developed to simulate dewatering scenarios and assess impacts to groundwater levels, based on current knowledge of the aquifers and their behaviour at the adjacent Mesa J Iron Ore Development; hydrogeological conceptualisation based on hydrogeological knowledge of the surrounding geological formations; and calibrated against meteorological data, pump testing and monitoring bores.

The hydrogeological investigations indicate that the Brockman Iron Formation at the Base of Mesa H forms an impermeable boundary between the CID Aquifer and the Robe River

Alluvial Aquifer, which acts to restrict the extent of the dewatering cone of depression in the CID from extending laterally into the Robe River, particularly around Yeera Bluff (Figure 5-12). Based on this, the modelling indicates a short term (less than one year) maximum drawdown of less than 0.5 m to the Robe River to the north of Mesa H and less than 0.7 m drawdown around Yeera Bluff (Figure 5-21 and Figure 5-22).

Complete aquifer recovery in the CID is predicted to take between 50 and 60 years, however, the large majority of the drawdown along the Robe River and Jimmawurrada Creek is expected to recover 90% of the drawdown after the first or second significant rainfall events. The drawdown in the Yeera Bluff is estimated to take the longest to recover, with the last 20 cm of drawdown requiring up to 40 years to recover.

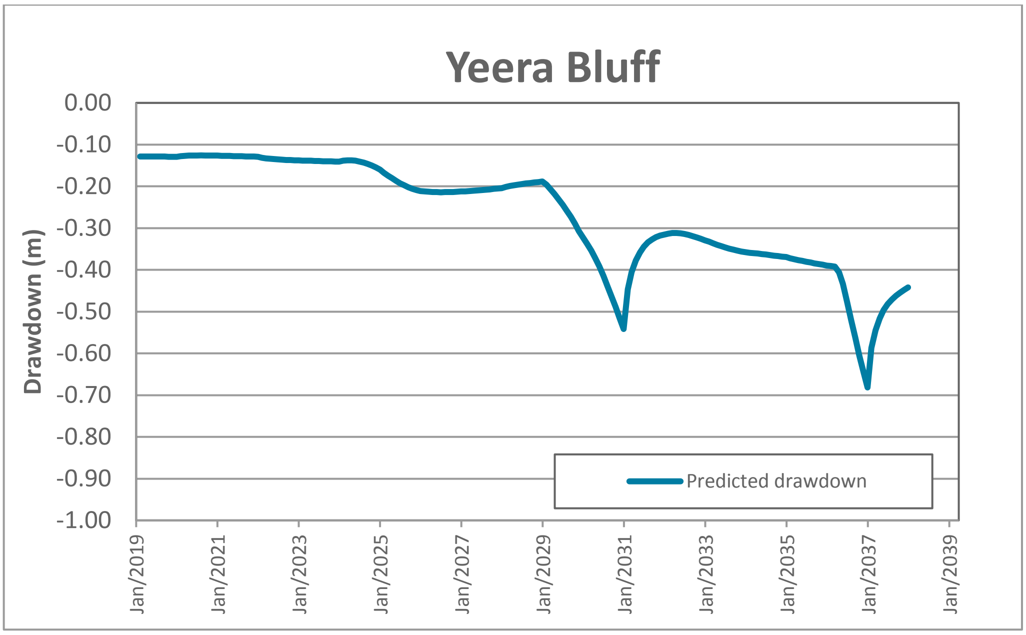


Figure 5-21: Predicted Groundwater Drawdown at Yeera Bluff

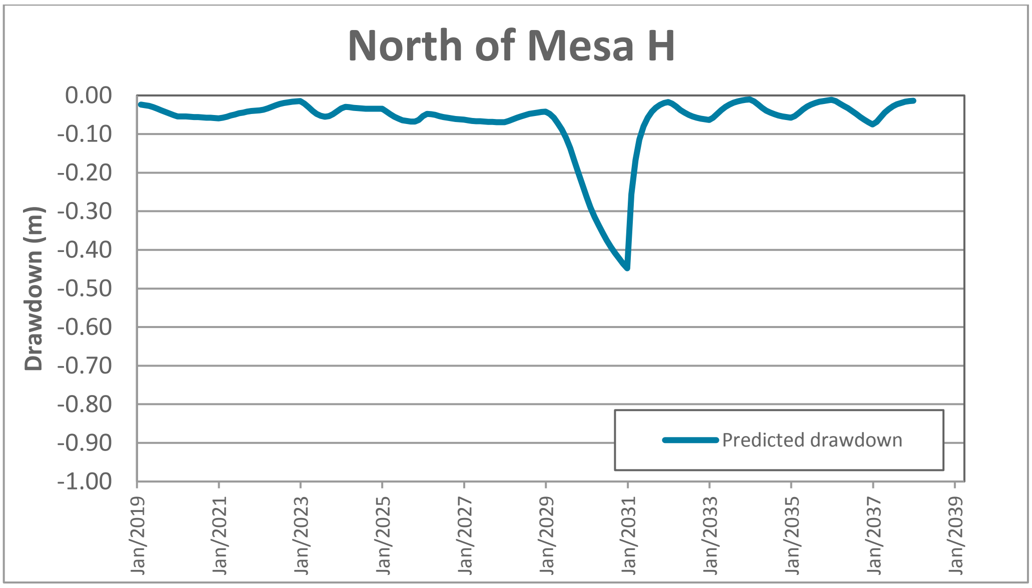


Figure 5-22: Predicted Groundwater Drawdown North of Mesa H

Although limited long-term monitoring data in the Robe River is available, monitoring records from bores in the Robe River Alluvium indicate seasonal variation of groundwater levels of approximately 3 m (Rio Tinto 2019a). This natural fluctuation of the water table in the Robe River Alluvium is consistent with observations made in the lower Robe River (DoW 2010).

5.5.2.2 Groundwater drawdown along Jimmawurrada creek from groundwater abstraction

The Southern Cutback Borefield is situated close to the Mesa J Iron Ore Development and to Jimmawurrada Creek. Groundwater abstraction from the borefield is within the Jimmawurrada CID aquifer and has already resulted in a groundwater drawdown cone of depression extending from the borefield, beneath the adjacent section of Jimmawurrada Creek, locally lowering the pre-mining groundwater table by approximately 4 – 6 m immediately to the east of the borefield. The current groundwater levels in RL at Mesa J (and current drawdown from pre-mining levels) are shown in Figure 5-17.

The local groundwater table is expected to be further lowered as a result of continued, and additional, abstraction from the Southern Cutback Borefield to meet operational water requirements. The cumulative effects of the groundwater drawdown from increased abstraction from the Southern Cutback Borefield, taking into consideration mine pit dewatering (Mesa J and H) and including the CWSP were integrated into the hydrological modelling for the Revised Proposal. This enabled an understanding of the overall catchment water balance and the cumulative groundwater drawdown.

Initial modelling for a higher water demand of up to 9 GL/a (without the thickener plant) predicted drawdown of between 15 mbgl and 20 mbgl along Jimmawurrada Creek. Given that the observed thickness of the alluvial aquifer along Jimmawurrada Creek is between 28 – 40 m in the deepest part of the channel (thalweg), the modelled groundwater drawdown had the potential to draw down the water table across a significant extent of the Jimmawurrada Creek Alluvial Aquifer. Given that this scenario was considered likely to have a significant impact on environmental and Aboriginal heritage values including the *Stygofauna Community of the Bungaroo Aquifer* PEC, and riparian vegetation, other water demand and water supply options were investigated (Section 5.5), including moving the borefield and review of options for reducing water demand.

As a result of the review, the option of implementing a thickener plant using a non-toxic and non-hazardous flocculent to reduce water in the wet processing circuit was considered the most efficient way to reduce operational water demand and reduce abstraction requirements from the Southern Cutback Borefield and has been selected for the Proposed Change. The use of a thickener will allow the reclamation of a significant volume of water used by the wet plant and is estimated that this will reduce the water demand by approximately 30% (~50 GL) over the LOM.

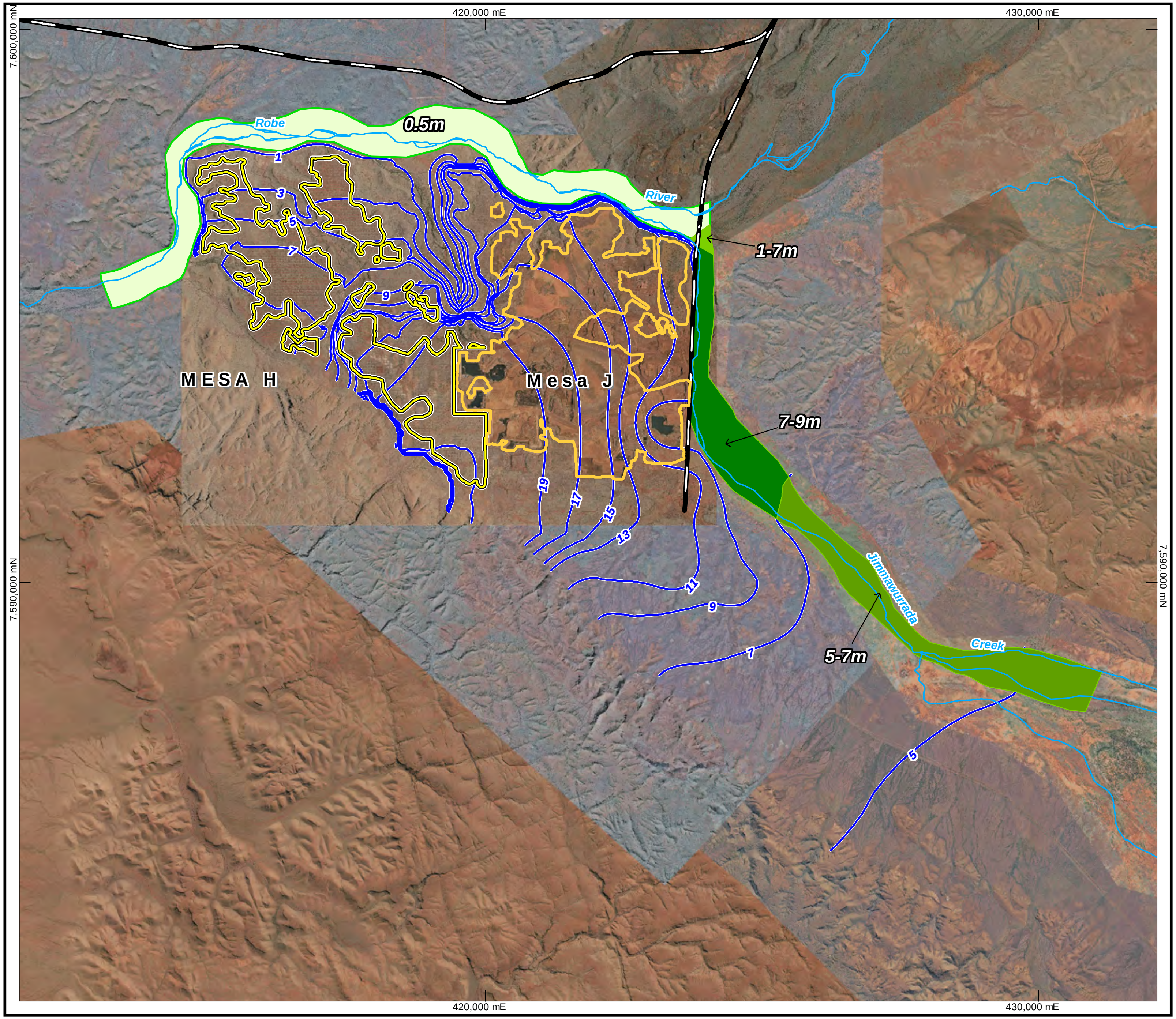
Based on the inclusion of a thickener plant, a water deficit is predicted for the Revised Proposal during the initial years of above-water table mining at Mesa H (2020 to 2024 assuming the Mesa H mining starts in late 2019). Dewatering at Mesa H will commence in 2025 (Figure 5-19). Additional water supply is therefore required to meet the operational demand of up to 7 GL/a during those initial years. Water is proposed to be sourced from an extension to the existing licenced Southern Cutback Borefield which currently supplies water to the Mesa J Iron Ore Development. Abstraction for the Revised Proposal water supply, in combination with the drawdown from the neighbouring CWSP, is predicted to result in a groundwater drawdown cone of depression extending below a section of Jimmawurrada Creek (Figure 5-23 and Figure 5-24).

In order to meet future wet processing water demands as a result of implementing the Revised Proposal, an ongoing water supply from the Southern Cutback borefield will be required. To simplify model predictions, the water demand (including the Thickener Plant) was averaged at 5 GL/a between 2020 and 2033 and reduced to 4 GL/a until 2037 (Figure 5-19), for a total of 86 GL (modelled) required to meet LOM demand. In order to achieve this, water is proposed to be sourced from a combination of dewatering at both Mesa H and J pits (when available), the existing Southern Cutback Borefield, surface water harvesting and sump pumping, and seepage from in pit water storage and WFSFs. This approach could require the installation of an additional three water supply bores in the existing borefield.

Updated hydrogeological modelling based on this approach (inclusion of thickener plant) (Rio Tinto 2019a) predicts that drawdown will lower the water table across a 12 km section of Jimmawurrada Creek, with a maximum predicted drawdown of 9 m over a 6.5 km section (based on pre-mining water table levels) by 2030 (Figure 5-23), mostly as a result of BWT mining at Mesa J.

Climate change has been considered in the numerical model (uncertainty run #2) by reducing the natural recharge in Jimmawurada Creek by 50% (Rio Tinto 2019a). In this prediction, the water table levels in Jimmawurrada Creek could be lowered by almost 3 m in addition to the historical seasonal fluctuations (2 – 3 m); this would translate to localised changes in water table depths of up to 14 m from pre-mining conditions (equivalent to ~18 mbgl) in Jimmawurrada Creek Alluvium Aquifer by 2030. The Robe River receives most of its recharge from the upper Robe River, rather than Jimmawurrada Creek. Hence total change to the Robe River and associated pools are modelled to remain as <1 m of drawdown taking into account this reduced recharge climate change scenario and the proposed groundwater abstraction.

However, cessation of dewatering at Mesa J and natural rebound of the water level during wet season, the drawdown at the end of operations (Dec 2037) is expected to be between 1 and 5 m along a 12 km section of Jimmawurrada Creek, and up to 7 m east from that point due to the overlap with the CWSP drawdown cone of depression (Figure 5-24). Modelled cumulative drawdown along Jimmawurrada Creek east of the Southern Cutback Borefield (based on pre-mining groundwater levels) is shown in Figure 5-25.



LEGEND

Drawdown contour

Mesa H proposed pit

Mesa J Pit

Railway

Major Watercourse

Groundwater drawdown contours

0.5m

1-7m

5-7m

7-9m

N

SCALE

0 2 4km

1:100 000 @ A4

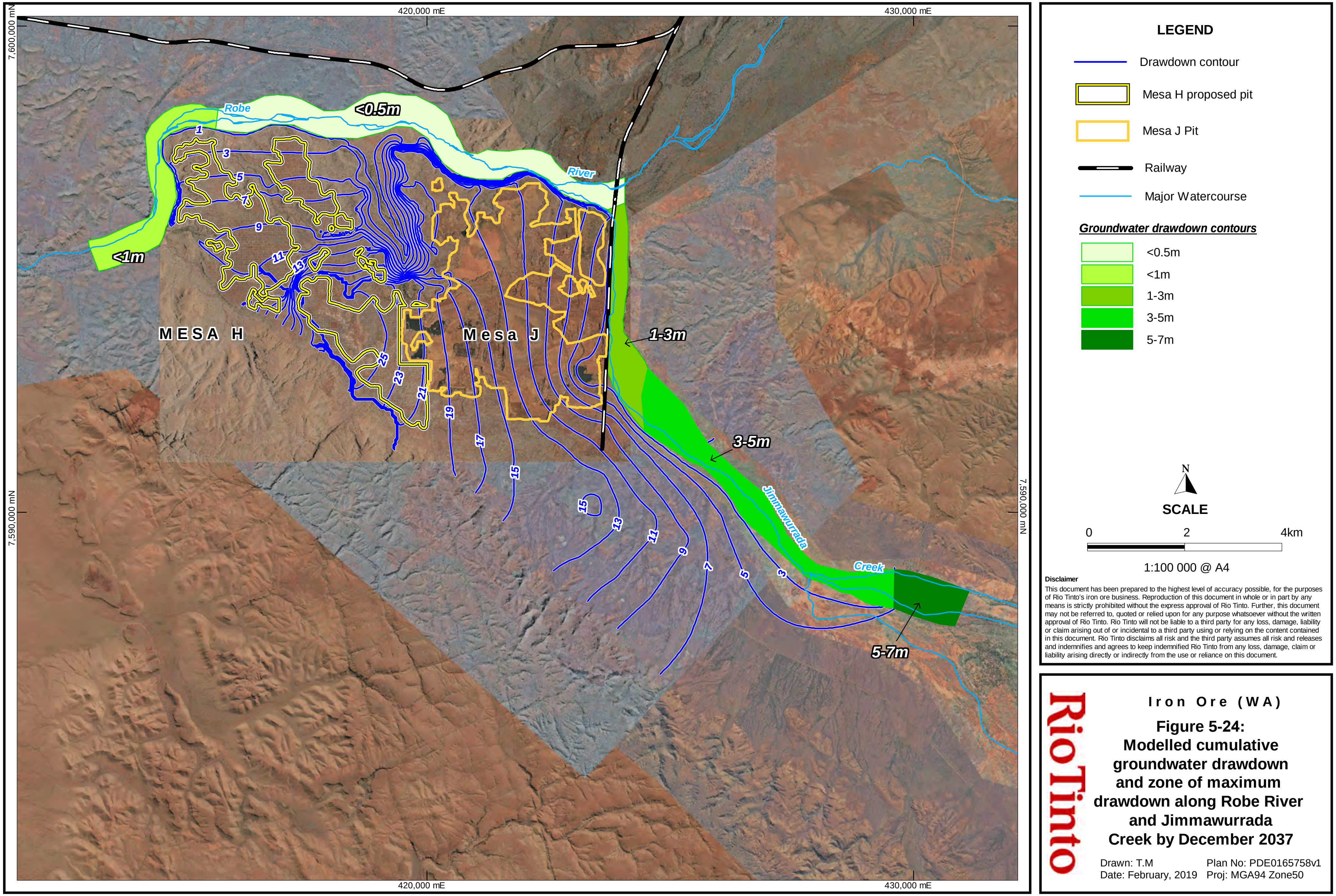
RioTinto

Iron Ore (WA)

Figure 5-23: Modelled cumulative groundwater drawdown and zone of maximum drawdown along Robe River and Jimmawurrada Creek by December 2030

Drawn: T.M
Date: February, 2019

Plan No: PDE0165759v1
Proj: MGA94 Zone50



Rio Tinto

Iron Ore (WA)

Figure 5-24: Modelled cumulative groundwater drawdown and zone of maximum drawdown along Robe River and Jimmawurrada Creek by December 2037

Drawn: T.M
Date: February, 2019

Plan No: PDE0165758v1
Proj: MGA94 Zone50

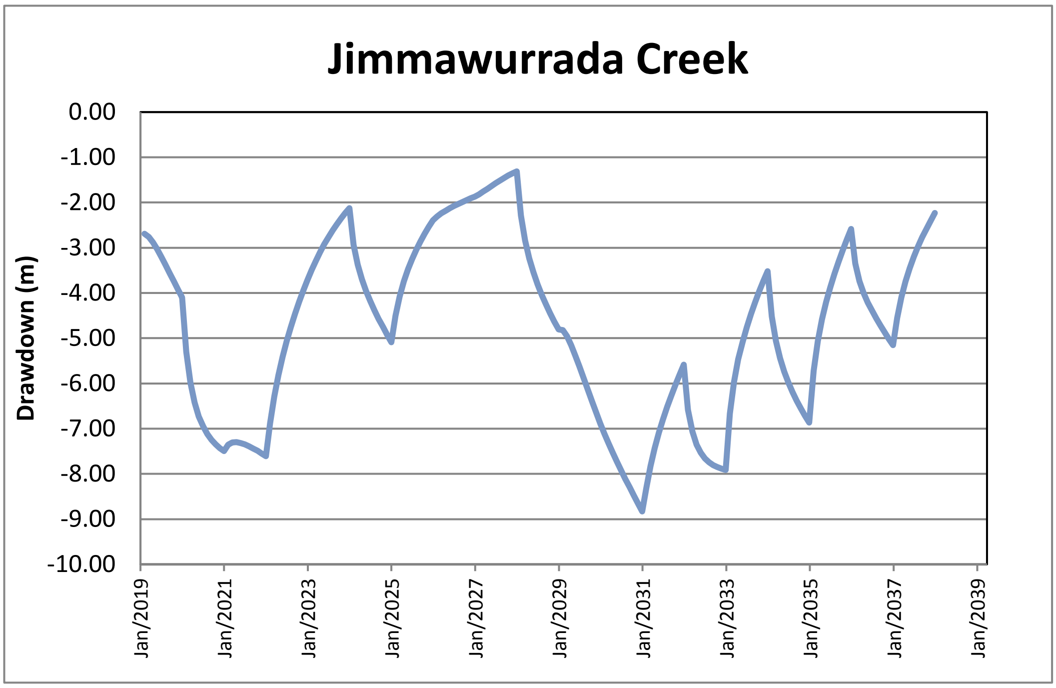


Figure 5-25: Modelled Cumulative Drawdown Along Jimmawurrada Creek East of the Southern Cutback Borefield (Based on Pre-Mining Groundwater Levels)

5.5.2.3 Changes to the hydrological regime of Jimmawurrada Creek and the Robe River from surplus water discharge

Surplus water will be generated for the Revised Proposal during periods of active BWT mining. In line with the approach of the existing Mesa J Iron Ore Development, surplus water generated as a result of the Revised Proposal during these periods is proposed to be used on site for operational purposes. However, during periods where surplus water is greater than storage capacity, surplus water will be periodically discharged into tributaries of the Robe River and may result in continuous surface flow extending up to 8 km downstream of the discharge point(s) during times of peak discharge.

The Revised Proposal is estimated to generate between 1 and 7 GL/a of surplus water above operational water demand. Any surplus water exceeding operational water requirements will be stored on site, in mined out pits. Where surplus water exceeds site storage capacity, the surplus is proposed to be discharged into Jimmawurrada Creek and / or West creek, both tributaries of the Robe River. Surplus water discharge is mostly required during and directly post wet season for surface water management purposes. This approach remains in-line with the current surplus water management approach for the Mesa J Iron Ore Development. However, the discharge locations may be subject to change based on site water management optimisation and to support adaptive management to meet environmental objectives.

A 2D hydraulic model was developed to estimate the surface discharge extent of surplus water discharge along the tributaries of the Robe River for a number of scenarios (Rio Tinto 2017a). The modelling investigated a number of discharge rate scenarios ranging from 5 ML/day to 30 ML/day. The discharge modelling identified a footprint of up to 8 km for prolonged continuous flow from the discharge point(s) when the on-site storage capacity is exceeded – predominantly during wet season (Figure 5-26).

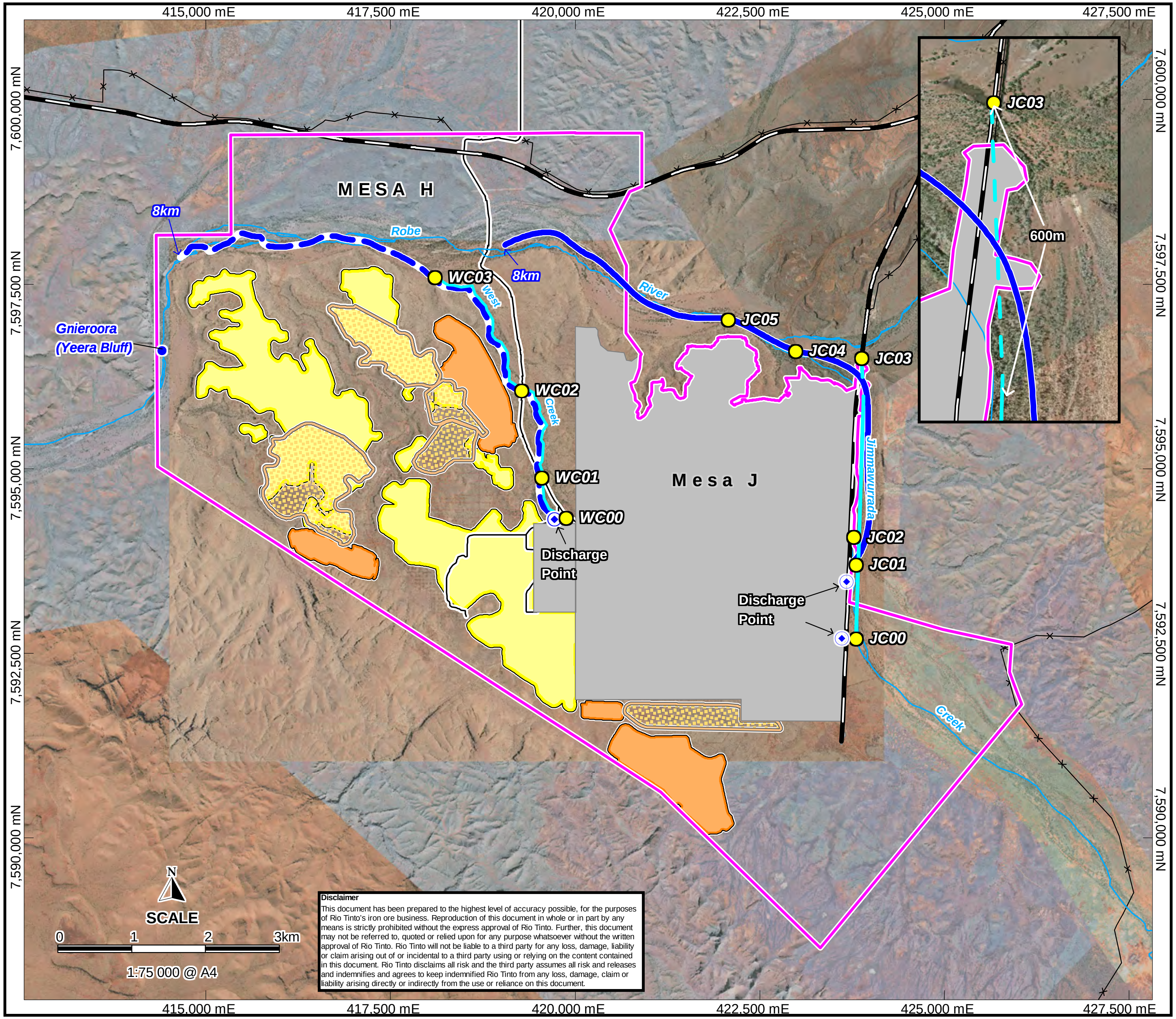
Field observations of the Mesa J discharge creek during 2017 for volumes of 10- 20 ML/day found flowing water present within the creek channel until it reached the Robe River gravels (4 km) where it infiltrates within a short distance. In dry conditions, sub-surface gravel flows containing discharge water is not expected to persist further than the Martangkuna pool

(5 km) (Figure 5-6). Following high rainfall events, discharge water will mix with channel aquifer water and may reach Parkunya pool (7.5 km), with any residual water subsequently entering Yeera Bluff pool (8 - 9 km downstream) (Figure 5-6) being completely mixed and diluted.

Intermittent discharges during late 2017 and early 2018 of up to 7 ML/day have not been sufficient to maintain the lower tributary pools upstream of the confluence with the Robe River (Rio Tinto 2018c).

5.5.2.4 Changes to the overland flow from surface water infrastructure

Mesa H West and East pits do not encroach on the 1:100 AEP floodplain of the main channel of the Western catchment (refer Figure 5-27). However, mining operations do interact with local runoff associated with the central creek and creek flows originating in the hills south of the Mesa H and Mesa J tenure boundary. Direct flow interruption occurs due to active mining areas in Mesa H (east) and Mesa J intersecting creeklines. Some minor flow regime changes will also occur in the central creekline between the west and east mining areas due to additional diverted water flowing down this route and some minor flow mitigation by culverts associated with the haul road land-bridge. These are shown in Figure 5-28.



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Powerline
- LV Road
- Major Watercourse
- Existing observed Mesa J operations discharge footprint
- Existing observed Mesa J operations discharge footprint 600m
- Observation Point
- Existing Discharge Point

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile
- Modelled extent of maximum discharge (periodically)

Alternate discharge point

- Modelled extent of maximum discharge (periodically)
- Permanent Pool

RioTinto

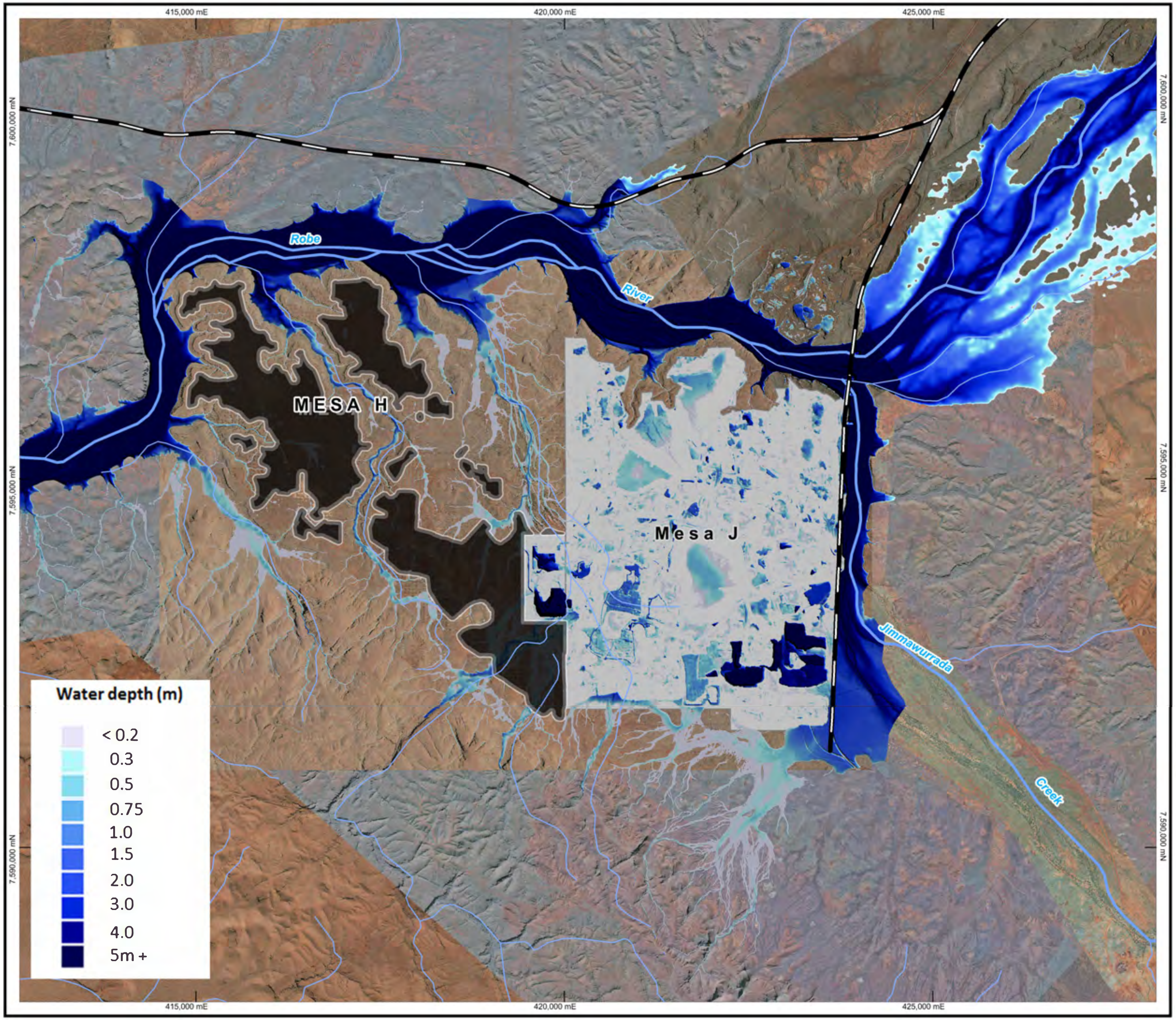
Iron Ore (WA)

Figure 5-26: Modelled extent of maximum periodic discharge

Drawn: T.M.
Date: February, 2019

Plan No: PDE0162823v3
Proj: MGA94 Zone50

Geospatial Information and Mapping



LEGEND

- Mesa H Proposed Pit
- Ministerial Statement 208
- Major Watercourse
- Minor Watercourse
- Railway

N

SCALE

1 0 1 2 3km

1:75 000 @ A4

Rio Tinto

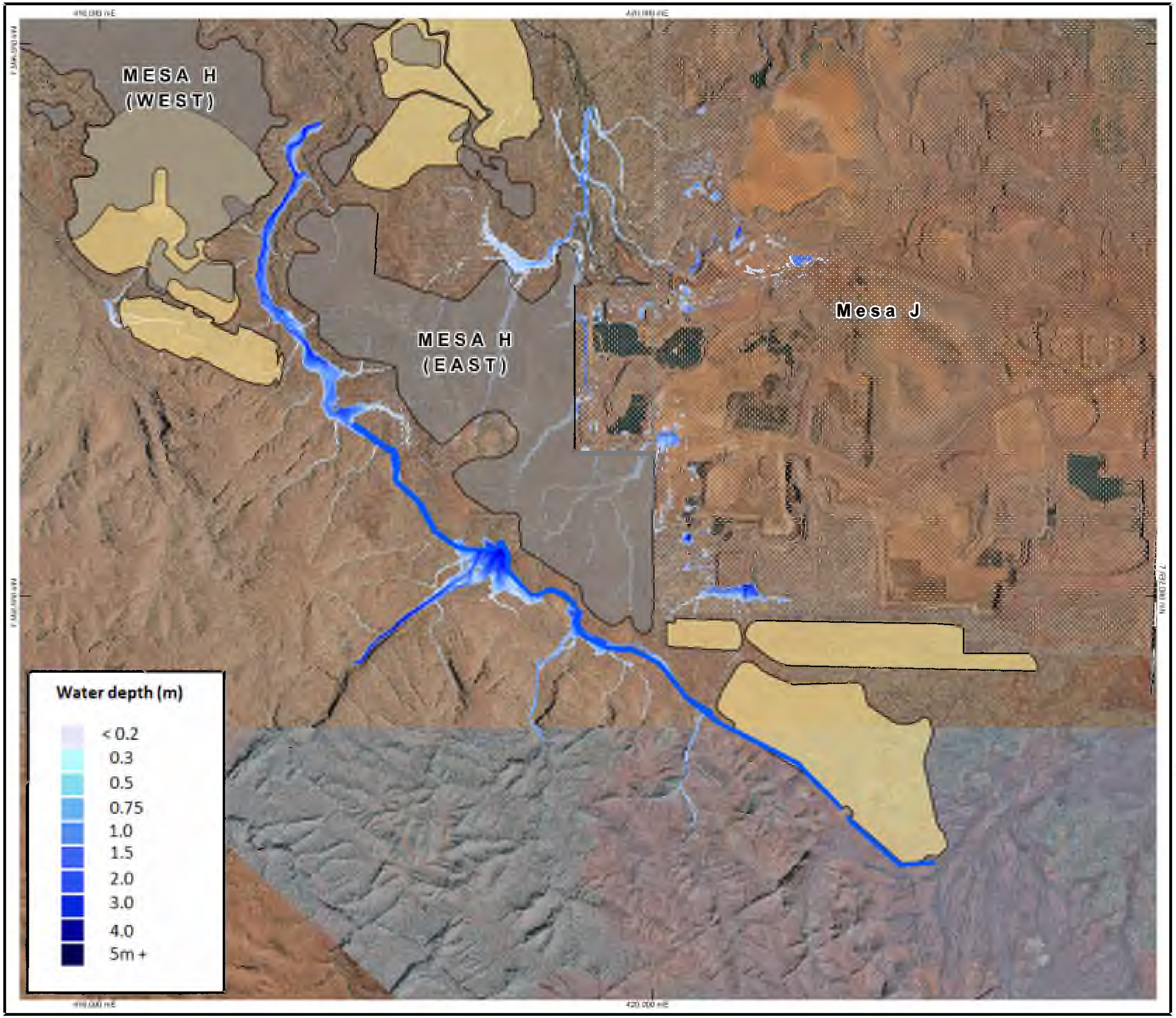
Iron Ore (WA)

Figure 5-27: Modelled innundation extent of the 1:100 AEP flooding for the Mesa H Deposit

Drawn: T.M.
Date: February, 2019

Plan No: PDE0162919v4
Proj: MGA94 Zone50

Geospatial Information and Mapping



LEGEND

- Mine Pit
- Waste Dump / Topsoil / Subsoil
- Diversion Channel
- Ministerial Statement 208

N

SCALE

0 0.5 1 1.5 2km

1:40 000 @ A4

RioTinto

Iron Ore (WA)

Figure 5-28:
Proposed surface water diversion simulation for the of 1:50 AEP runoff event showing transfer of water along the south-west boundary to the 9.5 km2 sub-catchment watercourse for conveyance to the Robe River

Drawn: T.M
Date: February

Plan No: PDE0162746v3
Proj: MGA94 Zone50

The south-eastern extent of Mesa H is subject to flooding from the Central and Eastern catchments shown in Figure 5-3. These creeks represent a combined 23 km^2 catchment (to the Mesa H pit edge) which potentially deliver more than 1,000 ML of water for events beyond 1:10 AEP (approximately 100 mm of rainfall). Peak flows have been estimated at 150-200 m^3/s for the 1:100 AEP event. Flood protection is required during mining to manage the runoff from these creeks.

The proposed Mesa H pits will further affect runoff that would normally (pre-mining) flow into the Robe River between Japanese Pool and Yeera Bluff. Without mitigation runoff from approximately 43 km^2 of the 65 km^2 contributing area south of the Robe River is affected in some manner by Mesa J and Mesa H (approximately 65%). Engineering diversion proposed to protect mine pits (discussed below) enables runoff from 26 km^2 of these contributing areas to continue to reach the Robe River within 1 km of its natural creek confluence.

The diversion structure is proposed along the south side of the Development Envelope to manage catchment flows during operations and redirect these flows around active mine pits. The proposed diversion is approximately 5.5 km in length and engineered to manage flows up to the 1:50 AEP level event. The proposed diversion will redirect flow along the south-west boundary of Mesa J and H through to the Mesa H central gully drainage line (Figure 5-28). A benefit of this diversion is that it reduces the mining affected catchment area from 43 km^2 to 17 km^2, and results in 74% of the natural runoff source area still being able to flow with minimum interruption to the Robe River channel gravel aquifers and associated pools. The proposed diversion route ensures that water management remains within tenure, with surface flows being safely conveyed down the central gully drainage line to a natural confluence during the operational phase of the mine.

A waste dump and stockpile are proposed to the north of Mesa H and also at the fringes of the creek on the western edge of the Mesa (Figure 2-3). Hydrology assessments determined that these waste dump locations are not vulnerable to flooding from the Robe River or creek flows from contributing catchments and they do not impede natural flows.

Two additional waste dumps are proposed to the south of Mesa J, east of the Eastern catchment. Temporary dumps for topsoil and backfill waste material are proposed adjacent to the Mesa J boundary. These are temporary and help to provide pit protection during mining. These dumps will be reclaimed at closure. Hydraulic modelling for the area identifies that inundation flows for 1:20 to 1:100 AEP events are predominantly less than 1 m deep with corresponding velocities generally lower than 2 m/s. Surface water management options for these waste dumps have been assessed and the dump footprints have been aligned to enable continued movement of water to the east.

A large waste dump is to be located against the natural topography within tenure south of Mesa J. This is a permanent dump that intercepts direct runoff water from 1.9 km^2 of local gullies and slopes. It is proposed to collect this runoff at the base of the dump and divert it to the upper section of the diversion structure discussed above.

The diversion is ultimately proposed to be remediated at closure to promote safe water flows back through post-mining landscapes to the natural watercourses.

5.5.3 Potential Indirect impacts

5.5.3.1 Changes to surface and groundwater quality

Surplus water discharge

Surplus water discharge from the Revised Proposal has the potential to change the quality of surface water in Jimmawurrada Creek, West Creek and ultimately the Robe River having a geochemical signature more representative of groundwater in the area, rather than the largely rainfall derived surface water.

Groundwater chemistry data for samples collected from bores most likely to represent the proposed surplus water discharge were compared with data from surface water samples collected from pools. The groundwater chemistry of the surplus water proposed for discharged has a neutral to mildly alkaline pH and is considered fresh. The mean groundwater electrical conductivity value and mean concentrations of nitrogen and dissolved silver, boron, cobalt and copper were elevated compared with background levels in surface water collected from the Robe River. Electrical conductivity and nitrate values were typically an order of magnitude greater than recorded for surface water in the Robe River. Occasional elevated concentrations of arsenic, silver, cadmium and zinc have also been recorded in some bores. Under natural no-flow conditions, discharged surplus water has the potential to change sediment quality and water chemistry in an 8 km section of the Robe River tributaries where discharge will occur.

Mineral Waste Management

AMD from mineral waste stored ex-pit and/or backfilled to pits could potentially result in contamination of groundwater. The most significant geochemical risk posed by mining iron ore deposits in the Pilbara is associated with the sulphide mineral pyrite (FeS_2), which can form sulphuric acid when exposed to oxygen and water.

Extensive geochemical testing programs have been undertaken over several years to understand the potential for acidification and / or metalliferous drainage to occur as a result of exposing various waste rock types common to mining operations in the Pilbara. The geochemical characterisation process has assessed the sulphur content as an indicator of acid generation potential, and undertaken static (acid base accounting) and, where appropriate, kinetic testing of materials.

The Mount McRae Shale, most commonly associated with pyrite and AMD in the Pilbara, is not anticipated to be exposed during the development of the Revised Proposal. However, pyrite may also occur in BIF of the Marra Mamba Iron Formation, as well as within the Wittenoom Formation (WD), which are known to underlie the CID associated with the Mesa J Iron Ore Development.

A detailed analysis of the sulphur content in drill hole data, including historical data was undertaken to identify rock types requiring more detailed analysis due to potential AMD risk. The basement Wittenoom Formation located beneath the CID and BWT has the potential to include black shale, which is considered to pose an AMD risk. However, the current pit design is considered unlikely to expose, or expose significant volumes of this rock type.

A number of elements have been identified as being enriched or elevated when compared to average crustal abundances, however these elements are naturally occurring and typically elevated within Pilbara lithologies, hence they are unlikely to mobilise into groundwater unless exposed to acidic or saline conditions. These conditions are not expected to occur within the Development Envelope.

Waste fines storage

In-pit storage of waste fines could potentially result in changes to groundwater quality from seepage to groundwater. Waste fines generated from Mesa H are proposed to be disposed of in-pit at the adjacent Mesa J Iron Ore Development which currently contains existing in-pit WFSF. The waste fines will be disposed of either in existing or potentially new WFSFs at the Mesa J Iron Ore Development.

The proposed waste fines stream is considered to be chemically benign with its geochemistry similar to the original ore excavated from Mesa J with slight enrichment in some minerals (such as Al_2O_3 and SiO_2).

Based on rheology testing, the waste fines produced from Mesa H will be similar in chemistry to the current operating waste fines at Mesa J. The WFSF at Mesa J currently includes monitoring of groundwater chemistry in the area surrounding the facilities.

Natural background levels (i.e. upgradient of the Mesa J WFSFs) of some analytes in the groundwater exceed the ANZECC 95% TVs. This indicates that the ANZECC 95% TVs do not represent suitable triggers for analytes such as nitrate, phosphate and zinc, in groundwater within the Robe Valley. The most notable changes downgradient of the WFSF that may be attributable to the WFSF are an increase in the median electrical conductivity, an increase in the median and maximum concentrations of nitrogen, nitrate and NO_x and an increase in the median and maximum concentrations of zinc. There is some evidence to indicate that some of these changes originate from mobilisation of analytes from the underlying formation rather than directly from the WFSF seepage.

Based on results of monitoring around the Mesa J WFSFs, it is anticipated that the proposed waste fines from Mesa H will result in increases in salinity, nitrogen, nitrate, NO_x and some metals in the immediate vicinity of the WFSF. During operations, these changes in groundwater chemistry are likely to be mainly confined to the cone of depression generated by the proposed borefield extending 15 m vertically and 3.5 km horizontally by 2017, and much of the affected groundwater will be recirculated through the process plant.

Placement of waste fines into the WFSF will cease prior to closure. There will then be a limited period of time where seepage occurs from the waste fines until the WFSF dries out through a combination of evaporation and seepage, at which stage rehabilitation of the WFSF will be undertaken.

Seepage from the proposed WFSF is expected to recharge the local aquifer immediately below the WFSF, potentially creating a localised groundwater mound. However, groundwater drawdown as a result of mine pit dewatering at Mesa J is expected to limit the degree of mounding development. During operations, most of this seepage volume will be captured by in-pit dewatering bores and re-circulated through the wet plant, with an estimated 3 GL/a recirculated to the adjacent pits based on current volumes. Monitoring of the existing Mesa J Iron Ore Development indicates that seepage has a very steep gradient, and its extension cannot be readily measured as active dewatering creates a cone of depression in the vicinity and captures most of the seepage.

Site drainage

There is the potential for the quality of surface water flowing through the Proposed Change to be impacted from hydrocarbons. There is also the potential for sediment-laden surface water runoff to be produced in the vicinity of the waste dumps and other infrastructure.

5.5.4 Potential cumulative impacts

The Proposed Change has the potential to contribute to cumulative hydrological impacts to the Robe River Catchment. The potential impacts are contexted in relation to existing and foreseeable groundwater users in proximity to the Proposed Change, including the current Mesa J Iron Ore Development. Relevant projects and considerations are included in Table 5-7. As discussed in the preceding sections, the operations will be integrated for Mesa J and H so the potential cumulative impacts from Mesa J and H have been discussed in the preceding sections (5.5.1 to 5.5.3). Abstraction from the existing Mesa J Iron Ore Development, the Southern Cutback Borefield and from the CWSP have also been integrated into the hydrological modelling. The potential cumulative impacts from these projects have been discussed in Sections 5.7 and 5.5.2.3.

Table 5-7: Summary of Identified Existing and foreseeable Developments

Project	User / Company	Max Volume (GL/a)	Comments
Mesa J operations – Dewatering.	Rio Tinto	8.5	Included in hydrological modelling for the Revised Proposal.
Southern Cutback Borefield.	Rio Tinto	5	Included in hydrological modelling for the Revised Proposal.
CWSP.	Rio Tinto	10	Included in hydrological modelling for the Revised Proposal.
Pannawonica Town Water Supply.	Rio Tinto	0.7	May be required to increase based on additional personnel.
Mesa H – Dewatering.	Rio Tinto	3	Included in hydrological modelling for the Revised Proposal.
Mesa J Hub Camp Water Supply.	Rio Tinto	0.1	
Pastoral Bores.	Yalleen Station	N/A	
Other Projects considered			
Mesa A Hub Revised Proposal.	Rio Tinto	15	Not considered further as outside of immediate Bungaroo / Jimmawurrada / Upper Robe River Catchment.
Buckland Hills Project.	Iron Ore Holdings Ltd	5	Not considered further as outside of immediate Bungaroo / Jimmawurrada / Upper Robe River Catchment.
BHP Billiton (BHP) Strategic Assessment.	BHP	N/A	Not considered further as outside of immediate Bungaroo / Jimmawurrada / Upper Robe River Catchment.

5.6 Assessment of Impacts

The assessment of impacts on Inland Waters is addressed in this section. The assessment of potential indirect impacts from abstraction and surplus discharge on other factors are addressed under the relevant factor, e.g. Impacts on riparian vegetation in Flora and Vegetation (Section 6.6) and impacts on subterranean fauna habitat (Section 7.5).

The following assessment is based on the modelling results outlined in Section 5.5.

5.6.1 Direct impacts

5.6.1.1 Changes to groundwater levels from groundwater abstraction

The activities associated with the Proposed Change which will lower groundwater levels (including pools) include dewatering to facilitate BWT mining at Mesa H, and groundwater abstraction from the existing Southern Cutback Borefield to supply water for operations, predominantly for wet ore processing.

Groundwater drawdown along the Robe River from mine pit dewatering

As discussed in Section 5.5.2, the peak abstraction for the Revised Proposal (Mesa J and H) is predicted to decrease from the current peak of 10 GL/a at the Mesa J Iron Ore Development to 8 GL/a for the Revised Proposal, mostly due to the inclusion of a thickener plant. To date, aquifer recharge resulting from leakage of the WFSF and water reservoirs appears to play an important role in limiting the extent of the dewatering cone of depression from mine dewatering to the north towards the Robe River and east towards the Jimmawurrada Creek (described in Section 5.4.7). However, the dewatering at Mesa H, combined with lower rainfall since 2011 and periodic drought conditions, has the potential to impact pools along the Robe River. Modelling indicates a maximum drawdown less than 0.5 m to the Robe River to the north of Mesa H and a short term maximum, less than one year of 0.7 m drawdown around Yeera Bluff (Figure 5-21 and Figure 5-22). To account for any modelling uncertainty, this potential impact has been rounded up to be <1 m drawdown for the purposes of impact assessment.

The potential impacts of mining and dewatering from the Revised Proposal on the pools along the Robe River are predicted to be localised, temporary in duration and relatively small, as the predicted groundwater drawdown of less than 1 m along the Robe River falls within the natural fluctuations observed in the water levels of the Robe River (2 – 3 m). The pool at Yeera Bluff is considered to be one of the most important pools as it is the only permanent pool along the Robe River in the vicinity of the Proposed Change and it has important Aboriginal cultural and social value. Permanent and semi-permanent pools greater than 1 m depth are not expected to be significantly impacted (Table 5-3 e.g. Yeera Bluff pool), however shallower (less than 0.5 m) semi-permanent or seasonal pools, immediately to the north of Mesa H (e.g. Duck Pool), could potentially dry out more quickly during extended periods of low rainfall or during extended periods of drought. Available literature (DoW 2012; SKM 2008) indicates that sediments or riverbeds below a dry river pool may still provide habitat for some river pool fauna, provided that the water table decline below the base of the pool is no more than 1 m.

Given the magnitude and frequency of stream flow events however, a single large rainfall event can completely replenish and effectively ‘re-set’ the aquifer water levels, so any effects would be seasonal and temporary, and the deeper pools and permanent pool at Yeera Bluff are expected to continue to persist without active management. Groundwater drawdown in the Robe River alluvium is therefore considered unlikely to cause a significant impact through any long term or permanent adverse impact to the pools' levels. An option of localised water supplementation into the permanent pool of Yeera Bluff in the Robe River may be implemented as a mitigation measure to maintain water levels if greater than expected reduction in levels occurs as a result of mining. This approach would be based on monitoring results indicating a variation of water levels beyond natural climatic variability and reference monitoring sites.

Groundwater drawdown along Jimmawurrada Creek from abstraction for water supply

There are no permanent or semi-permanent pools along Jimmawurrada Creek, however groundwater along the creek does support environmental and heritage values. The current operation of the Southern Cutback Borefield for the Mesa J Iron Ore Development has resulted in drawdown of 4 – 6 m along Jimmawurrada Creek, immediately east of the borefield. While the inclusion of a thickener plant will reduce the complementary water supply abstraction required for Mesa H, the cumulative water supply abstraction from the Southern Cutback Borefield, Mesa J dewatering and the CWSP borefield operation will lower the water table across a 12 km section of Jimmawurrada Creek, resulting in a cumulative drawdown of 9 m (along a 6.5 km section) from pre-mining water table levels by 2030. Given the pre-mining groundwater levels varied between 3 – 5 mbgl (along this specific section of Jimmawurrada Creek), the cumulative drawdown of up to 9 m would translate to a water depth of up to 14 mbgl. However, if natural recharge in Jimmawurrada Creek is reduced by 50% due to an extended period of drought (H3 numerical model 'Uncertainty Run 2' (Rio Tinto 2019a)), the water table levels could be lowered by almost 3 m in addition to the historical seasonal fluctuations (2 – 3 m); this would translate to localised changes in water table depths of up to 14 m from pre-mining conditions, or ~18 mbgl by 2030. Whilst the shallower outer margins of the alluvial aquifer may experience temporal loss of habitat, between 10 – 22 m of saturated alluvium is estimated to be retained within the deepest part of the channel (thalweg) if the peak groundwater drawdown coincides with a period of extreme extended dry conditions (through either climate change or an extended dry period). This peak drawdown is expected to occur for a brief period of time (~1 year, depending on overprinting seasonal variabilities) due to decreased mine pit dewatering requirements and increased borefield abstraction; with the estimated aquifer recharge and throughflow returning the water level in the alluvial aquifer.

By the anticipated end of mine life (Dec 2037), the cumulative drawdown from when mining began at Mesa J is expected to be between 7 and 11 mbgl along a 12 km section of Jimmawurrada Creek, and up to 13 mbgl along the eastern extent of drawdown due to the overlap with the CWSP drawdown cone of depression (Figure 5-24). Given that the thickness of the alluvial aquifer along Jimmawurrada Creek is observed to be in the order of between 28 – 40 m along the thalweg, it is expected that a connected saturated thickness will be maintained in the Jimmawurrada alluvial aquifer, and thus support maintaining associated environmental and heritage values as discussed in Sections 6, 7, 9 and 11.1. An option to optimise the discharge outlet locations on Jimmawurrada Creek further upstream, in the area of greatest drawdown may also be implemented to reduce the potential impact from groundwater drawdown.

Given that drawdown in the Robe River and associated pools will be within natural water table fluctuations and cumulative drawdown in Jimmawurrada Creek will maintain a saturated thickness of the alluvial aquifer, it is the Proponent's view that the impacts from groundwater abstraction will not be significant and can be managed through existing authorisations and management plans (see Section 5.9).

5.6.1.2 Changes to Jimmawurrada Creek and the Robe River from surplus water discharge

The peak discharge for the Revised Proposal is estimated to be higher (7 GL/a) than the current peak discharge for the Mesa J Iron Ore Development (4 GL/a), however the range is estimated to vary from 1 to 7 GL/a, averaging around 3 GL/a and as for the existing operations, discharge is likely to be periodic; only when demand and in-pit storage is exceeded which is expected to occur during wet conditions. Surplus water is proposed to be discharged into Jimmawurrada Creek and / or West creek, both tributaries of the Robe River. Discharge of water directly into the Robe River is not proposed, as it is generally not supported by the Robe River Kuruma People.

Although the peak discharge will increase for the Revised Proposal, the maximum surface discharge extent is modelled to extend intermittently less than 8 km from the discharge outlets, due to the high infiltration capacity of the Robe River channel gravels (once discharge from Jimmawurrada Creek and / or West Creek reaches the Robe River).

Field observations for Jimmawurrada Creek during 2017 indicate that discharges can reach the Yarramudda Pool at the Robe River confluence (3 km) but to not continue above ground beyond that point. Sub-surface discharge water within the gravels enter a heavily vegetated channel section that extends for 1.8 km and is likely to evapotranspire the remaining water during dry conditions. During Robe River flow situations, the discharge volume reaching the Robe River is expected to be a small percentage of the total downstream water volume.

The discharge extent for the Revised Proposal is predicted to periodically extend 4 km from the discharge outlets in Jimmawurrada Creek, and eventually reach the Robe River.

However, the discharge is unlikely, at its peak, to reach the Parkunya Pool (which is 7 km downstream of the discharge outlet) under dry conditions and is not expected to reach Yeera Bluff pool (~8 km downstream of the discharge outlet on West Creek) (Figure 5-26). Surface discharge occurrence within the Robe River channel sections will be intermittent and infrequent, and relatively small compared to natural seasonal flow volumes and flood events.

The Proponent's view is that the impacts from surplus water discharge will not be significant and can be managed through existing authorisations and management plans (Section 5.8).

5.6.1.3 Changes to catchment flows from surface water infrastructure

As discussed in Section 5.5.2.4, Mesa H largely lies beyond the 1% AEP floodplain so minimal surface water infrastructure is required for flood protection. The Mesa H development will reduce the current contributing catchment area to the Robe River at Yeera Bluff by 10.4 km^2, i.e. 0.2%.

The main part of the Proposed Change requiring flood protection is the south-eastern extent of Mesa H. The proposed diversion will redirect flow along the south side of Mesa J and H, through the Mesa H central gully drainage line, (Figure 5-1) which drains into the Robe River. The proposed surface water diversion has been designed to collect runoff from 26 km^2 of the 43 km^2 of contributing catchment potentially affected by mining operations and redirect these flows back into the Robe River. The diversion is ultimately proposed to be removed upon closure resulting in a very small contribution of local overland catchment flow captured in pit to the Robe River. The changes to flows from the Proposed Change will be within natural variation of flood flows experienced in the catchment. Surface water flows in the region are only associated with high intensity rainfall events. Based on rainfall data and flow analysis, rainfall events that result in flow are expected to occur once per year on average. The Proponent's view is that the changes to flows in the Robe River from surface water infrastructure will not be significant, as long as the diversion drain is designed appropriately and managed appropriately at closure.

5.6.2 Indirect impacts

5.6.2.1 Changes to surface and groundwater quality

Surplus water discharge

As discussed in Section 5.5.3, discharge of surplus dewater has the potential to change the quality of surface water in Jimmawurrada Creek, West Creek and ultimately the Robe River. Although there are likely to be differences in the chemistry of the groundwater discharged and background levels in the Robe River, surplus water discharge is mostly required during and directly post wet season for surface water management purposes, when the impact of any difference in water chemistry will be negligible, due to dilution.

Where surplus dewater is required to be discharged during natural no-flow conditions, some channel pools will persist. As discussed in Section 5.4.4, the water quality (including salinity, nutrients, metals and turbidity) in pools is naturally highly variable. The changes to water quality in pools from surplus water discharge is expected to be within natural variation. As discussed in Section 5.5.2.3, from a field evaluation of discharge, upon reaching the Robe River channel gravels, the remnant flowing water (around 50% of discharge volume) rapidly infiltrated and showed no further downstream presence beyond the infiltration point.

Therefore, the Proponent's view is that surface water discharge from the Proposed Change will not have a significant impact on the water quality of the Robe River and tributaries.

As discussed in Section 5.5.1, the Proponent proposes to continue to discharge surplus water from existing (or optimised) discharge outlets in Jimmawurrada and / or West Creek for the Revised Proposal (Mesa J and Mesa H) under the existing EP Act Part V licence L6820/1993- 12. The Proponent proposes to manage potential significant impacts to the Robe River and Jimmawurrada Creek from surplus water discharge through the updated Mesa J Hub EMP (see Section 5.8).

Mineral Waste Management

As discussed in Section 5.5.3, material containing pyrite with the potential to cause AMD (including Mount McRae Shale and black shale) is not likely to be exposed during mining. Enriched elements are unlikely to be mobilised as acidic or saline conditions are not expected to occur.

Detailed analysis has determined that the risk of acid drainage being generated during operations and upon closure as a result of the Proposed Change is assessed as Low. As a result, waste rock stockpiles are not considered to present a risk to water chemistry in the surrounding environment.

Waste fines storage

As discussed in Section 6.5.5, the proposed waste fines stream from Mesa H is considered to be chemically benign with its geochemistry similar to the original ore excavated from Mesa J. Seepage from the proposed WFSF is expected to recharge the local aquifer immediately below the WFSF, potentially creating a localised groundwater mound and resulting in increases in salinity, nitrogen species such as nitrate, NOx and some metals in the immediate vicinity of the WFSF, however during operations, these changes in groundwater levels and chemistry are likely to be mainly confined to the footprint of the facility and largely contained within the cone of depression generated by the proposed borefield extending 15 m vertically and 3.5 km horizontally by 2037 and the existing cone of depression generated by the dewatering at Mesa J. Thus, during operations it is believed that much of the affected groundwater will be recirculated through to the process plant. At closure, seepage from WFSF is expected to cease and any affected groundwater is expected to flow with the natural groundwater direction away from the Bungaroo Creek P1 Water Reserve; therefore, any affected groundwater will not migrate towards the Bungaroo Creek P1 Water Reserve, located to the south-west of the Development Envelope.

Site drainage

Site drainage will be designed to minimise or eliminate surface runoff into areas where hydrocarbon contamination may occur. Hydrocarbon storage facilities and all associated connections will be within appropriately contained areas. Storm water will be collected from these areas and treated to remove hydrocarbons prior to discharge.

The Proponent's view is that the impacts to surface and groundwater quality will not be significant and can be managed through existing authorisations and management plans (see Section 5.8).

5.7 Cumulative Impacts

Groundwater has been abstracted to facilitate BWT at the Mesa J Iron Ore Development since 1992, and to provide operational water supply from the Southern Cutback Borefield since 2013. In addition, the adjacent CWSP in the upstream Bungaroo valley has been supplying water to the Pilbara Coastal towns since 2014.

BWT mining at Mesa J is ongoing and planned to continue until 2029, hence modelling of groundwater level drawdown and aquifer yields have taken into account the combined effects of both the Proposed Change and Mesa J Iron Ore Development's mine pit dewatering and water supply abstraction requirements (Rio Tinto 2019a). As discussed in the preceding sections, the operations will be integrated for Mesa J and H so the assessment of cumulative impacts of the Revised Proposal have been discussed in the preceding sections (Section 5.6.1 to 5.6.2).

In addition, the combined groundwater modelling for the Revised Proposal has included the upstream model inputs of the CWSP Borefield in order to enable predictions of cumulative impacts to the groundwater table in the vicinity of Jimmawurrada Creek. The predicted impacts to the groundwater table in the vicinity of Jimmawurrada Creek have been based on the cumulative drawdown from the three projects as discussed earlier in Sections 5.5.2 and 5.5.3. The assessment of cumulative impacts from these projects have been discussed in Sections 5.6.1 and 5.6.2.

A site water balance has also been developed to forecast water demand across the entire Robe Valley, including the existing Mesa J Iron Ore Development, Pannawonica Town, the Mesa A Hub Revised Proposal, and the CWSP borefield forecast abstraction and the Proposed Change (Figure 5-29). The overall cumulative water balance estimates that approximately 25 GL will be abstracted from the Robe Valley aquifers by 2021 with the majority of the water abstracted for wet processing and water supply rather than dewatering, except between 2020 and 2021 when the majority of the water will be abstracted for the Mesa A Hub; surplus discharge is mostly required for wet season water management during operations.

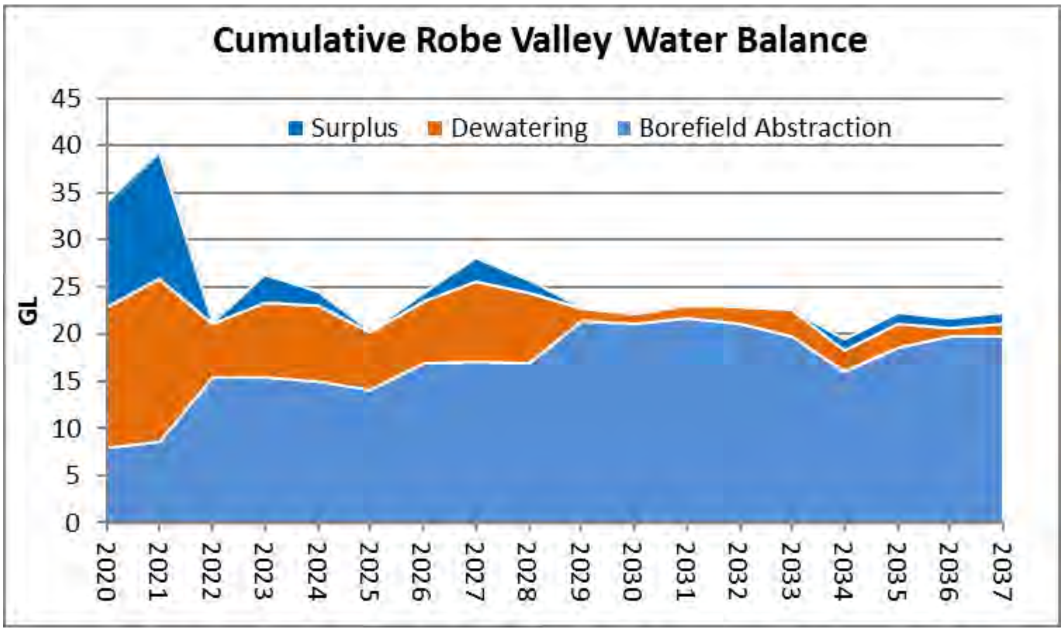


Figure 5-29: **Robe Valley Cumulative Water Balance**

5.8 Closure

The Mesa J Hub Closure Plan (Rio Tinto 2018a) is an integrated closure plan encompassing the existing Mesa J and Mesa K operations, together with the inclusion of the Proposed Change, in order to optimise closure outcomes. The plan is an update to and supersedes previous closure plans for the existing Mesa J and K Operations. The Closure Plan includes the mine developments and associated infrastructure contained within the Revised Development Envelope (Mesa J and H) and within Mesa K's Development Envelope. A summary of the approach to closure of the Revised Proposal and how it relates to the Inland Waters factor is provided below.

The closure strategy focusses on backfilling of pit voids at closure to appropriate levels to prevent the formation of pit lakes[2].

Once mining is complete and dewatering ceases, groundwater levels in the Mesa J and Mesa H mining areas will recover until a balance is reached between groundwater inflows and groundwater outflows. Backfilled pit voids will enable groundwater levels to eventually recover to pre-development levels. Complete aquifer recovery is predicted to take between 50 and 60 years, however, the large majority of the drawdown along the Robe River and Jimmawurrada Creek is expected to recover 90% of the drawdown after the first or second significant rainfall events. The drawdown in the Yeera Bluff is estimated to take the longest to recover, with the last 20 cm of drawdown requiring up to 40 years to recover.

A key closure objective is to ensure that the Robe River permanent pools function similar to the pre-mining state, with completion criteria focussing on water quality and ecological function being maintained (incorporating climate changes). Water monitoring during closure will focus on monitoring of the permanent and semi-permanent pools of the Robe River and confirming groundwater recovery and quality. A specific program of monitoring including timeframes for completion will be developed prior to decommissioning.

A closure task has also been identified to assess the potential for seepage from the WFSF into the aquifer. This will ensure any seepage from the facility is considered in terms of potential impact to groundwater chemistry and subterranean habitats. This will ensure any seepage from the Revised Proposal is managed in terms of potential impacts to groundwater quality, and subterranean habitats, and also to prevent migration of seepage towards the Bungaroo Creek P1 Water Reserve.

No major permanent creek diversions are required for the Proposed Change. However, a surface water diversion of 26 km^2 of small local catchments will be required during operations to manage surface catchment flows from entering into active mine pits. Upon closure, the structure and its remediation will be considered as part of the overall closure objective to create a safe, stable landform. Sections of the diversion may be retained if required to meet post-mining safety regulations and stability of the site. These are not expected to have any long-term adverse impacts on the Robe River or its tributaries. Minor updates to designs and layouts will occur during the closure planning process; these updates will be incorporated into periodic updates of the Closure Plan.

5.9 Mitigation

Mitigation strategies to address the above potential impacts and predicted outcomes are presented in Table 5-8.

The Mesa J Hub EMP (Appendix 6) addresses the key environmental factors which were determined by the EPA as being relevant to the appropriate management of dewatering, surface water discharge, conservation significant vegetation communities and fauna species associated with the Mesa J Hub. The EMP identifies:

- Mitigation strategies proposed to minimise impacts to significant environmental values
- The environmental criteria that the Proponent will use to monitor performance of the mitigation strategies to ensure environmental objectives are met
- Trigger criteria, threshold criteria, trigger level actions and threshold contingency actions aligned with the overall management approach

[2] With the exception of Pit 15 at Mesa J, currently used as a water storage area, and subject to appropriate quality modelling

- The management actions that will be implemented in response to monitoring results.

Management of water on Rio Tinto managed sites follows environmental and water use standards. These standards require an integrated approach to water management that promotes, maintains or improves water quality, minimises fresh water use and maximises reuse and recycling, and aligns with the *Pilbara Water in Mining Guideline* (DoW 2009).

The Proponent's Pilbara Surface Water Management Strategy (Rio Tinto 2011) provides guidance on the management of surface water. The objective of the strategy is to prevent adverse impacts on the natural function and environmental value of water courses, water quality and flow downstream from the mine area. The strategy also aims to minimise the impact of uncontrolled surface water movement on mine safety and mine production.

The key measures to address potential impacts to Inland Waters according to the mitigation hierarchy are outlined in this section. The management of potential indirect impacts from abstraction and surplus discharge are addressed under the relevant factor, e.g. Impacts on riparian vegetation in Flora and Vegetation (Section 6.6) and impacts on subterranean fauna habitat (Section 7.5).

5.9.1 Avoid

The Proposed Change has been designed to largely avoid direct impacts to the Robe River and Jimmawurrada Creek and associated river landforms and floodplains. Disturbance will be limited to clearing for access tracks for monitoring locations. There will be no diversion of surface water flows in major creeks including Jimmawurrada Creek and the Robe River.

The Proposed Change mine pits have also been designed to avoid PAF materials.

5.9.2 Minimise

5.9.2.1 Minimise abstraction

Groundwater abstraction will be minimised to that required to access the BWT resource and to meet site water requirements. Water balance forecasts indicate that peak abstraction for the Revised Proposal will be similar to current abstraction for Mesa J only. There will be no increase in the RIWI licensed abstraction allocation.

The Proposed Change has been designed with a thickener plant for the WFSF, to optimise water recovery and reduce the Revised Proposal's water demand from the Southern Cutback Borefield. The implementation of a thickener plant will significantly reduce the water demand by approximately 30% (~50 GL over the life of the Revised Proposal) which will result in less drawdown along Jimmawurrada Creek.

5.9.2.2 Minimise declines in groundwater levels and pool levels

Declines in groundwater levels (including pools) attributable to abstraction will be minimised. Monitoring of groundwater levels (including pool water levels) along the Robe River and Jimmawurrada Creek will continue to be undertaken along the Robe River and Jimmawurrada Creek in the vicinity of the Revised Proposal. If adverse changes to groundwater levels are detected, then appropriate mitigation measures will be undertaken, which will include:

- Ceasing of dewatering below 120 m RL in the Mesa H Pit 7 (Figure 5-21) during dry periods and resuming mining once a stream flow event occurs, if monitoring of semi-permanent and permanent pools of the Robe River shows a decline in pool water levels beyond that predicted in this impact assessment (i.e. up to 1 m beyond natural seasonal fluctuations) as a direct result of dewatering.

Other mitigation measures may include:

- Optimisation of the location of discharge points in Jimmawurrada Creek to provide periodic supplementary water in areas predicted to be affected by groundwater drawdown
- Targeted supplementary water (derived from Mesa H mine pit dewatering) directly to permanent pools to reduce the potential for impacts to the pool water levels.

The Proponent will continue to manage abstraction in accordance with the existing RIWI Groundwater Licence GWL107678-13 and associated GWOS, and any amendments as required. The Proponent proposes to manage potential significant impacts to pools in the Mesa J Hub EMP.

5.9.2.3 Minimise volumes and extent of surplus water discharge

The impacts of surplus water discharge on the Robe River will be minimised, as modelling indicates that the extent of discharge will be similar to the current extent for Mesa J only.

The Proponent will continue to apply the surplus water management options that are currently used for the existing Mesa J Iron Ore Development:

- water is re-used on site where possible
- passive recharge is managed such that re-circulation is minimised when possible
- surface discharge is managed such that intermittent surface water expression from surplus water discharge will extend no more than 8 km from the discharge outlets to the downstream reaches of the Robe River depending on seasonal water availability and plant water demand, under natural no-flow (dry) conditions.

Discharge of water directly into the Robe River is not proposed, however an option of localised water supplementation into the permanent pools of Yeera Bluff is only planned as a mitigation measure to maintain water levels in these significant pools, to protect both cultural and environmental values. This approach would be based on monitoring of water levels in the pools and only implemented when dewatering of Mesa H commences, and based on monitoring results indicating a variation of water levels beyond natural climatic variability and reference monitoring sites.

The location of discharge points may also be optimised to reduce the potential for impacts to significant environmental values or areas considered to be at higher risk from the effects of groundwater drawdown, including along Jimmawurrada Creek (near the Southern Cutback Borefield) and the permanent pool (Yeera Bluff) of the Robe River.

The Proponent will continue to manage discharge in accordance with existing requirements under Licence L6820/1993-12 issued under Part V of the EP Act, and any amendments as required. The Proponent proposes to manage potential significant impacts from surplus water discharge in the Mesa J Hub EMP.

5.9.2.4 Minimise impacts on surface water flows

The proposed 5.5 km surface water diversion drain has been designed to redirect flows back into the Robe River, which would otherwise be captured by the Proposed Change (and is currently captured by the Mesa J pits), to maintain the continuation of natural surface water flows into the Robe River.

5.9.2.5 Minimise impacts to surface and groundwater quality

The Proponent has well established management strategies for the management of PAF materials. While the likelihood of encountering PAF is low, if PAF materials are encountered, existing management strategies within the Iron Ore (WA) Mineral Waste Management Plan and the Iron Ore (WA) Spontaneous Combustion and Acid Rock Drainage (SCARD) Management Plan will be implemented to ensure waste material is adequately geochemically characterised and PAF material that poses an AMD risk is appropriately managed.

Rio Tinto has well established strategies for the management of wastes at its Pilbara operations to ensure that risk of contamination of groundwater is minimised. Hydrocarbons will be handled, stored and disposed of in accordance with all legal requirements. Hydrocarbon storage facilities and all associated connections will be within appropriately contained areas and storm water will be collected from these areas and treated to remove hydrocarbons prior to discharge. Hydrocarbon storage facilities and bunds will be inspected on a regular basis to identify any leaks or maintenance requirements.

The Proponent has well-established management strategies to reduce the potential for sediment-laden surface water runoff to be discharged from site. Practices include design of waste dumps to minimise erosion, use of windrows and on-site drainage and sedimentation structures. The Proponent will continue to implement these strategies.

The Proponent will continue to groundwater quality in accordance with the existing RIWI Groundwater Licence GWL107678-13 and associated GWOS, and any amendments as required. The Proponent will continue to manage discharge surface water quality in accordance with existing requirements under Licence L6820/1993- 12 issued under Part V of the EP Act, and any amendments as required. The Proponent has also included additional monitoring of the surface water chemistry in the pools of the Robe River pools in the Mesa J Hub EMP.

5.9.3 Rehabilitate

The rehabilitation and closure strategy is described in Section 5.8.

Table 5-8: Mitigation measures and predicted outcomes for Inland Waters

Potential impacts	Mitigation to address potential impacts	Residual impact / Predicted outcome
EPA Objectives: *To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.* *To maintain the quality of groundwater and surface water so that environmental values are protected.*		
Direct Impact: Changes to groundwater levels as a result of groundwater abstraction. Groundwater drawdown as a result of mine pit dewatering will lower the groundwater table in the Mesa H CID Aquifer and basement aquifers which has some connectivity to the Robe River Alluvial aquifer and associated pools. The groundwater table is modelled to be lowered by approximately 25 m in the CID aquifer. Groundwater abstraction for water supply from the Southern Cutback Borefield, in combination with the upstream CWSP, and abstraction from the Mesa J Iron Ore Development will lower the groundwater table in the adjacent Jimmawurrada Creek alluvial aquifer by up to 9 m (or 14 mbgl) The loss or degradation of potentially groundwater dependant vegetation as a result of groundwater drawdown is included in Section 6.6. The loss or degradation of potential subterranean fauna habitat as a result of groundwater drawdown is included in Section 7.	The following key management strategies will be implemented to manage impacts to the hydrological and hydrogeological regimes of as a result of dewatering: **Avoid:** Avoidance of mine dewatering or abstraction for water supply is not possible. However, the use of the existing Southern Cutback Borefield avoids the need for a new water supply borefield. **Minimise:** Based on monitoring of water levels within the semi-permanent and permanent pools of the Robe River during active mine dewatering, should pool water levels decline beyond that predicted in this impact assessment (i.e. up to 1 m beyond natural seasonal fluctuations) as a direct result of dewatering, the Proponent will cease dewatering below the water table (~120 m RL) in the adjacent Pit 7 during dry periods and resume mining once a stream flow event occurs. Groundwater abstraction will be minimised to that required to access the BWT resource and to meet site water requirements. The use of a thickener is proposed to be used for the WFSF, specifically to optimise water recovery and reduce the overall Revised Proposal's water demand from the Southern Cutback Borefield. The implementation of a thickener plant will significantly reduce the water demand by approximately 30% (~50 GL over the life of the Revised Proposal) with a maximum drawdown along the Jimmawurrada Creek predicted to be 9 m (equating to a maximum depth to groundwater of 14 mbgl). Monitoring of riparian vegetation and groundwater levels will continue to be undertaken along the Robe River and	The Revised Proposal will result in groundwater drawdown as a result of dewatering BWT resources and supplying water for processing requirements. Groundwater drawdown as a result of mine pit dewatering will result in further reduction of groundwater levels within the Mesa H CID aquifer. Groundwater recovery to pre-mining water table levels is expected to begin after groundwater abstraction activities cease upon closure, with recovery timeframes estimated in the order of ~60 years post mine closure with approximately 50% of the recovery occurring in the first 30 years. High rainfall events associated with cyclones, however, have the ability to recharge and completely reset the aquifer water table back to baseline water levels after a single event, depending on the magnitude and location of rainfall within the catchment. **Robe River** Dewatering of the Mesa H CID aquifer is considered unlikely to result in a significant impact to the groundwater levels in the Robe River. Groundwater levels are predicted to temporarily reduce by up to 1 m (modelled duration of less than one year) during dry conditions. It is possible that shallow intermittent and semi-permanent pools (e.g. Duck Pool) have the potential to dry out more quickly during extended dry periods, however the effects would be seasonal and temporary, and the deeper pools and permanent pool at Yeera Bluff are expected to continue to persist without active management. However, proposed contingency mitigation measures will ensure that permanent pools are not impacted as a result of mining. **Jimmawurrada Creek** Groundwater drawdown as a result of abstraction for operational water supply from the Southern Cutback Borefield

Potential impacts	Mitigation to address potential impacts	Residual impact / Predicted outcome
	Jimmawurrada Creek in the vicinity of the Revised Proposal. If irreversible changes to riparian vegetation health are detected as a result of the Revised Proposal, then appropriate mitigation measures will be undertaken, which may include: • optimisation of the location of discharge points in Jimmawurrada Creek to provide periodic supplementary water in areas predicted to be affected by groundwater drawdown • targeted supplementary water (derived from Mesa H mine pit dewatering) directly to permanent pools to reduce the potential for impacts to the pool water levels. **Rehabilitate:** Mine pits will be backfilled to levels to prevent the formation of pit lakes. **Other legislation:** Groundwater abstraction for dewatering purposes has been, and will continue to be, managed in accordance with the existing Groundwater Licence GWL107678-13, issued under the RIWI Act and associated GWOS, and any amendments as required.	will, when combined with groundwater drawdown from the existing Mesa J Iron Ore Development and drawdown from the upstream CWSP, cause a drawdown cone of depression. The construction and operation of a thickener will reduce water demand by approximately 30%, translating to a drawdown ranging between 1 – 9 m (resulting in a maximum depth to groundwater of 14 mbgl) below a 12 km section of the ephemeral Jimmawurrada Creek. No permanent or semi-permanent pools have been identified in this section of the creek that would be affected.

Potential impacts	Mitigation to address potential impacts	Residual impact / Predicted outcome
Direct impact: Changes to the hydrological regime of Jimmawurrada Creek, West Creek and the Robe River as a result of surplus water management. Surplus water from mine pit dewatering which exceeds the operational water requirements will be discharged via existing (and or optimised) operational discharge outlets at Jimmawurrada Creek and or West Creek, both being tributaries of the Robe River. Modelling indicates surplus water volumes will be approximately the same as the current Mesa J Iron Ore Development which may result in a continuous surface discharge expression of up to 8 km periodically generated from the discharge point(s). The surface discharge extent is not expected to extend beyond Yeera Bluff.	The following key management strategies will continue to be implemented to manage the potential changes to the hydrological regime of the Robe River as a result of the discharge of surplus water: **Avoid:** Avoidance of surface water discharge is not possible for this Revised Proposal. **Minimise:** Surplus water generated from mine pit dewatering will be used onsite in the first instance to supply water for operational purposes. Only surplus water exceeding the operational requirements will be discharged to local ephemeral tributaries of the Robe River. The location of discharge points may also be optimised to reduce the potential for impacts to significant environmental values or areas considered to be at higher risk from the effects of groundwater drawdown, including along Jimmawurrada Creek (near the Southern Cutback Borefield) and the permanent pools of the Robe River. The Proponent proposes that the discharge of surplus water from mine pit dewatering be subject to a new MS (Appendix 3). The contemporary conditions of the new MS shall require the Proponent to implement an EMP (Appendix 6), which includes monitoring of the health of riparian vegetation. **Other legislation:** Jimmawurrada Creek and West Creek have been subject to discharge of surplus water from existing operations since 1993. Discharge of surplus water has been, and will continue to be, managed in accordance with the existing Mesa J Operating Licence L6820/1993-12, issued under Part V of the EP Act, and any amendments as required.	This Revised Proposal is expected to result in ongoing but minor alteration of the natural hydrological regime of the Robe River as a result of the ongoing periodic discharge of surplus water into Jimmawurrada and West Creeks. The Proponent considers that the potential impacts can be managed, and the residual impact is not considered to be significant and therefore does not warrant the application of offsets.

<table>
<tr><th>Potential impacts</th><th>Mitigation to address potential impacts</th><th>Residual impact / Predicted outcome</th></tr>
<tr><td>Direct impact:
Changes to the Hydrological regime of the Robe River as a result of minor surface water flow diversions.
Development of mine pits and a surface water flood diversion are expected to result in minor alteration of the natural hydrological regime, changing natural catchment water flows into the Robe River.
Similar to Mesa J, Mesa H will intercept the same local small overland catchment flow. A 5.5 km surface water management diversion structure will be required to redirect the surface water flows of this minor catchment to avoid pit flooding during mining operations.</td><td>The following key management strategies will be implemented to manage the potential alteration of the natural hydrological regime of the Robe River as a result of the Revised Proposal:
Avoid:
Diversion of surface water flows in major creeks including Jimmawurrada Creek and the Robe River will be avoided.
Minimise:
The Proposed surface water diversion has been designed to redirect flows back into the Robe River, which would otherwise be captured by the Proposed Change (and is currently captured by the Mesa J pits), to maintain the continuation of natural surface water flows into the Robe River.</td><td>This Revised Proposal is expected to result in minor alteration of the natural catchment flows into the Robe River. However, the proposed surface water management structure will ensure the natural surface water flows are maintained in the Robe River during mining.
Further, surface water flows in the region are only associated with high intensity rainfall events. Based on rainfall data and flow analysis, rainfall events that result in flow are expected to occur once per year on average.
The Proponent therefore considers that this Revised Proposal can be managed to meet the EPA's objective for this factor.</td></tr>
<tr><td>Indirect Impact:
Changes to surface and groundwater chemistry.
Discharge of surplus water may change surface water chemistry in the Robe River and its associated pools.
Contamination has the potential to reduce the quality of groundwater and surface water via sediment-laden run-off from waste dumps or hydrocarbon spills.
In-pit storage of waste fines will lead to recharge of the local aquifer below the proposed WFSF and has potential to alter groundwater chemistry.
The potential for exposure of PAF and resultant acid drainage during operations and closure is low.</td><td>The following key management strategies will be implemented to manage impacts of potential reduced surface and groundwater chemistry:
Avoid:
Mine design will avoid exposure of PAF materials.
Seepage from in-pit storage of waste fines will be captured by the water supply borefield and re-circulated in the wet plant circuit.
Hydrocarbon storage facilities and all associated connections will be within appropriately contained areas and storm water will be collected from these areas and treated to remove hydrocarbons prior to discharge, Hydrocarbon storage facilities and bunds will be inspected on a regular basis to identify any leaks or maintenance requirements.
Minimise:
The Proponent has well established management strategies for the management of PAF materials, While the likelihood of encountering significant quantities of PAF material is considered low, if PAF materials are encountered, then existing management strategies within the Rio Tinto Iron Ore</td><td>The Proponent considers that this Revised Proposal can be managed to meet the EPA's objective for this factor.
The proposed WFSF may result in changes in groundwater chemistry in the immediate vicinity of the WFSF. However, changes in groundwater chemistry will be mainly confined to the footprint of the facility and largely contained within the cone of depression generated by the proposed borefield extending 30 m vertically and 3.5 km horizontally by 2037 and the existing cone of depression generated by the dewatering in the CID at Mesa J.
Surface water discharge will be required during and directly post wet season so the alteration of surface water chemistry and sediment quality in the Robe River will be negligible, due to dilution. The changes to water quality in pools from surplus water discharge is expected to be within natural variation.
Given the likelihood of encountering significant quantities of PAF materials is low and that appropriate management would be implemented if PAF materials were encountered, no significant impacts to surface and groundwater quality from PAF material are expected.</td></tr>
</table>

Potential impacts	Mitigation to address potential impacts	Residual impact / Predicted outcome
	(WA) Mineral Waste Management Plan, and the SCARD Management Plan will be implemented to ensure waste material is adequately geochemically characterised and PAF material that poses an AMD risk is appropriately managed. Water management structures such as windrows around the base of waste dumps and sediment traps will be constructed in key risk areas to minimise discharge of sediment-laden run-off from the site. The Proponent proposes that the discharge of surplus water be subject to a new MS (Appendix 3). The Condition shall require the Proponent to implement an EMP (Appendix 6). Monitoring of the surface water chemistry in the pools of the Robe River will be included in the EMP. **Other legislation:** Compliance with the requirements of the *Contaminated Sites Act 2003* if contamination occurs. Groundwater quality has been, and will continue to be, managed in accordance with the existing Groundwater Licence GWL107678-13, issued under the RIWI Act and associated GWOS, and any amendments as required	Given that hydrocarbon management measures will be implemented, no significant impacts to surface and groundwater quality from hydrocarbons are expected. The Proponent considers that the potential impacts can be managed and the residual impact is not considered to be significant and therefore does not warrant the application of offsets.

5.10 Predicted Outcome

The key Inland Waters values identified in the Development Envelope that are considered relevant to the Proposed Change include:

- The Robe River alluvial aquifer and associated surface and subsurface flows:
  - Supports locally and sub-regionally significant riparian vegetation, including Groundwater Dependant Vegetation.
  - Supports aquatic and subterranean fauna including conservation listed stygofauna and the conservation listed Blind Cave Eel.
- Semi-permanent and permanent pools of the Robe River.
- The Jimmawurrada alluvial aquifer and associated surface flows:
  - Supports locally significant riparian vegetation.
  - Supports aquatic and subterranean fauna including conservation listed stygofauna and the conservation listed Blind Cave Eel.
- The CID aquifer including groundwater levels and groundwater quality (generally classified as fresh).

After the mitigation hierarchy has been applied (Section 5.9), the Proposed Change (together with the existing Mesa J Iron Ore Development and other foreseeable proposals) would result in the following key outcomes in relation to Inland Waters:

- Direct disturbance to the Robe River and Jimmawurrada Creek will be avoided through Restricted Clearing Areas.
- Groundwater levels in the Alluvial aquifer will be lowered up to 1 m along the Robe River.
- Lowering of the water table across Mesa H and Mesa J is not expected to cause significant water level changes in the permanent pool (Yeera Bluff) located on the Robe River northwest of Mesa H, however shallow (<0.5 m) semi-permanent and seasonal pools may dry out more quickly during prolonged periods of drought.
- Groundwater abstraction from the Southern Cutback Borefield, Mesa J dewatering and CWSP borefield operation will lower the water table across a 12 km section of the Jimmawurrada Creek, with a maximum predicted drawdown of 9 m across a 6.5 km section (equating to water levels of 14 mbgl over a 6.5 km section) of Jimmawurrada Creek) by 2030.
- If natural recharge in Jimmawurrada Creek is reduced by 50% due to an extended dry period (numerical model uncertainty run 2, Rio Tinto 2019a), the drawdown could increase by almost 3 m, in addition to the historical seasonal fluctuations, translating to a maximum drawdown of 14 m (equating to water levels of 18 mbgl) in the immediate proximity of the Southern Cutback Borefield by 2030.
- Robe River pools will be protected by limiting dewatering below 120 m RL (as a contingency) in the northern pit 7 of Mesa H and/or by providing supplementary water directly to permanent pools.
- Intermittent surface water expression from surplus water discharge will not extend beyond 8 km from the discharge point(s), and will remain within the existing Mesa J Iron Ore Development discharge footprint (in dry conditions).
- Through use of a diversion structure, At least 75% of the current contributing landscape for surface water runoff up to the 1:50 AEP event level will continue to flow to the Robe River.
- Aquifer recovery is modelled to take up to 60 years to fully recover to pre-mining levels within the Mesa H and J areas. However, water levels along the Jimmawurrada Creek and Robe River are expected recover 90% of the drawdown after the first or second significant rainfall events. The drawdown in the Yeera Bluff is estimated to take the longest to recover, with the last 20 cm of drawdown requiring up to 40 years to recover.

- Surface and groundwater quality is expected to be maintained due to the natural high variability in pool water quality compared to discharge water quality, the low likelihood of encountering significant quantities of PAF materials, the recirculation of seepage from the WFSFs and the low risk of contamination from hydrocarbon spills.
- Seepage will not migrate towards the Bungaroo Creek P1 Water Reserve.

The Proponent recognises the ecological, social and cultural values associated with Robe River and Jimmawurrada Creek, and the value of the aquifers as a water supply. The Proponent has designed the Proposed Change to minimise abstraction and surplus water discharge, which will be within authorised limits for the existing Mesa J Iron Ore Development. The Proposed Change will result in a small increase to current and future impacts associated with approved projects (Mesa J Iron Ore Development and CWSP). However, the Proponent has recognised that the Proposed Change may contribute to cumulative impacts within the Robe Valley and has accounted for this in the Proposed Change design and proposed management.

The Proponent considers that the Revised Proposal can be managed to meet the EPA's objective for Inland Waters through:

- the Proposed Change design;
- the continued management in accordance with the existing RIWI and EP Act Part V licences; and
- the implementation of the updated Mesa J Hub EMP and the Mesa J Hub Closure Plan.

The Proponent therefore considers that there would be no significant residual impacts from the Revised Proposal on Inland Waters.

6. FLORA AND VEGETATION

This section describes the flora and vegetation that occur within the Proposed Change Area and broader Study Area and provides an assessment of the potential impacts of the Proposed Change to conservation significant flora and vegetation, proposed mitigation measures and the predicted outcome for this factor.

6.1 EPA Objectives

The EPA applies the following objective from the *Statement of Environmental Principles, Factors and Objectives* (2018c) in its assessment of proposals that may affect Flora and Vegetation:

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

6.2 Policy and Guidance

6.2.1 EPA Policy and Guidance

The following guidelines are relevant to the Proposed Change with respect to the protection of flora and vegetation values and the above EPA objective:

- EPA (2014) Cumulative environmental impacts of development in the Pilbara region: Advice of the Environmental Protection Authority to the Minister for Environment under Section 16(e) of the *Environmental Protection Act 1986*
- EPA (2018c) Statement of Environmental Principles, Factors and Objectives
- EPA (2004) Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia
- EPA (2016d) Environmental Factor Guideline: Flora and Vegetation
- EPA (2016e) Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment
- EPA (2016c) Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans
- DMP and EPA (2015) Guidelines for Preparing Mine Closure Plans.

6.2.2 Other Policy and Guidance

- Department of Water (2013a) Western Australian Water in Mining Guideline
- Government of Western Australia (2011) WA Environmental Offsets Policy
- Government of Western Australia (2014b) WA Environmental Offsets Guidelines.

6.3 Environmental Scoping Document

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Table 6-1 summarises where the requirements of the ESD are addressed in this section.

Table 6-1: Requirements of the ESD for Flora and Vegetation

Task number	Requirement of ESD	Section number
1	Identify and characterise flora and vegetation in accordance with the requirements of EPA 2016e Technical Guidance – Flora and Vegetation Surveys for EIA. The survey should take into account areas that are likely to be directly or indirectly impacted as a result of the Proposal.	Section 6.4
2	Map weed occurrences in areas likely to be directly or indirectly impacted by the Proposal.	Figure 6-9
3	Describe the vegetation and conservation significant flora species present and likely to be present within the Development Envelope and indirect disturbance areas outside of the Development Envelope. Include an assessment of the relevance of any vegetation and conservation significant flora species in a local and regional context.	Section 6.4
4	Provide an analysis of any additional potential impacts from the Proposal in relation to dewatering and discharge activities including consideration of potential impacts from WFSF.	Section 6.5 and 6.6
5	Provide a detailed description of the cumulative impacts associated with the Proposal, including direct impacts from clearing, and indirect impacts such as groundwater drawdown, altered drainage, changes in water quality, spread of weeds, fragmentation of vegetation, altered fire regime, and dust.	Section 6.5 and 6.6
6	Provide tables and maps of the proposed clearing and predicted indirect impact to vegetation and conservation significant flora species, including but not limited to threatened and/or PEC, threatened flora, Priority flora or new flora species.	Section 6.5 and 6.6
7	Discuss, and determine significance of, potential direct, indirect (such as dust, weeds and downstream impacts) and cumulative impacts to conservation listed flora and vegetation as a result of the Proposal at a local and regional level (i.e. the Robe Valley).	Section 6.5 and 6.6
8	Demonstrate that all practical measures have been taken to reduce the area of the proposed disturbance footprint based on progress in the Proposal design and understanding of the environmental impacts.	Section 6.8
9	Discuss proposed objectives, management, monitoring and mitigation methods to be implemented demonstrating that the design of the Proposal has addressed the mitigation hierarchy to avoid and minimise impacts to flora and vegetation.	Section 6.8
10	Review and revise the existing Mesa J EMP to apply to the Proposal. The objective of the plan is to ensure the protection of conservation significant vegetation communities within the Development Envelope and areas of indirect impact. The following should be addressed in the plan: • Invasive species control – control of weeds, in particular through transport and/or entry and exit points, and in areas of vegetation units considered to have high local significance • Monitoring program – to monitor the health of conservation listed vegetation communities including (but not limited to) the	Appendix 6

Task number	Requirement of ESD	Section number
	protection of obligate phreatophytic communities that will be impacted by the Proposal.	
11	Prepare a Mine Closure Plan consistent with DMP and EPA Guidelines for Preparing Mine Closure Plans (2015) which considers the proposed rehabilitation methodologies to achieve successful progressive rehabilitation of all areas disturbed by mining with vegetation composed of native species of local provenance.	Appendix 7
12	Predict the inherent and residual impacts before and after applying the mitigation hierarchy and identify whether the residual impacts are significant by applying the Significant Residual Impact Model in the WA Environmental Offsets Guideline.	Section 6.8 and 6.9
13	Quantify any significant residual impacts by completing the Offset Template, spatially defining the area of 'good' to 'excellent' native vegetation that will be disturbed as a result of this proposal (excluding the approved Mesa J Operation) and propose an appropriate offsets package that demonstrates application of the WA Environmental Offsets Policy and Guideline.	Section 13
14	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Section 6.8 and 13

6.4 Receiving Environment

6.4.1 Summary

The Revised Proposal is located within Hamersley sub-region the Pilbara IBRA bioregion. Apart from Rio Tinto's mining operations (including adjacent Mesa J, Mesa K, and Mesa A / Warramboo), the main (and historical) land use in the Robe Valley is pastoral activities (predominantly cattle grazing).

The EPA's assessment of the Mesa J Iron Ore Development (EPA 1991) discussed the values of the Robe River-Jimmawurrada Creek environment, including its riverine vegetation. Conditions of MS 208 for the Mesa J Iron Ore Development relate to the protection of the vegetation of the Robe River-Jimmawurrada Creek system.

The vegetation in the Development Envelope has been affected from direct disturbance from grazing and mining exploration. Most of the vegetation (80%) within the Proposed Change Area is in 'Very Good' to 'Excellent' condition with disturbed areas accounting for 8% of the Proposed Change Area). Vegetation rates from 'Very Poor' to 'Excellent' condition in the Robe River and its tributaries. Poorer condition along drainage lines is generally from weed proliferation, grazing and trampling from cattle. Of the introduced species (weeds), most were recorded prior to the commencement of the Mesa J Iron Ore Development. Most of these weed species are disturbance specialists, so colonise anthropogenic disturbance or fluvial disturbance in drainage systems. Monitoring to date has shown that the level of weed infestation has been relatively stable since the Mesa J Iron Ore Development began.

Riparian vegetation, including Groundwater Dependent Vegetation (GDV) occurs along the Robe River (including pool ecosystems) and Jimmawurrada Creek, supporting woodland to open forests comprising silver cadjeput (*Melaleuca argentea*) and eucalypt (*Eucalyptus camaldulensis*, *E. victrix*). Riparian GDV in the Proposed Change Area broadly represents a "terrestrial vegetation" type Groundwater Dependent Ecosystem (GDE). GDEs are characterised by the presence of species that rely on shallow groundwater, known as phreatophytic species.

Permanent and semi-permanent pools along the Robe River support “River Pool Ecosystem” type GDEs. These ecosystems are an important component of the river ecosystem, supporting a diverse range of aquatic fauna and specialised flora, and rely on consistent surface expressions of groundwater. The fringing vegetation surrounding the pools generally support a high diversity of flora species and the pools themselves were found to have elevated to high macrophyte (including sedges) and ephemeral taxa diversity (Astron 2016a; Rio Tinto 2018d).

Riparian vegetation along Jimmawurrada Creek has been subject to the indirect impacts of groundwater drawdown from:

- approved projects, including dewatering at Mesa J (since the 1990s), abstraction at the Mesa J Southern Cutback Borefield since 2013, and influences of the CWSP on the Bungaroo Valley aquifer since 2014
- climatic effects (likely to represent a significant proportion of the influence on groundwater levels) from lower rainfall since 2011.

The Robe River and Jimmawurrada Creek have been subject to the indirect impacts of surplus discharge from Mesa J Iron Ore Development, since the 1990s.

Riverine vegetation can be also significantly altered due to destructive flow events associated with cyclonic and storm events. Cyclonic events and associated rainfall can significantly alter the size and position of permanent pools through scouring and aggradation.

Surveys undertaken prior to December 2016 were consistent with the EPA’s guidance current at that time (*Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* [EPA 2004]). Surveys undertaken since December 2016 are consistent with the EPA’s current guidance (*Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016e). The proponent’s view is that the surveys meet the requirements of the ESD.

No Threatened Ecological Communities (TEC) were recorded in the Development Envelope or Study Area. Conservation significant vegetation includes riparian vegetation communities along the Robe River and associated pools (*Melaleuca argentea* dominated), riparian vegetation communities along Jimmawurrada Creek (dominated by *Eucalyptus camaldulensis* and *Eucalyptus victrix)* and a vegetation community analogous to the P3 PEC ‘*Triodia sp. Robe River assemblages of the West Pilbara*’.

No threatened flora were recorded; however, some priority flora occur (two priority 3 and one priority 4 species only).

6.4.2 Flora and vegetation surveys

Numerous historical vegetation and flora surveys have been undertaken in or near the Development Envelope since 2003 (Figure 6-1 and Figure 6-2). More recently Astron conducted Level 2 (now a ‘Detailed Survey’ under the new Guidance Statement) flora and vegetation surveys within the Proposed Change Area (Astron 2016a). Astron were also commissioned to conduct a Level 2 flora and vegetation assessment in riparian areas potentially impacted by water management (Astron 2016a). A consolidated list of all flora and vegetation surveys completed to date in the vicinity of the Development Envelope and broader Study Area is provided in Table 6-3. Astron’s (2016a, 2016b) and other recent flora and vegetation surveys are presented in Figure 6-1. These most recent flora and vegetation survey reports are provided in Appendix 9.

A total of 137 quadrats and 17 releves have been sampled by Astron (2016a; 2016b) in the Study Area, with 93 quadrats and three releves sampled twice. Including historic surveys, 228 quadrats and 37 releves have been sampled in the Proposed Change Area.

Phase 1 surveys in October 2014 and October 2015 were both conducted with below average rainfall in the months preceding the surveys. Seasonal conditions for the first Phase 2 survey were also considered poor with below mean rainfall (Astron 2016a). Despite this, the suite of species recorded was typical of what may be expected in the area and aligns with what has been previously recorded in surrounding areas (Astron 2016a).

In addition to the Astron (2016a) vegetation mapping, a Rio Tinto botanist conducted a “Targeted Survey” of Riparian vegetation and subsequently further refined the mapping within the riparian zones of the Robe River and Jimmawurrada Creek (Rio Tinto 2018d; 2018e).

6.4.3 Regional context

The IBRA (Version 7) recognises 89 geographically distinct bioregions based on common climate, geology, landform, native vegetation and species information. The 89 bioregions are further defined into 419 sub-regions, which are more localised and homogenous geomorphological units in each bioregion (DotEE 2016).

The Revised Proposal is located within the Pilbara bioregion, in the north of WA (DotEE 2016). The Pilbara bioregion is divided into four sub-regions which include Chichester, Roebourne, Fortescue Plains, and Hamersley. The Revised Proposal falls within the Hamersley (PIL03) sub-region.

The Revised Proposal lies within the Eremaean Botanical Province (Beard 1975a) with the Proposed Change Area intersecting four vegetation units defined by Beard (1975a; 1975b; Table 6-2). Each vegetation unit has the majority of their pre-European extent remaining (Government of Western Australia 2014a).

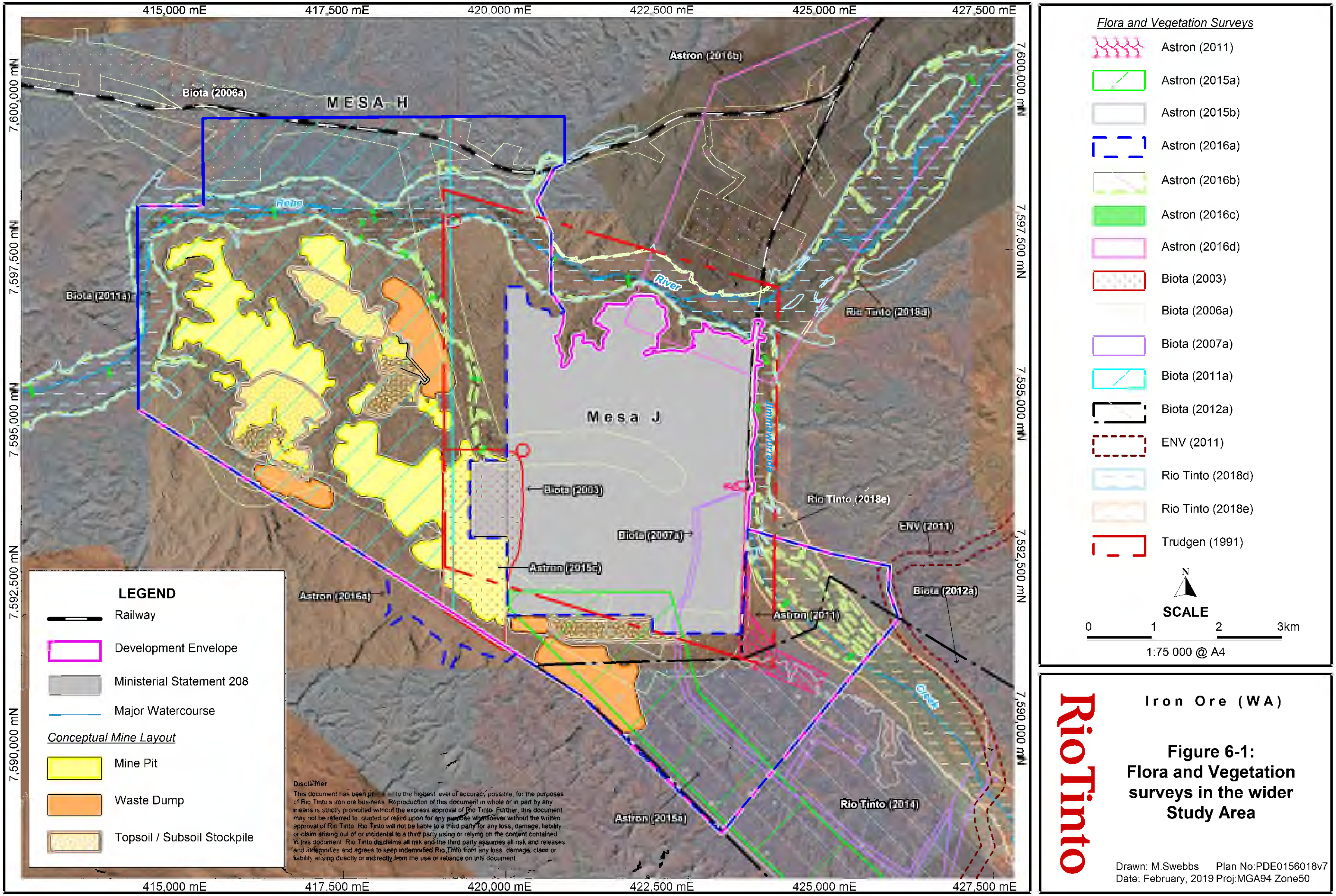
Table 6-2: Vegetation Units in the Development Envelope as Defined by Beard (1975a, 1975b)

Beard description	Pre-European Extent in the Pilbara bioregion (ha)	Extent in Proposed Change Area (ha) (% of current mapped extent)
Hamersley 82: Hummock grasslands, low tree steppe; snappy gum over *Triodia wiseana*.	2,169,360	1,959 (<0.1%)
Stuart Hills 603: Hummock grasslands, sparse shrub steppe; *Acacia bivenosa* over hard spinifex.	54,800	534 (1%)
Stuart Hills 605: Hummock grasslands, shrub steppe; *Acacia pachycarpa* & waterwood over soft spinifex.	25,730	966 (4%)
Hamersley 609: Mosaic: Hummock grasslands, open low tree steppe; bloodwood with sparse kanji shrubs over soft spinifex / Hummock grasslands, open low tree steppe; snappy gum over *Triodia wiseana* on a lateritic crust.	74,130	1,379 (2%)

Table 6-3: Summary of Supporting Flora and Vegetation Surveys

Survey Report	Survey Description / Summary	Survey Date
Assessment of Groundwater Dependent Vegetation distribution on the Robe River – Targeted Riparian Vegetation Survey - Stage 1. Rio Tinto (2018d)	Targeted survey focusing on delineating riparian GDE communities with high accuracy. Survey comprised extensive riparian traverses and fine scale mapping of vegetation targeting groundwater dependent species and Obligate Phreatophytic Vegetation (OPV) communities. Included additional survey focus on assessing age distribution within obligate phreatophyte populations, community significance, and mesic species composition and structure.	December 2016, January / February 2017
Addendum to Assessment of Groundwater Dependent Vegetation distribution on the Robe River – Targeted Riparian Vegetation Survey- Stage 1: Groundwater Dependent Vegetation distribution within Jimmawurrada Creek. Rio Tinto (2018e)	Targeted survey focusing on delineating riparian GDE communities with high accuracy. Survey comprised extensive riparian traverses and fine scale mapping of vegetation targeting groundwater dependent species and communities. Included additional survey focus on assessing mesic and OPS abundance, composition, and structure.	May 2017
Mesa H Level 2 Vegetation and Flora Assessment. Unpublished report prepared for Rio Tinto Iron Ore, May 2016. Astron (2016a)	Two-phase Level 2 assessment of vegetation and flora including database searches and literature review, vegetation and flora survey, targeted searches for Threatened and Priority flora and weeds, vegetation mapping and assessment.	October 2014, September / October 2015, April / May 2016 and May and July 2016
Mesa H Riparian Community Assessment. Astron (2016b)	Level 2 vegetation and flora assessment of the Robe River riparian community, and a Level 1 fauna desktop assessment, including database searches and literature review of available resources, vegetation and flora assessment, fauna and fauna habitat assessment and baseline aquatic fauna assessment.	2016
Mesa H Riparian Vegetation Baseline Monitoring. Astron (2016c)	Riparian monitoring transects established across riverine vegetation in the Robe River, including impact and reference sites. Additional baseline monitoring points established in Jimmawurrada during October 2017.	May-June 2016 And October 2017
Middle Robe and East Deepdale Level 2 Vegetation and Flora Assessment Astron (2016d)	Two phase Level 2 vegetation and flora survey covering 11,816 ha in the Middle Robe and East Deepdale region.	June and September / October 2015
Bungaroo Iron Ore Mine and Infrastructure Project, Level 2 Vegetation and Flora Assessment. Astron (2015a)	Two-phase Level 2 assessment of vegetation and flora values including database searches and literature review of available resources, ground truthing and refinement of existing mapping, vegetation and flora survey, targeted searches for Threatened and Priority flora and weeds, vegetation mapping and assessment.	April / May 2015 and August 2015

Survey Report	Survey Description / Summary	Survey Date
Mesa J Pit Extension - Level 2 Vegetation and Flora Assessment (Astron 2015b)	Level 2 vegetation and flora survey of the Mesa J Pit Extension area.	September 2015
Greater Bungaroo Flora and Vegetation Survey. Biota (2012a)	Two-phase Level 2 baseline flora and vegetation survey including quadrats and releves of representative areas, mapping of vegetation types and opportunistic records of priority flora and weeds.	July 2009 and June 2011
Baseline Flora and Vegetation Assessment of Robe Valley Mesas (Mesas B, C, D, E, F, H and I). Biota (2011a)	A baseline flora and vegetation survey including quadrats and releves of representative areas, mapping of vegetation types and opportunistic records of priority flora and weeds.	October 2010
Bungaroo Alternate Powerline Routes Flora, Vegetation and Fauna Assessment. ENV (2011)	Level Two Flora and Vegetation Survey and a Level One Fauna assessment survey including quadrats and releves of representative areas; mapping of vegetation types; opportunistic records of priority flora and weeds.	May 2011
Mesa J Tail Track Extension Vegetation, Flora and Fauna Survey. Astron (2011)	Level 1 vegetation, flora and fauna survey, mapping and assessment consistent with level 5 (association) of the National Vegetation Inventory System vegetation classification system.	June 2011
A Vegetation and Seasonal Flora Survey of the Bungaroo Trial Pit and Transport Corridor to Mesa J, near Pannawonica and Sampling of the Broader Bungaroo Valley. Biota (2007a)	Two-phase Level 2 baseline flora and vegetation survey including quadrats and releves of representative areas, mapping of vegetation and fauna habitat types and opportunistic records of priority flora and weeds.	March 2005, June 2005, July 2006 and August 2006
A vegetation and flora survey of the proposed Mesa A Transport Corridor, Warramboo Deposit and Yarraloola Borefield. Biota (2006a)	A baseline flora and vegetation survey including quadrats and releves of representative areas, mapping of vegetation types and opportunistic records of priority flora and weeds.	7 surveys between July 2004 and September 2005
Mesa J Extension Vegetation, Flora and Fauna Assessment. Biota (2003)	Single phase Level 2 assessment of vegetation and flora including database searches and literature review, vegetation and flora survey, targeted searches for Threatened and Priority flora and weeds, vegetation mapping and assessment.	September 2003
A flora and Vegetation Survey of an Area on the Robe River near Pannawonica. Trudgen (1991)	Desktop assessment and ground truthing / mapping of vegetation and flora.	July 1991 and August 1991



RioTinto

Iron Ore (WA)

Figure 6-1: Flora and Vegetation surveys in the wider Study Area

Drawn: M.Swebbs Plan No:PDE0156018v7
Date: February, 2019 Proj:MGA94 Zone50

Geospatial Information and Mapping

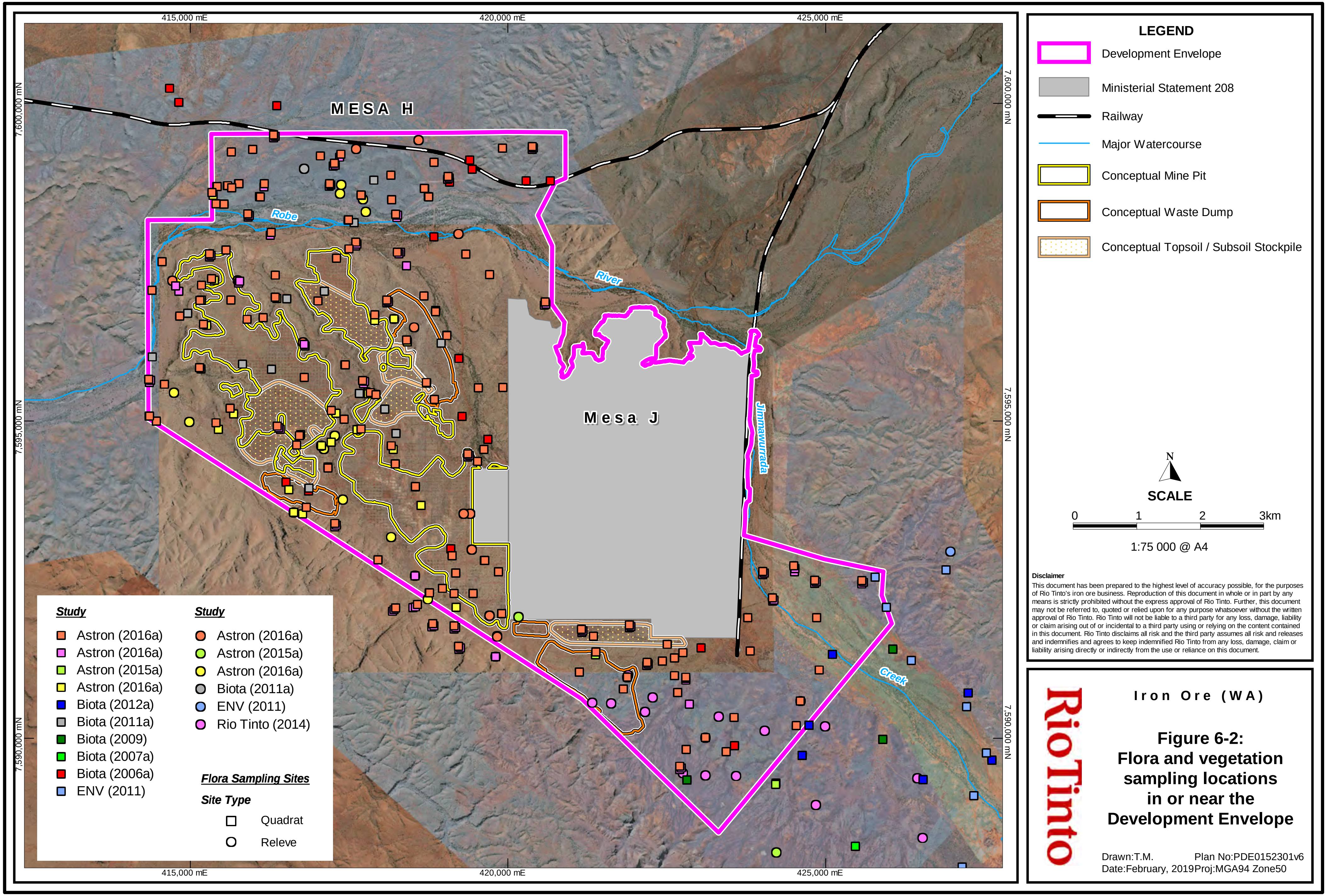


Figure 6-2: Flora and vegetation sampling locations in or near the Development Envelope

Geospatial Information and Mapping

6.4.4 Vegetation units

Astron mapped and described a total of 38 vegetation associations (and three mosaic vegetation associations) in the Proposed Change Area and the additional riparian areas (Astron 2016a; 2016b) (Figure 6-3). Vegetation associations have been grouped according to the major landform with which they are associated and are summarised in Table 6-4.

In addition to the Astron groupings, a Rio Tinto botanist conducted GDE focused riparian mapping which significantly increased the accuracy and further refined the mapping within the riparian areas of the Robe River and Jimmawurrada Creek. The intent of the detailed riparian mapping was to improve the understanding of these systems; to provide an increased knowledge of areas more likely to be susceptible to fluctuations in groundwater levels; and to improve impact risk predictions. Based on this work, the original Astron riverine units were further differentiated and are shown in Figure 6-3. Refer to Appendix 9 for full descriptions of refined riparian vegetation units (Rio Tinto 2018d, 2018e).

Table 6-4: Summary of Dominant Vegetation Associations by Landform Units

Mesa tops / hilltops / mesa slopes / hillslopes
Seventeen associations dominated by *Corymbia / Eucalyptus* sp. scattered low trees over *Acacia* sp. shrublands over *Triodia* sp. Hummock grasslands. Condition was Very Good to Excellent.
Major and Minor Drainage lines
Eleven associations predominantly comprising low woodlands of *Eucalyptus camaldulensis* subsp *refulgens* and *Eucalyptus victrix* and open forests of *Melaleuca argentea*, and *Eucalyptus camaldulensis* subsp *refulgens*. Condition ranged from Poor to Excellent. One vegetation association was listed as Poor to Good and represented 6.3%. Disturbance from weeds and cattle grazing was more evident on the deeper soils of drainage line vegetation.
Plains
Ten associations in Very Poor to Excellent condition dominated by *Acacia* sp. shrublands over *Triodia* sp. hummock grasslands occasionally with emergent scattered *Corymbia* low trees. Disturbance from weeds (especially **Cenchrus*) and cattle grazing was more evident on the deeper soils of plains vegetation associations.
Mosaics
Astron (2016a) mapped three mosaic associations comprising a dense network of drainage lines and plains at a scale too fine to capture on the mapping.

The dominant vegetation units constituting 80% of the Proposed Change Area are presented in Table 6-5 (Astron 2016a).

Most of the vegetation was in Very Good to Excellent condition (80% or 4,838 ha) with disturbed areas accounting for 8% of the Proposed Change Area (367 ha).

Table 6-5: Vegetation Associations >100 ha (2%)

Vegetation association code and description	Landform unit	Total area (ha) and proportion (%) of Proposed Change Area
ChAiAbTw *Corymbia hamersleyana* scattered low trees over *Acacia inaequilatera* scattered tall shrubs over *A. bivenosa* scattered shrubs over *Triodia wiseana* hummock grassland.	Mesa tops and hilltops and mesa slopes and hillslopes landform	784 (16%)
AiAbTw *Acacia inaequilatera* scattered tall shrubs over *A. bivenosa* scattered shrubs over *Triodia wiseana* hummock grassland.	Mesa tops and hilltops and mesa slopes and hillslopes landform	578 (12%)
Disturbed.		367 (8%)
EcEvAtrApyPlTw *Eucalyptus camaldulensis* subsp. *refulgens* woodland over *E. victrix* low woodland over *Acacia trachycarpa, A. pyrifolia* var. *pyrifolia, Petalostylis labicheoides* tall open shrubland over mixed open herbland and *Triodia wiseana* scattered hummock grass.	Major and minor drainage	311 (6%)
AbTw *Acacia bivenosa* open shrubland to open heath over *Tridia wiseana* hummock grassland.	Mesa tops and hilltops and mesa slopes and hillslopes landform	266 (6%)
AiAanTw *Acacia inaequilatera* and *A. ancistrocarpa* scattered tall shrubs to tall open shrubland over *Triodia wiseana* open hummock grassland to hummock grassland.	Mesa tops and hilltops and mesa slopes and hillslopes landform	249 (5%)
ChAtuTw *Corymbia hamersleyana* and/ or *Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Acacia tumida* var. *pilbarensis* tall open scrub over *Triodia wiseana* open hummock grassland.	Major and minor drainage	197 (4%)
AiAaAbTw Acacia inaequilatera, A. bivenosa, A. ancistrocarpa open shrubland over Triodia wiseana open hummock grassland.	Plains	193 (4%)
AsTe *Acacia synchronicia* scattered shrubs over *Triodia epactia* hummock grassland.	Plains	191 (4%)

Vegetation association code and description	Landform unit	Total area (ha) and proportion (%) of Proposed Change Area
Mosaic of AaAbTw/ChAtuTw Mosaic of *Acacia inaequilatera, A. bivenosa, A. ancistrocarpa* open shrubland over *Triodia wiseana* open hummock grassland / and *Corymbia hamersleyana* and / or *Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Acacia tumida* var. *pilbarensis* tall open scrub over *Triodia wiseana* open hummock grassland.	Mosaic	177 (4%)
MaEcCv *Melaleuca argentea, Eucalyptus camaldulensis* subsp. *refulgens* open forest over *Cyperus vaginatus* scattered sedges to very open sedgeland.	Major and minor drainage	147 (3%)
ChAbTwTe *Corymbia hamersleyana* scattered low trees to low woodland over *Acacia bivenosa* open shrubland over *Triodia wiseana, T. epactia* hummock grassland.	Plains	127 (3%)
AiAptTw *Acacia inaequilatera* scattered shrubs to scattered tall shrubs over *A. ptychophylla* scattered low shrubs to low open shrubland over *Triodia wiseana* open hummock grassland.	Mesa tops and hilltops and mesa slopes and hillslopes landform	116 (2%)
ChAsppGOrGsppPlSsTeTw *Corymbia hamersleyana* scattered low trees to low open woodland over *Acacia* spp., *Gossypium robinsonii, Grevillea* spp., *Petalostylis* labicheoides, *Stylobasium spathulatum* tall shrubland over *Triodia epactia, T. wiseana* hummock grassland.	Major and minor drainage	112 (2%)

6.4.5 Significant vegetation

None of the vegetation units mapped within the Proposed Change Area are associated with any State or Federally listed TEC under the EPBC Act or listed by the DBCA (Astron 2016a).

Two PEC's: '*Triodia* sp. Robe River *assemblages of mesas of the West Pilbara*' P3 and '*Four plant assemblages of the Wona Land System*' P1, have been previously recorded within a 20 km search radius of the survey area (Astron 2016a) (Figure 6-4). In addition, the Sandsheet Vegetation (Robe Valley) Priority 3 PEC occurs approximately 28 km to the west, adjacent to Mesa A.

Four vegetation associations in the Proposed Change Area are considered to be of sub-regional or local significance, including three riparian associations along the Robe River and Jimmawurrada Creek and one other unit analogous to the P3 PEC '*Triodia* sp. Robe River *assemblages of the West Pilbara*'.

Vegetation that is considered analogous to the P3 PEC '*Triodia* sp*.* Robe River *assemblages of the West Pilbara*' was recorded by Astron (2016a) from discrete locations on the edge of the mesa landform (rocky slopes of the mesa adjacent to gullies and breakaways). Almost 15 ha (14.6 ha) of vegetation mapped as AprTwTsr *Acacia pruinocarpa* low woodland over *Triodia wiseana, Triodia* sp*.* Robe River open hummock grassland was recorded in the Proposed Change Area.

The remaining vegetation units were considered to be of either low local significance or negligible local significance based on the definitions below:

- High significance: supports listed threatened flora; supports significant populations of Priority 1 flora; associated with listed TECs or PECs; or associated with major drainage systems supporting groundwater dependant riparian vegetation (OPV) and sub-regionally to regionally restricted landforms, habitats or communities
- Moderate significance: supports Priority 1 - Priority 4 flora; associated with large local drainage systems supporting riparian vegetation (facultative phreatophytic vegetation [FPV]); or has restricted / limited local representation
- Low significance: supports Priority 1 – Priority 4 flora; associated with local drainage systems supporting riparian vegetation / GDV; or has limited local to relatively common representation
- Negligible significance: supports Priority 4 flora and flora that are regionally and locally common.

The significant vegetation in the Proposed Change area is depicted in Figure 6-5, described in Table 6-6 and summarised in the following sections.

Table 6-6: Significant Vegetation Communities in the Proposed Change Area (Rio Tinto 2018d, 2018e)

Code	Description	Location	Significance
Regional (to sub-regional) Significance			
C1AA (a&b)	Mature *Melaleuca argentea* dominated open-closed forest.	Scattered along low points in the river bed where groundwater appears shallow, often up against steep massive bank formations and near mesa features.	Locally and sub-regionally to regionally restricted and relatively rare / uncommon. High mesic flora species diversity. Cryptic and conservation significant flora species habitat (e.g. *Livistona alfredii*). Cryptic and Conservation significant fauna habitat (known to include the Pilbara Olive Python, Northern Quoll, and potentially the Ghost Bat and Pilbara Leaf Nosed Bat). High aquatic invertebrate and avifauna diversity. Elevated sedge and macrophyte diversity, possibly including conservation significant species. Some reduced value from direct impacts (e.g. rail line footings) and cumulative impacts. Some vegetation augmentation from surplus water discharge (mainly in the Mesa J vicinity). Unique representation of communities associated with a relatively upland positioned River System of the Pilbara.
High Local Significance			
AprTwTsr	*Acacia pruinocarpa* low woodland over *Triodia wiseana*, *Triodia* sp. Robe River open hummock grassland.	Mesa tops and slopes in the centre of the Proposed Change Area.	Analogous to the P3 PEC '*Triodia* sp. Robe River *assemblages of the West Pilbara*.
C1A	Mature *Melaleuca argentea* and *Eucalyptus camaldulensis* dominated open forest to low woodland.	Consistently fringing low flow channels or scattered around permanent water features where groundwater appears shallow.	Locally and somewhat sub-regionally restricted and significant. Above average mesic flora species diversity. Cryptic and conservation significant fauna habitat. Cryptic and conservation significant flora species habitat (e.g. *Livistona alfredii*). High subsurface aquatic invertebrate diversity. High local avifauna and bat species diversity. Some reduced value from direct impacts (e.g. tracks & rail line footings) and cumulative impacts. Some vegetation augmentation from surplus water discharge (mainly in the Mesa J vicinity). Above average representation of communities associated with the Major Creek lines of the 'Pilbara Ecosystems at Risk'. Above average to high quality representation of riverine Eucalyptus forest. Potential for elevated sedge diversity, including conservation significant species.

Code	Description	Location	Significance
Moderate to High Local Significance			
C1b	*Melaleuca argentea* and *Eucalyptus camaldulensis* dominated low woodland.	Scattered along low flow or secondary channels of the main river bed, including some high flow channels.	Locally restricted and somewhat uncommon. Relatively high mesic flora species diversity. At times relevant as cryptic and conservation significant fauna habitat. Cryptic flora species habitat and some potential as habitat for conservation significant flora. High subsurface aquatic invertebrate diversity. Relatively high local avifauna and bat species diversity. Some reduced value from direct impacts (e.g. tracks & rail line footings) and cumulative impacts. Some reduced value due to the likely transient nature of this type of community.
Moderate Local Significance			
C2AA	Mesic *Eucalyptus camaldulensis* dominated open forest.	Generally larger representations scattered along secondary channels and banks of the main river bed, including some high flow channels.	Locally and potentially sub-regionally restricted. Relatively high to above average mesic flora species diversity. Cryptic and mesic fauna habitat. Cryptic flora species habitat. Potentially possesses above average aquatic invertebrate diversity. Above average local avifauna diversity. Some reduced value from direct and cumulative impacts. May represent a higher risk GDE (compared to other local FPV communities) due the abundance of mesic indicator species. Above average to high quality representation of riverine Eucalyptus forest.

6.4.5.1 Riparian vegetation

Riparian vegetation, occurs along the Robe River and Jimmawurrada Creek, supporting woodlands comprising silver cadjeput (*Melaleuca argentea*) and eucalypt (*Eucalyptus camaldulensis*, *E. victrix*) (Figure 6-6).

Riparian GDV in the Proposed Change Area broadly represents a "terrestrial vegetation" type GDE. GDEs are characterised by the presence of species that rely on groundwater, known as phreatophytic species. Such species inhabit areas where they have access to groundwater in order to satisfy at least some proportion of their Ecological Water Requirements (EWRs) (Eamus *et al.* 2006 in Rio Tinto 2018d).

Phreatophytic species are classified depending on their degree of reliance on groundwater. Obligate phreatophytes (OPV) are species for which access to groundwater is critically important to their presence in the landscape. Faculative phreatophytes (FPV) are those species that opportunistically utilise groundwater to satisfy a proportion of their EWR but, if available and where required (i.e. during extended dry periods), may also satisfy their EWR via stored soil water reserves (Eamus *et al.* 2006 in Rio Tinto 2018d).

Vadophytes tend to use water held in the vadose (unsaturated) zone that occurs above the watertable. The tree species *Melaleuca argentea* (obligate phreatophyte), *Eucalyptus camaldulensis* subsp*. refulgens* (FPV) and *Eucalyptus victrix* (facultative phreatophyte or vadophyte) are the three most common phreatophytic species within riparian systems of the Pilbara bioregion. *Sesbania formosa*, a tree of relevance in the river systems of the study area, is also thought to be a phreatophyte, with some potential to be obligate in its water use strategy (Rio Tinto 2018f).

Due to its exclusive dependence on groundwater, the obligate phreatophyte *Melaleuca argentea* is considered the best indicator of consistently shallow groundwater or permanent (perennial) surface water and as such, this species is also widely considered the best indicator of a GDE in the arid tropical zone of WA. *Eucalyptus camaldulensis* is one of the most broadly distributed Eucalyptus species in Australia and commonly occurs along ephemeral creek lines in the Pilbara. Table 6-7 shows the best estimates for the degree of dependency of Pilbara riparian species upon groundwater.

Table 6-7: Tree species dependence on groundwater (From Rio Tinto 2018d, 2018e)

Species dependence on Groundwater	Plant Physiology/water use strategy	Relevant Species in the Pilbara
High	Phreatophyte	*Melaleuca argentea, Sesbania Formosa.*
Moderate	Facultative phreatophyte	*Eucalyptus camaldulensis* (in anomalous cases potentially vadophytic).
Low to Moderate	Facultative phreatophyte or vadophyte (depending on the physical environment)	*Eucalyptus victrix, Melaleuca glomerata* and *Eucalyptus xerothermica.*
Low (virtually negligible)	Vadophyte or Xerophyte	E.g. *Eucalyptus leucophloia, Corymbia hamersleyana, Corymbia deserticola, Corymbia candida*.*

*Larger individuals have the potential to be phreatophytic.

Riparian vegetation can be significantly altered due to destructive flow events associated with cyclonic and storm events. For example, high flows and flash flooding associated with cyclone Monty in 2004 permanently altered channel flow paths and uprooted much of the

Cadjeput woodland along the river channel in the vicinity of the Jimmawurrada-Robe confluence (WRM 2018).

Robe River

The Robe River is an ephemeral river with significant base-flow in its alluvial aquifer, which maintains permanent and semi-permanent pools; a number of which are within the Development Envelope (Section 5, Rio Tinto 2019a). These pools are maintained by groundwater in the absence of surface water inputs, with a range in seasonal groundwater levels of up to 3 m, as recorded in alluvial bores within the Study Area (Rio Tinto 2019a). As groundwater levels drop during prolonged dry periods, the semi-permanent pools may dry out.

Key features of the vegetation associated with the Robe River in the Study Area (as summarised by Astron 2018) include:

- No threatened or PECs and no Threatened flora; however, does contain Priority flora (primarily *Rhynchosia bungarensis* P4)
- Permanent and semi-permanent pools. These pools generally support high species diversity. Vegetation surrounding these pools is typically dominated by dense *Melaleuca argentea* and *Eucalyptus camaldulensis* subsp. *refulgens* over sedge, grass and herbaceous species
- Pools and main channels support GDEs including GDV, dominated by *M. argentea*
- Vegetation condition rates from 'Very Poor' to 'Excellent' condition in the Robe River and its tributaries. Poorer condition is generally as a result of weed proliferation, grazing and trampling. **Cenchrus* species (spp.) (Buffel and Birdwood Grasses) are a common component of the vegetation in some areas.

Jimmawurrada Creek

Jimmawurrada Creek is an ephemeral creek which possesses stretches of riparian vegetation which has been modified by changes to drainage lines; drawdown associated with the Mesa J Iron Ore Development, the Southern Cutback Borefield and the Coastal Water Supply; and mine dewatering discharge through existing licensed outlets.

Key features of the vegetation associated with Jimmawurrada Creek in the Study Area include:

- No threatened or PECs and no Threatened flora
- No Permanent and semi-permanent pools
- Vegetation is dominated by Eucalyptus camaldulensis subsp. refulgens and E. victrix
- Vegetation condition rates from 'very poor' to 'excellent' condition. Poorer condition is generally as a result of weed proliferation, grazing and trampling. **Cenchrus* species (Buffel and Birdwood Grasses) are a common component of the vegetation in some areas.

Refined Riparian Mapping

Given the local and sub-regional significance of the riparian zone vegetation, a refined riparian mapping program was undertaken via a targeted vegetation survey across both the Robe River and Jimmawurrada Creek (Rio Tinto 2018d, 2018e) in order to attribute a potential impact 'risk rating' to each vegetation association. This involved an interpretation of the degree of sensitivity (or vulnerability) of each community to hydrological change and the risk that "measurable" impact / change to a community could result from significant hydrological changes. This interpretation was aided by the collection of *Melaleuca argentea* age structure data throughout the study area.

Within the Proposed Change Area, Astron (2016a) mapped two riparian communities which they identified as potential GDE's; MaEcCv (147 ha) representing the obligate phreatophytic or generally "high risk" (sensitivity to groundwater change) type communities mapped by Rio Tinto (2018d) and EcEvAtrApyPlTw (312 ha) representing the FPV or generally "moderate risk" (sensitivity to groundwater change) type communities mapped by Rio Tinto (2018d) Table 6-8. Vegetation association MaEcCv was considered a GDE due to the dominant species being *Melaleuca argentea* (an obligate phreatophyte) and *E. camaldulensis* var. *refulgens* (a FPV). *M. argentea* and *E. camaldulensis* var. *refulgens*, and therefore the vegetation community in which they predominate, is highly likely to be sensitive to changes in groundwater depth and availability. These two vegetation associations are typical of riparian vegetation communities which occur along minor and major channels within the River Land System in the Pilbara.

The two broad riparian vegetation units identified by Astron (2016a; 2016b) as GDE's have been further refined into ten units mapped by Rio Tinto (2018d; 2018e), only three of which are considered to contain obligate phreatophytes (Table 6-5). The detailed differentiation by Rio Tinto (2018d; 2018e) is based on differences in canopy structure, the dominance or co-dominance of *E. camaldulensis* versus *E. victrix*, and differences in mesic understorey composition observed through detailed field mapping (Rio Tinto 2018d, 2018e).

The three key vegetation associations identified by Rio Tinto (2018d, 2018e) as representing GDE communities and dominated by obligate phreatophytes comprise; C1AA (a&b), C1A, and C1B. The C1AA (a&b) and C1A communities possess relatively mature populations of obligate phreatophytes, while the C1B community comprises a relatively immature population. The mature communities generally possessed an even age structure among obligate phreatophyte populations, likely indicating more consistent groundwater access, whereas the skewed age structure of the immature community tends to indicate a more transient nature, less consistent groundwater access and increasing potential to have established in response to dewatering discharge.

The C1AA communities have a canopy dominated by *Melaleuca argentea,* which generally form an open forest overstorey, whereas C1A and C1B communities had an overstorey only co-dominated by *Melaleuca argentea* (and *Eucalyptus* spp.).

Table 6-8: Significant Riparian Vegetation Units in the Study Area

Astron (2016a, 2016b) vegetation association	Equivalent (or associated) Rio Tinto (2018d, 2018e) units*	Broad Rio Tinto (2018d, 2018e) GDE classification type	Rio Tinto (2018d, 2018e) Residual Significance
MaEcCv	**C1AA (a&b)** **C1A, C1B**	Vegetation at least co-dominated by the obligate phreatophyte *Melaleuca argentea* of varying age structure.	High to Moderate (locally to sub-regionally significant).
EcEvAtrApyPlTw	**C2AA**, C2AACr, C2A, C2B, C2A-B, C2B-B, C3A	Vegetation at least co-dominated by the facultative phreatophyte *Eucalyptus camaldulensis.*	Moderate to Minor (locally restricted but common locally and regionally).

*Bold and underlined units indicate significant vegetation

Of the Rio Tinto (2018d) refined riparian vegetation units, only the *Melaleuca argentea* dominated and co-dominated communities (C1AA (a&b)), are considered locally and sub-regionally significant as potential GDE's (Rio Tinto 2018d, 2018e). Unit C2AA (*Eucalyptus camaldulensis* open forest) is considered to be locally significant and similar to Astron's (2016a) EcEvAtrApyPlTw community.

Unit C2A (*Eucalyptus camaldulensis* woodland-open forest) mapped on Jimmawurrada Creek is similar to the significant C2AA community but the conservation significance is reduced on the basis of it being restricted to creek landforms, possessing lower species diversity, having reduced condition due to grazing pressure and alteration of the community from discharge. The remaining units are typically found in mesic riparian environments and are widely represented in creek and river systems in the Pilbara (Rio Tinto 2018d).

In total, there was 149 ha of mapped GDV (Rio Tinto 2018d) in the Proposed Change Area which was considered to be locally and sub-regionally significant (3.1% of the Proposed Change Area). A further 6,915 ha of riparian vegetation was mapped within the wider Study Area (approx. 30 km radius from the Development Envelope); including 639 ha of significant GDV (Table 6-9). The detailed mapping is described in Rio Tinto (2018d, 2018e) (Figure 6-6).

Table 6-9: Significant Riparian Vegetation Units in the Proposed Change Area and Broader Study Area

Vegetation unit	Vegetation description	Hectares in Proposed Change Area (ha)	Hectares mapped within the broader Study Area (ha) – 30 km radius
C1AAa	Mature *Melaleuca argentea* dominated open-closed forest.	1.1	77
C1AAb	Mature *Melaleuca argentea* dominated open forest.	31.6	119
C1A	Mature *Melaleuca argentea* and *Eucalyptus camaldulensis* dominated open forest to low woodland.	66.4	172
C1b	*Melaleuca argentea* (immature) and *Eucalyptus camaldulensis* dominated low woodland.	50.1	155
C2AA	Mesic *Eucalyptus camaldulensis* dominated Open Forest - large Representations.	0	116

6.4.5.2 Pool ecosystems

Springs and pools of the Robe River are listed as 'Wetlands of Subregional Significance' in Kendrick (2001). These springs and pools occur approximately 30 km east of the Proposed Change Area, downstream towards the North West Coastal Highway.

Beyond terrestrial vegetation based GDE's which rely on shallow groundwater; permanent and semi-permanent pools along the Robe River support "River Pool Ecosystem" type GDEs. These ecosystems are an important component of the river ecosystem, supporting a diverse range of aquatic fauna and specialised flora, and rely on consistent surface expressions of groundwater. They are often characterised by a specific assemblage of phreatophytes, macrophytes, mesic shrubs and ephemeral taxa including flora such as yellow bladderwort (*Utricularia australis*) and water chestnut (*Eleocharis dulcis*) (WRM 2018). Phreatophytes only inhabit areas where they have access to groundwater in order satisfy at least some proportion of their EWRs (Eamus *et al.* 2006) whereas macrophytes are aquatic plants which are completely dependent on surface or groundwater for their continued existence.

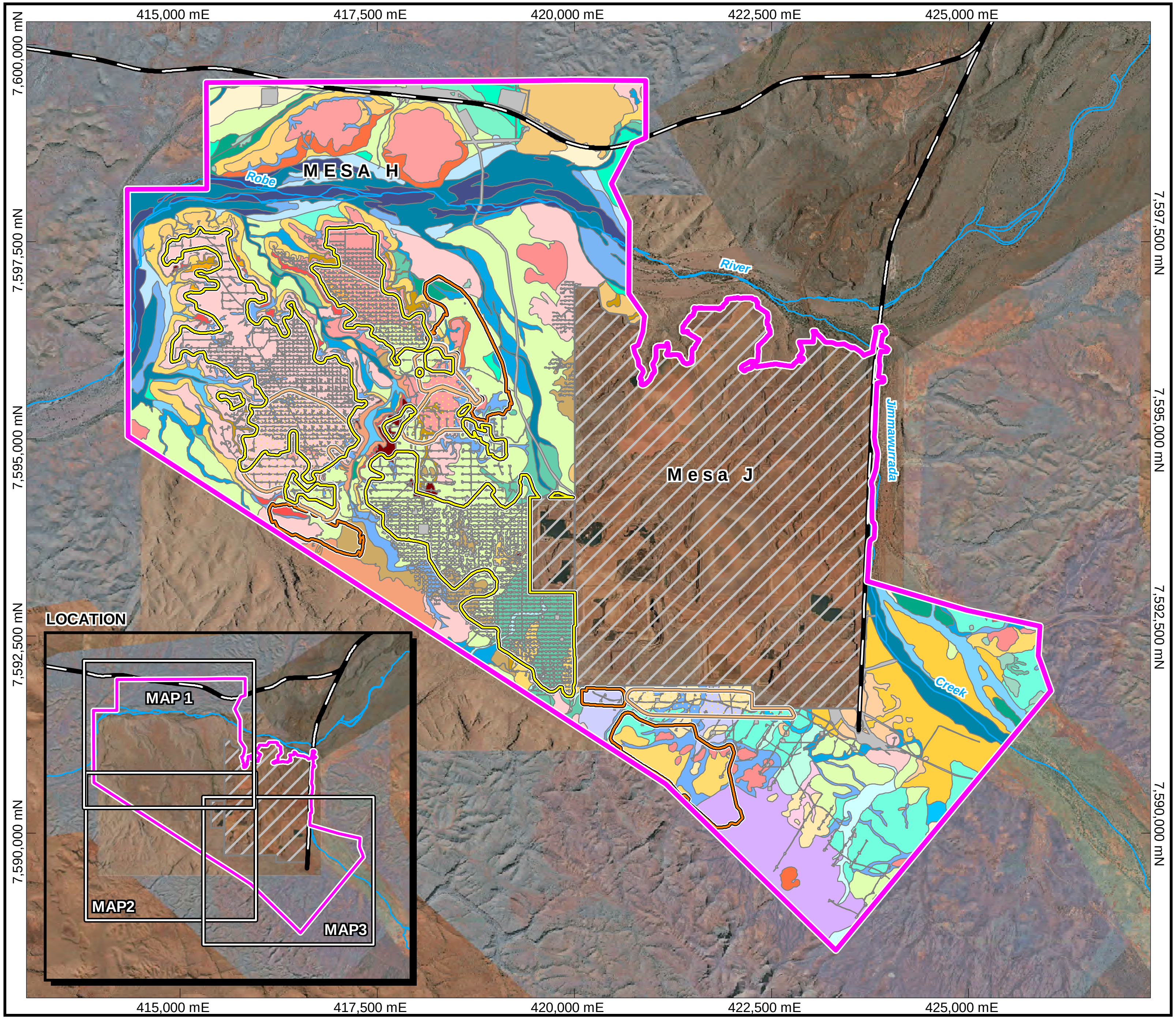
Astron (2016a; 2016b), and Rio Tinto (2018d) identified the scattered presence of several pools along the Robe River within the Proposed Change Area as supporting assemblages of species unique from other habitats. The main pools identified include Yeera Bluff pools, Duck Pool, Japanese Pool, Paturarr, and Watpari, together with numerous smaller more ephemeral pools.

The woodland / open-forest communities which have established around these pool features typically comprise vegetation association MaEcCv dominated by *M. argentea* and *E. camaldulensis* var. *refulgens*. These vegetation associations are consistent with the vegetation that typically occurs along minor and major channels within the River land system. The fringing vegetation generally supported a high diversity of flora species and the pools themselves were found to have elevated to high macrophyte (including sedges) and ephemeral taxa diversity (Astron 2016a; Rio Tinto 2018d).

Cyclonic events and associated rainfall however, can severely affect the riparian vegetation and alter the size and position of permanent pools through scouring and aggradation (Dobbs & Davies 2009).

6.4.5.3 Wetland Mosaic

An intermittent wetland or floodplain derived vegetation mosaic was recorded 9 km to the south-east of Mesa J in the Jimmawurrada – Bungaroo valley. The species assemblages and their large spatial extent is very unusual outside of riverine / creekline environments however the communities are outside the Development Envelope and outside the modelled influence of groundwater drawdown from the Revised Proposal.



LEGEND

Development Envelope
Ministerial Statement 208
Railway
Major Watercourse

Conceptual Mine Layout

Mine Pit
Waste Dump
Topsoil / Subsoil Stockpile

N

SCALE

0 1 2 3km

1:70 000 @ A4

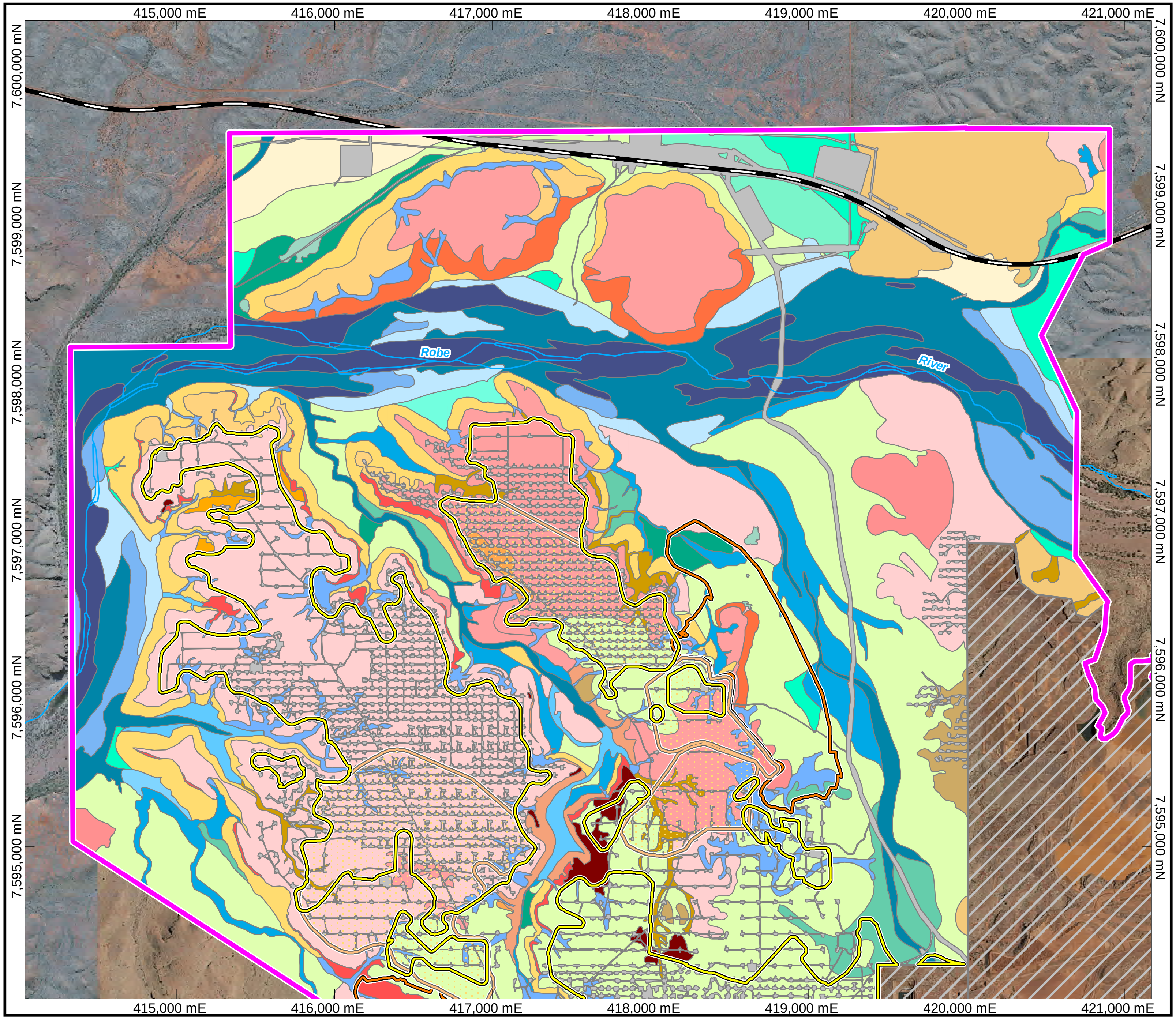
Rio Tinto

Iron Ore (WA)

Figure 6-3 (Overview): Vegetation communities in the Development Envelope

Drawn: M.Swebbs
Date: February, 2019
Plan No: PDE0152232v9
Proj: MGA 94 Zone 50

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile

N

SCALE

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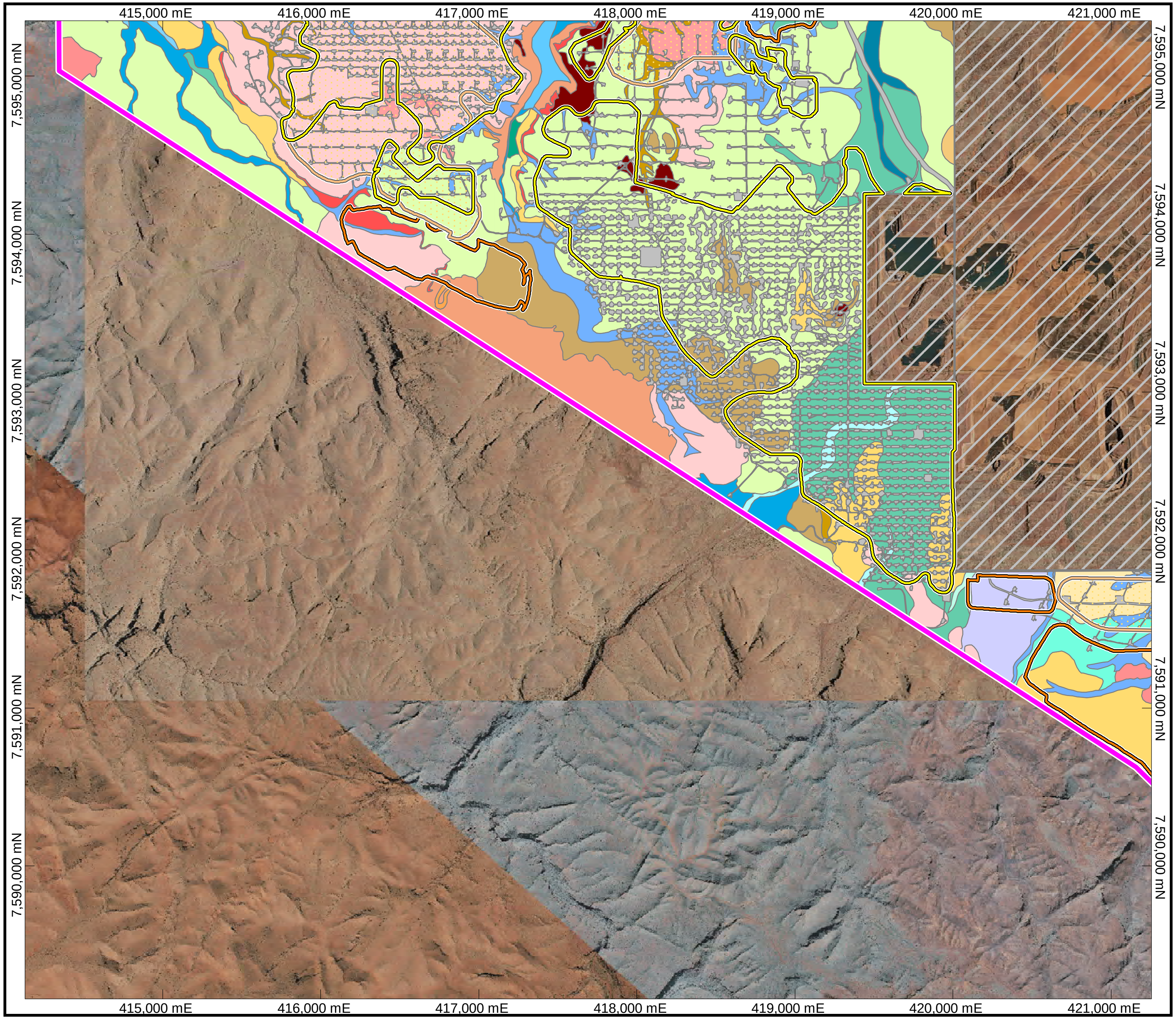
1:35 000 @ A4

Iron Ore (WA)

Figure 6-3 (Map 1): Vegetation communities in the Development Envelope

Drawn: M.Swebbs
Date: February, 2019
Plan No: PDE0152232v9
Proj: MGA 94 Zone 50

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile

N

SCALE

0 0.5 1 1.5km

1:35 000 @ A4

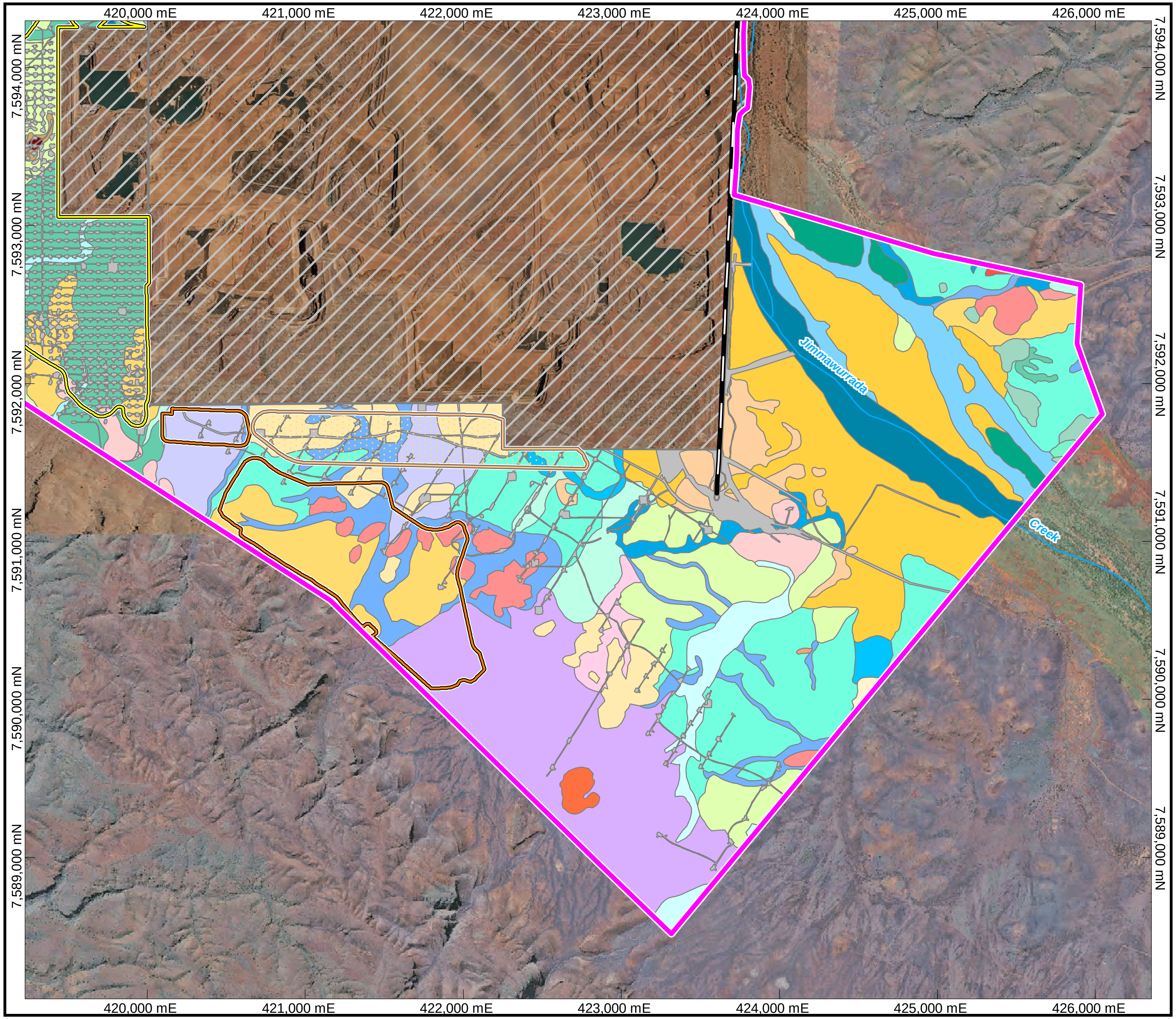
RioTinto

Iron Ore (WA)

Figure 6-3 (Map 2): Vegetation communities in the Development Envelope

Drawn: M.Swebbs Plan No: PDE0152232v9
Date: February, 2019 Proj: MGA 94 Zone 50

Geospatial Information and Mapping



LEGEND

Development Envelope

Ministerial Statement 208

Railway

Major Watercourse

Conceptual Mine Layout

Mine Pit

Waste Dump

Topsoil / Subsoil Stockpile

N

SCALE

0 0.5 1 1.5km

1:35 000 @ A4

Disclaimer

Rio Tinto

Iron Ore (WA)

Figure 6-3 (Map 3): Vegetation communities in the Development Envelope

Drawn: M.Swebbs
Date: February, 2019
Plan No: PDE0152232v9
Proj: MGA 94 Zone 50

Geospatial Information and Mapping

Figure 6-3 (Legend): Vegetation Communities in the Development

Mesa tops / Hilltops / Mesa slopes / Hillslopes

AaAbTwTspR
Acacia ancistrocarpa, A. bivenosa scattered shrubs to open shrubland over Triodia wiseana (T. sp. Robe River (M.E. Trudgen et al. MET 12367)) open hummock grassland.

AacTw
Acacia acradenia tall shrubland over Triodia wiseana hummock grassland.

AacTwTsr
Acacia acradenia open shrubland to open heath over Triodia wiseana (T. sp. Robe River (M.E. Trudgen et al. MET 12367)) hummock grassland.a

AbTw
Acacia bivenosa open shrubland to open heath over Triodia wiseana hummock grassland.

AiAanTw
Acacia inaequilatera and A. ancistrocarpa scattered tall shrubs to tall open shrubland over Triodia wiseana open hummock grassland to hummock grassland.

AiAbTw
Acacia inaequilatera scattered tall shrubs over A. bivenosa scattered shrubs over Triodia wiseana hummock grassland.

AiAptTw
Acacia inaequilatera scattered shrubs to scattered tall shrubs over A. ptychophylla scattered low shrubs to low open shrubland over Triodia wiseana open hummock grassland.

AiTwTsr
Acacia inaequilatera scattered tall shrubs over Triodia wiseana, T. sp. Robe River (M.E. Trudgen et al. MET 12367) open hummock to hummock grassland.

AprTw
Tall open shrubland of Acacia pruinocarpa. Open hummock grassland of Triodia wiseana.

AprTwTsr
Acacia pruinocarpa low woodland over Triodia wiseana, T. sp. Robe River (M.E. Trudgen et al. MET 12367) open hummock grassland.

AptTw
Acacia ptychophylla low open shrubland over Triodia wiseana open hummock grassland.

AtuTwTsr
Acacia tumida var. pilbarensis tall shrubland over Triodia wiseana, T. sp. Robe River (M.E. Trudgen et al. MET 12367) open hummock grassland.

ChAiAbTw
Corymbia hamersleyana scattered low trees over Acacia inaequilatera scattered tall shrubs over A. bivenosa scattered shrubs over Triodia wiseana hummock grassland.

ElAiAbTw
Eucalyptus leucophloia subsp. leucophloia scattered low trees over Acacia inaequilatera scattered tall shrubs over A. bivenosa scattered shrubs to open shrubland over Triodia wiseana hummock grassland.

ElAiTwTsr
Eucalyptus leucophloia subsp. leucophloia low open woodland over Acacia inaequilatera scattered tall shrubs over Triodia wiseana (T. sp. Robe River (M.E. Trudgen et al. MET 12367) on breakaways) open hummock grassland.

ElTw
Eucalyptus leucophloia subsp. leucophloia scattered low trees to low open woodland over Triodia wiseana very open hummock grassland.

Tw
Triodia wiseana open hummock grassland.

Major and Minor drainage

AtrPl
Acacia trachycarpa, Petalostylis labicheoides tall open scrub.

CcTeTw
Corymbia candida low woodland over Triodia epactia and/or T. wiseana open hummock grassland.

ChAsppGOrGsppPlSsTeTw
Corymbia hamersleyana scattered low trees to low open woodland over Acacia spp., Gossypium robinsonii, Grevillea spp., Petalostylis labicheoides, Stylobasium spathulatum tall shrubland over Triodia epactia, T. wiseana hummock grassland.

ChAtuTe
Corymbia hamersleyana scattered low trees over Acacia tumida var. pilbarensis tall open scrub over Triodia epactia open hummock grassland to hummock grassland.

ChAtuTw
Corymbia hamersleyana and/or Eucalyptus leucophloia subsp. leucophloia scattered low trees over Acacia tumida var. pilbarensis tall open scrub over Triodia wiseana open hummock grassland.

ChPlAbGOrTw
Corymbia hamersleyana low open woodland over Petalostylis labicheoides, Acacia bivenosa, Gossypium robinsonii tall open scrub over Triodia wiseana (T. angusta) open hummock grassland.

EcEvAtrApyPlTw
Eucalyptus camaldulensis subsp. refulgens woodland over E. victrix low woodland over Acacia trachycarpa, A. pyrifolia var. pyrifolia, Petalostylis labicheoides tall open shrubland over mixed open herbland and Triodia wiseana scattered hummock grasses.

Es
Euphorbia schultzii scattered herbs.

EvAtrTwCspp
Eucalyptus victrix low open woodland over Acacia trachycarpa tall open shrubland over Triodia wiseana open hummock grassland and *Cenchrus spp. very open tussock grassland.

MaEcCv
Melaleuca argentea, Eucalyptus camaldulensis subsp. refulgens open forest over Cyperus vaginatus scattered sedges to very open sedgeland.

TspFCAoTe
Tephrosia rosea var. Fortescue creeks (M.I.H. Brooker 2186) low open shrubland to low open heath over Triodia epactia scattered hummock grasses to very open hummock grassland, with *Argemone ochroleuca subsp. ochroleuca scattered herbs.

Disturbed

Plains

AaTeTw
Acacia ancistrocarpa tall open shrubland over Triodia epactia, T. wiseana hummock grassland.

AiAaAbTw
Acacia inaequilatera, A. bivenosa, A. ancistrocarpa open shrubland over Triodia wiseana open hummock grassland.

AsAbTwCspp
Acacia synchronicia, A. bivenosa tall open shrubland over Triodia wiseana very open hummock grassland and *Cenchrus ciliaris, *C. setiger open tussock grassland.

AsTe
Acacia synchronicia scattered shrubs over Triodia epactia hummock grassland.

AsTw
Acacia synchronicia open shrubland over Triodia wiseana open hummock grassland.

AxTe
Acacia xiphophylla tall open shrubland over Triodia epactia (T. wiseana) very open hummock grassland.

AxTw
Acacia xiphophylla low woodland to tall shrubland over Triodia wiseana open hummock grassland.

CcAsppTeTwCEc
Corymbia candida scattered low trees over mixed Acacia species tall open shrubland over Triodia wiseana and T. epactia very open hummock grassland to open hummock grassland, with *Cenchrus setiger scattered tussock grasses to very open tussock grassland to hummock grassland.

ChAbTwTe
Corymbia hamersleyana scattered low trees to low woodland over Acacia bivenosa open shrubland over Triodia wiseana, T. epactia hummock grassland.

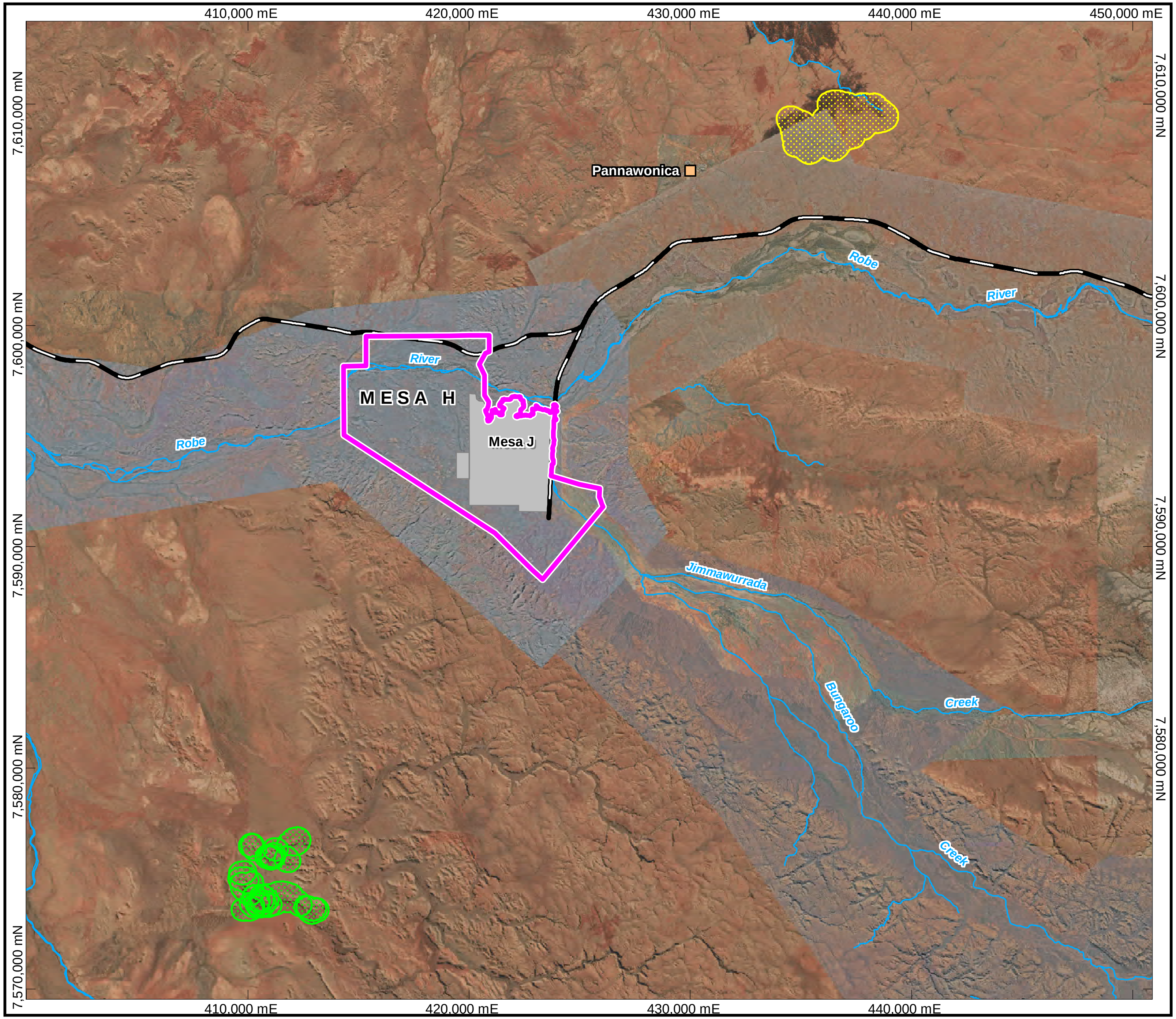
ChTe
Corymbia hamersleyana scattered low trees to low open woodland over Triodia epactia open hummock grassland.

Mosaics

Mosaic of AaTeTw/ChAtuTw
Mosaic of P1 (No upper stratum) and D5 (Scattered low trees of Corymbia hamersleyana). Mosaic of P1 (Tall open shrubland of Acacia ancistrocarpa) and D5 (Tall open scrub of Acacia tumida var. pilbarensis). Mosaic of P1 (Hummock grassland of Triodia epactia and Triodia wiseana) and D5 (Open hummock grassland of Triodia wiseana)

Mosaic of AiAaAbTw/AaTeTw/ChAtuTw
Mosaic of P2 (No upper stratum), P1 (No upper stratum) and D5 (Scattered low trees of Corymbia hamersleyana). Mosaic of P2 (Open shrubland of Acacia inaequilatera, Acacia bivenosa and Acacia ancistrocarpa), P1 (Tall open shrubland of Acacia ancistrocarpa) and D5 (Tall open scrub of Acacia tumida var. pilbarensis). Mosaic of P2 (Open hummock grassland of Triodia wiseana), P1 (Hummock grassland of Triodia epactia and Triodia wiseana) and D5 (Open hummock grassland of Triodia wiseana)

Mosaic of AiAaAbTw/ChAtuTw
Mosaic of P2 (No upper stratum) and D5 (Scattered low trees of Corymbia hamersleyana). Mosaic of P2 (Open shrubland of Acacia inaequilatera, Acacia bivenosa and Acacia ancistrocarpa) and D5 (Tall open scrub of Acacia tumida var. pilbarensis). Mosaic of P2 (Open hummock grassland of Triodia wiseana) and D5 (Open hummock grassland of Triodia wiseana).



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse

Priority Ecological Community

- Triodia sp. Robe River assemblages of mesas of the west Pilbara
- Four plant assemblages of the Wona Land System (previously 'Cracking clays of the Chichester and Mungaroona Range')

N

SCALE

0 2.5 5 7.5 10km

1:250 000 @ A4

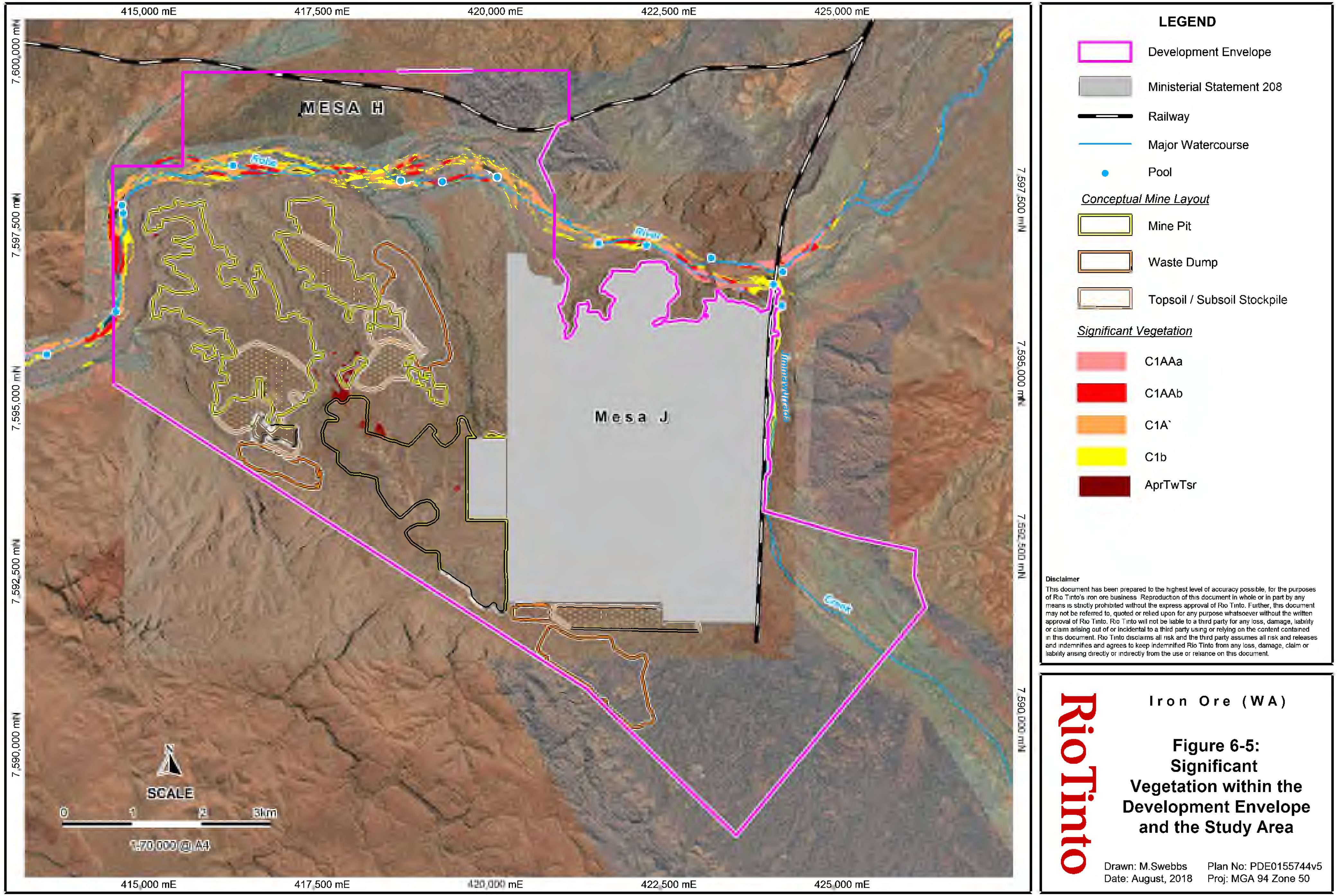
RioTinto

Iron Ore (WA)

Figure 6-4: Vegetation and Flora Priority Ecological Communities in the Broader Study Area

Drawn: M.Swebbs
Date: Dec, 2018

Plan No: PDE0161255v3
Proj: MGA 94 Zone 50



RioTinto

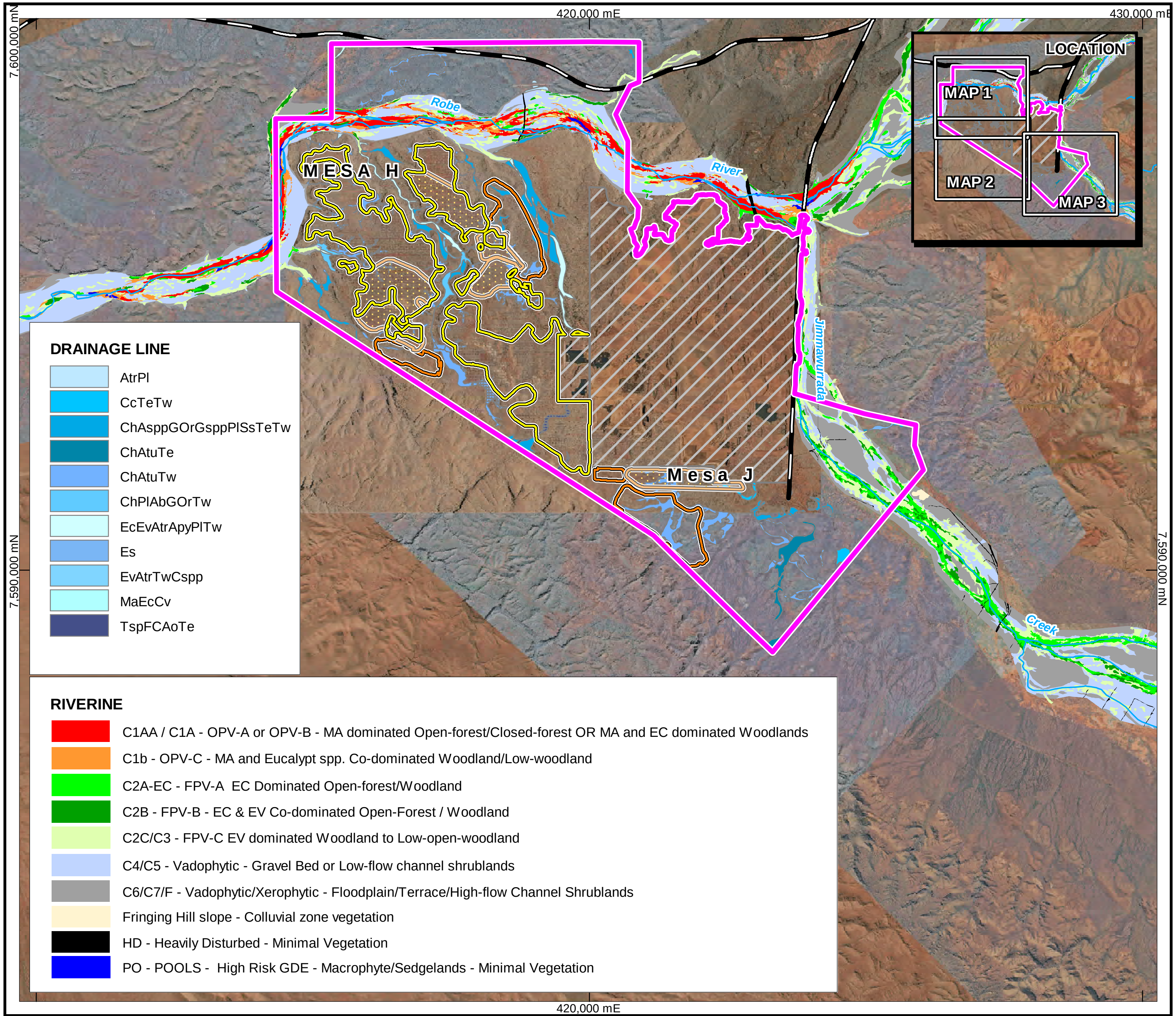
Iron Ore (WA)

Figure 6-5: Significant Vegetation within the Development Envelope and the Study Area

Drawn: M.Swebbs
Date: August, 2018

Plan No: PDE0155744v5
Proj: MGA 94 Zone 50

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile

N

SCALE

1 0 1 2 3km

1:100 000 @ A4

RioTinto

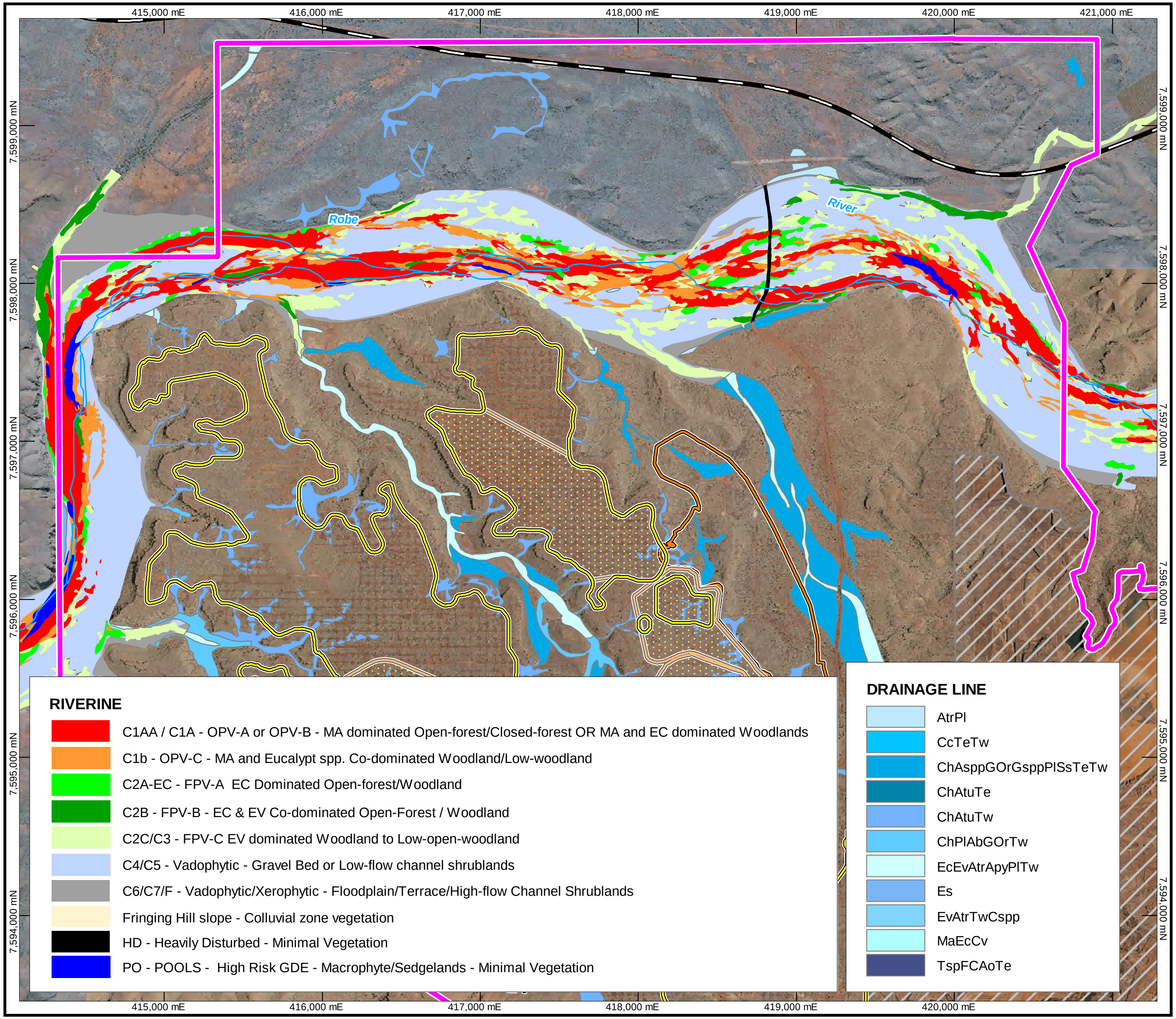
Iron Ore (WA)

Figure 6-6 (Overview): Refined Riparian vegetation units in the Development Envelope and Study Area

Drawn: M.Swebbs
Date: Feb, 2019

Plan No: PDE0155742v5
Proj: MGA 94 Zone 50

Geospatial Information and Mapping



RIVERINE

- C1AA / C1A - OPV-A or OPV-B - MA dominated Open-forest/Closed-forest OR MA and EC dominated Woodlands
- C1b - OPV-C - MA and Eucalypt spp. Co-dominated Woodland/Low-woodland
- C2A-EC - FPV-A EC Dominated Open-forest/Woodland
- C2B - FPV-B - EC & EV Co-dominated Open-Forest / Woodland
- C2C/C3 - FPV-C EV dominated Woodland to Low-open-woodland
- C4/C5 - Vadophytic - Gravel Bed or Low-flow channel shrublands
- C6/C7/F - Vadophytic/Xerophytic - Floodplain/Terrace/High-flow Channel Shrublands
- Fringing Hill slope - Colluvial zone vegetation
- HD - Heavily Disturbed - Minimal Vegetation
- PO - POOLS - High Risk GDE - Macrophyte/Sedgelands - Minimal Vegetation

DRAINAGE LINE

- AtrPl
- CcTeTw
- ChAsppGOrGsppPlSsTeTw
- ChAtuTe
- ChAtuTw
- ChPlAbGOrTw
- EcEvAtrApyPlTw
- Es
- EvAtrTwCspp
- MaEcCv
- TspFCAoTe

LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile

N

SCALE

0 0.5 1 1.5km

1:35 000 @ A4

RioTinto

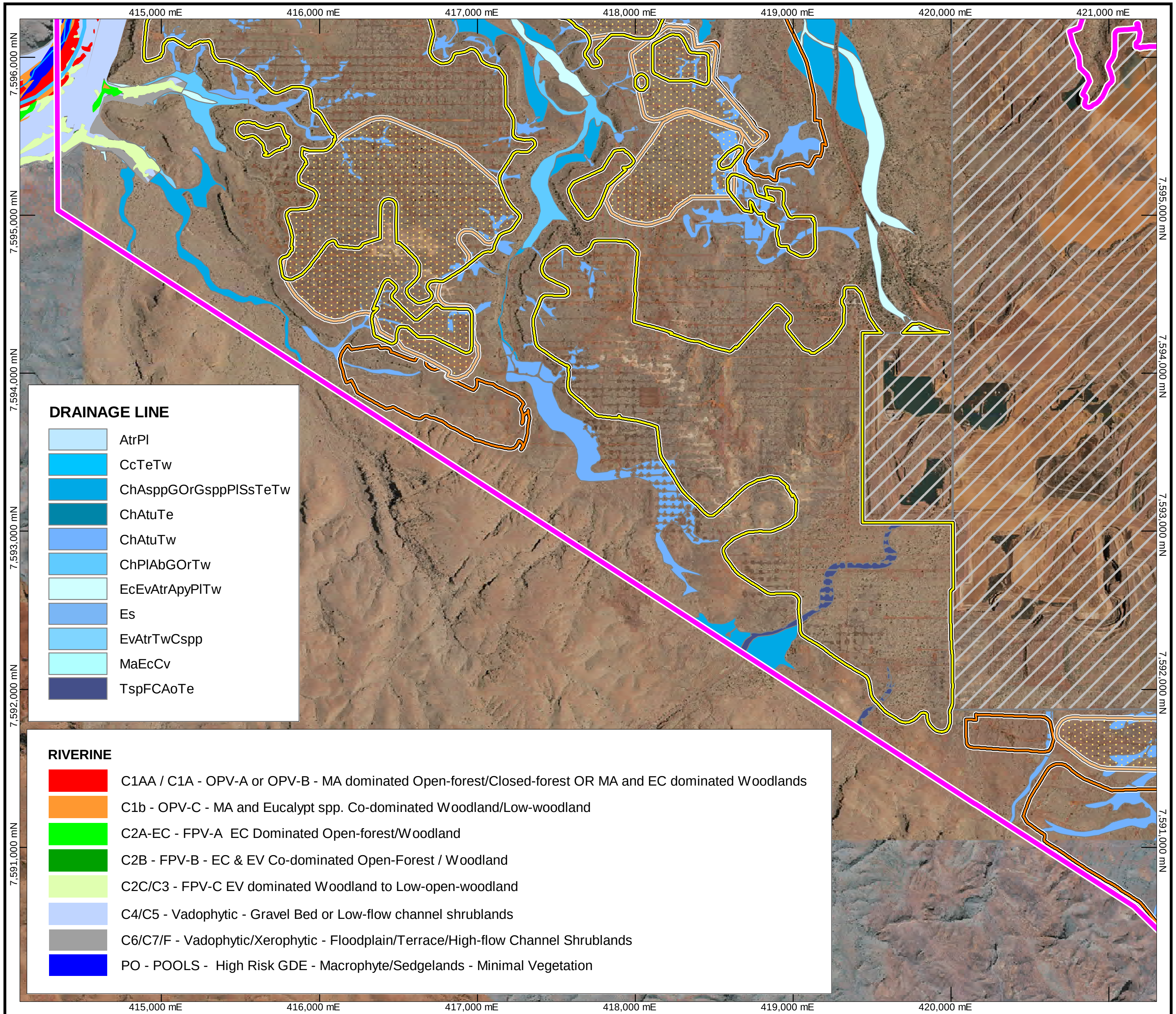
Iron Ore (WA)

Figure 6-6 (Map 1): Refined Riparian vegetation units in the Development Envelope and Study Area

Drawn: M.Swebbs
Date: Feb, 2019

Plan No: PDE0155742v5
Proj: MGA 94 Zone 50

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile

N

SCALE

0 0.5 1 1.5km

1:35 000 @ A4

RioTinto

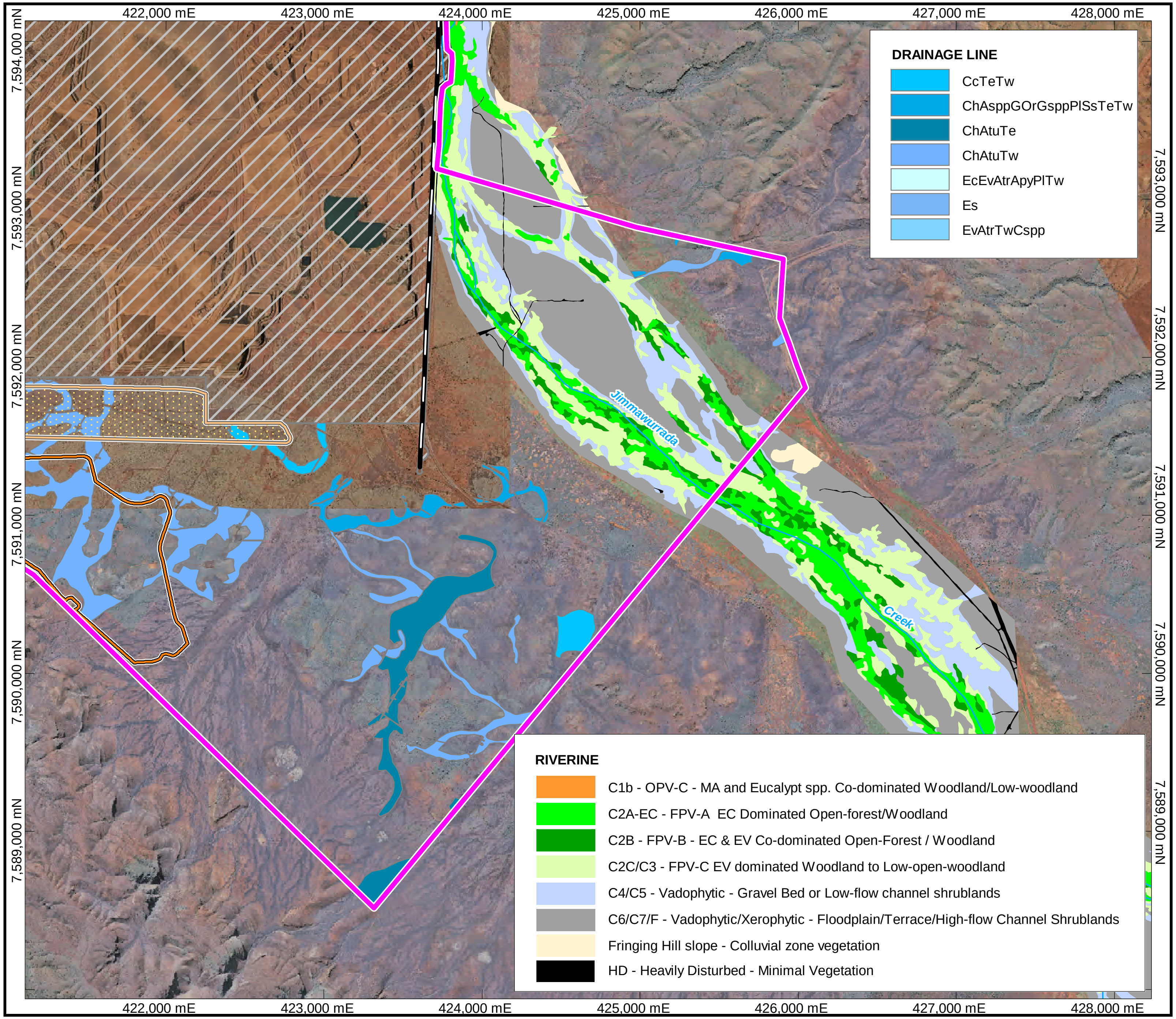
Iron Ore (WA)

Figure 6-6 (Map 2): Refined Riparian vegetation units in the Development Envelope and Study Area

Drawn: M.Swebbs
Date: Feb, 2019

Plan No: PDE0155742v5
Proj: MGA 94 Zone 50

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile

N

SCALE

0 0.5 1 1.5km

1:35 000 @ A4

Iron Ore (WA)

Figure 6-6 (Map 3): Refined Riparian vegetation units in the Development Envelope and Study Area

Drawn: M.Swebbs
Date: Feb, 2019

Plan No: PDE0155742v5
Proj: MGA 94 Zone 50

Geospatial Information and Mapping

6.4.6 Significant flora

Astron (2016a) recorded a total of 310 vascular flora taxa within the Proposed Change Area from 53 families and 150 genera including 20 introduced taxa (weeds). A further 36 specimens were unable to be identified to species level and these may represent additional taxa.

No State or Federally listed Threatened Flora were recorded or are likely to occur in the Proposed Change Area (Astron 2016a).

Targeted searches by Astron (2016a) identified three State Listed Priority species in the Proposed Change Area. These are identified in Table 6-10 and their recorded locations shown on Figure 6-7.

Table 6-10: Priority Species Recorded in the Development Envelope (Astron 2016a)

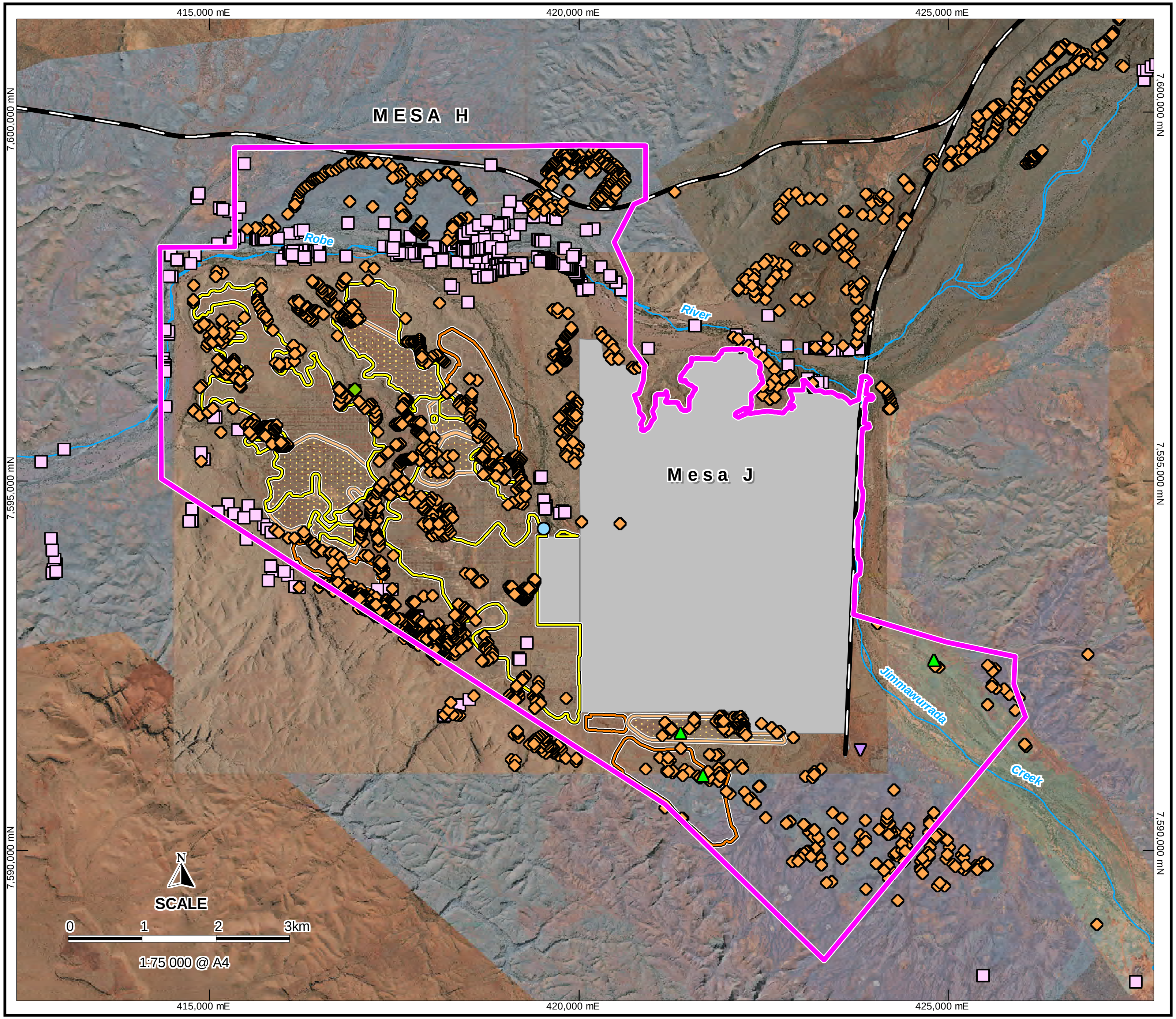
Taxon	Conservation Status	No. of individuals in Proposed Change Area	No. of populations in the Proposed Change Area	Habitat
Indigofera sp. Bungaroo Creek (S van Leeuwin 4301).	Priority 3	24	3	Floodplain of major creek.
Triodia sp. Robe River (M.E Trudgen *et al*. MET 12367).	Priority 3	90, 270	1,719	Crests and upper slopes of mesas, gullies / gorges.
Rhynchosia bungarensis.	Priority 4	2,944	306	Major drainage (Robe River).

Three additional taxa of interest were recorded in the Proposed Change Area. Single records of *Cynanchum pedunculatum, Sauropus crassifolius* and *Senna* sp. Meekatharra (E. Bailey 1-26) were considered to fall beyond their normal range of occurrence (Table 6-11; Figure 6-7). All three species have been recorded previously in the Pilbara and their presence in the Proposed Change Area does not represent a significant range extension in the context of their known distribution (Atlas of living Australia 2018).

Table 6-11: Other Flora of Interest Recorded in the Proposed Change Area

Taxon	Nearest Known Location	Information
Cynanchum penduncculatum.	160 km	Single specimen recorded. Typically occurs further east, around Tom Price or in the northern Kimberley.
Sauropus crassifolius.	180 km	Single specimen recorded. Previously recorded in the southern Pilbara, as well as Cape Range, Gascoyne, Murchison, Yalgoo and Geraldton sandplains.
Senna sp. Meekatharra (E. Bailey 1-26).	Tom Price (190 km)	Single specimen recorded. Records extend from Tom Price to the Gascoyne, Cape Range, Gascoyne, Murchison and Yalgoo regions.

The absence of previous recordings in the area is more likely to be a product of broad-scale under-collection and visual misidentification (without collection of physical specimens) than actual restriction to the locality. Therefore, given that these taxa likely have a wider distribution, combined with no records occurring within the current proposed disturbance footprint, these species have not been considered further in the assessment of impacts from the Proposed Change.



LEGEND

Development Envelope

Ministerial Statement

Railway

Major Watercourse

Conceptual Mine Layout

Mine Pit

Waste Dump

Topsoil / Subsoil Stockpile

Priority 3 Flora

Indigofera sp. Bungaroo Creek (S. van Leeuwen 4301)

Triodia sp. Robe River (M.E. Trudgen at al. MET 12367)

Priority 4 Flora

Rhynchosia bungarensis

Species of Interest

Cynanchum pedunculatum

Sauropus crassifolius

Senna sp. Meekatharra (E. Bailey 1-26)

Iron Ore (WA)

Figure 6-7: Priority flora in or near the Development Envelope

Drawn: M.Swebbs
Date: Jan, 2019

Plan No: PDE0152304v6
Proj: MGA 94 Zone 50

Geospatial Information and Mapping

6.4.7 Vegetation condition

Vegetation within the Proposed Change Area ranged from Very Poor to Excellent (Figure 6-8). The majority of vegetation (80%) was identified as being Excellent or Very Good (Astron 2016a). Approximately 2% of the Proposed Change Area was considered to be in Poor or Very Poor condition. Disturbance was mostly related to high weed infestation of the deeper soils on plains and drainage lines; cattle grazing and trampling; exploration drill lines, drill pads and vehicle tracks.

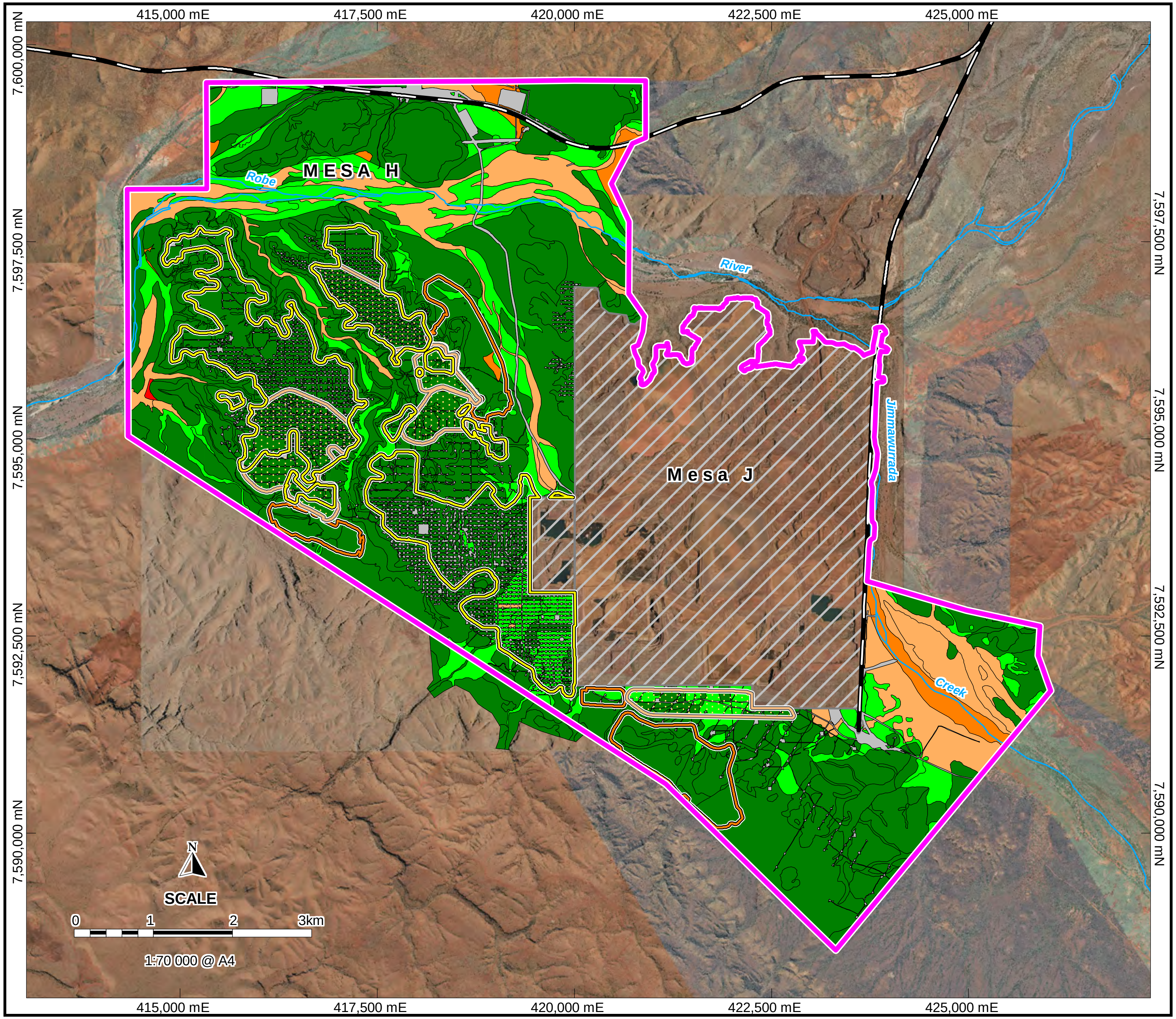
A total of 26 introduced flora species have been recorded within the Proposed Change Area as listed in Table 6-12 and shown on Figure 6-9, none of which were listed as Declared Pests or as Weeds of National Significance (Astron 2016a). **Cenchrus ciliaris* (Buffel Grass) and **Cenchrus setiger* (Birdwood Grass) were the most abundant weed species occurring predominantly in disturbed areas, in major and minor drainages and on plains (Astron 2016a).

Tamarisk, a declared weed / WONS has been recently observed along a tributary to the Robe River, north of Mesa H, outside the Development Envelope by a Rio Tinto botanist.

Table 6-12: Introduced Flora Taxa Present within the Proposed Change Area

Species	Family	Habitat
**Aerva javanica* (Kapok Bush)	Amaranthaceae	Disturbed, major and minor drainage, plains.
**Argemone ochroleuca*	Orobanchaceae	Disturbed, major and minor drainage.
**Argemone ochroleuca* subsp. *ochroleuca* (Mexican Poppy)	Papaveraceae	Disturbed, major and minor drainage.
**Bidens bipinnata* (Bipinnate Beggartick)	Asteraceae	Major and minor drainage.
**Cenchrus ciliaris* (Buffel Grass)	Poaceae	Disturbed, plains, major and minor drainage.
**Cenchrus setiger* (Birdwood Grass)	Poaceae	Disturbed, major and minor drainage, plains.
**Chloris barbata* (Purpletop Chloris)	Poaceae	Disturbed, major and minor drainage, plains.
**Citrullus colocynthis* (Colocynth)	Cucurbitaceae	Disturbed, major and minor drainage, plains.
**Cynodon dactylon* (Couch Grass)	Poaceae	Major and minor drainage.
**Datura leichhardtii*	Solanaceae	Disturbed
**Echinochloa colona* (Awnless Barnyard Grass)	Poaceae	Major and minor drainage.
**Euphorbia hirta* (Asthma Plant)	Euphorbiaceae	Major and minor drainage.
**Flaveria trinervia* (Speedy Weed)	Asteraceae	Disturbed, major and minor drainage, plains.
**Lactuca serriola* (Prickly Lettuce)	Asteraceae	Major and minor drainage, plains.
**Malvastrum americanum* (Spiked Malvastrum)	Malvaceae	Disturbed, major and minor drainage, plains.
**Ocimum basilicum* (Basil)	Lamiaceae	Major and minor drainage.

Species	Family	Habitat
**Passiflora foetida*	Passifloraceae	Major and minor drainage.
*Passiflora foetida subsp. hispida	Passifloraceae	Major and minor drainage.
**Passiflora foetida* var. *hispida* (Stinking Passion Flower)	Passifloraceae	Major and minor drainage.
**Phoenix dactylifera* (Date Palm)	Araceae	Major and minor drainage.
**Rumex vesicarius* (Ruby Dock)	Apocynaceae	Disturbed, major and minor drainage, mesa tops and hilltops and mesa slopes and hillslopes, plains.
**Setaria verticillata* (Whorled Pigeon Grass)	Poaceae	Disturbed, major and minor drainage, plains.
**Solanum nigrum*	Solanaceae	Major and minor drainage
**Sonchus oleraceus* (Common Sowthistle)	Asteraceae	Major and minor drainage.
**Tribulus terrestris* (Caltrop)	Zygophyllaceae	Major and minor drainage, plains.
**Vachellia farnesiana* (Mimosa Bush)	Fabaceae	Disturbed, major and minor drainage, plains.



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile

Vegetation Condition

- Excellent
- Very Good
- Good
- Poor
- Very Poor
- Completely Degraded

RioTinto

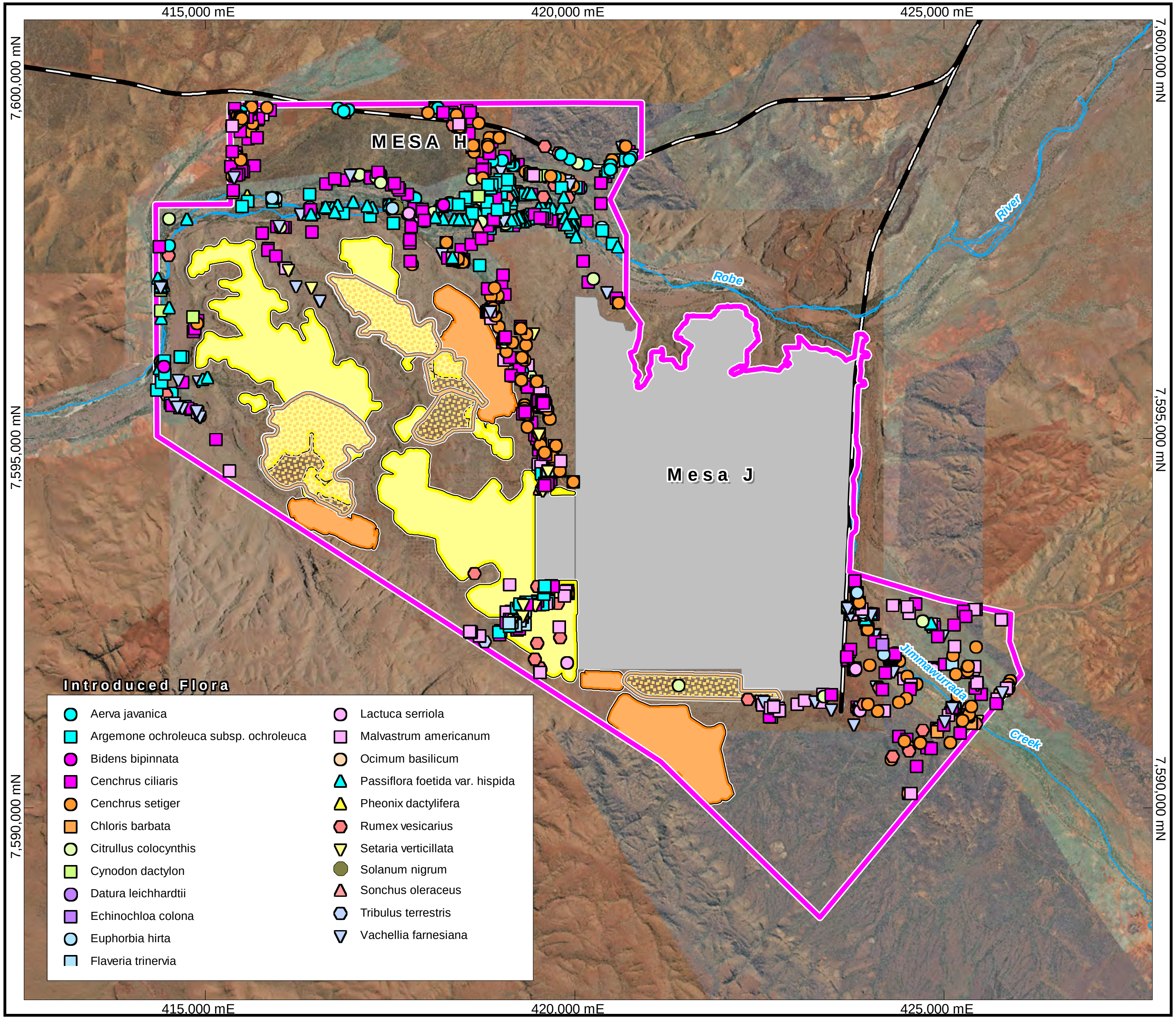
Iron Ore (WA)

Figure 6-8: Vegetation condition in the Development Envelope

Drawn: M.Swebbs
Date: August, 2018

Plan No: PDE0152303v4
Proj: MGA 94 Zone 50

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile

N

SCALE

0 1 2 3km

1:75 000 @ A4

RioTinto

Iron Ore (WA)

Figure 6-9: Distribution of introduced flora in the Development Envelope

Drawn: M.Swebbs
Date: Sept, 2018

Plan No: PDE0161256v4
Proj: MGA94 Zone50

6.5 Potential Impacts

A number of potential impacts to Flora and Vegetation are identified in the ESD. The key potential direct, indirect and cumulative impacts relevant for the Proposed Change on the basis of biological surveys completed to date are addressed in Section 6.6.

6.5.1 Direct impacts

Potential direct impacts of the Proposed Change to flora and vegetation have been identified as:

- Loss of vegetation due to clearing
- Loss of conservation significant flora due to clearing.

The Proposed Change involves clearing of up to 2,200 ha of native vegetation within the Development Envelope to enable construction of the mine and associated infrastructure. Clearing will potentially result in loss of vegetation, including loss of vegetation units of elevated conservation significance. These significant vegetation units include:

- Riparian Vegetation
    - o Robe River: Ground Water Dependant Vegetation (dominated by the Obligate Phreatophyte – *Melaleuca argentea*) along the river and surrounding the semi-permanent and permanent pools
    - o Jimmawurrada Creek: Riparian Vegetation (dominated by Facultative Phreatophytes – *Eucalyptus camaldulensis* and *Eucalyptus victrix)*
- Vegetation analogous to *Triodia sp.* Robe River PEC (AprTwTsr).

The Proposed Change will avoid known locations of Priority Flora as far as practicable however clearing is expected to result in the direct loss of some individuals of conservation significant flora, including the loss of known records within the Proposed Change Area for three Priority Flora taxa:

- *Triodia sp.* Robe River (M.E. Trudgen et al. 12367)
- *Indigofera* sp. Bungaroo Creek (S. van Leeuwen 4301)
- Rhynchosia bungarensis.

6.5.2 Indirect impacts

Potential indirect impacts of the Proposed Change to flora and vegetation have been identified as:

- Loss or degradation of GDV as a result of groundwater drawdown
- Loss or degradation of riparian vegetation as a result of surface water discharge
- Loss or degradation of riparian vegetation as a result of surface water management
- Degradation of vegetation due to ingress of weeds
- Degradation of vegetation due to increased dust deposition.

The Proposed Change will require groundwater abstraction to facilitate mining of the ~20% of ore currently located below the water table, which has the potential to lower groundwater levels in the adjacent sections of the Robe River.

Additional groundwater abstraction for water supply will be required to be sourced from the Southern Cutback Borefield, which currently supplies water to Mesa J Iron Ore Development. This is especially the case during early stages of AWT mining where additional water is required to be sourced to support operational water demand until surplus water is available from dewatering ore below the water table. The additional (~2 GL/a) volume of groundwater abstraction will result in further lowering of the existing lowered groundwater table around the borefield, with the cone of depression ranging from between 4 to 9 m below the pre-mining water table levels along a 12 km stretch of Jimmawurrada Creek. Taking into consideration baseline water table levels fluctuating between 3 – 5 mbgl (within this section of the creek) the peak drawdown equates to up to a maximum of 14 mbgl, which will be experienced below a 6.5 km section of Jimmawurrada Creek. However, if natural recharge in Jimmawurrada Creek is reduced by 50% in Jimmawurrada Creek due to an extended dry period (H3 numerical model 'Uncertainty Run 2' (Rio Tinto 2019a)), the water table levels could be lowered by almost 3 m in addition to the historical seasonal fluctuations; this would translate to localised changes in water table depths of up to 14 m from pre-mining conditions, or ~18 mbgl by 2030. Whilst the shallower outer margins of the alluvial aquifer may experience temporal loss of saturation, between 10 – 22 m of saturated alluvium is estimated to be retained within the deepest part of the channel (thalweg).

The lowered water table levels may reduce the availability of water to GDV occurring within the Proposed Change Area and adjacent sections of Jimmawurrada Creek immediately upstream of the Development Envelope, potentially resulting in health decline of these communities and in some cases death of obligate phreatophytes.

Abstracted groundwater is planned to be used on site for operational requirements where possible however during wet season or significant rainfall events when storage capacity is exceeded, surplus water will be discharged. Discharge of surplus water will be via a number of existing Mesa J discharge outlets into Jimmawurrada Creek and / or West Creek, and may intermittently result in a surface water expression in the downstream Robe River up to 8 km from the discharge outlet(s) depending on seasonal water availability and processing plant water demand. Consequently, discharge rates for the operations will be variable and dependant on seasonal effects. Discharge directly into the Robe River is not proposed unless required as a mitigation strategy for maintaining the pools.

The Proposed Change will result in disruption of natural surface water flows and / or patterns of surface water flow in order to prevent creek flows from entering active mine pit areas. This includes diversion of numerous small creeks from the south, currently intercepted by the Mesa J pits. A 5.5 km diversion drain is proposed along the southern extent of Mesa J and H and will redirect these flows via an existing natural drainage line which bisects Mesa H, back into the Robe River.

Weeds can spread into natural environments by a number of mechanisms including wind, water, vehicles, machinery and fauna (including native fauna and livestock). The most relevant of these mechanisms in relation to the Proposed Change include vehicle and earth moving activities and surplus water discharge.

Dust deposition from the Proposed Change is expected to be generated during vegetation clearing activities; vehicle, heavy haulage and machinery movements; and blasting and excavation. Dust deposition on vegetation as a result of these activities is expected to be localised to immediately adjacent vegetation.

6.5.3 Cumulative Impacts

Potential cumulative impacts of the Revised Proposal to flora and vegetation comprise the clearing of vegetation, including sub-regionally significant vegetation and Priority flora species within the broader Robe Valley.

Table 6-13 shows current, and proposed clearing for Mesa J, Mesa K, Mesa A / Warramboo Iron Ore Project, and the Proposed Change.

Table 6-13: Approved, Current and Proposed Clearing

Mesa J	Mesa K Remnant Mining	Mesa A/Warramboo Iron Ore Project	Mesa A Hub Proposal	Mesa H (The Proposed Change)
Clearing approved under MS 208 (ha)	Clearing approved under MS 776 (ha)	Clearing approved under MS 756 (ha)	Proposed additional clearing (ha)	Proposed total clearing (ha)
1,800	30	3,680	3,000	2,200

Detailed mapping at the scale undertaken for the Proposed Change Area is not broadly available for the Pilbara region. Identification and assessment of potential cumulative impacts to vegetation, therefore, requires broader vegetation mapping such as that completed by Beard (1975a, 1975b) to be used.

Table 6-14 shows the pre-European extent of vegetation units in the Pilbara as defined by Beard (1975a, 1975b), the proposed clearing and the total cumulative clearing taking into account historical, proposed and reasonably foreseeable clearing:

- Existing and historical mining projects: Mining operations (Mesa A / Warramboo, Mesa J, Mesa K, East Deepdale and Middle Robe)
- Existing clearing from other infrastructure: Mesa J and Mesa A Railways, borrow pits, power lines, roads and tracks
- Reasonably foreseeable projects: The Mesa A Hub Revised Proposal and the Proposed Change (currently being assessed).

An assessment of cumulative impacts to vegetation is provided in Section 6.6.4.

Table 6-14: Cumulative Impacts to Vegetation Units Defined by Beard 1990

Vegetation unit	Pre-European extent in Pilbara (ha)	Robe Valley historical clearing (% of pre-European extent)	Proposed Change clearing (% of Pre-European extent)	Total cumulative clearing[1] (% of pre-European extent)
Hamersley 82	2,169,360	<1%	<1%	<1%
Stuart Hills 605	25,730	<1%	4%	4%
Stuart Hills 603	54,800	2%	<1%	2%
Hamersley 609	74,130	2%	2%	4%

[1] Total cumulative clearing = historical + proposed + reasonably foreseeable.

Table 6-15 shows potential cumulative impacts on Priority Flora in the Robe Valley. Only two Priority flora species proposed to be impacted at Mesa H have been (knowingly – based on existing database records) impacted by the Proponent at other operations in the Robe Valley; *Triodia* sp. Robe River (M.E. Trudgen et al. Met 12367) and *Rhynchosia bungarensis*. The existing disturbance provided is the disturbance from implementation of the approved Mesa A / Warramboo Iron Ore Project. Baseline flora surveys for other disturbed areas in the Robe Valley pre-date the Rio Tinto database Total cumulative disturbance includes disturbance from the existing Mesa A / Warramboo Iron Ore Project, proposed disturbance for the Revised Proposal and reasonably foreseeable disturbance that may occur as part of the Mesa A Hub Revised Proposal. Assessment of cumulative impacts to Priority Flora is provided in Section 6.6.4.

Table 6-15: Cumulative impacts on Priority Flora in the Robe Valley

Taxon	Conservation Status	Individuals in Rio Tinto database	Disturbance from existing Mesa J and K, Mesa A / Warramboo	Individuals (% of total Rio Tinto records)		
				Mesa A Hub proposed disturbance	Disturbance from Proposed Change	Total cumulative disturbance[1]
Triodia sp. Robe River (M.E. Trudgen *et al*. Met 12367)	Priority 3	288,681	1 (<1%)	1,774 (<1%)	28,293 (9.8%)	30,068 (10%)
Rhynchosia bungarensis	Priority 4	12,736	12 <1%	38 (<1%)	121 (1%)	171 (1%)

[1] Total cumulative disturbance = Mesa H, Mesa A + reasonably foreseeable. Mesa J & K records pre-date spatial data capture.

6.6 Assessment of Impacts

6.6.1 Direct impacts

6.6.1.1 Loss of vegetation due to clearing

The Proposed Change involves the clearing of up to 2,200 ha of vegetation within a Development Envelope of 6,638 ha to enable the development of the mine and associated infrastructure including mine pits, mineral waste dumps, topsoil / subsoil stockpiles, borefield and haul roads as outlined in Section 2.2.

During the planning for the Proposed Change, a number of options affecting the Proposed Change footprint were considered. These included access roads, water supply, haul road routes and waste dump locations. Preferred options were selected to meet project requirements while minimising clearing of vegetation, particularly significant vegetation, as described below:

- **Access road:** the main access road to Mesa H was selected along an existing unsealed track which crosses the Robe River to the north of the Proposed Change Area. This route minimises the clearing requirements for the section of the track which crosses the Robe River, to limit clearing of stands of *Melaleuca Argentea* (groundwater dependant vegetation). The proposed widening of the access track will be <10 m through the Robe River and largely within a rehabilitated section of the creek line which was previously cleared
- **Water supply**: Water supply options considered included an expansion to the existing water supply borefield at the Southern Cutback Borefield; an extension of the CWSP; or potentially sourcing water from the Warramboo Borefield. An expansion to the existing local Southern Cutback Borefield was selected based on proximity; reduced pipework and associated clearing requirements, in conjunction with consideration of aquifer sustainable yields
- **Haul road routes:** Routes were designed to minimise haulage distances for heavy haulage trucks, however the final routes were designed to specifically avoid impacts to significant riparian vegetation and minimise clearing of vegetation stands analogous to the PEC; balanced with prioritising avoidance of impact to significant fauna habitats (See Section 8.9)
- **Waste dump locations**: The placement of waste is proposed to be backfilled in pit where feasible to limit clearing of native vegetation. Where external waste dumps are required, locations have been selected to avoid interactions with the major creeklines and flood flows, balanced with prioritising avoidance of impact to significant fauna habitats, heritage and landform values associated with the mesa landform.

The conceptual layout of the Proposed Change is shown in Figure 2-3. Where practicable, the final mine site layout and infrastructure alignment has been designed to minimise disturbance to areas of elevated conservation significance.

Clearing will result in direct loss of vegetation, including loss of vegetation units of conservation significance. The majority (1,214 ha) of the vegetation proposed to be cleared was assessed to be in Excellent condition. In addition, up to 211 ha of vegetation in Good and Very Good condition is proposed to be cleared. Already disturbed or cleared areas comprise 252 ha (18%) of total clearing proposed.

Vegetation within the proposed clearing footprint is largely typical of that occurring on similar (mesa-form) habitats in the western Hamersley sub region. The majority of clearing (993 ha) is of vegetation of mesa tops and hilltops and mesa slopes and hillslopes vegetation associations (Table 6-16).

The remainder of the clearing is within Plains and Major and minor drainage landforms. These vegetation units extend beyond the Development Envelope and are not considered to be locally restricted. Therefore, the proposed impact to these vegetation units is not expected to be significant.

Table 6-16: Area of Vegetation Proposed to be Cleared Showing Units Where Clearing is Greater than 10 ha

Vegetation by landform unit	Total Extent (ha) in Proposed Change Area	Extent (ha) proposed to be cleared	Clearing % of total extent
Mesa tops / hilltops and mesa slopes / hillslopes			
AiAbTw	577	351	61
ChAiAbTw	784	325	41
AiAanTw	249	128	51
AbTw	266	83	31
AaAbTwTspR	60	39	64
AiTwTsr	76	36	48
AptTw	70	17	24
AtuTwTsr	29	13	46
Plains			
ChAbTwTe	127	93	73
AiAaAbTw	193	38	20
CcAsppTeTwCEc	28	14	50
AsTw	47	11	22
Major and minor drainage			
ChAtuTw	197	102	52
ChAsppGOrGsppPlSsTeTw	112	23	21
Mosaics			
Mosaic of AiAaAbTw/AaTeTw/ChAtuTw	47	34	72
Mosaic of AiAaAbTw/ChAtuTw	177	26	15

6.6.1.2 Loss of conservation significant vegetation due to clearing

The Proposed Change is expected to impact two vegetation communities considered to be of elevated conservation significance: riparian vegetation communities and a vegetation community analogous to the *Triodia* sp. Robe River PEC as described below and presented in Table 6-17.

Table 6-17: Proposed Clearing of Significant Vegetation

Vegetation Unit	Condition	Extent (ha) in DE	Proposed clearing (ha)	Significance
High sub-regional significance				
MaEcCv (C1AAb)	Disturbed-Very Good	31.6	<0.1	Mature OPV
C1A	Disturbed-Very Good	66.4	0.74	Mature OPV and FPV.
C1b	Disturbed-Very Good	50	0.2	FPV and immature OPV.
High Local Significance				
AprTwTsr	Excellent-Very Good	14.6	5.7	Analogous to *Triodia* sp. Robe River PEC.

AprTwTsr

Almost six hectares (5.7 ha) of a vegetation unit (AprTwTsr) resembling the Priority 3 PEC *Triodia* sp. Robe River *assemblages of the West Pilbara* are proposed to be cleared. This represents 39% of the total mapped extent (14.6 ha) of AprTwTsr (*Acacia pruinocarpa* low woodland over *Triodia wiseana, T.* sp. Robe River (M.E. Trudgen *et al*. MET 12367) open hummock grassland) within the Proposed Change Area. Mapped areas of this unit which will be impacted occur on the top, breakaways and gullies of the mesa landform where clearing is required due to the location of the ore body in the mesa and the location of key infrastructure, which has already been modified to avoid other significant features (e.g. Ghost bat roosts). The vegetation proposed to be cleared is in Excellent to Very Good condition. The DBCA have mapped an additional 360 ha of the *Triodia* sp. Robe River *assemblages of the West Pilbara* PEC, which sit outside the Development Envelope. Further to this, API has conducted mapping which delineates additional areas (36,900 ha) considered analogous to this PEC within the West Pilbara (API 2011). Clearing of 5.7 ha of AprTwTsr constitutes 0.04% of the potential regional mapped extent of *Triodia* sp. Robe River *assemblages of the West Pilbara* PEC within the region. In light of the reported extent and likely additional unmapped areas of this community in the West Pilbara, this loss is not considered locally or regionally significant.

Riparian Vegetation

Clearing of <2 ha of sub-regionally and locally significant GDE vegetation is proposed (*Melaleuca* dominated communities), mostly for widening of an existing access road; some of which is regrowth. Minor clearing is also potentially required for additional hydrogeological investigations and to support contingency environmental management options or investigations (e.g. a pipeline to supply supplementary water to key pools along the Robe River), should monitoring indicate the requirement to implement. The vegetation ranges from Disturbed to Very Good condition. The proposed disturbance is not considered a significant loss at a local or regional scale.

Progressive rehabilitation will be undertaken across the cleared areas and will involve revegetation using species selected to replicate pre-clearing vegetation distributions.

6.6.1.3 Loss of conservation significant flora due to clearing

No flora listed as threatened under the *Biodiversity Conservation Act 2016* (BC Act) or the EPBC Act will be impacted by the Proposed Change.

The proposed locations of pits, waste dumps and infrastructure are still conceptual. A range of conceptual disturbance footprints have, therefore, been considered during the Environmental Impact Assessment and the maximum disturbance to Priority Flora is presented in this ERD. This approach has been taken in order to limit disturbance to significant environmental values while maintaining some flexibility for development within the Development Envelope. The Proposed Change will preferentially avoid known locations of Priority Flora as far as practicable, however clearing will result in the direct loss of some individuals (limited to the maximum disturbance presented in this ERD) of the following three conservation significant flora species:

- *Triodia sp.* Robe River (M.E. Trudgen *et al*. MET 12367) (P3)
- *Indigofera* sp. Bungaroo Creek (S. van Leeuwen 4301) (P3)
- Rhynchosia bungarensis (P4).

The potential impacts to these species are discussed further below and summarised in Table 6-18.

Table 6-18: Potential Direct Impacts to Known Populations of Priority Flora

Species	Conservation Status	Number of individuals in Proposed Change Area	Records in Rio Tinto database	Number of individuals proposed to be disturbed	Proposed disturbance (% of records in Proposed Change Area)	Proposed disturbance (% of records in Rio Tinto database)	Approx. Range on Naturemap (km)
Triodia sp. Robe River (M.E. Trudgen *et al*. Met 12367)	Priority 3	90,270	288,681*	28,293	31	9.8 *(0.05% of known populations)	180
Indigofera sp. Bungaroo Creek	Priority 3	24	50,255	4	17	0.01	230
Rhynchosia bungarensis	Priority 4	2,944	12,736	121	4	1	540

*An additional 60 million plants have been recorded on behalf of API (API 2011).

Triodia sp. Robe River P3

The Proposed Change will result in potential impact to 438 locations containing 28,293 individuals of the Priority 3 species *Triodia* sp. Robe River (M.E. Trudgen *et al*. MET 12367), being 31% of individuals (1,719 locations, 90,270 individuals) found within the Proposed Change Area. Of the 28,293 individuals to be impacted, 7.8% (2,392) are situated in areas where clearing may not be required or is flexible in its location e.g. infrastructure.

The Rio Tinto database has 11,083 records of *Triodia* sp. Robe River (M.E. Trudgen *et al*. MET 12367) comprising more than 288,681 individuals. This species has a range of approximately 180 km on Naturemap (Parks and Wildlife 2018). However; it is likely that *T.* sp. Robe River is far more abundant, with surveys conducted on behalf of API identifying 24 populations containing 60 million individuals in a 35,000 km targeted search area in the West Pilbara (API 2011).

Clearing of 28,293 individuals constitutes 0.05% of the potential 60 million records of *T.* sp. Robe River in the West Pilbara. This proposed disturbance is not considered a significant loss at a local or regional scale and has little potential to affect the species' conservation status.

Indigofera sp. Bungaroo Creek P3

Only four individuals of *Indigofera* sp. Bungaroo Creek (S. van Leeuwen 4301) are proposed to be cleared as part of the Proposed Change, representing 17% of individuals found within the Proposed Change Area, and only 0.01% of the 50,225 individuals within the Rio Tinto flora database.

Clearing of these individuals is highly unlikely to be a significant impact at a local or regional level and has negligible potential to affect the species' conservation status.

Rhynchosia bungarensis P4

The Proposed Change will result in clearing of 121 individuals of *Rhynchosia bungarensis* or 4% of the individuals recorded within the Proposed Change Area and only 1% of the total 12,736 Rio Tinto database records.

This species is unlikely to be significantly impacted at a local or regional level and clearing has negligible potential to affect the species' conservation status.

6.6.2 Range extension species

The Proposed Change will not result in clearing of recorded range extensions species.

6.6.3 Indirect impact

Potential indirect impacts of the Proposed Change to flora and vegetation have been identified as:

- Loss or degradation of GDV as a result of groundwater drawdown
- Loss or degradation of riparian vegetation as a result of surface water discharge
- Loss or degradation of vegetation as a result of surface water management
- Degradation of vegetation due to ingress of weeds
- Degradation of vegetation due to increased dust deposition.

6.6.3.1 Loss or degradation of Groundwater Dependent Vegetation as a result of groundwater drawdown

Groundwater abstraction to enable both BWT mining and for water supply will lower the groundwater table at Mesa H and in the vicinity of the Southern Cutback Borefield (south-east of Mesa J).

Approximately 20% of ore proposed for mining at Mesa H is below the current water table, with dewatering expected to commence later, in approximately 2025. This may reduce the availability of water to GDEs occurring in the Proposed Change Area and potentially lower water levels in significant permanent and semi-permanent pools of the adjacent Robe River.

Groundwater from dewatering will supply the majority of the operational water demand for the life of the Proposed Change. Additional water supply will be required when operational demands exceed dewatering (Section 5.5.1) which will be drawn from the Southern Cutback Borefield. In combination with the upstream CWSP, and abstraction from the Mesa J Iron Ore Development, this will lower groundwater in the vicinity of the Southern Cutback Borefield, including along a section of the adjacent ephemeral Jimmawurrada Creek.

Jimmawurrada Creek

Due to the sequence of mining, additional water will be required for operational use from the existing licenced Southern Cutback Borefield to the south of the Mesa J Iron Ore Development. Riparian vegetation in the vicinity of the borefield has already been subjected to a drop in the water table in the order of 4 to 8 m (water table levels now largely recovered) associated with groundwater supply Mesa J Iron Ore Development, dewatering activities at Mesa J (since 1995), climatic effects (likely to represent a significant proportion of this influence) and influences of the CWSP on the Bungaroo Valley aquifer. Groundwater monitoring data indicate pre-mining water table depths across the extent of Jimmawurrada Creek ranging from 2 – 12 m. Some decline in health has been noted recently in the Eucalypts on Jimmawurrada Creek in the vicinity of the Southern Cutback Borefield compared to reference sites (Astron 2018). This accompanies a climatic transition from a period (approximately 20 years) of above average rainfall and stream-flow, thought to have increased stem densities and canopy cover of riparian vegetation, to a recent drier period.

Hydrological modelling predicts up to 9 m (resulting in a maximum groundwater depth of 14 mbgl) peak groundwater drawdown from the cumulative effect of abstraction for water supply (including the CWSP) and Mesa J mine pit dewatering in Jimmawurrada Creek. Modelling is conservative and has excluded the mitigating influence of cyclonic inputs and associated aquifer and soil moisture recharge derived from these flooding events. Whilst dependent on timing, the rainfall regimes and low pressure systems of the dry tropics have considerable potential to mitigate the more significant negative effects of drawdown, through flooding and ponding of water leading to replenished soil moisture stores and pools while also providing seed and nutrient inputs to allow regeneration. The influence of such climatic regimes is substantial and in many situations these events effectively replenish the aquifer water levels present throughout the Bungaroo Valley. However, if natural recharge in Jimmawurrada Creek is reduced by 50% due to an extended dry period (H3 numerical model 'Uncertainty Run 2' (Rio Tinto 2019a)), the water table levels could be lowered by almost 3 m in addition to the historical seasonal fluctuations; this would translate to localised changes in water table depths of up to 14 m from pre-mining conditions, or ~18 mbgl by 2030. Whilst the shallower outer margins of the alluvial aquifer may experience temporal loss of saturation, between 10 – 22 m of saturated alluvium is estimated to be retained within the deepest part of the channel (thalweg).

For the purpose of understanding risk to vegetation from hydrological change within the broader Study Area, riparian vegetation was attributed a risk rating based on the degree of sensitivity (or vulnerability) of each community to groundwater availability and the risk that "measurable" impact/change to a community could result (Figure 6-10, Rio Tinto 2018d, 2018e). Three main zones (Figure 6-11; Table 6-19) of potential impact were delineated along Jimmawurrada Creek based upon hydrological modelling of the extent of the groundwater drawdown cone of depression extending below the main flow channel of the creekline (Rio Tinto 2018d). Vegetation in these zones is expected to exhibit varying degrees of canopy decline, mortality, changes in understorey composition and reduced seedling recruitment as a result of the reduced extent and consistency of water availability. The impact on vegetation is likely to occur progressively as the groundwater level is reduced into the lower extents of, and in some cases below the root zone of, phreatophytic species. The extent of impact is affected by the degree of groundwater dependence, the natural groundwater variability, the peak groundwater drawdown, the rate of groundwater level change, the influence of additional stressors on riparian vegetation (e.g. discharge, waterlogging, insect attack) and the timing of annual discharge and surface water inputs (particularly cyclonic / low-pressure-cell events). This extent of impact is also linked to the duration over which vegetation is exposed to reduced water availability, and how regularly more favourable conditions are re-established via rainfall and cyclonic rainfall events. Seasonal and cyclonic re-establishment of the water table will not only allow some degree of vegetation recovery, but through repeat exposure will also aid in the process of incrementally increasing the degree of drought adaptation held by local populations of phreatophytes. Varying degrees of hydraulic connection between the alluvium and underlying CID, combined with the influence of clays in the deep alluvials may significantly reduce the transfer of aquifer drawdown in the alluvial aquifer in sections and preferential flow zones within the creek bed.

The greatest impact to riparian vegetation is likely to occur in ‘Zone Three’ (Figure 6-11) (6.5 km stretch of creekline) where the water table will be drawn down by up to 9 m, equating to a water table level of approximately 11-14 mbgl (which is 3 – 9 m of total drawdown since 1995). Water table levels may be further reduced as a result of an extended dry period and seasonal water table lows, which could result in a water table as low as 18 mbgl. Whilst no significant (*Melaleuca argentea* dominated) groundwater dependant vegetation occurs through these zones, the riparian vegetation in this area is expected to experience some level of adjustment including canopy decline and some mortality, together with changes in understorey composition and abundance. A total of 422 ha of riparian vegetation occurs in this area, of which 349 ha is considered to represent FPV (the remainder generally represents vadophytic type riparian communities). A summary of estimates of the degree of canopy decline and mortality are presented in Table 6-20 for each of the three defined zones. This assessment is dependent on the maintenance of average climatic and biotic conditions, and average subsurface physical conditions. Seasonal rainfall surface water inputs and intermittent surplus water discharge, whilst periodic, are also expected to provide additional inputs to help maintain adequate soil moisture.

Zones One and Two (0.2 km and 5 km respectively) are predicted to experience a modelled maximum drawdown level (depth to water) of 2 – 7 m and 7 – 11 mbgl respectively or between 1 – 8 m total drawdown from current groundwater levels. This drawdown could be further exacerbated during extended dry periods and seasonal water table lows as described earlier. Only 12 ha of *Melaleuca argentea* dominated communities have been mapped in these zones (only 1.6 ha of which is thought to have been present pre mining, the majority of which is considered to have developed in response to surplus water discharge from the Mesa J Iron Ore Development) and are likely to experience some canopy decline and increased mortality, however impacts are expected to be reduced and intermittently recovered (at least partially) by seasonal surface water flows and associated aquifer recharge, combined with periodic surplus water discharge from the Proposed Change. A significant proportion of the vegetation in Zone 1 and parts of Zone 2 has been augmented by intermittent surplus water discharge from the existing Mesa J Iron Ore Development since the early 1990’s resulting in increased leaf area index and biomass and increased recruitment of riparian vegetation. The vegetation close to the confluence of the Robe River is also likely to be exposed to additional subsurface flow input from the upper Robe River at the confluence of Jimmawurrada creek which may mitigate any impacts associated with cumulative related drawdown.

Table 6-19: Riparian Vegetation (ha) in Groundwater Drawdown Zones Along Jimmawurrada Creek

Zone	Maximum water table depth at 2030 (m)	Modelled Drawdown range (m)	Total mapped riparian vegetation (ha)	High Risk/OPV (ha)	Moderate Risk/FPV (ha)	Zone Length (km)
1	<7	1 – 4	6	0.3	2.4	0.2
2	7-11	4 - 8	262	3.1	147	5.2
3	11 - 14	8-9 (3A) 4-8 (3B)	318.5	7	109	6.6
TOTAL			586.5	12	258	12

Table 6-20: Zones of potential impact on Riparian Vegetation associated with modelled drawdown on Jimmawurrada Creek. Colour coded system: Green: minor potential impact, Yellow: minor to moderate potential impact, Orange: moderate potential impact.

Zone		Max water table depth - (bgl)	Magnitude of Drawdown	Mitigating factors	Presence/Absence of OPV or FPV in the Riparian Zone	Potential Impacts to Riparian Flora and Vegetation
JIM 1		*<7	*1-4	Discharge and Robe River alluvial aquifer; large scale influence. Surface water flows; moderate to large scale influence (due to creek attenuation by range).	Some OPV present, although FPV broadly dominant. Potential baseline OPV restricted to low flow channels skirting the west bank within this zone. The remainder of OPV in this zone appears to have established post mining. Single riparian corridor present.	Considering mitigating factors; periodic canopy decline and recovery cycles, with some mortality are likely. Peaks in hydrological sensitivity among riparian communities in this zone combined with modelled drawdown and previous observations to groundwater level changes suggest that under drought conditions (including abnormally late onset of wet season rainfall conditions) mortality events among young OPS cohorts in this zone are likely. More mature OPS communities are favourably located in the lowest and most protected zone of the creek channel. Favourable hydrological conditions are likely to be reinstated annually and replenishment of soil moisture stores and regeneration of impacted communities is expected to regularly occur.
JIM 2	A	*7-11	*4-8	Discharge; large scale Influence. Robe River alluvial aquifer; moderate to large scale influence. Surface water flows; moderate to large scale influence (due to creek attenuation by the range).	Some pre and post-mining (augmented) OPV present, however creek broadly dominated by FPV. OPV generally restricted to a strip surrounding the low flow channel skirting the west boundary of the creek. Single riparian corridor present.	Considering mitigating factors; periodic canopy decline and recovery cycles, with increased mortality are likely (in the order of -10 – 20%). Peaks in hydrological sensitivity among some riparian communities in this zone combined with modelled drawdown suggest that under drought conditions (including abnormally late onset of wet season rainfall conditions) mortality events among young to semi-mature OPS cohorts in this zone are likely. The gradient of increasing drawdown (moving upstream) coincides with a general absence of mature OPS (less than 0.5 ha) and decreasing hydrological vulnerability among vegetation communities. However, during extended drought conditions, particularly in the eastern extents of the riparian zone away from the low flow channel, or in zones of high basal area stem density (where water demand per unit area is at a peak); may lead to more significant increases in mortality among canopy species and mesic understorey components. However,

Zone		Max water table depth - (bgl)	Magnitude of Drawdown	Mitigating factors	Presence/Absence of OPV or FPV in the Riparian Zone	Potential Impacts to Riparian Flora and Vegetation
						favourable hydrological conditions are expected to be reinstated annually and as such, replenishment of soil moisture stores and regeneration of impacted vegetation should regularly support the continued viability of resident FPV communities through this zone.
	B			Discharge; low to negligible influence. Surface water flows; moderate scale influence.	OPV absent. Creek dominated by FPV. Single riparian corridor present in the west, dual corridors (Channel splits to Bungaroo and Jimmawurrada Creeks) in the eastern end of polygon.	Considering mitigating factors; some canopy decline (-10 - 30%) among FPV communities is likely under average to seasonal drought-type conditions. While some drawdown related mortality within overstorey populations may occur under average conditions, mortality is likely to be <10% of trees in the absence of significant drought stress. Following onset of extended drought conditions, this decline may also manifest in increased mortality in the order of <20% of trees among overstorey populations. Understorey impacts are likely in this zone, particularly in the eastern half of this zone where these communities are generally more mesic in composition. Understorey changes likely to be in the form of reduced abundance of biomass and mesic constituents.

Zone		Max water table depth - (bgl)	Magnitude of Drawdown	Mitigating factors	Presence/Absence of OPV or FPV in the Riparian Zone	Potential Impacts to Riparian Flora and Vegetation
JIM 3	A	*11-14	*8-10	Discharge; minor to moderate scale influence. Surface water flows; moderate to large scale influence.	Some post-mining (augmented) OPV present, however creek broadly dominated by FPV. OPV generally restricted to a thin strip surrounding the low flow channel skirting the west boundary of the creek. Single riparian corridor present in the north, dual corridors in the southern 1/3 of polygon.	Considering mitigating factors; some canopy decline (-10 - 50%) among FPV communities is likely under average to seasonal drought type conditions. While some drawdown related mortality within overstorey populations may occur under average conditions, mortality is likely to be <20% of trees in the absence of significant drought stress, particularly along the southern channel and terrace zones adjacent to the Southern Cutback Borefield and away from the direct/indirect influence of surface water inputs. Following onset of extended drought conditions, this decline may also manifest in increased mortality in the order of <35% of trees among overstorey populations (and -30 – 50% canopy decline). Understorey impacts are likely, particularly in the northern half of this zone where understorey communities have been augmented by surface water discharge and are more mesic in composition. Understorey changes likely to be in the form of reduced abundance of biomass and mesic understorey constituents.

Zone		Max water table depth - (bgl)	Magnitude of Drawdown	Mitigating factors	Presence/Absence of OPV or FPV in the Riparian Zone	Potential Impacts to Riparian Flora and Vegetation
	B		*4-8	Discharge; low to negligible scale influence. Surface water flows; moderate scale influence.	No OPV present; area dominated by FPV. Dual riparian corridor present in two sections, with a central section where a single corridor is present.	Considering mitigating factors; some canopy decline (-10 - 40%) among FPV communities is likely under average to seasonal drought type conditions. While some drawdown related mortality within overstorey populations may occur under average conditions, mortality is likely to be <15% of trees in the absence of significant drought stress, particularly in the northern half of this zone, on the southern channel and terrace zones adjacent to the Southern Cutback Borefield and away from the direct/indirect influence of surface water inputs. Following onset of extended drought conditions, this decline may also manifest in increased mortality in the order of <25% of trees (- 30 – 50% canopy decline) among overstorey populations. Understorey impacts are likely in this zone, particularly in the southern half of this zone where understorey communities are more mesic in composition. Understorey changes likely to be in the form of reduced abundance of understorey biomass and mesic understorey constituents.

* Maximum water table depth and drawdown magnitudes are modelled to occur at 2030, or at an alternative worst case period (likely 2037) and attributed to groups/ranges. All figures are in meters and all are approximate.

Robe River

Conservation significant GDV communities on the Robe River are predicted to experience less than one metre of groundwater drawdown which is considered to be well within the range of natural groundwater variability (1 – 3 m) observed in bores within the Robe River alluvial aquifer near the Development Envelope (Rio Tinto 2019a). Mine pit dewatering for the Revised Proposal is not expected to impact the presence or persistence of permanent pools around Yeera Bluff, however semi-permanent and seasonal pools shallower than 0.8 m may dry out more quickly in periods of drought as they currently do from time to time e.g. Duck Pool (Rio Tinto 2019a).

Compared to Jimmawurrada Creek there are greater uncertainties in the accuracy of prediction of vegetation response to groundwater drawdown, particularly the first 10 – 50 m of the riparian zone near the southern bank of the Robe River and adjacent to Mesa H. In the Robe River, impacts to GDV in Zones One and Two are likely to be minimal and could include minor canopy decline in certain areas and potentially death of obligate and facultative individuals. Drawdown may be mitigated by discharge, surface water inputs and base flow. Some impacts may potentially be seen in understorey vegetation, most likely to the shallow macrophyte communities occupying the ephemeral to semi-permanent pools and wet channels as well as some potential for impact in the outer fringing phreatophytic type communities where groundwater heights are only just consistently shallow enough for maintenance of populations of obligate phreatophytes.

While certain riparian communities are unlikely to be susceptible to such change, higher risk OPV comprising *Melaleuca argentea* dominated communities (Rio Tinto 2018d, 2018e) are quite sensitive to this type of change due to their potential reliance on aquifers associated with porous subsurface lithologies. To date, long term monitoring has detected no significant impacts associated with drawdown in this vicinity (Streamtec 2017, Astron 2016c).

Loomes (2010) reported a natural five-year range in variability in depth to groundwater at *Melaleuca argentea* sites of 1.22 - 7.31 m on the De Grey River showing that the species can adapt to significantly varying groundwater levels. This range in water availability is significantly greater than modelled for this Revised Proposal. As a contingency, an option for all Mesa H surplus water derived from mine pit dewatering can be directly discharged to supplement water levels in key pools on the Robe River to protect both cultural and environmental values (including vegetation and significant fauna habitat), should monitoring or further hydrogeological studies indicate that there is a risk from dewatering. In addition, further contingency actions can be undertaken if significant risk to the permanent pools are identified (i.e. greater than up to 1 m drawdown beyond natural seasonal fluctuations); mining below the water table in the pit (Pit 7) closest to the Robe River can be limited to a dewatering level of 120 m RL, which will ensure that the water levels in the CID aquifer do not fall below the levels of the adjacent permanent pools. Alternatively, mining below 120 m RL in this pit may be scheduled to occur only during the wet season when pools are full and above 120 m RL to reduce any potential impact on environmental and cultural values of Robe River pools.

Zones One and Two (13 km and 5 km respectively) are predicted to experience a modelled maximum depth to groundwater of 1.5 – 3 m and 2 - 3.5 mbgl respectively or <0.5 – 1 m total drawdown from current groundwater levels. 283 ha of *Melaleuca argentea* dominated communities have been mapped in these zones which may experience some canopy decline. Such impacts are most likely to be restricted and patchy, and are expected to be at least partially mitigated by seasonal surface water flows and associated aquifer recharge combined with periodic surplus water discharge from the Proposed Change. A summary of estimates of potentially affected areas are presented in Table 6-21 and Table 6-22 for each of the defined zones.

Table 6-21: Riparian Vegetation (ha) in Groundwater Drawdown Zones Along the Robe River

Maximum water table depth at 2037 (m)	Zone	Modelled Magnitude of Drawdown (m)	Total mapped riparian vegetation (ha)	High Risk/OPV (ha)	Moderate Risk/FPV (ha)	Zone Length (km)
<0.5	1	<0.5	782	197	167	9
1	2	1	276	86	48	5
TOTAL		<1	1058	283	215	14

Table 6-22: Zones of potential impact on Riparian Vegetation associated with modelled drawdown on the Robe River (worst case) Colour coded system: Green: minor potential impact, Yellow: minor to moderate potential impact, orange, moderate potential impact.

Zone		Max water table depth - (bgl)	Magnitude of Drawdown	Mitigating factors	Presence / Absence of OPV or FPV in the Riparian Zone	Potential Impacts to Riparian Flora and Vegetation*
RR-1A	Zone A*: Low flow and secondary channel Zones.	~1.5-3 m	~<0.5 m	Discharge; minor to moderate scale influence. Surface water flows and subsurface base-flow; large scale influence.	OPV represents the dominant riparian vegetation present. FPV is also common and relatively widespread.	Impacts to GDV in this zone are likely to be minimal, and could include canopy decline in certain areas, and the death of some obligate and facultative phreatophyte individuals. For obligate phreatophytes; individuals distributed on the outer margins (laterally) of where OPV communities are normally distributed are most likely to experience impacts including the death of certain individuals. For facultative phreatophytes, the opposite is likely true and those individuals in the lower traditionally wetter zones have greater potential for impact (than those on the outer margins) due to root clipping processes reducing their adaptive capability. Where OPV communities are distributed more tightly along the south bank of the river (more closely adjacent to dewatered orebodies), some level of uncertainty surrounding the completeness of the disconnection between the orebodies and the alluvium means that vegetation decline in these areas is a potential outcome (however considered unlikely). In areas where pools support aquatic macrophyte communities and associated faunal assemblages, exacerbation of climatic trends has the potential to contribute to cycles of decline in such communities.

Zone		Max water table depth - (bgl)	Magnitude of Drawdown	Mitigating factors	Presence / Absence of OPV or FPV in the Riparian Zone	Potential Impacts to Riparian Flora and Vegetation*
RR-1B	Zone B*: Outer/flanking, and generally more elevated cobbled bed zones – includes minor channels.	~3 - 5.5 m	<0.5 m	Discharge; minor scale influence. Surface water flows and subsurface base-flow; large to moderate scale influence.	FPV represents the dominant riparian vegetation present. OPV is also common throughout.	Impacts to GDV in this zone are likely to be minimal, and could include canopy decline in certain areas, and the death of some obligate and facultative phreatophyte individuals. The presence and abundance of GDV in the "B" zone component is generally significantly reduced when compared to the "A" zone Component. Impact potential is considered lowest in this zone due to the generally reduced sensitivity of vegetation within. However; with some OPV communities in this zone also occupying the outer margins of their potential lateral distribution, uncertainty surrounding potential impacts for such communities is high. More broadly these zones represent areas of significant deposition and scour due to the predominance of poorly vegetated open cobbled bed habitats. This determines that change in vegetation distribution in these areas may also be high and broadly attributed to flow patterns rather than any potential influence from the Proposed Change.

Zone		Max water table depth - (bgl)	Magnitude of Drawdown	Mitigating factors	Presence / Absence of OPV or FPV in the Riparian Zone	Potential Impacts to Riparian Flora and Vegetation*
RR-2A	Zone A*: Low flow and secondary channel Zones.	2 - 3.5 m	*<1 m	Discharge; minor to moderate scale influence. Surface water flows and subsurface base-flow; large scale influence.	OPV represents the dominant riparian vegetation present. FPV is also common and relatively widespread.	Impacts to GDV in this zone are likely to be minimal, and could include canopy decline in certain areas, and the death of some obligate and facultative phreatophyte individuals. For obligate phreatophytes; individuals distributed on the outer margins (laterally) of where OPV communities are normally distributed are most likely to experience impacts including the death of certain individuals. For facultative phreatophytes, the opposite is true and those individuals in the lower traditionally wetter zones have greater potential for impact (than those on the outer margins) due to root clipping processes reducing their adaptive capability. Where OPV communities are distributed more tightly along the south bank of the river (more closely adjacent to dewatered orebodies), some level of uncertainty surrounding the completeness of the disconnection between the orebodies and the alluvial's means that more substantial impact in these areas is a potential outcome (however considered unlikely). In areas where drawdown in the vicinity of 1 m is realised, impacts to GDV will be greater, but the proportion of this impact which is attributable to the Proposed Change is still predicted to be minor. In areas where pools support aquatic macrophyte communities and associated faunal assemblages, exacerbation of climatic trends has the potential to significantly contribute to cycles of decline in such communities.

Zone		Max water table depth - (bgl)	Magnitude of Drawdown	Mitigating factors	Presence / Absence of OPV or FPV in the Riparian Zone	Potential Impacts to Riparian Flora and Vegetation*
RR-2B	Zone B*: Outer/flanking, and generally more elevated cobbled bed zones – includes minor channels.	~3.5 – 6 m	*<1 m	Discharge; minor scale influence. Surface water flows and subsurface base-flow; large to moderate scale influence.	FPV represents the dominant riparian vegetation present. OPV is also common throughout.	Impacts to GDV in this zone are likely to be minimal, and could include canopy decline in certain areas, and the death of some obligate and facultative phreatophyte individuals. The presence and abundance of GDV in the B zone component is generally significantly reduced when compared to the A zone Component. Impact potential is considered lowest in this zone due to the generally reduced sensitivity of vegetation within. However; with some OPV communities in this zone also occupying the outer margins of their potential lateral distribution, uncertainty surrounding potential impacts for such communities is high. In areas where drawdown is modelled to approach 1 m, impacts to GDV will be greater, but the proportion of this impact which is attributable to the Proposed Change is still predicted to be minor. More broadly these zones represent areas of significant deposition and scour due to the predominance of poorly vegetated open cobbled bed habitats. This determines that change in vegetation distribution in these areas may also be high and broadly attributed to flow patterns rather than any potential influence from the Proposed Change.

*Overarching concepts relevant to biological and physical conditions in A and B river profile Zones.

Monitoring

Annual biophysical / ecological survey of the Robe River aquatic ecosystems has been conducted since 1991 as part of an ongoing commitment to assess environmental impacts of mine development at Mesa J on the adjacent and downstream aquatic ecosystem of the river (largely the semi-permanent and permanent 'refugial' pools) (Streamtec 2017). The long-term biophysical / ecological surveys of the Robe River are an integrated, long-term assessment of environmental parameters including aquatic fauna (i.e. aquatic macroinvertebrates and fish), channel / pool morphology, riparian / bank condition, weeds, water flows and water quality. Detailed statistical (e.g. aquatic fauna) and qualitative analyses (e.g. of riparian condition) show that there have been no statistically significant or qualitatively detectable changes to the aquatic ecology / environmental conditions of the Robe River pools adjacent to and downstream of Mesa J that could be attributable to mining and its operations alone. Instead it is concluded that extreme natural events (e.g. tropical cyclones and extended dry spells) determine the structure of pool morphology, riparian condition and consequently the pool ecological assemblages.

In 2016 Astron established riparian vegetation monitoring transects in zones of potential drawdown, discharge and in reference sites (Astron 2016c). Transects capture floristic data, population structure, vegetation and crown condition of phreatophytic species. Worldview imagery covering the Development Envelope and reference areas was also acquired and vegetation biomass abundance extracted using the Modified Soil Adjusted Vegetation Index. Subsequent monitoring periods will allow change against this initial baseline data to be assessed. Leaf water potential monitoring was added at three sites along Jimmawurrada Creek in October 2017 in order to quantify levels of water stress. Management trigger and thresholds levels have been developed based on satellite imagery of canopy changes to manage any potential impacts associated with groundwater drawdown including differentiating change from natural perturbations due to climate and other natural events such as flooding and fire.

Additionally, Control and Impact Digital Canopy Photography tree health monitoring sites have been monitored since 2009 along with an array of riparian monitoring transects (monitored since 2013) across the Bungaroo Valley, centred around monitoring the impacts of the CWSP. The results of this monitoring may also assist in understanding impact associated with wider climatic variability.

Summary

Riparian vegetation along Jimmawurrada Creek has already experienced 4 – 6 m of groundwater drawdown and recovery over the past ten years and is currently exhibiting some signs of drought stress (Astron 2018). A predicted maximum drawdown of up to 9 m along a 6.5 km stretch of Jimmawurrada Creek (encompassing 108 ha of FPV) is likely to result in some impacts, including areas of significant canopy decline and occasional tree mortality. Less significant effects may occur within a further 5.5 km stretch of Jimmawurrada, which will incur a reduced level of groundwater drawdown or, where downstream of a discharge outlet, the effects may be reduced due to periodic surface water discharge.

These impacts may be mitigated or reduced by considerable catchment surface water flows derived from seasonal rainfall and cyclonic events which seasonally top up the local alluvial aquifers, however taking into consideration climatic factors as presented in Rio Tinto (2019a) extended dry periods combined with seasonal water table lows may exacerbate the predicted impacts. As a mitigation strategy, options for optimising the location of the discharge outlets in Jimmawurrada Creek have been factored into the Proposed Change's engineering design and can be implemented should monitoring indicate the requirement to do so (including to support subterranean fauna values).

Within the Robe River, an additional 232 ha of OPV may experience some canopy decline during the period of dewatering for Mesa H, however the magnitude of drawdown is predicted to be small (≤1 m) and temporary. The river and associated pools in this area receive seasonal surface water flows from rainfall events, with up to ~90% of flows derived from the upper Robe River rather than Jimmawurrada Creek, which periodically tops up the Robe River alluvial aquifer, with additional intermittent operational surface water discharge.

Groundwater sensitive, significant *Melaleuca argentea* dominated communities along the Robe River and fringing the semi-permanent and permanent pools are predicted to experience less than 1 m of groundwater drawdown from the Revised Proposal and are therefore considered unlikely to be significantly impacted. If impacted, vegetation recovery is predicted to be relatively swift on account of the optimal growth conditions which are common through this system.

If groundwater drawdown is greater than anticipated in the Robe River alluvial aquifer as a result of dewatering, proposed contingency mitigation options include:

- providing abstracted water directly back into the permanent pools of the Robe River; and
- avoiding mining below the 120 m RL in the northern-most pit, particularly during extended drought periods.

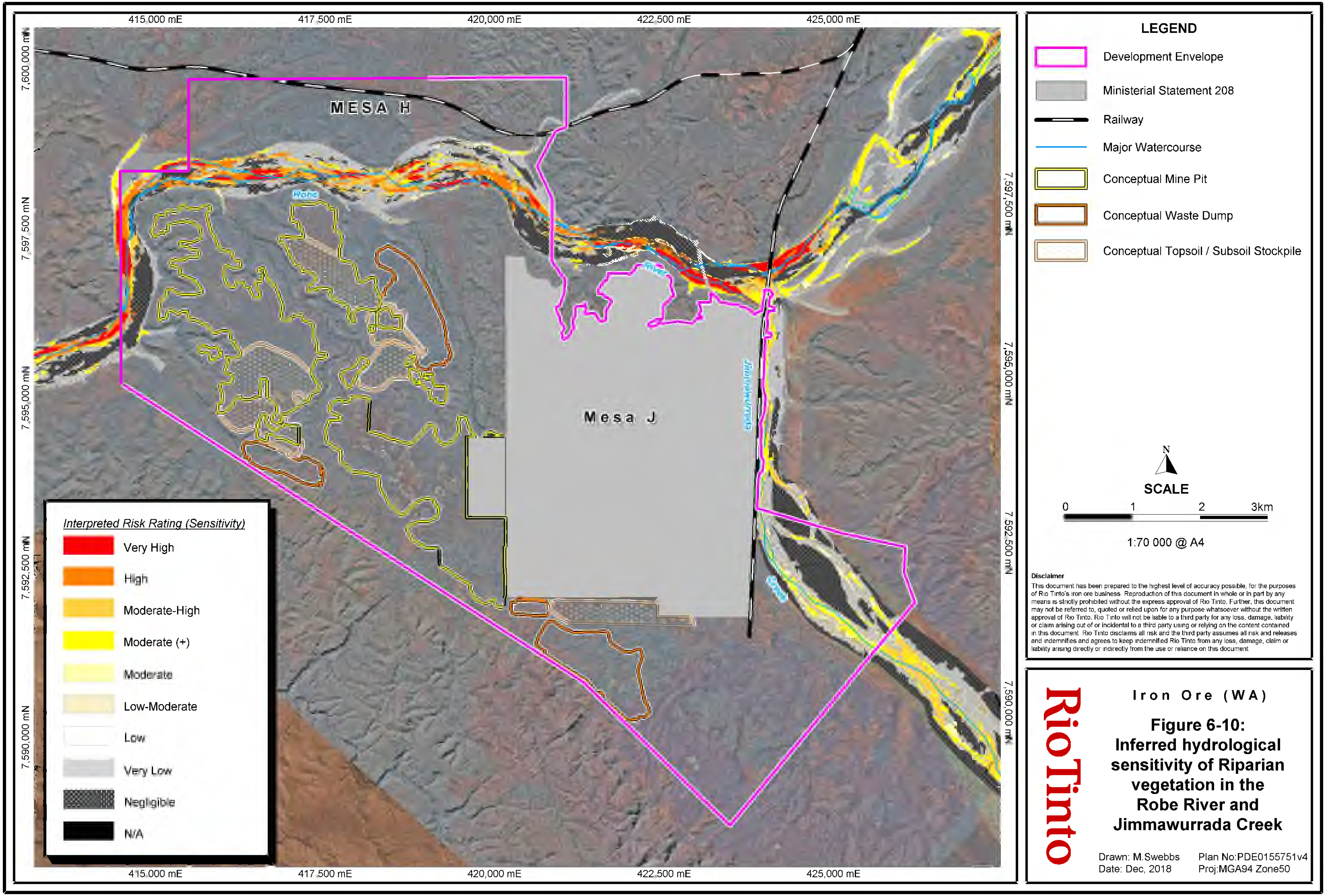
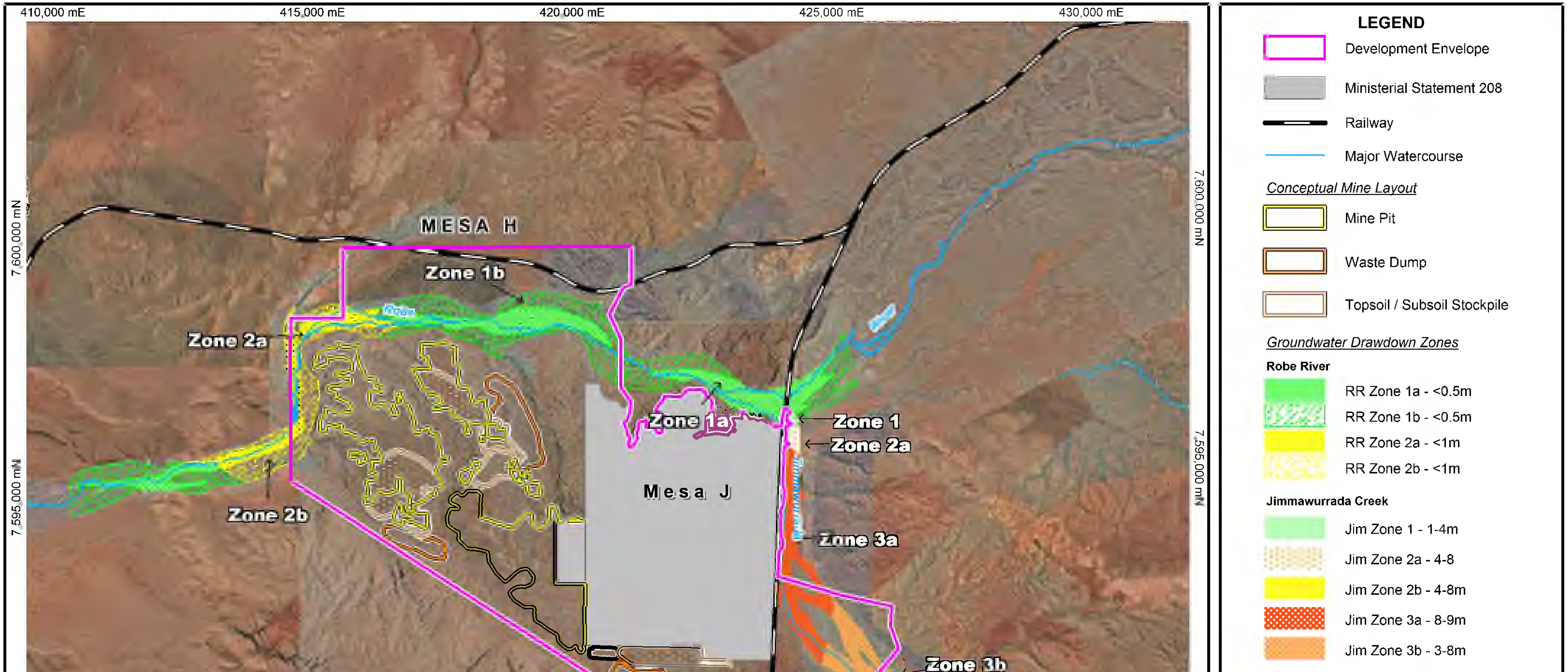


Figure 6-10: Inferred hydrological sensitivity of Riparian vegetation in the Robe River and Jimmawurrada Creek



RioTinto

Iron Ore (WA)

Figure 6-11: Predicted Groundwater Drawdown Zones across Jimmawurrada Creek and the Robe River

Drawn: M.Swebbs
Date: September, 2018

Plan No:PDE0161829v4
Proj:MGA94 Zone50

Geospatial Information and Mapping

6.6.3.2 Loss or degradation of riparian vegetation as a result of surface water discharge

Groundwater abstracted for dewatering purposes will primarily be used to meet operational demands of the Revised Proposal. However, where surplus water storage capacity is exceeded, an average of 3 GL/a (up to 15 ML/day during wet season) will be required to be periodically discharged to Jimmawurrada and / or West Creek (tributary). Discharge is currently proposed through the existing licensed outlets in Jimmawurrada and West Creeks during and directly post wet season rains (Rio Tinto 2019a), however the discharge locations may be subject to change based on water management optimisation and to support management of environmental objectives. Rates of discharge will be periodic and intermittent, in line with the current Mesa J discharge regime (current average discharge of ~3 GL/a).

The discharge is modelled to result in an intermittent and temporary footprint of <8 km of continuous flow from the discharge points when the on-site storage capacity is exceeded – predominantly during wet season. Discharge would extend along the Robe River, confined to the channels and small pools downstream, estimated to extend no further than Martangkuna pool for volumes up to 15 ML / day. For the central Mesa H creek (West Creek) discharge, the footprint would likely terminate at Parkunya pool. Surface water beyond this point would terminate upon entering the alluvial gravels near Yeera Bluff and would be completely mixed with natural water from within gravel flows.

Discharge of water directly into the Robe River is not proposed, however localised water supplementation into the permanent pool at Yeera Bluff may be implemented as a contingency mitigation measure to maintain water levels to protect both cultural and environmental values. This would be based on the commencement of dewatering for the Proposed Change, and pool level monitoring indicating requirement to do so. Further details regarding proposed management and mitigation are provided in Section 6.8.

Jimmawurrada Creek

Riparian vegetation along Jimmawurrada Creek is predominantly comprised of two of the common Pilbara species known to be phreatophytic: *Eucalyptus victrix* and *Eucalyptus camaldulensis*, with some patches of *Melaleuca argentea* occurring within the current discharge footprint, near the confluence with the Robe River.

Eucalyptus camaldulensis and to a significantly lesser extent *Eucalyptus victrix* display a moderate level of flooding tolerance, and are able to tolerate temporary inundation. Prolonged or permanent inundation of ephemeral creeks as a result of discharge is expected to result in inevitable changes to riparian vegetation including the following:

- changes in riparian vegetation community structure
- changes in the health of the dominant riparian tree species *Eucalyptus victrix* and *Eucalyptus camaldulensis* which may include:
    - declining health (decreasing biomass / abundance), leaf chlorosis or death of species susceptible to waterlogging stress (i.e. *Eucalyptus victrix*, but in certain circumstances also *E. camaldulensis*)
    - increasing biomass / abundance and enhanced artificial recruitment of species relatively tolerant to waterlogging (*Eucalyptus camaldulensis*)
- establishment or increasing biomass / abundance of other species which are tolerant to waterlogging (particularly sedges and rushes, but also including mesic riparian shrub species)
- enhanced potential for weed ingress / proliferation (particularly by *Cenchrus* spp.)
- significant drought stress, accumulated hydrological regime change stress, and potential for substantial senescence events upon change to or cessation of discharge regimes.

Discharge of surplus water into Jimmawurrada Creek is unlikely to further alter the structure and health of riparian vegetation (broadly relating to the *E. Camaldulensis* and *E. Victrix* dominated woodland communities) beyond changes that may have already occurred associated with Mesa J Iron Ore Development. These changes include a degree of increased vegetation density in the overstorey and understorey, increased phreatophyte recruitment, establishment of a wide range of phreatophyte age distributions and some level of accumulated hydrological regime change stress within ephemeral species assemblages.

Whilst some of the influence of discharge will be reduced by drawdown and its influence on water availability, discharge is still likely to result in increases in the recruitment, dominance and cover of *Eucalyptus camaldulensis, Melaleuca argentea* and mesic understorey species. Some decline in the health of *Eucalyptus victrix* due to waterlogging (including dead trees) is also possible but is considered low risk based on the relatively low discharge volumes proposed. Historic rates of discharge have been variable and intermittent, occurring traditionally in wetter months. Vegetation is unlikely to have become dependent on a constant supply of water discharge and is therefore more likely to be resilient to hydrological change. Additionally, there appears to be a noticeable influence from the Robe River aquifer and the Bungaroo Valley aquifer on water availability and vegetation distribution in the discharge effected stretch of Jimmawurrada Creek. As a result, the resilience of local vegetation to drought stress is unclear, and likely to be lower than more ephemeral stretches of the creek further upstream of Zones 1 and 2.

Taking into account the discharge history and current degree of vegetation augmentation from surface water discharge; the proposal to continue periodically discharging surplus water into Jimmawurrada Creek and / or West Creek, albeit potentially reduced in volume / frequency compared to previous levels, is anticipated to result in very minimal changes to vegetation beyond that already realised (following over 20 years of discharge).

After the cessation of discharge, riparian vegetation communities are expected to gradually revert to a condition similar to pre-impact but more likely representative of the climatic regime operating at the time.

The licensed discharge outlet at West Creek (Discharge Point B) may be decommissioned, once the adjacent Mesa J BWT pits reach the end of their mine life. Vegetation in this tributary has been subjected to discharge since the 1990s and as such has been altered from its pre-mining state. Historical surveys and historical aerial photo assessments suggest that pre-discharge, West Creek possessed limited riparian vegetation dominated by *Eucalyptus victrix* in low flow channels and co-occurring with *Corymbia hamersleyana* in terrace and floodplain zones. In 2016, vegetation within and adjacent to low and high flow channels was mapped by Astron (2016a) as a *Eucalyptus camaldulensis* subsp. *refulgens, E. victrix* woodland (EcEvAtrApyPITw). Recent surveys of the area by Rio Tinto (2018d) indicate that in particular, the low flow channel has become dominated by a woodland (to open forest) of *E. camaldulensis* saplings, with a scattering of mature *E. victrix* and occasional more mature *E. camaldulensis* trees. There is evidence of isolated mature *E. victrix* which have succumbed to water logging stress in the low flow channel.

In regard to potential erosion impacts, discharge of excess groundwater is predicted to occur at a rate which is significantly less than the flow rates generated during flood events and on this basis, discharge is unlikely to overtop the creek bank. Discharge velocities are predicted to be less than 1 m/s which are considered unlikely to result in significant channel erosion within the Robe River (Rio Tinto 2015).

Robe River

No direct discharge into the Robe River is proposed. The consistency of the alluvial aquifer within the Robe River determines that proposed discharge inputs via its tributaries are minimal in comparison to throughput and as such, discharge related impacts within the Robe River are considered to be minimal when compared to Jimmawurrada Creek.

Summary

Discharge associated with the Proposed Change is not expected to cause significant additional impacts beyond those that have already been experienced as a result of over 20 years of mining operations and may serve to reduce impacts associated with groundwater drawdown beneath Jimmawurrada Creek and potential minor drawdown in the Robe River. Discharge of surplus groundwater via the proposed discharge points may alter surface water chemistry and sediment quality downstream of the discharge point during natural no-flow conditions. Changes to water chemistry and sediment quality may result in short-term changes to vegetation health.

The Proponent proposes to monitor the structure, abundance and health of riparian vegetation communities (both native and introduced species) within the extent of surface water discharge and in reference areas. Monitoring results are expected to show, at worst, changes to riparian vegetation community structure and composition, declining health of *Eucalyptus victrix* due to waterlogging (including dead trees), artificial recruitment of *Eucalyptus camaldulensis* and *Melaleuca argentea*, establishment of other species which are tolerant to waterlogging and increased abundance of weeds.

6.6.3.3 Loss or degradation of vegetation as a result of surface water management

A drainage diversion is required to the south of the Revised Proposal southern pits during operations to divert surface water away from entering the Mesa J and H mine pits and into a minor watercourse which ultimately drains back into the Robe River. The diversion is currently not proposed to be maintained post closure.

This diversion will manage small overland catchments of 24 km^2 which are currently captured in the pits at the existing Mesa J Iron Ore Development. The proposed diversion during operations will ensure that all catchment flows are diverted back into the Robe River, thus limited impact to significant riparian vegetation is anticipated. The redirection of flows back to the Robe River during operations may also be of some benefit for limiting potential impacts to the pools of the Robe River during periods of active mine pit dewatering.

6.6.3.4 Degradation of vegetation due to ingress of weeds

The Proposed Change may introduce and spread weed species within and in the vicinity of disturbance. Weed species have the potential to spread further downstream with altered hydrological regimes, specifically, discharge to Jimmawurrada and West Creeks, which are tributaries into the Robe River.

Most weeds species recorded in the Proposed Change Area and the broader Study Area occurred along drainage lines, disturbed areas, and areas frequented by the public and Pastoral livestock. Clearing activities associated with drainage lines will be limited to an access road across the Robe River and minor clearing associated with groundwater monitoring or discharge infrastructure.

The Proponent has well established strategies for the management of weeds at its Pilbara operations to minimise the risk of the spread of weeds. Weed management via the existing Mesa J Iron Ore Development Weed Action Plan will continue be implemented and extended to include the Proposed Change, including:

- Annual inspections to monitor weed species and assess extent of infestations
- Vehicle and equipment hygiene practices
- Regular weed control, including prior to the wet season, when weeds are known to flourish
- Weed control in areas prior to disturbance, to minimise risk of seed spread from vehicle movements.

On this basis, it is unlikely that the Proposed Change will significantly impact vegetation through introduction and spread of weed species. Any impacts are predicted to be localised to the areas of disturbance and will not impact vegetation regionally.

6.6.3.5 Degradation of vegetation due to increased dust deposition

Construction and operation of the Proposed Change is likely to increase airborne dust, which in turn may result in increased dust deposition on retained native vegetation in the Proposed Change Area, particularly during high wind events.

Vegetation in the Pilbara is often exposed to high dust loadings, as such, much of the native vegetation is considered to have reasonable tolerance to dust deposition. Studies by Butler (2009) and Matsuki *et al.* (2016) of the effects of dust loading on vegetation in semi-arid environments in WA, including the Pilbara, have indicated various species tolerances to dust loading showed no detectable negative impacts on the vegetation health for deposition rates up to 77 g/m^2/month. The predicted depositions at the closest pools and associated fringing riparian vegetation are all not more than 33% of the criterion of 3 g/m^2/month (Envall 2018).

To minimise airborne dust and dust deposition on vegetation, the Proponent will implement well established strategies for the management of dust emissions currently used across its Pilbara operations. These strategies include:

- Minimising exposed surfaces by minimising clearing and rehabilitating disturbed areas no longer in use
- Applying water (water carts or other dust suppressants) to roads, working surfaces and stockpiles as required
- Restricting vehicle access to designated roads and tracks and implementing speed limits to minimise dust generation from roads.

Dust monitoring of key receptors will enable dust management performance to be assessed and strategies to manage dust emissions refined where necessary.

The Proposed Change may result in a minor, temporary and localised increase in dust deposition on vegetation but is not expected to significantly impact vegetation regionally. On this basis, it is considered unlikely that the Proposed Change will significantly impact vegetation through increased dust emissions.

6.6.3.6 Degradation of vegetation due to increased fire risk

The Proposed Change will not alter the fire frequency in the local area through implementation of fire controls. Vegetation in the Pilbara typically burns relatively frequently, at least every few years, and is understood to contribute to regeneration and recruitment by triggering germination. Reduced fire frequency may result in lower regeneration in retained vegetation within, and in the vicinity of, the buffered footprint.

The impact on vegetation is expected to be localised and will not impact vegetation regionally. On this basis, the altered fire regime is considered unlikely to significantly impact vegetation condition in the Proposed Change Area.

6.6.4 Cumulative impacts

Potential cumulative impact of the Proposed Change include clearing, impacts to riparian vegetation and loss of priority flora.

6.6.4.1 Clearing

The Proposed Change will result in the clearing of up to 2,200 ha of vegetation, in addition to the 1,800 ha approved under MS 208 for the existing Mesa J Iron Ore Development, totalling 4,000 ha of clearing within a 6,638 ha Development Envelope. Existing and proposed clearing at other mining operations total 10,710 ha of clearing by Rio Tinto in the Robe Valley (Table 6-13).

6.6.4.2 Riparian vegetation

Additional indirect vegetation degradation and or losses are predicted to be incurred associated with site water management (drawdown and discharge).

Groundwater drawdown from the existing Mesa J Iron Ore Development and drawdown from abstraction from the Southern Cutback Borefield has already lowered the groundwater table by approximately 20 m in the adjacent Mesa H deposit CID and by approximately 4 – 6 m in the adjacent section of Jimmawurrada Creek; however, this has not resulted in significant impacts to riparian vegetation on the Robe River (Streamtec 2017, Rio Tinto, 2018d), however monitoring has noted some degree of decline in riparian health in Jimmawurrada Creek (Astron 2018). The Proposed Change will require further drawdown of the groundwater table at Mesa H, which conservative modelling indicates may result in <1 m drawdown to the semi-permanent and permanent pools of the Robe River. This is considered unlikely to result in a discernible impact to phreatophytic vegetation. A predicted drawdown of up to 9 m (14 mbgl) along a 6.5 km stretch of Jimmawurrada Creek (encompassing ~ 7 ha OPV and 84 ha of FPV) in 2030 is likely to result in significant impacts including canopy decline and increased tree mortality. This impact may be exacerbated taking into consideration an extended dry period combined with seasonal water table lows as described in Table 6-20.

The Proposed Change will result in minimal cumulative impacts to riparian vegetation from surplus water discharge as the vegetation is already augmented by discharge associated with the existing Mesa J Iron Ore Development. The effect of additional discharge on the communities of the Robe River is likely to be relatively minimal. There is some evidence of altered vegetation structure and composition on Jimmawurrada Creek downstream of the discharge outlet, generally in the form of relatively uneven age structures within phreatophytic tree populations (dominated by young tree cohorts, and leading to increased susceptibility to drought stress induced senescence events), increasing structural density in overstorey and understorey riparian strata, potentially unsustainable vegetation water demands per unit area (when the creek reverts to more ephemeral conditions) and reductions in the abundance and diversity of ephemeral and xerophytic taxa within certain riparian zones.

No significant impacts to riparian vegetation at the existing Mesa A / Warramboo Project have been observed, and no significant impacts to riparian vegetation as a result of the Mesa A Hub Revised Proposal are anticipated as a result of dewatering or discharge.

6.6.4.3 Priority Flora

Only two Priority flora species proposed to be impacted at Mesa H have been (knowingly – based on existing database records) impacted by the Proponent at other operations in the Robe Valley as outlined in Table 6-15 in Section 6.5.3; *Triodia sp.* Robe River (M.E. Trudgen et al. Met 12367) and *Rhynchosia bungarensis*. Considering historical disturbance, the proposed disturbance and reasonably foreseeable disturbance in the Robe Valley, cumulative impacts to these two Priority Flora species will be 10% or less. Cumulative impacts to Priority Flora are estimated to be:

- 10% of Rio Tinto records of *Triodia* sp. Robe River (M.E. Trudgen et al. Met 12367)
- 1% of Rio Tinto records of *Rhynchosia bungarensis.*

The greatest contribution of the Proposed Change to cumulative impacts is 10% of Rio Tinto records of *Triodia* sp. Robe River (M.E. Trudgen et al. Met 12367) however; it is likely that *T. sp*. Robe River is far more abundant, with surveys conducted on behalf of API identifying 24 populations containing 60 million individuals in a 35,000 km targeted search area in the West Pilbara (API 2011). Proposed clearing of 28,293 individuals at Mesa H constitutes 0.05% of the potential 60 million records of *T. sp*. Robe River in the West Pilbara. This proposed disturbance is not considered a significant cumulative impact and has little potential to affect the species' conservation status.

6.7 Closure

The Mesa J Hub Closure Plan (Rio Tinto 2018a) is an integrated closure plan encompassing the existing Mesa J and Mesa K operations, together with the inclusion of the Proposed Change, in order to optimise closure outcomes. The plan is an update to and supersedes previous closure plans for the existing Mesa J and K Operations. The Closure Plan includes the mine developments and associated infrastructure contained within the Development Envelope (Mesa J and H) and within Mesa K's Development Envelope. A summary of the approach to closure in the Revised Proposal and how it relates to the flora and vegetation factor is provided below.

The proposed final land use assumes that the site will be rehabilitated to create a safe, stable and non-polluting landscape revegetated with native species, to maximise environmental and cultural heritage outcomes and ensure the site does not adversely impact on the current surrounding land use. Due to the nature of the mining activity undertaken, the final landform will include large voids and waste dumps, and will therefore be unlikely to support pastoral activities in the immediate vicinity of the mining areas. The final land use will be determined prior to closure during final planning phases and in consultation with relevant stakeholders.

Rehabilitation at Mesa J to date comprises approximately 148 ha of progressive rehabilitation, of which some areas have been re-disturbed due to ongoing mining activities and the limited available footprint. Rehabilitation has been completed in Pit 10 with good vegetation establishment with a range of native vegetation species in areas where topsoil cover was focussed. Two waste dumps and a WFSF were also successfully rehabilitated and monitored (S and T Dumps and TSF1 respectively) (Refer to Appendix 7). Progressive backfill of pits to meet closure commitments and other opportunistic rehabilitation where available will be undertaken during operations, however the majority of rehabilitation will be completed at closure.

The key objective for vegetation on rehabilitated land is that it is self-sustaining and compatible with the final land use. This will be measured via rehabilitation monitoring and site inspections combined with analysis of historical monitoring data. Seed used in rehabilitation works will be of local provenance where possible. Weeds in rehabilitation are managed under the company's Weed Management Strategy which has control measures such as periodic spraying and equipment hygiene procedures.

6.8 Mitigation

Mitigation strategies to address the potential impacts and predicted outcomes are presented in Table 6-23.

The Mesa J Hub EMP (Appendix 6) addresses the key environmental factors which were determined by the EPA as being relevant to the appropriate management of dewatering, surface water discharge, conservation significant vegetation communities and fauna species associated with the Mesa J Hub. The EMP identifies:

- Mitigation strategies proposed to minimise impacts to significant environmental values
- The environmental criteria that the Proponent will use to monitor performance of the mitigation strategies to ensure environmental objectives are met
- Trigger criteria, threshold criteria, trigger level actions and threshold contingency actions aligned with the overall management approach
- The management actions that will be implemented in response to monitoring results.

Table 6-23: Mitigation Measures, Residual Impacts and Significance / Offset Assessment for Flora And Vegetation

Inherent impact	Mitigation	Residual impacts	Assessment of significance[3]	Offset required?
EPA Objective: ***To protect flora and vegetation so that biological diversity and ecological integrity are maintained.***				
Direct Impacts				
Loss of vegetation and conservation significant flora as a result of clearing: Clearing will remove up to 2,200 ha of native vegetation including vegetation units of local and sub-regional significance and priority flora.	The following key management strategies will be implemented to manage the loss of flora and vegetation as a result of clearing: **Avoid**: The Proposed Change has been designed to avoid known locations of Priority Flora and significant vegetation as far as practicable. The Proposed Change has been designed to avoid impact to areas of *Triodia* sp. Robe River Priority 3 flora and *Triodia* sp. Robe River analogous to the PEC where practicable. The Proponent will ensure clearing only occurs in approved ground disturbance areas through continued implementation of the Proponent's Approvals Request system. Priority Flora are also flagged with restriction zones in Rio Tinto's internal GIS system. **Minimise:** The clearing footprint has been minimised through project optimisation to reduce the total extent of clearing required and particularly to minimise the clearing within high value areas of vegetation and flora; Infrastructure has been located to avoid or limit clearing within creek lines to minimise clearing of locally and sub-regionally significant riparian vegetation; utilising existing roads and utilising / optimising existing infrastructure from Mesa J Iron Ore Development; placement of waste-fines in-pit	This Proposed Change is expected to result in the loss of up to 2,200 ha of vegetation including up to 1,986 ha of vegetation in Good to Excellent condition. Approximately 6 ha (5.7 ha) of vegetation analogous to the *Triodia* sp. Robe River Priority 3 PEC will be cleared as a result of the Proposed Change. Approximately 2 ha of sub-regionally significant riparian vegetation will be cleared within the Robe River by the Proposed Change. The Proposed Change is expected to impact three Priority flora species: • *Triodia* sp. Robe River (P3) • *Indigofera* sp. Bungaroo Creek (P3) • *Rhynchosia bungarensis* (P4). The loss of 9.8%, 1% and 0.01% of records in the Rio Tinto database for *Triodia* sp. Robe River (M.E. Trudgen *et al.* Met 12367), *Rhynchosia bungarensis* and *Indigofera* sp. Bungaroo	The Proposed Change is considered to meet the EPA objective for this factor; the proposed loss of vegetation is not expected to cause any loss of biological diversity at the local or regional scale and the ecological integrity of the area surrounding the footprint is expected to be maintained. Given the proposed avoidance and minimisation of disturbance to the most significant vegetation communities and priority flora; the Proposed Change is not expected to adversely affect the conservation status of any community or species. The loss of 6 ha of vegetation analogous to the *Triodia* sp. Robe River PEC is not expected to result in a significant impact on the representation of the *Triodia* sp. Robe River PEC at a local or regional scale. The riparian vegetation communities in the vicinity of the Proposed Change are of local and sub-regional conservation significance. The proposed clearing of <2 ha of	Yes. The Proponent proposes the provision of an environmental offset ($750/ha) for the clearing of vegetation in Good to Excellent condition, and an environmental offset at the higher offset rate ($1,500/ha for the clearing of conservation significant vegetation; vegetation analogous to the *Triodia* sp. Robe River P3 PEC and phreatophytic riparian vegetation.

[3] Assessed in accordance with the residual impact significance model (EPA 2014)

Inherent impact	Mitigation	Residual impacts	Assessment of significance[3]	Offset required?
	into the existing Mesa J Iron Ore Development footprint; waste and ore/topsoil stockpiles are proposed to be placed in-pit where mine schedules have allowed. The Proponent proposes that clearing be subject to a new MS (Appendix 3). Schedule 1 of the MS shall authorise clearing of no more than 4,000 ha within the Development Envelope of 6,638 ha (2,200 ha of which is associated with the Proposed Change). **Rehabilitate:** The conditions of the new MS shall require the Proponent to implement a Closure Plan in accordance with the DMP / EPA *Guidelines for Preparing Mine Closure Plans.* The Proponent commits to undertake progressive rehabilitation to minimise the extent of cleared areas and to restore vegetation using recovered topsoil and seed of local provenance. The Closure Plan (Appendix 7) also includes a Closure Objective to ensure that vegetation on rehabilitated land is self-sustaining and compatible with the final land use. Indicative closure completion criteria include: • Seed used in rehabilitation works is of local provenance (except where seed pre-dates accurate recording of area) • Native plants within rehabilitated areas are observed to flower and/or fruit • Recruitment of native perennial plants is observed • Species richness of native perennial plants within rehabilitated areas is not less than reference sites • Any weed species recorded within rehabilitation areas are present within the local area	Creek, respectively is unlikely to affect the species' conservation status at a local or regional scale.	riparian vegetation is not expected to have a significant impact on the representation of the riparian vegetation at a local or regional scale. Similar riparian vegetation communities occur relatively extensively throughout the Hamersley Ranges.	

<table>
<tr><th>Inherent impact</th><th>Mitigation</th><th>Residual impacts</th><th>Assessment of significance[3]</th><th>Offset required?</th></tr>
<tr><td></td><td>Erosion from landforms does not threaten surrounding significant natural ecosystems.</td><td></td><td></td><td></td></tr>
<tr><td colspan="5">Indirect Impacts</td></tr>
<tr><td>Loss or degradation of riparian vegetation as a result of groundwater drawdown

<u>Jimmawurrada Creek</u>
Groundwater drawdown as a result of groundwater abstraction for water supply may result in a decline in riparian health along a 12 km section of Jimmawurrada Creek.

<u>Robe River</u>
Groundwater drawdown as a result of mine pit dewatering may result in changes to the vegetation understorey in the vicinity of the semi-permanent and permanent pools but is unlikely to result in significant changes to the riparian vegetation health</td><td>The following key management strategies will be implemented to manage the loss of flora and vegetation as a result of groundwater drawdown:

Avoid:
The Proposed Change will utilise an existing water supply borefield and therefore avoid creating a new drawdown area for groundwater supply.

Minimise:
Hydrogeological modelling has been and will continue to be undertaken to facilitate understanding of current and future abstraction requirements. Groundwater abstraction will be minimised to that required to access the BWT resource and meet water supply requirements.

The impacts of groundwater drawdown on vegetation and flora will be minimised through the use of the existing Southern Cutback Borefield rather than the creation of a new water supply.

The Proponent will abstract groundwater within the existing licence limits regulated under the RIWI Act and monitor groundwater levels to ensure impact remains within the predicted range of impact.

If groundwater drawdown is greater than anticipated in the Robe River alluvial aquifer as a result of dewatering, proposed contingency mitigation options include:
providing abstracted water directly back into the permanent pools of the Robe River</td><td>Jimmawurrada Creek

Groundwater drawdown of up to 9 m is predicted to occur along a 6.5 km stretch of Jimmawurrada Creek (encompassing 349 ha of moderate risk FPV in zone 3) is likely to result in impacts including canopy decline and increased tree mortality. However, if natural recharge in Jimmawurrada Creek is reduced by 50% due to an extended dry period, the water table levels could be lowered by almost 3 m in addition to the natural seasonal fluctuations; this would translate to localised changes in water table depths of up to 14 m from pre-mining conditions, which would increase riparian canopy decline and mortality.

A further 7 km (172 ha) of FPV in Zone 2 is likely to be impacted but to a lesser degree (4-8 m drawdown). Impacts could include some canopy decline however impacts are likely to be mitigated by seasonal surface water flows combined with periodic surplus water discharge from the Proposed Change.</td><td>The predicted impacts are not considered significant on a regional scale, however in a worst-case scenario (e.g. extended drought, periods of low discharge) local impacts are possible. However, the impacts are expected to be temporary and the system is anticipated to revert back to its ephemeral / pre-mining state once dewatering ceases. The potential temporary changes to riparian vegetation within a 6.5 km stretch of Jimmawurrada Creek (up to 9 m drawdown in dry conditions) and reduced risk of changes within an additional 5.5 km section (4 – 5 m drawdown) are not considered to be a significant residual impact.</td><td>No.

The Proponent considers that the potential impacts can be managed, and the residual impact is not considered to be significant and therefore does not warrant the application of offsets.</td></tr>
</table>

Inherent impact	Mitigation	Residual impacts	Assessment of significance[3]	Offset required?
	• avoiding mining below the 120 m RL in the northern-most pit, particularly during extended drought periods. In-pit water storage management on site (e.g. Dan's Dam – refer to Section 5) also provides passive aquifer recharge and limits the requirement to draw from the Southern Cutback Borefield. The Proponent proposes that groundwater abstraction be subject to a new MS (Appendix 3). The conditions of the new MS shall require the Proponent to implement an EMP (Appendix 6) to manage groundwater abstraction such that there are no irreversible impacts to GDV within the Robe River and Jimmawurrada Creek. The Proponent proposes to monitor the health of the dominant groundwater dependent species using ground base monitoring and remote sensing **Rehabilitate**: No active rehabilitation/revegetation is planned beyond allowing natural recruitment and regeneration to take place.	In total, 12 ha of OPV is present in Zones 1 - 3 and is considered to be most sensitive to groundwater drawdown, however most of the OPV appears to have resulted from surface water discharge with only approximately 0.5 ha of OPV potentially pre-existing / naturally occurring. The additional mitigating influence of the Robe River aquifer, seasonal aquifer recharge, discharge through existing licensed outlets and rainfall events support that significant impacts are unlikely. **Robe River** Groundwater drawdown of <1 m is predicted to occur along a 14 km stretch of the Robe River. 232 ha of *Melaleuca argentea* dominated communities have been mapped in Zone 1 and 2 which may experience some canopy decline. Impacts are expected to be reduced by seasonal surface water flows combined with periodic surplus water discharge from the Proposed Change.		
Loss or degradation of riparian vegetation as a result of surface water discharge Sporadic discharge of surplus groundwater into Jimmawurrada Creek and West Creek (both tributaries of the Robe River) is	The following key management strategies will be implemented to manage the impacts to riparian vegetation as a result of discharge of surplus groundwater: **Minimise**: Abstracted groundwater will be used on site for processing and dust suppression to avoid discharge as far as practicable.	The Revised Proposal is expected to result in temporary changes to riparian vegetation as a result of change in hydrological regime within the discharge zone, up to approximately 8 km downstream of the discharge outlets in either Jimmawurrada Creek or West Creek. However, the discharge will be temporary and intermittent,	The proposed discharge is not expected to have any long-term adverse effects on the riparian vegetation community. The Proponent considers that the Proposed Change can be managed to meet the EPA's objective for this factor. No significant residual impact on riparian vegetation is anticipated.	No. The Proponent considers that the potential impacts can be managed, and the residual impact is not considered to be significant and therefore does not warrant the application of offsets.

Inherent impact	Mitigation	Residual impacts	Assessment of significance[3]	Offset required?
expected to extend the already changed hydrological regime where water is more readily available beyond seasonal availability in the low flow channel. This may impact riparian vegetation by favouring the establishment of OPV	Surplus groundwater will be discharged at a rate which is not expected to cause bank erosion. The Proponent proposes to monitor the health of the riparian vegetation within the discharge extent to ensure there are no irreversible impacts to health as a result of the Proponent's discharge of surplus water. Water quality will also be monitored from the discharge points and in the permanent and semi-permanent pools. The Proponent proposes that the discharge of surplus water by subject to a new MS (Appendix 3). The conditions of the MS shall require the Proponent to implement an EMP (Appendix 6) to ensure that discharge of surplus water from mine pit dewatering does not have an irreversible impact on the health of riparian vegetation of Jimmawurrada Creek. The Proponent proposes to monitor the health of the dominant groundwater dependent species using ground base monitoring and remote sensing. Discharge of surplus water from mine pit dewatering will be managed in accordance with an amended Operating Licence issued under Part V of the EP Act.	lasting for the duration of discharge activities, which is anticipated to be substantially less than the LOM. Given the temporary nature of the discharge to a system that is adapted to highly variable flow conditions, it is unlikely that there will be any significant residual impact on riparian vegetation. It is anticipated that impacts to vegetation will be minimal beyond the changes that have already occurred. At most, there could be some increase in the dominance and cover of *Eucalyptus camaldulensis Melaleuca argentea*, and sedges and rushes. Some decline in health of *Eucalyptus victrix* (including dead trees) is also possible. Discharge may help mitigate the impacts of drawdown to groundwater dependent communities. Once discharge ceases, it is anticipated that the riparian vegetation will revert to that adapted to an ephemeral system.		
Vegetation condition may decline as a result of introduced weed species Ground disturbance, vehicle movements and changes to the hydrological regime of Jimmawurrada Creek	The following key management strategies will be implemented to manage impacts to loss of flora from introduced weed species: **Avoid**: The Proponent will implement strict hygiene procedures to prevent introduction and/or spread of Declared Weed Species into the Development Envelope.	The Proposed Change will likely result in some minor increase in weed infestation adjacent to disturbed areas; however, this is not expected to significantly alter the condition of retained vegetation in the Proposed Change Area.	No significant change in vegetation condition is expected.	No. The Proponent considers that the potential impacts can be managed, and the residual impact is not considered to be significant and therefore does not warrant the application of offsets.

Inherent impact	Mitigation	Residual impacts	Assessment of significance[3]	Offset required?
may introduce or spread Declared Weed species within the Proposed Change Area.	**Minimise**: The Proponent will undertake annual weed control prior to the wet season, to minimise weed infestations in the Development Envelope. The conditions of the MS shall require the Proponent to implement an EMP (Appendix 6) to ensure that discharge of surplus water from mine pit dewatering does not have an irreversible impact on the health of riparian vegetation of Jimmawurrada Creek, including the spread of weeds. **Minimise**: Weed inspection and control will be undertaken in weed management areas which will include both manual and chemical control measures. Areas of high priority for weed management include Jimmawurrada Creek; Robe River permanent pools and river crossings; MEZ; and topsoil stockpiles. **Rehabilitate**: The Proponent proposes that closure be subject to a new MS (Appendix 3). The MS shall require the Proponent to implement a Closure Plan in accordance with the DMP / EPA *Guidelines for Preparing Mine Closure Plans*. The Closure Plan (Appendix 7) includes a Closure Objective to ensure that vegetation on rehabilitated land is self-sustaining and compatible with the final land use. Weed management during rehabilitation and post-closure will be in alignment with the Closure Plan and based on the outcomes of proposed monitoring. **Other legislation:**			

Inherent impact	Mitigation	Residual impacts	Assessment of significance[3]	Offset required?
	Weed management will be in accordance with the requirements of the *Agriculture and Related Resources Protection Act 1976*			
Degradation of vegetation due to increased dust deposition Dust emissions may impact vegetation within the Development Envelope including the vegetation analogous to the *Triodia sp.* Robe River PEC.	The following key management strategies will continue to be implemented to manage dust emissions: **Minimise**: The Proponent will minimise exposed surfaces by minimising clearing to that required to implement the Proposed Change. The Proponent will implement dust controls including water sprays, dust suppressants and other measures to minimise the extent of dust deposition on vegetation. **Rehabilitate**: The Proponent will rehabilitate disturbed areas that are no longer in use.	Dust emissions are not anticipated to change the health of vegetation outside of disturbance areas.	No significant residual impact on vegetation and flora from dust deposition is anticipated.	No. The Proponent considers that the potential impacts can be managed, and the residual impact is not considered to be significant and therefore does not warrant the application of offsets.

6.9 Predicted outcome

The key Flora and Vegetation values identified in the Study Area and considered relevant to the Proposed Change include:

- Conservation Significant Vegetation:
    - Riparian Vegetation:
        - Robe River: Ground Water Dependant Vegetation (dominated by OPV – *Melaleuca argentea*) along the river and surrounding the semi-permanent and permanent pools.
        - Jimmawurrada Creek: Riparian Vegetation (dominated by Facultative Phreatophytic Vegetation – *Eucalyptus camaldulensis* and *Eucalyptus victrix).*
    - Vegetation analogous to the *Triodia* sp. Robe River PEC (AprTwTsr).
- Priority Flora Species:
    - *Triodia* sp. Robe River (P3);
    - *Indigofera* sp. Bungaroo Creek (P3); and
    - Rhynchosia bungarensis (P4).

After the mitigation hierarchy has been applied (Table 6-23), the Proposed Change would result in the following key outcomes in relation to Flora and Vegetation:

- Clearing of up to 2,200 ha of native vegetation of which up to 1,986 ha will be within vegetation in Good to Excellent condition.
- Clearing of 2 ha (less than 2% within the Proposed Change Area) of significant *Melaleuca argentea* (Obligate Phreatophyte) and *Eucalyptus camaldulensis* (Facultative phreatophyte) dominated riparian vegetation within the Robe River.
- Clearing of approximately 6 ha of AprTwTsr (*Acacia pruinocarpa* low woodland over *Triodia wiseana*, *T.* sp. Robe River open hummock grassland) vegetation, analogous to the Priority 3 PEC '*Triodia* sp. Robe River *assemblages of the West Pilbara'*, less than 2% of the mapped extent of the Priority 3 PEC.
- Clearing of less than 10% of the total of Rio Tinto records of each priority flora species; *Triodia* sp. Robe River P3, *Indigofera* sp. Bungaroo Creek P3 and *Rhynchosia bungarensis* P4.
- Potential for some decline in canopy of *Melaleuca argentea* and *Eucalyptus Camaldulensis* dominated riparian vegetation along a 14 km section of the Robe River including pools (Zones 1 and 2) during the period of dewatering for Mesa H.

The Revised Proposal (together with other foreseeable proposals and a drier climate) would result in the following key outcomes in relation to Flora and Vegetation:

- Significant canopy decline and potential for increased mortality of up to 7 ha of *Melaleuca argentea* and Eucalyptus dominated riparian vegetation (0.3 ha of which was present pre-mining) and up to 84 ha of Eucalyptus dominated riparian vegetation along a 6.5 km section of Jimmawurrada Creek (Zone 3).
- Decline in canopy and some potential for increased mortality of up to 3.4 ha of *Melaleuca argentea* and Eucalyptus (1 ha of which was present pre-mining) dominated riparian vegetation and up to 174 ha of Eucalyptus dominated riparian vegetation along an 5.5 km section of Jimmawurrada Creek (Zones 1 and 2 and 3B).
- Some temporary changes in structure, cover and health of both *Melaleuca argentea* and Eucalyptus dominated riparian vegetation communities up to 8 km downstream from the discharge point on Jimmawurrada Creek and West Creek.
- Rehabilitation of landforms including revegetation by natural recruitment and regeneration.

After the mitigation hierarchy has been applied (Section 6.8), the Proponent considers that there is a significant residual impact from:

- The clearing of up to 1,986 ha of native vegetation in Good to Excellent condition, including:
  - o approximately 2 ha of sub-regionally significant riparian vegetation along the Robe River; and
  - o 6 ha of vegetation analogous to the *Triodia* sp. Robe River PEC (AprTwTsr).

Consistent with the Government of Western Australia Offsets Guidelines (2014b), a significant residual impact to areas of high environmental, or where the cumulative impact may reach critical levels, may require an offset. The Proponent has proposed an offset for the significant residual impact of the Proposed Change. The Proposed offset is discussed in Section 13.

The Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Flora and Vegetation through:

- a limit on the extent of clearing up to 2,200 for the Proposed Change;
- continued management of abstraction and discharge in accordance with the existing RIWI and EP Act Part V licences respectively;
- the implementation of the updated Mesa J Hub EMP and the Mesa J Hub Closure Plan; and
- the implementation of an appropriate offset to counterbalance the significant residual impact of loss of 'Good to Excellent' native vegetation (including vegetation analogous to the PEC and significant riparian vegetation).

Given the proposed mitigation and offset, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Flora and Vegetation.

7. SUBTERRANEAN FAUNA

This Section describes the subterranean fauna that occur within the Proposed Change Area and the surrounding Study Area, including the potential subterranean fauna habitats; provides details regarding the potential impacts to conservation significant subterranean fauna and proposed mitigation and management to ensure that the Proposed Change meets the EPA's objectives for subterranean fauna.

7.1 EPA Objective

The EPA applies the following objective from the Statement of Environmental Principles, Factors and Objectives (2018c) in its assessment of proposals that may affect subterranean fauna:

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

7.2 Policy and Guidance

7.2.1 EPA Policy and Guidance

The relevant policy and guidance for subterranean fauna is:

- DMP and EPA (2015) Guidelines for Preparing Mine Closure Plans;
- EPA (2018c) Statement of Environmental Principles, Factors and Objectives;
- EPA (2016f) Environmental Factor Guideline: Subterranean Fauna;
- EPA (2018d) Environmental Factor Guideline – Inland Waters Environmental Quality;
- EPA (2016g) Technical Guidance: Sampling methods for Subterranean fauna (the content of this Guidance has not yet been updated from EPA Guidance Statement No. 54a: technical appendix to Guidance Statement No. 54);
- EPA (2016h) Technical Guidance: Subterranean fauna survey (the content of this Guidance has not yet been updated from EPA Guideline 12. Issued June 2013);
- EPA (2018b) Instructions on how to prepare an Environmental Review Document; and
- EPA (2016c) Instructions on how to *prepare Environmental Protection Act 1986* Part IV Environmental Management Plans.

7.2.2 Other Policy and Guidance

- The Government of Western Australia (2011) WA Environmental Offsets Policy; and
- The Government of Western Australia (2014b) Environmental Offsets Guidelines.

7.2.3 Requirements of the Environmental Scoping Document

Table 7-1 summarises where the requirements of the ESD are addressed in this section.

Table 7-1: Requirements of the Environmental Scoping Document

Item	Requirements	Section and Comment
15	Conduct Level 2 fauna surveys within areas to be impacted and in surrounding areas in accordance with EPA 2016 Environmental Factor Guideline - Subterranean Fauna.	Sections 7.4.1.1 and 7.5.1.1
16	Present the results of the subterranean fauna surveys and discuss the potential for direct, indirect and cumulative impacts to subterranean fauna and habitat including consideration of altered water regimes and water quality as a result of the Proposal, and other operating/planned mining operations within the Robe River Valley.	Sections 7.4.1, 7.4.2, 7.5.1 and 7.5.2
17	Assess any impacts to subterranean fauna with reference to relevant impacts from the Proposal (including taking into consideration any relevant guidelines, policies, plans and statutory provisions). For species which are likely to be impacted, including MNES listed species (Blind Cave Eel), provide information, including maps on habitat extent and an appropriate explanation of the likely distribution of species within those habitats, including information to support habitat connectivity.	Sections 7.4.4 and 7.5.3
18	Provide a detailed description of the cumulative impacts to conservation significant and other species within the Development Envelope and on a regional scale.	Sections 7.4.3.3, 7.4.4.3, 7.5.2.3 and 7.5.3.3
19	Discuss proposed objectives, management, monitoring and mitigation methods to be implemented demonstrating that the design of the Proposal has addressed the mitigation hierarchy to avoid and minimise impacts to subterranean fauna.	Sections 7.4.6 and 7.5.5
20	Develop a Subterranean fauna management plan(s) to apply to the Proposal. The objective of the plan is to ensure the protection of conservation listed subterranean fauna species within the Development Envelope and areas of indirect impact.	Appendix 6
21	Prepare a Mine Closure Plan consistent with DMP and EPA Guidelines for Preparing Mine Closure Plans (2015) which delineate and considers the use of MEZ to protect troglofauna habitat and takes into consideration groundwater recovery to support stygofauna habitat.	Appendix 7

Item	Requirements	Section and Comment
22	Predict the inherent and residual impacts before and after applying the mitigation hierarchy and identify whether the residual impacts are significant by applying the Significant Residual Impact Model in the WA Environmental Offsets Guideline.	Section 7.6
23	Quantify any significant residual impacts by completing the Offset Template and propose an appropriate offsets package that demonstrates application of the WA Environmental Offsets Policy and Guideline.	Section 13
24	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Sections 7.4.6, 7.5.5 and 7.6

7.3 Receiving Environment

Subterranean fauna are highly specialised to subterranean habitats and whilst they may occur close to surface environments, the fauna are unable or highly unlikely to survive surface conditions (Biota 2019a). Subterranean fauna is defined for the purposes of EIA (EPA 2016f) as fauna which live their entire lives (obligate) below the surface of the earth. In WA, subterranean fauna have been recorded at Cape Range, Barrow Island, the Yilgarn, the Nullarbor, and throughout the Pilbara bioregion. They are generally considered to comprise two main categories based on habitats in which they occupy (Humphreys 2000a in Biota 2004):

- Troglofauna: obligate terrestrial subterranean fauna occurring in underground, air-filled cavities, fissures and interstitial spaces above the water table.
- Stygofauna: obligate groundwater-dwelling, aquatic fauna that live in subterranean voids and fissures in alluvial, karstic or fractured rock aquifers; springs and the hyporheic zone of streams (Eberhard *et al*. 2005).

EPA (2016f) define the subterranean fauna categories even more simply as:

- Stygofauna – aquatic and living in groundwater.
- Troglofauna – air-breathing and living in caves and voids.

Subterranean fauna have been collected from a range of geological units such as CID (pisolitic iron formations), unconsolidated alluvium and sedimentary basalt (Marmonier *et al.* 1993; Biota 2004, 2006a, 2010a, 2011a, 2013 in Biota 2019a).

7.3.1 Project setting

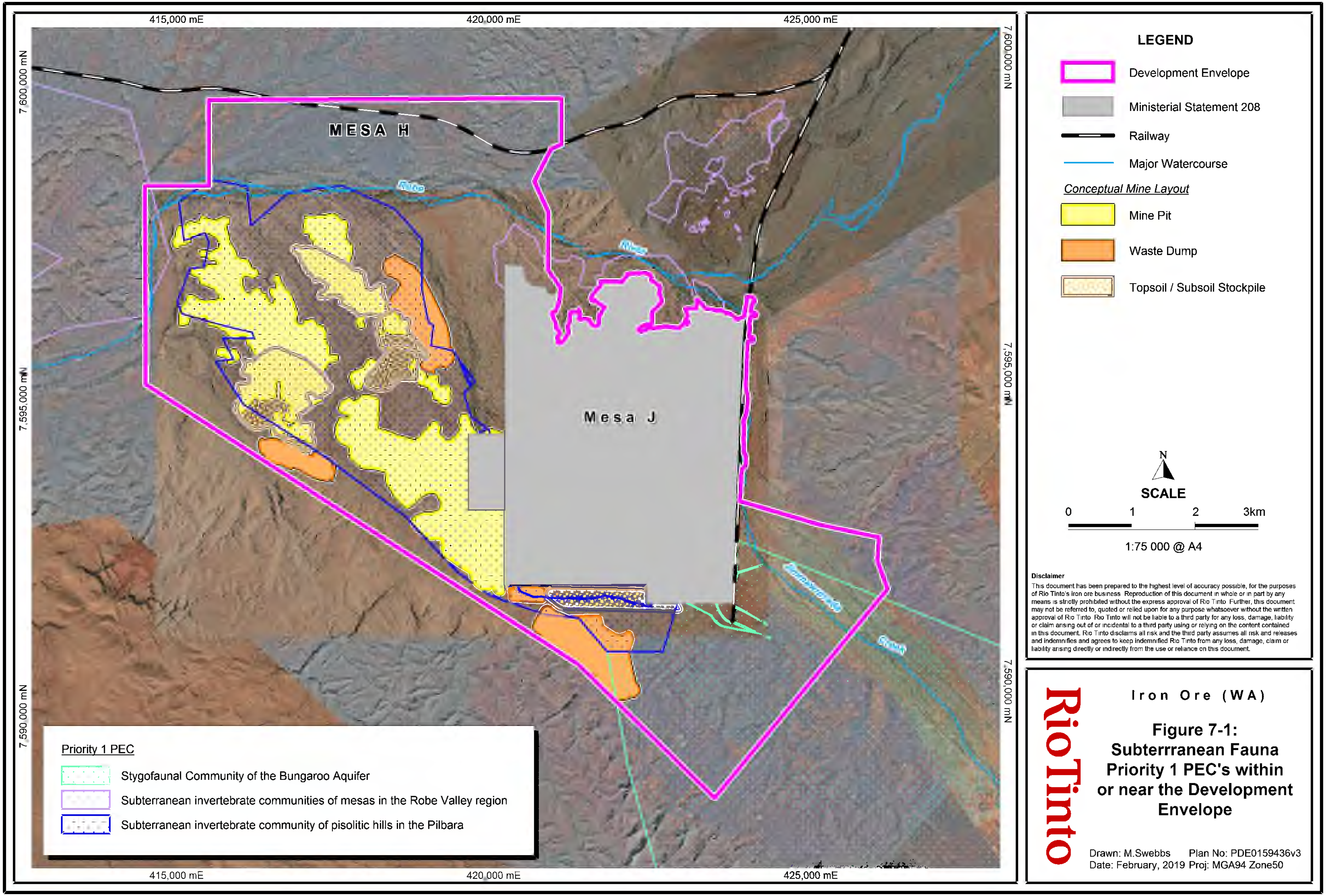
Subterranean fauna surveys within the Robe Valley have documented the occurrence of both troglobitic and stygobitic fauna communities.

The Robe Valley hosts a number of habitats important for subterranean fauna; in particular, CIDs, occurring both as valley-fill AWT and BWT, and as mesa landforms, which are prominent features in the Robe Valley landscape. The ephemeral river channels of the landscape also provide habitats for subterranean fauna in the alluvial gravels. The Development Envelope contains all of these habitats and include the Mesa H CID and valley fill CID along the Jimmawurrada – Bungaroo Valley, the ephemeral Robe River and a portion of Jimmawurrada Creek. These watercourses also provide opportunities for subterranean fauna dispersal, particularly as Jimmawurrada Creek has direct habitat connectivity with the underlying CID and is also a tributary of the Robe River.

Three Priority 1 PECs relevant to subterranean fauna are present in (or overlap with) the Development Envelope, (Figure 7-1) which include:

- Subterranean invertebrate communities of mesas in the Robe Valley region;
- Subterranean invertebrate community of pisolitic hills in the Pilbara; and
- Stygofaunal Community of the Bungaroo Aquifer.

A discussion of troglofauna and stygofauna and potential impacts are outlined below in Sections 7.4 and 7.5 respectively.


415,000 mE
420,000 mE
425,000 mE
7,600,000 mN
7,595,000 mN
7,590,000 mN
MESA H
Mesa J
LEGEND
Development Envelope
Ministerial Statement 208
Railway
Major Watercourse
Conceptual Mine Layout
Mine Pit
Waste Dump
Topsoil / Subsoil Stockpile
N
SCALE
0
1
2
3km
1:75 000 @ A4
Priority 1 PEC
Stygofaunal Community of the Bungaroo Aquifer
Subterranean invertebrate communities of mesas in the Robe Valley region
Subterranean invertebrate community of pisolitic hills in the Pilbara
Disclaimer
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RioTinto
Iron Ore (WA)
Figure 7-1:
Subterrranean Fauna
Priority 1 PEC's within
or near the Development
Envelope
Drawn: M.Swebbs
Plan No: PDE0159436v3
Date: February, 2019
Proj: MGA94 Zone50

7.4 Troglofauna

7.4.1 Receiving environment

7.4.1.1 Surveys and studies

Troglobitic fauna specimens were initially unintentionally discovered during a stygofauna sampling program undertaken at Mesa A during 2003[4] (Biota 2004); these records being the first documented records of troglobitic fauna occurring in mainland Australian and within a pisolitic (CID) iron formation.

Troglofauna demonstrate extreme short-range endemism, and in the Robe Valley, many of the documented troglofauna species appear to be isolated to individual mesa formations (Biota 2006a; Harvey *et al*. 2008).

A number of troglofauna surveys relevant to this Proposed Change have been undertaken since 2007 and are summarised in Table 7-2 and depicted in Figure 7-2. In addition, a desktop review of relevant existing information was undertaken in order to provide context to the assessment of subterranean fauna at Mesa H. The review considered:

- previous relevant studies conducted within 40 km of the Development Envelope;
- TECs and PECs listed by the DBCA that are of relevance to subterranean fauna and within 40 km of the development envelope;
- assessment of the geology of the Proposed Change Area in a local context; and
- database searches including:
  - NatureMap;
  - Atlas of Living Australia;
  - Western Australian Museum's (WAM) Arachnida, Myriapoda, Crustacea and Mollusca databases;
  - Biota Environmental Sciences Internal Database; and
  - Rio Tinto's internal database.

A total 136 sites were sampled for troglofauna across six phases via nine field mobilisations occurring between October 2015 and January 2017. The surveys included trapping and haul net sampling and are summarised in Table 7-2. Figure 7-2 shows the troglofauna sampling sites in the Proposed Change Area.

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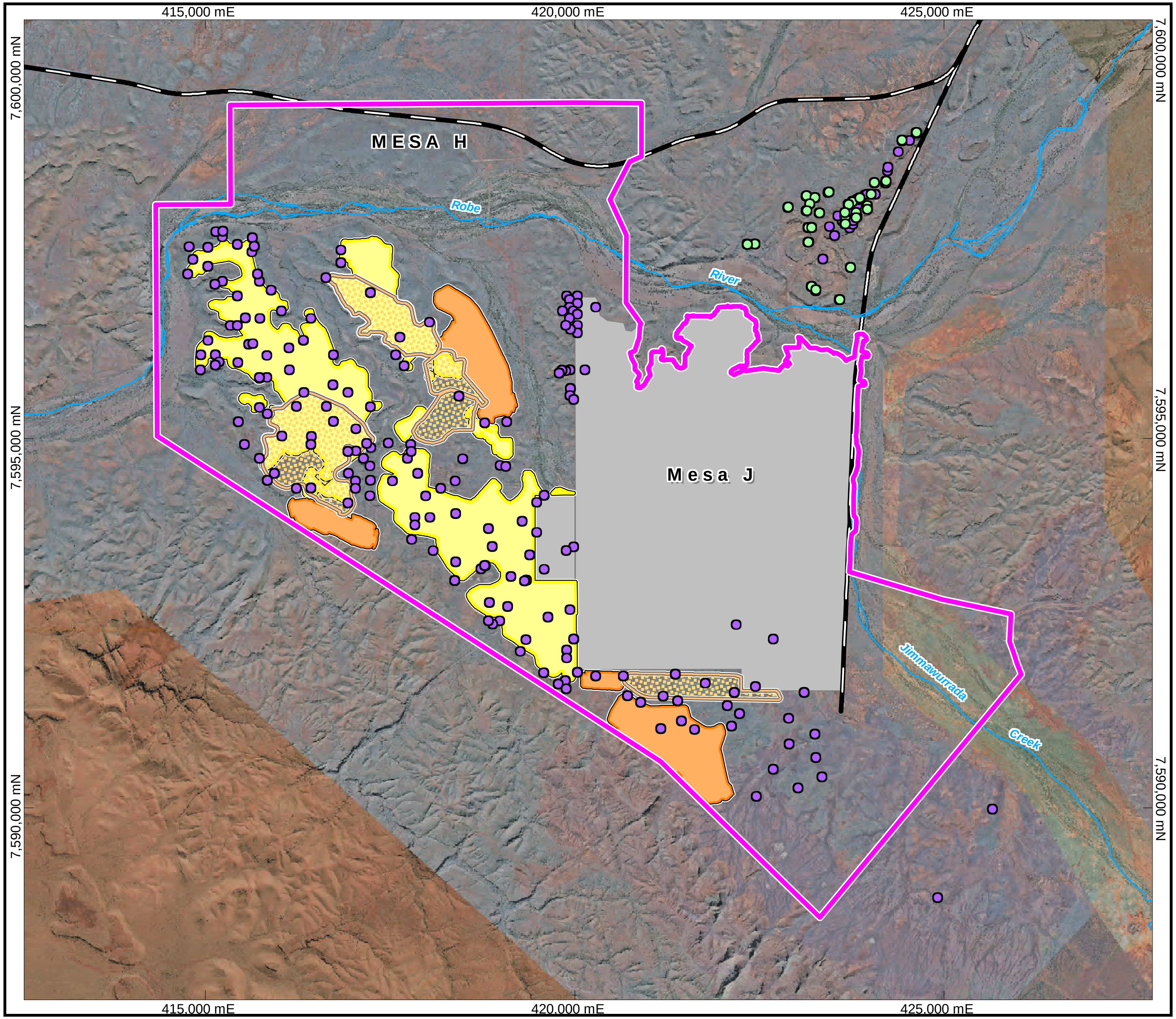
[4] Post approval and development of the Mesa J Iron Ore Development, which were approved in 1991.

Table 7-2: Summary of Supporting Troglofauna Surveys

Survey Report	Survey Description / Summary	Survey Date
Mesa H Subterranean Fauna Assessment 2018. Biota (2019a)	Six phases of troglofauna sampling and five phases of stygofauna sampling were undertaken via ten field mobilisations.	October 2015 and December 2017
Mesa H Subterranean Fauna habitat and impact risk assessment. Biota (2019b)	Independent assessment of habitat and risk to habitat as a result of implementing the Proposed Change.	N/A
Troglofauna habitat data analysis. Astron (2017a)	Astron (2017a) undertook a statistical analysis of a set of downhole temperature and relative humidity data from uncased drill holes at Mesa A, Mesa B and Mesa K recorded by Rio Tinto from 2013-2017. The aim of this analysis was to test for impacts of mining at Mesa A on variables which may delimit troglofauna habitat (down hole temperature and relative humidity).	2013 - 2017
Mesa J Extension Survey. Biota (2009)	Four phases of troglofauna sampling conducted. Study involved sampling of 61 sites across Mesa's J and H.	May 2008 and October 2009
Mesa A and Robe Valley Mesas Troglobitic Fauna Survey. Biota (2006b)	Initial documentation of troglobitic fauna from Mesa A, B, C, F, G, H, J, K, Middle Robe, Todd Bore and Warramboo. 597 traps were set at 186 sites.	November 2004 and September 2005



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse
- Troglofauna Sampling Site
- Troglofauna Monitoring Site

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil/Subsoil Stockpile

N

SCALE

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Iron Ore (WA)

Figure 7-2: Troglofauna sampling effort in or near the Development Envelope

Drawn: M.Swebbs
Date:Dec, 2018

Plan No: PDE0159867v4
Proj: MGA94 Zone50

7.4.1.2 Habitat

Subterranean fauna habitats are characterised by shared physical parameters that include a lack of light, stable temperature, limited nutrient infiltration from surface environments and a constant humidity (Juberthie 2000, Romero 2009; as cited in Biota 2019a). These habitat characteristics have resulted in convergence in body morphology evolution amongst many subterranean fauna (Biota 2019a).

The occurrence and distribution of subterranean fauna is influenced by the physical features of the geological formations in which they occur. The presence of subterranean cavities affects the pattern of occurrence, the density and distribution of subterranean fauna. Cavities for subterranean fauna are common within certain lithologies subject to high levels of secondary weathering (e.g. calcrete).

Certain geological formations have a greater likelihood of being predisposed to hosting certain physical features. The suitability of habitat for troglofauna is largely determined by geological formations above the water table containing key features such as the presence and interconnectivity of subterranean cavities, and also inputs of nutrients, water and oxygen from the surface, and the ability to maintain a stable humidity (Biota 2019b). Many of these formations include lithologies with important hydrological functions, such as impeding layers and clay lenses which store infiltrated water from recharge events, maintaining humidity in the system (Biota and DC Blandford & Associates 2013).

The Proposed Change Area comprises 13 surface geological units as mapped by the Geological Survey of WA 1:250,000 scale mapping. By area, the majority of the Proposed Change Area is accounted for by two main geological units at the surface: colluvium, covering 36%, and CID (Robe Pisolite Formation), covering 33%. Both of these geological units have been shown to represent suitable habitat for subterranean fauna in the Robe Valley and the wider Pilbara region (Biota 2019a), with CID in particular recognised as core habitat for troglofauna. Quaternary alluvium forms the next most abundant surface geology by area (9%) and is also known to support habitat for troglofauna.

The habitats identified as likely troglobitic fauna habitat in the Proposed Change Area were characterised both spatially (2D) and vertically (3D) using a combination of regional and local surface geological mapping, and site specific data including mapping of thickness AWT of prospective geological units; stratigraphic logging; and information from drill holes, including geophysical and cavity data; and integrated with troglofauna survey results (Biota 2019b). A more detailed schematic outlining the approach to the habitat modelling methodology followed is provided in Biota (2019b) (Appendix 10).

Geological units within the survey areas were categorised as Low, Moderate and High prospectivity for troglofauna based on the following characteristics (Biota 2019b; Table 7-3):

A. Presence of cavities, vugs and interstitial spaces.
B. Known hydration, weathering or significant cavity zones.
C. Presence of clay lenses or impeding layers to maintain stable humidity.
D. Demonstrated occurrence of troglofauna from equivalent rock types during past Pilbara surveys.
E. Occurs AWT within the survey area.

Table 7-3: Troglofauna Habitat Prospectivity Definitions (Biota 2019b)

Prospectivity	Definition
High	Majority (four or more) of habitat attributes confirmed for the unit, including, known to occur AWT (E), presence of interstitial spaces (A) and significance cavity zones (B), and troglofauna routinely recorded from the same rock type (D).
Medium	Suitable geology likely or known to occur above the water table in the survey area (E). Geology known to have interstices or vugs (A) and troglofauna have occasionally been detected in similar rock types previously (D). Geology may be subject to seasonal inundation (e.g. alluvium and colluvium). Where known, units of high prospectivity were categorised as medium if less than 5 m in thickness.
Low	Suitable geology only occurs BWT in the survey area. Rock type may have B), C) and E) characteristics but locally lacking suitable habitat space. Few or no troglofauna records from previous sampling of the same rock type (D).

Habitat prospectivity is determined by physical features of the geological strata. Based on the characteristics listed above, four geological units were identified as high and medium troglofauna habitat prospectivity in the Development Envelope:

- CID (Robe Pisolite):
  - greater than 5 m thickness (High prospectivity); and
  - less than 5 m thickness (Medium prospectivity).
- Alluvium (Qr) (Medium prospectivity);
- Colluvium (Qg) (Medium prospectivity); and
- Wittenoom Dolomite Formation (Medium prospectivity).

CID (Robe Pisolite), alluvium and colluvium have been recognised by the EPA as potential troglofauna habitat during past assessments (EPA 2016h; Biota 2019b). The CID (Robe Pisolite) is likely to be the primary habitat for troglofauna in the Proposed Change Area. The 5 m thickness threshold for designating Robe Pisolite as high or medium prospectivity was selected as a conservative threshold based on consideration of:

- The physical dimensions of troglofauna relative to the volume of habitat represented by habitat that is laterally connected with a thickness of 5 m.
- Sampling results from the Mesa A Hub where troglofauna have been recorded in areas with Robe Pisolite thickness of less than 5 m and in some areas with Pisolite thickness less than 2 m.
- Expert opinion regarding suitable habitat (Biota 2019b).

The Priority 1 PEC, the *Subterranean invertebrate community of pisolitic hills in the Pilbara*, occurs across the majority of Mesa H while the Priority 1 PEC, the *Subterranean invertebrate community of mesas in the Robe Valley region*, occurs across the Mesa J Iron Ore Development, with the buffer partially overlapping with the Proposed Change Area (Figure 7-1)[5]. The CID (Robe Pisolite) unit was also used as the basis for mapping the

[5] PEC buffers are shown on the map rather than PEC boundaries as the Conditions for supply of PEC location information allow only buffers to be shown in public reports.

local extent of the two troglofauna PECs that occur in the Proposed Change Area, and hence broadly aligns with the occurrence of outcropping CID (pisolite) in the area.

The remaining geological units in the Proposed Change Area (Lacustrine deposits (Ql), Duricrust (Czd), Yarraloola Conglomerate (Kny), Ashburton Formation (Wa), Woongarra Volcanics Formation (Hw), Mt McRae Shale Formation (Hr), Wittenoom Dolomite Formation (Hd), Brockman Iron Formation (Hb) and Marra Mamba Iron Formation (Hm), were identified as moderate to low troglofauna habitat prospectivity. Troglofauna have been recorded in these units, however, the physical characteristics of the units suggest they are less likely to provide core troglofauna habitat Biota (2019a).

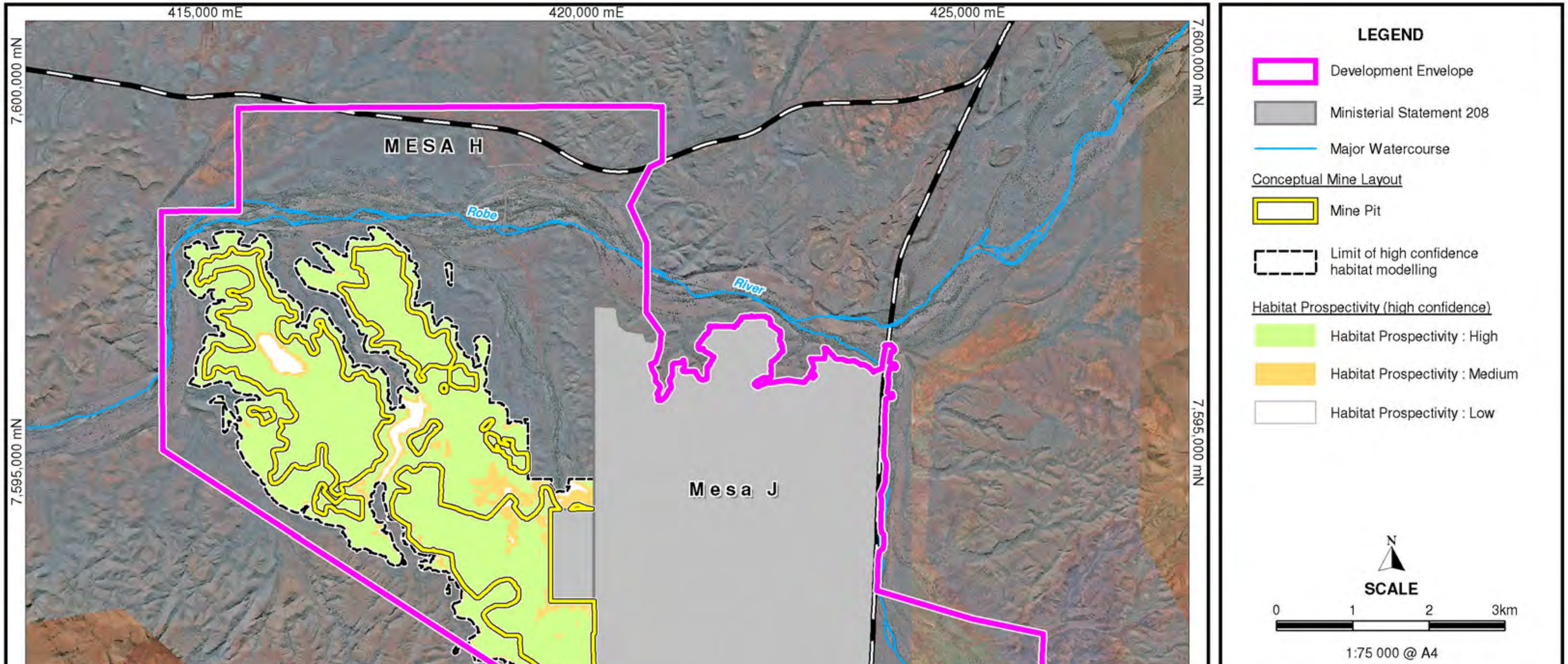
The modelled troglofauna habitat prospectivity was evaluated for the Proposed Change Area as determined from regional surface geology and site specific data including mapping of thickness of prospective geological units, stratigraphic logging, images and information from drill holes; 3D Habitat prospectivity is therefore inferred from physical geological characteristics (Figure 7-3). The limit of high confidence habitat modelling is delineated by the area over which the Proponent has a high density of drill holes and thus high confidence in the data. Habitat prospectivity has been modelled outside this area based on limited drill hole data and / or surface geology mapping; results in these areas are shown as low confidence modelling output (Figure 7-4).

Molecular evidence for some troglobitic orders indicates that there is unlikely to be continuous gene flow between the mesas of the Robe Valley. However, six species of potential Short Range Endemic (SRE) status that occur at Mesa H, also occur elsewhere, up to 60 km away (Biota 2019a):

- *Hubbardiidae* sp. ‘SCH011’ (Mesa J);
- *Hubbardiidae* sp. ‘SCH015/SCH016’ (‘Redgate’ 6 km to the southwest);
- *Armadillidae* sp. ‘ISA056/ISA057’ (Mesa C);
- *Ptilidae* sp. 1/'CP003' (Warramboo);
- *Ptilidae* sp. 'Robe Valley'/’CP002’ (Robe Valley, Middle Robe); and
- *? Nocticola* sp. 'West Pilbara Complex' (Red Hill).

The occurrence of these species on other mesas and other areas of CID within the Robe Valley suggests that the habitats have been historically connected in geological time, which is supported by the understanding of the geological evolution of the landscape where the Mesas represent the ancient paleodrainage of the Robe River. Habitat analysis to date has not been able to determine the level of connectivity between the mesas and the surrounding colluvium and alluvium (medium habitat prospectivity) (Biota 2019b). In previous studies throughout the Pilbara, areas of weathering or hydrated zones have been identified as potentially occurring in connection with superficial geologies such as colluvium and alluvium and provide possible avenues of habitat connection.

Some sampling has also been undertaken in medium prospectivity habitat in the central gully area of Mesa H, in the basal CID and Wittenoom Dolomite Formation to examine the degree of habitat connectivity. Sampling confirmed troglofauna records within this area, however, given that proposed mining at Mesa H will impact solely on high prospectivity habitat, only modelled high prospectivity habitat is considered when assessing potential impacts on troglofauna at Mesa H. This conservative approach allows modelling to be undertaken using a three-dimensional estimate of pisolite thickness with outputs as habitat volume.



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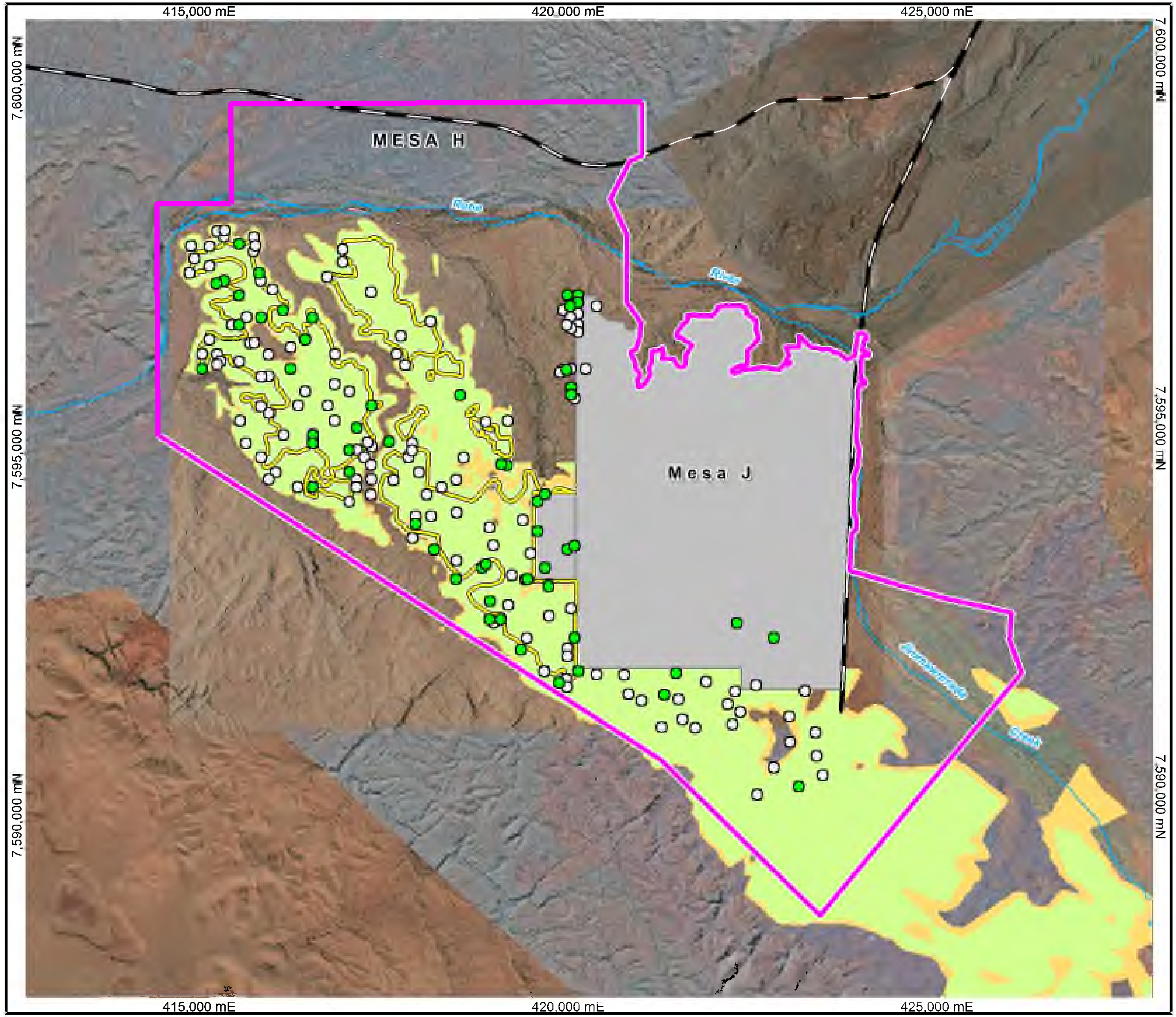
Iron Ore (WA)

Figure 7-3: Modelled Troglofauna habitat Prospectivity within the Development Envelope

Drawn: M.Swebbs
Date: Dec, 2018

Plan No: PDE0161816v4
Proj: MGA94 Zone50



LEGEND

- Development Envelope
- Ministerial Statement 208
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Record of Troglofauna
- Troglofauna Sampling Site

Habitat Prospectivity (high confidence)

- Habitat Prospectivity : High
- Habitat Prospectivity : Medium

N

SCALE

0 1 2 3km

1:75 000 @ A4

RioTinto

Iron Ore (WA)

Figure 7-4: Modelled Pre-mining Troglofauna habitat prospectivity and troglofauna records within the Development Envelope

Drawn: M.Swebbs
Date: Jan, 2019
Plan No: PDE0161845v4
Proj: MGA94 Zone50

7.4.1.3 Records

A total of 150 troglobitic specimens were collected across the six phases of sampling of the Mesa H survey area (Figure 7-5). The specimens represented five classes and nine orders and 32 taxa. The orders Coleoptera and Schizomida were the greatest contributors to faunal composition, accounting for 33% and 25% of the specimens, respectively.

Excluding indeterminate records, one additional species (*Troglarmadillo* sp. 1) were identified as occurring within the Proposed Change Area from historical surveys, bringing the total known fauna to 33 species (Table 7-4).

Six of the 33 taxa have been recorded from outside of the Proposed Change Area and have demonstrated wider distributions (Table 7-4), with the remaining 27 taxa currently only known from within the Proposed Change Area (Biota 2019a). Twenty of these latter records were singleton taxa, making comment on their potential wider distributions difficult, however they have been retained as potential SRE taxa as a conservative approach for this assessment.

Conservation significant troglofauna

No troglofauna of conservation significance (i.e. those listed as Priority, Schedule or Vulnerable at State or Federal levels) were recorded during the surveys at Mesa H.

One species of conservation significance was recorded from a desktop assessment, the schizomid *Paradraculoides kryptus* (Threatened – Vulnerable under Schedule 3 of the BC Act), which to date has been recorded solely from Mesa K (outside the Development Envelope). It is considered unlikely that this species would occur at Mesa H (Biota 2019a).

Potential SRE fauna

A number of troglofauna specimens could not be identified to species level, including *Diplura* sp. indet., *Pseudoscorpiones* sp. indet., *Isopoda* sp. indet., *Schizomida* sp. indet. and *Gnaphosidae* sp. indet. (Biota 2019a). While it is considered likely that these specimens represent range-restricted species, it is not feasible to determine whether they represent the same species as other records of their respective groups from within, or outside the Proposed Change Area (Biota 2019a). Whilst these specimens represent spatial records of potential SRE troglofauna (Figure 7-5), most have not been recognised as distinct taxa (Biota 2019b) for this assessment (and are therefore not listed in Table 7-4). The only exception to this is the spider *Gnaphosidae* sp. indet., as this was the only specimen of its family and is considered a discrete troglobitic taxon (Biota 2019a).

The six troglofauna species with records outside of the Proposed Change Area are considered to still have only have relatively restricted distributions in the Robe Valley, most of which are potentially subject to potential impacts from other proposals (see Table 7-4). To provide a conservative assessment, these records are treated as SRE's and key receptors for this assessment.

Table 7-4: Troglofauna Species Recorded (2011 - 2017)

Order	Species	Conservation significant / SRE	Known locations			Distribution (based on other locations)
			Mesa H Mine Pit Impact Area	Mesa H MEZ	Other location	
Araneae	*Prethopalpus* 'ARA052'	Potential SRE	×	×	✓	
	Gnaphosidae sp. indet.	Potential SRE	×	✓	×	
Blattodea (Cockroach)	?*Nocticola* sp. 'West Pilbara Complex'	Potential SRE	✓	✓	✓ Red Hill	115 km²
Coleoptera (Beetles)	*Curculionidae* sp. 'CCU014'	Potential SRE	✓	✓	×	0.7 km²
	Ptilidae sp. 1/'CP003'	Potential SRE	✓	✓	✓ Warramboo	35 km²
	Ptilidae sp. 'Robe Valley'/'CP002'	Potential SRE	✓	×	✓ Robe Valley, Middle Robe	19 km²
Diplura	*Parajapygidae* sp. 'DPA001'	Potential SRE	×	×	✓	
	Parajapygidae sp. 'DPA009'	Potential SRE	×	✓	×	
	Projapygidae sp. 'DPR008/DPR009/DPR011'	Potential SRE	✓	×	✓	5 km²
	Projapygidae sp. 'DPR010'	Potential SRE	×	×	✓	
	Japygidae sp. 'DJA003'	Potential SRE	×	✓	×	
	Japygidae sp. 'DJA011'	Potential SRE	✓	×	×	
	Campodeidae sp. 'DCA005'	Potential SRE	×	×	✓	
Isopoda	*Philosciidae* sp. 'ISP047'	Potential SRE	×	×	✓	
	Philosciidae p. 'ISP055'	Potential SRE	×	✓	×	
	Troglarmadillo sp. 1	Potential SRE	×	×	✓	
	Troglarmadillo sp. 'ISA046'	Potential SRE	×	×	✓	
	Armadillidae sp. 'ISA056/ISA057'	Potential SRE	✓	×	✓ Mesa C	28 km (linear distance)

Order	Species	Conservation significant / SRE	Known locations			Distribution (based on other locations)
			Mesa H Mine Pit Impact Area	Mesa H MEZ	Other location	
Scolopendromorpha	*Cryptopidae* sp. ‘SC018’	Potential SRE	×	✓	×	
Pseudoscorpiones	*Hyidae* sp. ‘PH017/PH027’	Potential SRE	×	✓	✓	2 km (linear distance)
	Hyidae sp. ‘PH026’	Potential SRE	×	✓	×	
	Olpiidae sp. ‘PO008’	Potential SRE	×	✓	×	
	Beierolpium sp. ‘PO014’	Potential SRE	×	×	✓	
	Beierolpium sp. ‘PO015’	Potential SRE	×	✓	×	
	Atemnidae sp. ‘PA004’	Potential SRE	×	✓	×	
	Chthoniidae sp. ‘PC014/PC015’	Potential SRE	✓	✓	×	0.1 km^2
	Chthoniidae sp. ‘PC055’	Potential SRE	×	×	✓	
Schizomida	*Paradraculoides* sp. ‘SCH038’	Potential SRE	✓	✓	✓	1.1 km^2
	Paradraculoides sp. ‘SCH039’	Potential SRE	×	×	✓	
	Hubbardiidae sp. ‘SCH011’	Potential SRE	×	✓	✓ Mesa J	2 km^2
	Hubbardiidae sp. ‘SCH015/SCH016’	Potential SRE	✓	×	✓ Redgate	6 km^2
Zygentoma (Silverfish)	*Nicoletiinae* sp. 'TN019'	Potential SRE	×	×	✓	
	Nicoletiinae sp. 'TN020'	Potential SRE	×	✓	×	

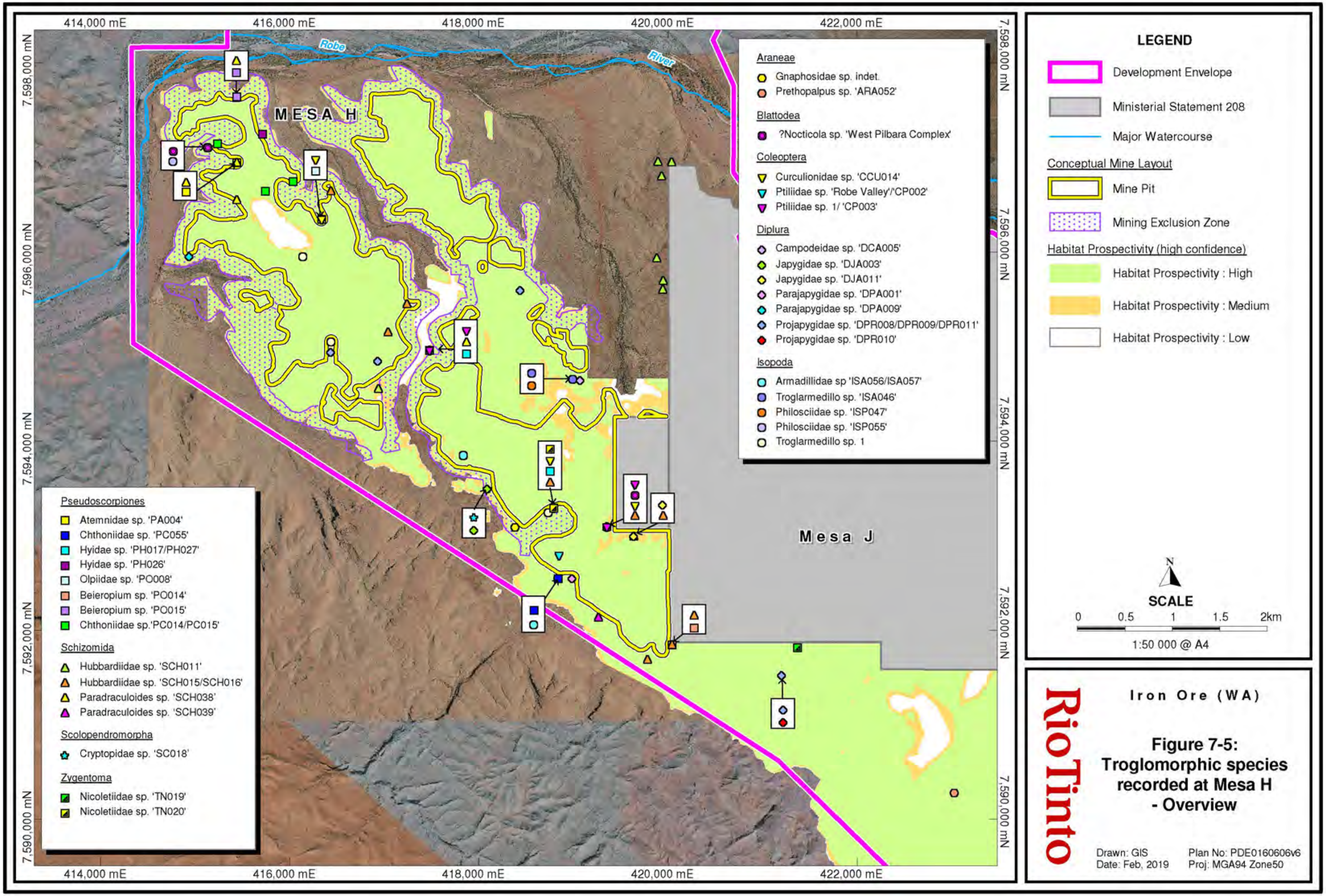
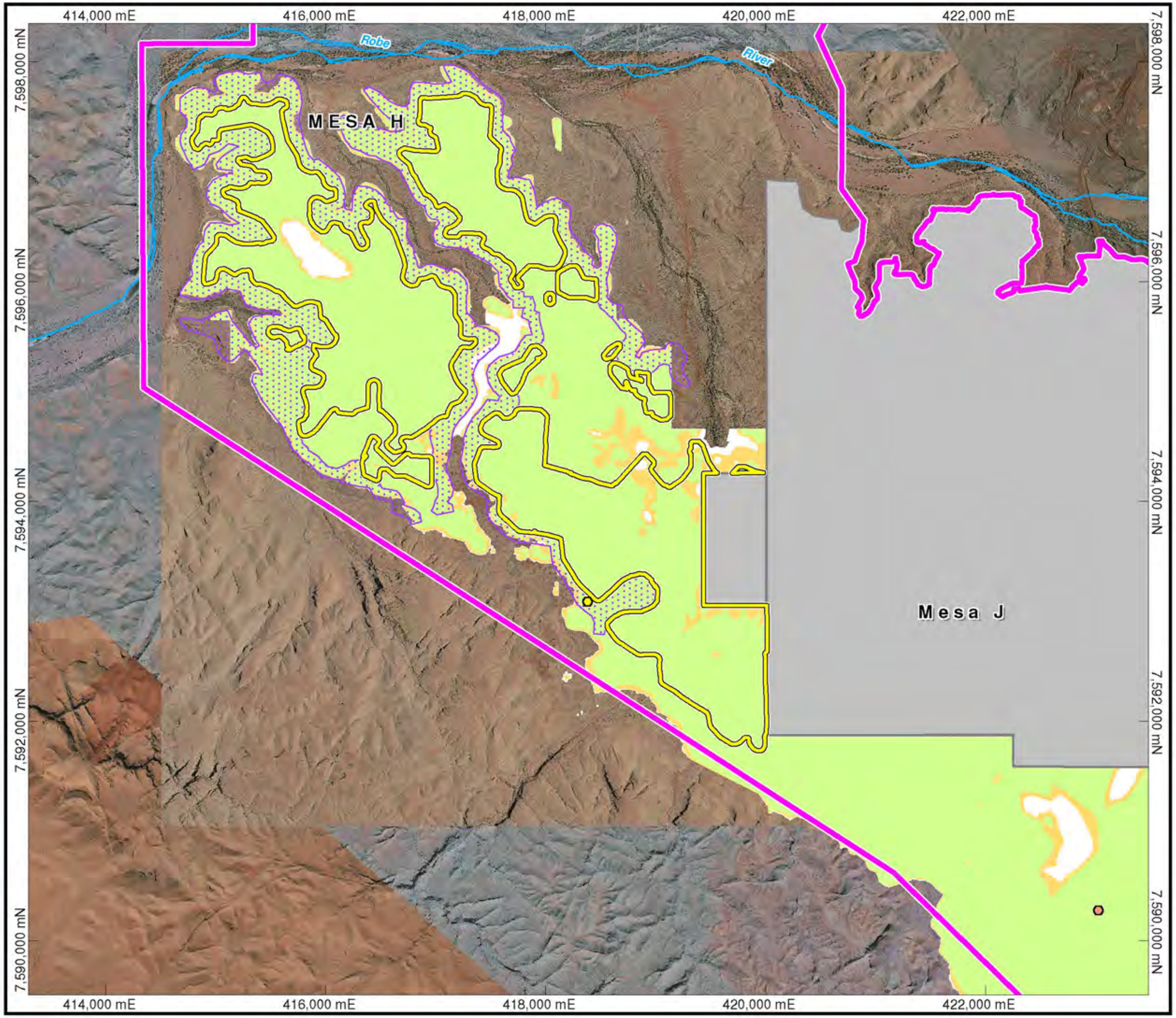


Figure 7-5: Troglomorphic species recorded at Mesa H - Overview



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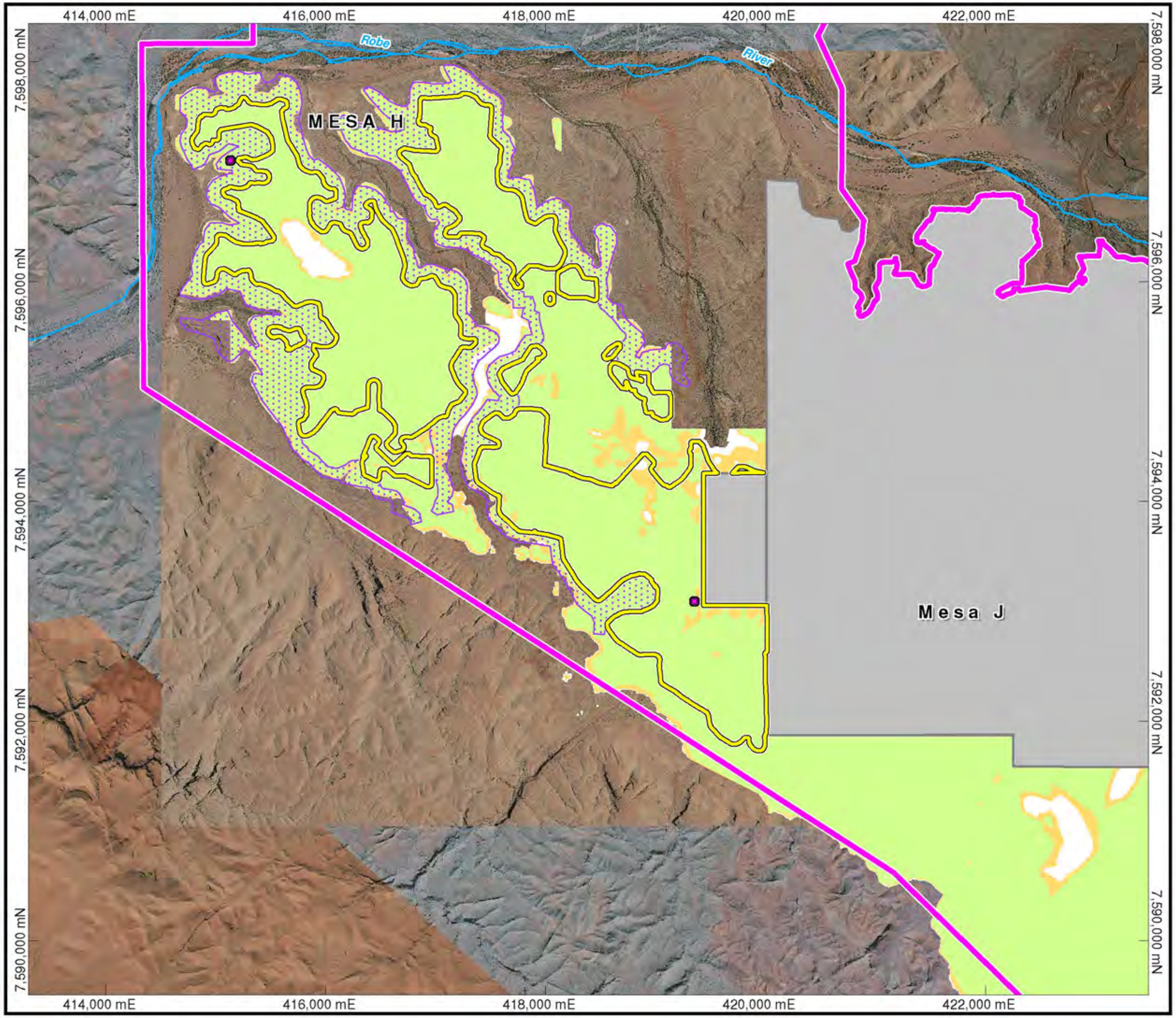
Iron Ore (WA)

Figure 7-5: Troglomorphic species recorded at Mesa H Map 1 - Araneae

Drawn: GIS
Date: Feb, 2019
Plan No: PDE0160606v6
Proj: MGA94 Zone50



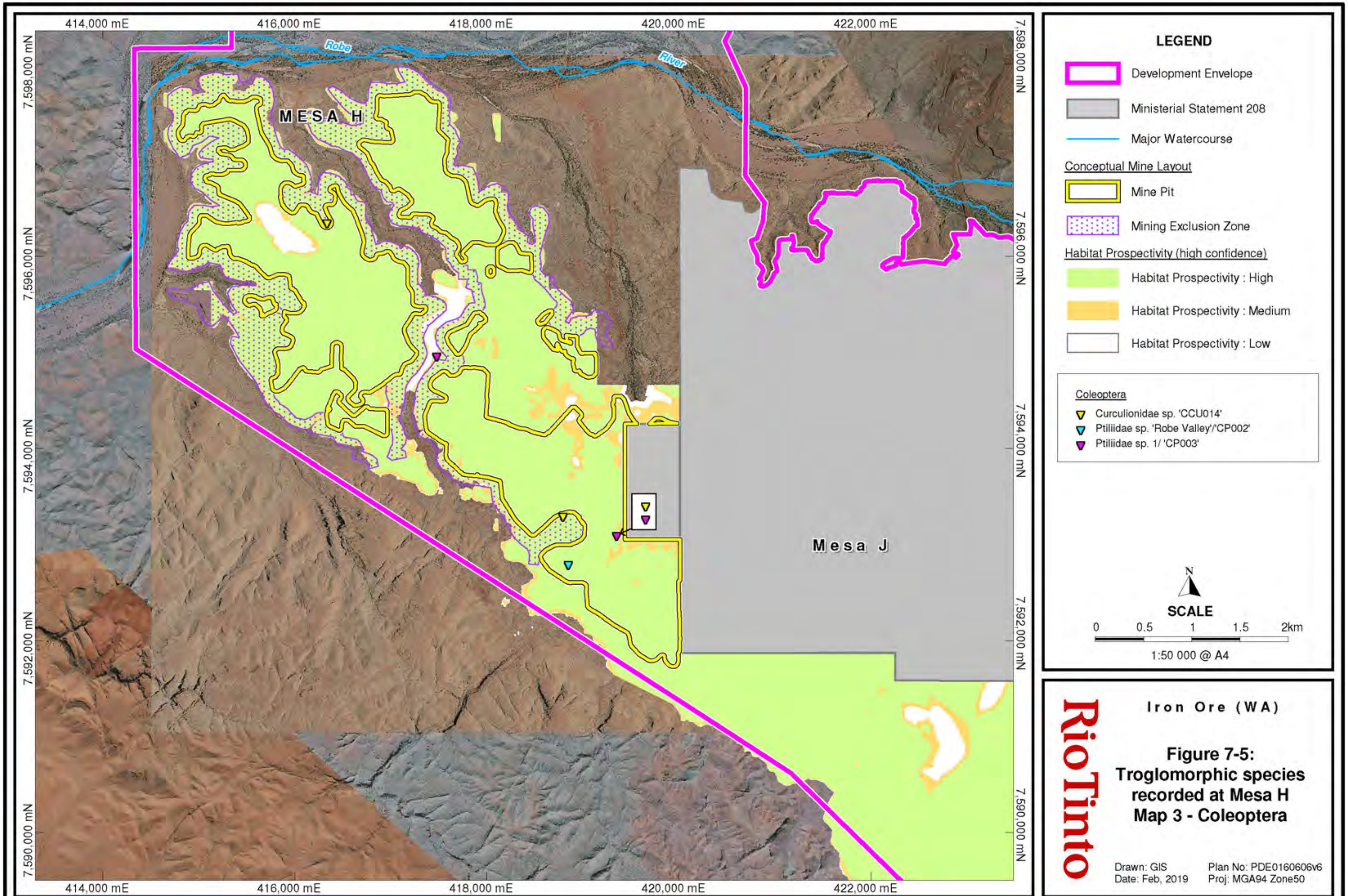
Rio Tinto

Iron Ore (WA)

Figure 7-5: Troglomorphic species recorded at Mesa H Map 2 - Blattodea

Drawn: GIS
Date: Feb, 2019

Plan No: PDE0160606v6
Proj: MGA94 Zone50



RioTinto

Iron Ore (WA)

Figure 7-5: Troglomorphic species recorded at Mesa H Map 3 - Coleoptera

Drawn: GIS
Date: Feb, 2019

Plan No: PDE0160606v6
Proj: MGA94 Zone50

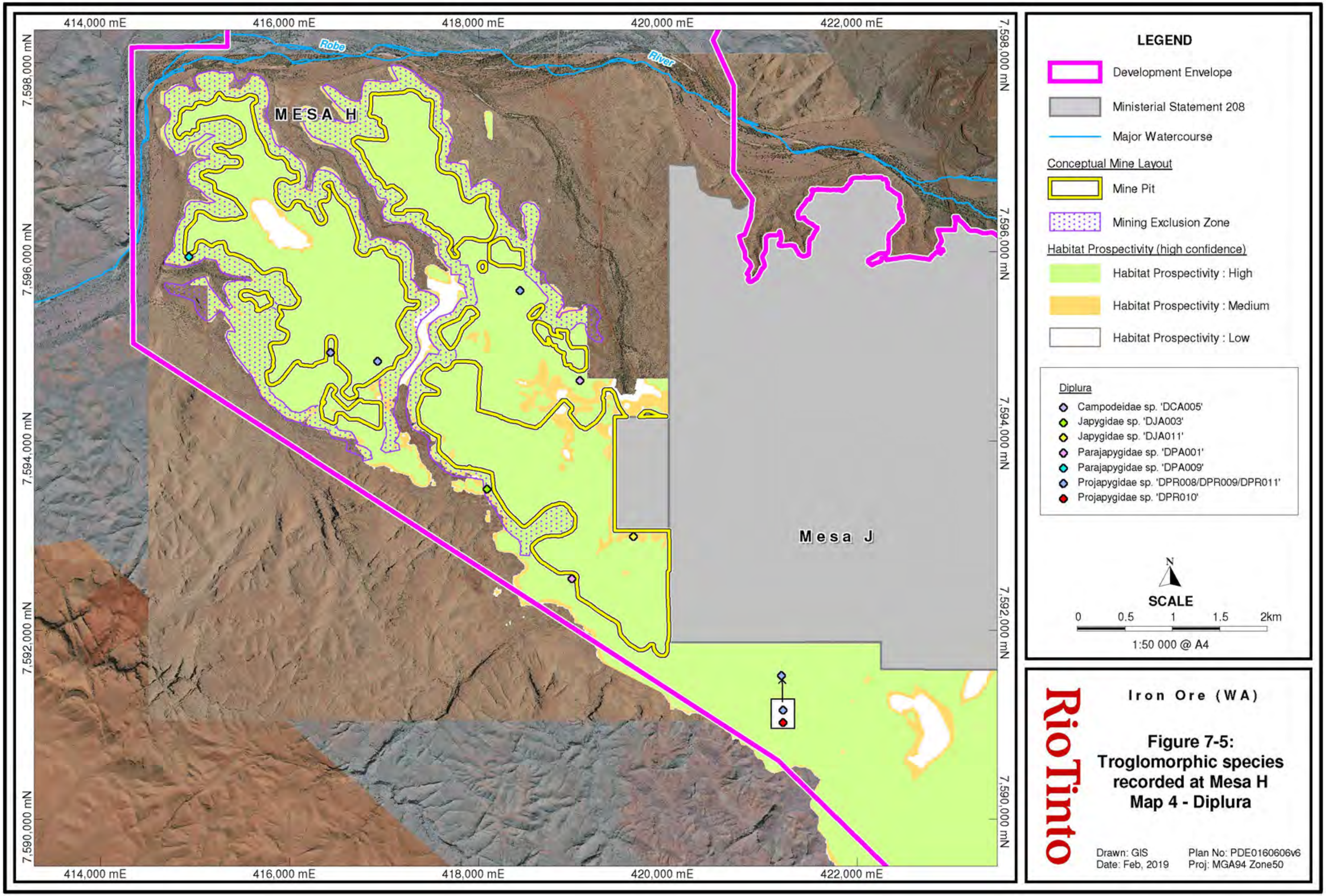
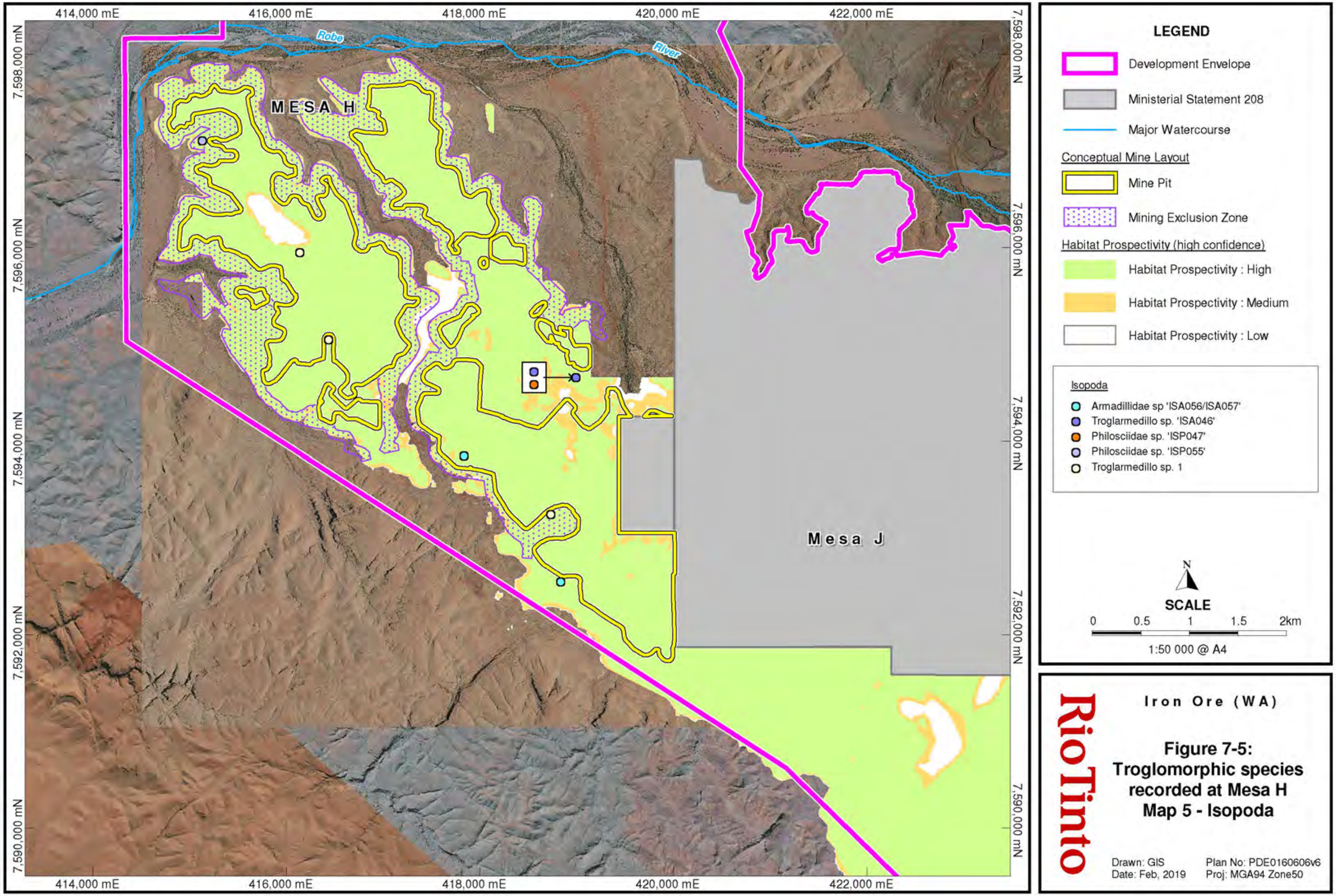


Figure 7-5: Troglomorphic species recorded at Mesa H Map 4 - Diplura



Rio Tinto

Iron Ore (WA)

Figure 7-5: Troglomorphic species recorded at Mesa H Map 5 - Isopoda

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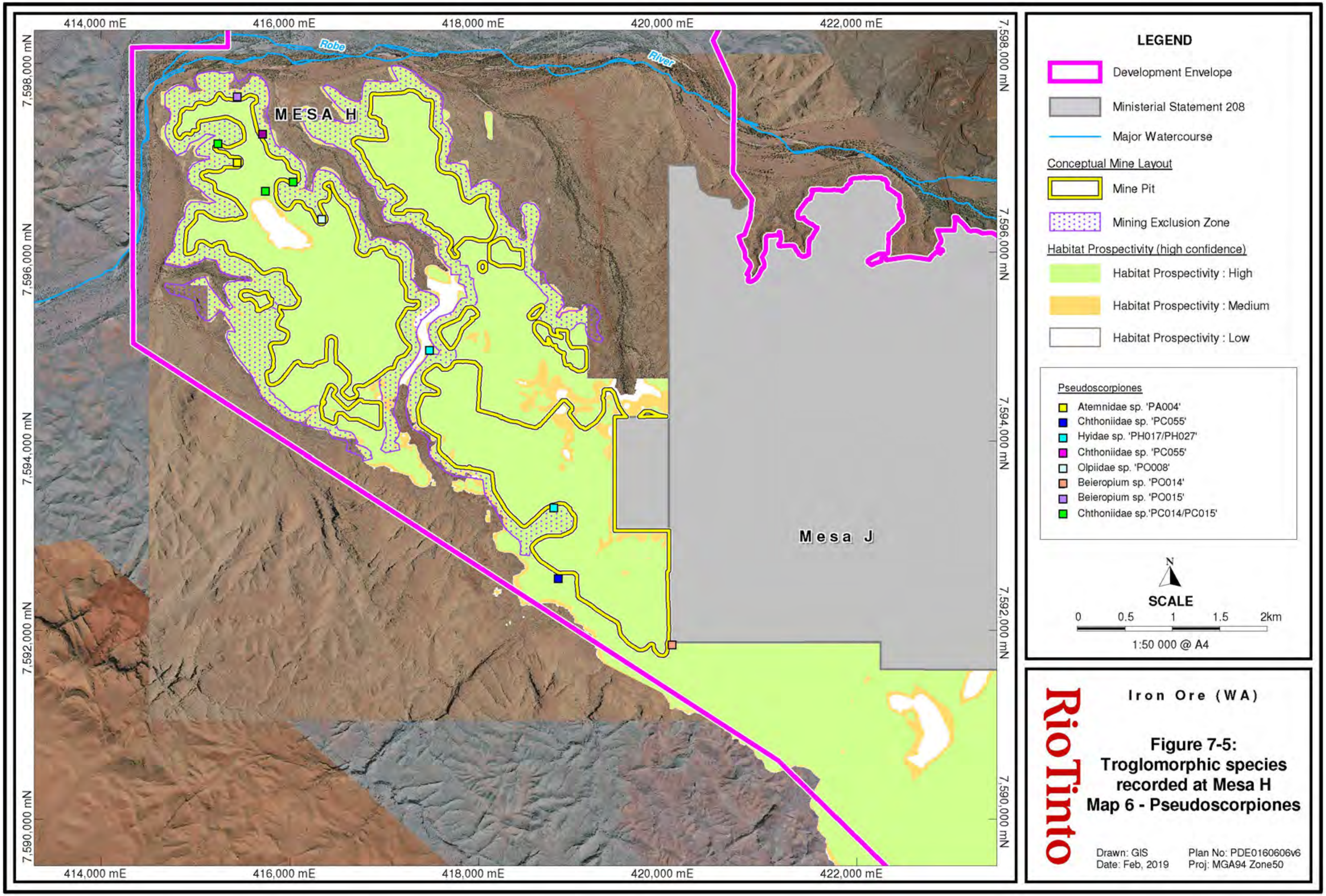
Plan No: PDE0160606v6
Proj: MGA94 Zone50

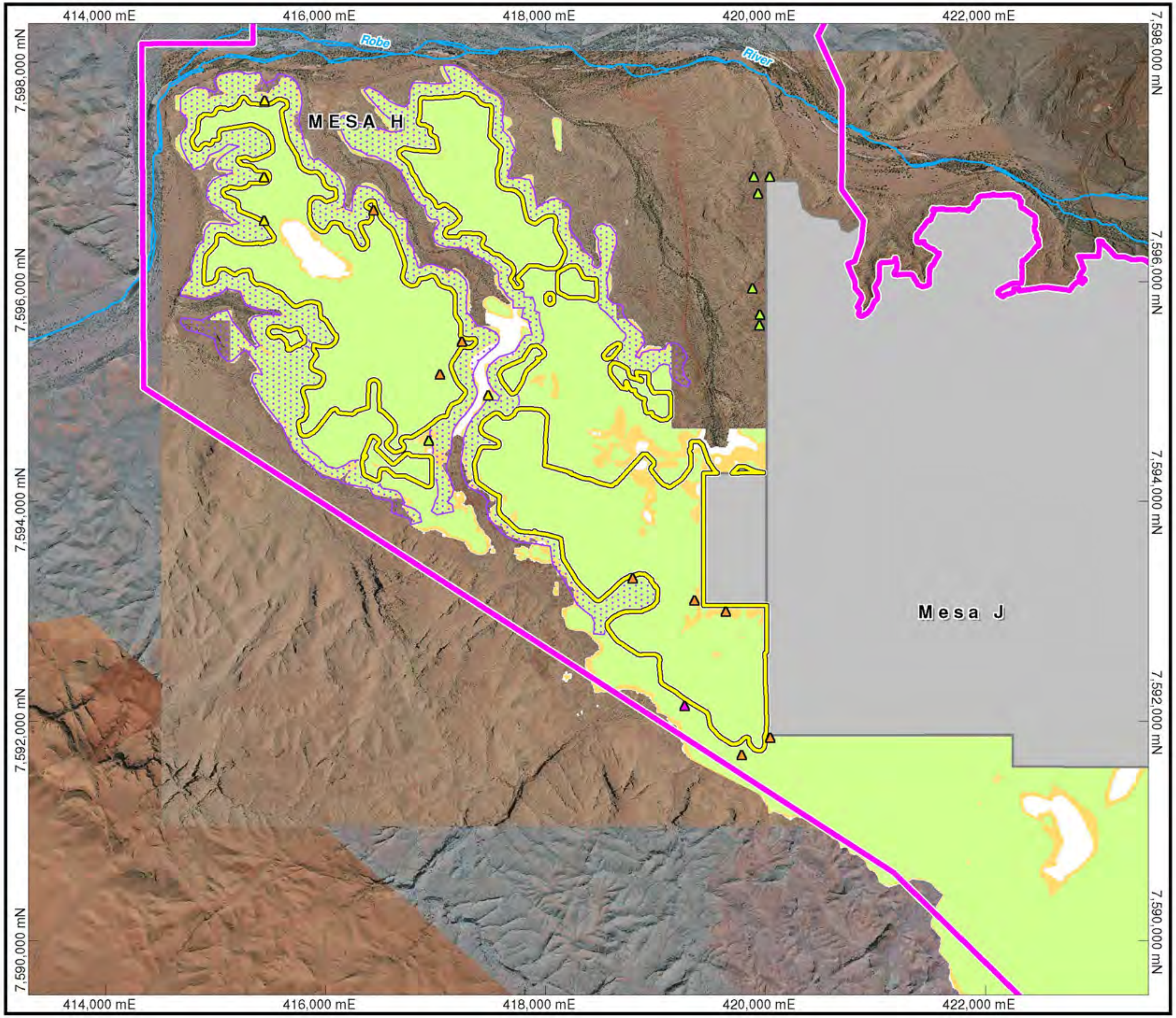


Rio Tinto

Iron Ore (WA)

Figure 7-5: Troglomorphic species recorded at Mesa H Map 6 - Pseudoscorpiones

Drawn: GIS
Date: Feb, 2019
Plan No: PDE0160606v6
Proj: MGA94 Zone50



LEGEND

Development Envelope

Ministerial Statement 208

Major Watercourse

Conceptual Mine Layout

Mine Pit

Mining Exclusion Zone

Habitat Prospectivity (high confidence)

Habitat Prospectivity : High

Habitat Prospectivity : Medium

Habitat Prospectivity : Low

Schizomida

Hubbardiidae sp. 'SCH011'

Hubbardiidae sp. 'SCH015/SCH016'

Paradraculoides sp. 'SCH038'

Paradraculoides sp. 'SCH039'

N

SCALE

0 0.5 1 1.5 2km

1:50 000 @ A4

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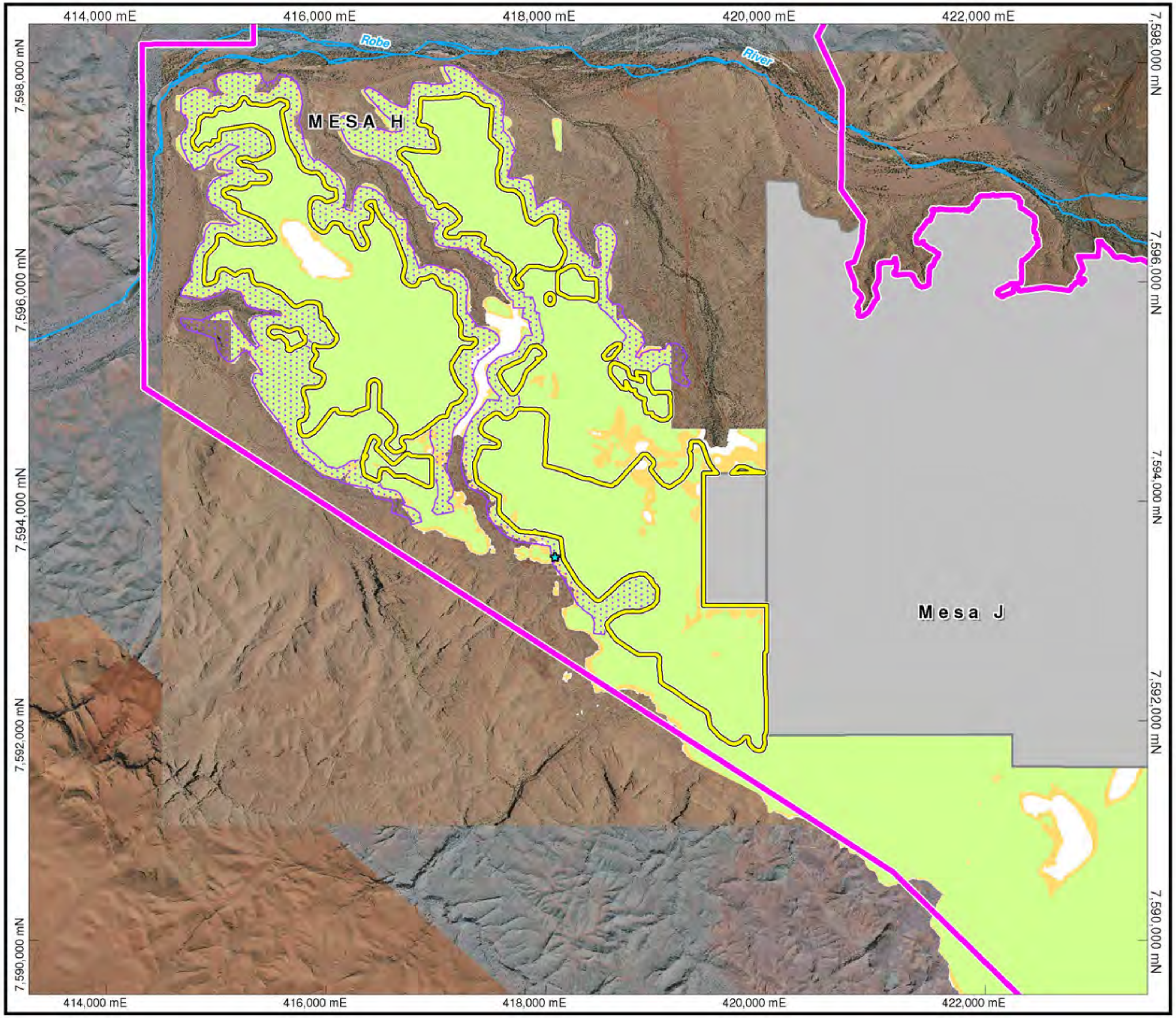
Iron Ore (WA)

Figure 7-5: Troglomorphic species recorded at Mesa H Map 7 - Schizomida

Drawn: GIS
Date: Feb, 2019

Plan No: PDE0160606v6
Proj: MGA94 Zone50



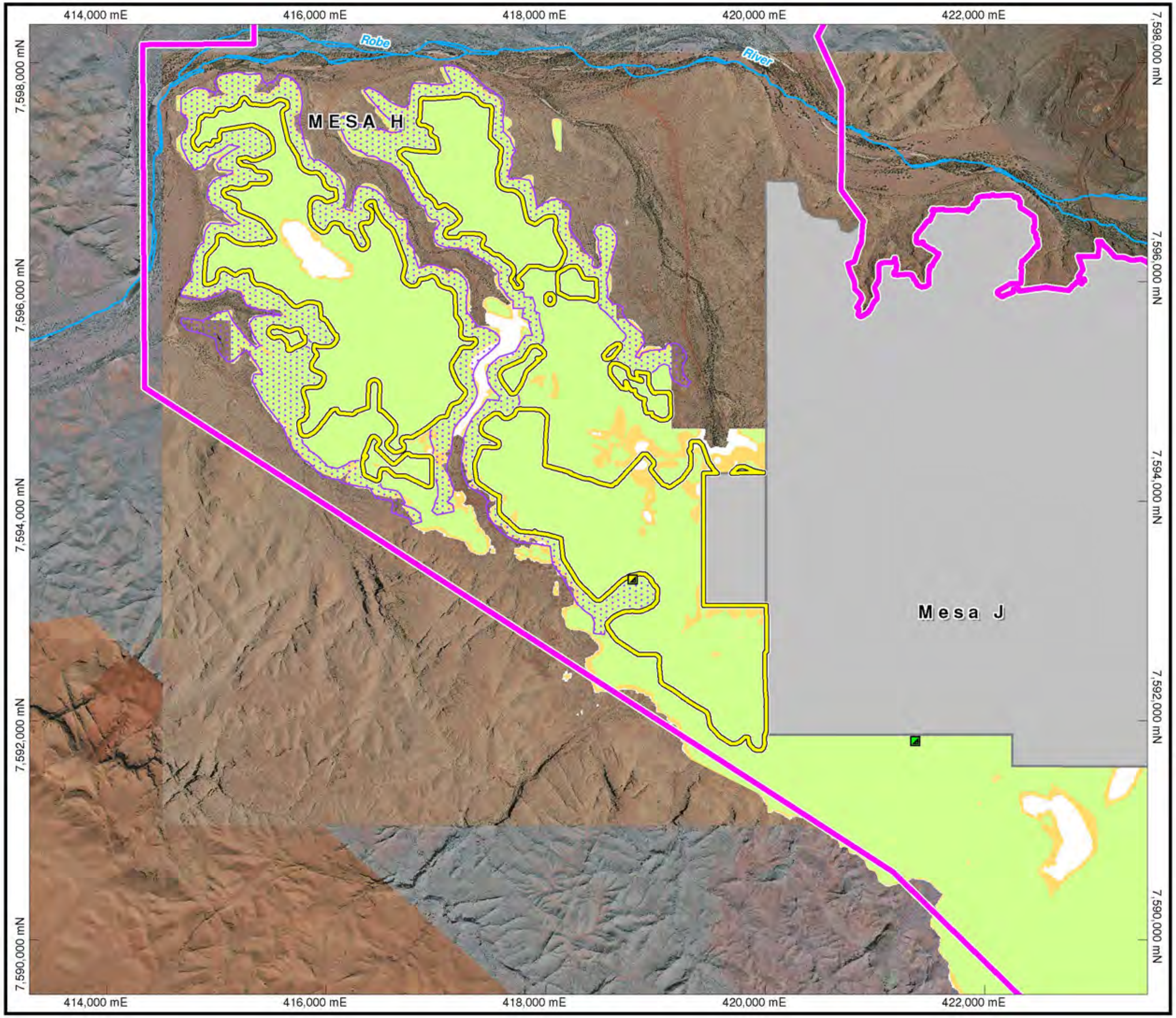
Rio Tinto

Iron Ore (WA)

Figure 7-5: Troglomorphic species recorded at Mesa H Map 8 - Scolopendromorpha

Drawn: GIS
Date: Feb, 2019

Plan No: PDE0160606v6
Proj: MGA94 Zone50



Rio Tinto

Iron Ore (WA)

Figure 7-5: Troglomorphic species recorded at Mesa H Map 9 - Zygentoma

Drawn: GIS
Date: Feb, 2019

Plan No: PDE0160606v6
Proj: MGA94 Zone50

7.4.2 Analysis of Robe Valley troglofaunal habitats and monitoring results

Historical monitoring and management of troglofaunal impacts at Mesa A, Mesa K and other projects in the Robe Valley are relevant to the assessment and mitigation of impacts associated with this Proposed Change. The following sections provide a comparison of habitats within the Robe Valley (Section 7.4.2.1) and a summary of monitoring results adjacent to mining at other sites (Section 7.4.2.2).

7.4.2.1 Habitat comparison of Robe Valley mesas

Mesa H is part of a series of mesas that are remnants of a palaeochannel formed by sedimentary deposition of iron rich material, more generically known as a CID (specifically, the Robe Pisolite Formation in the Robe Valley), within the Robe River palaeochannel between ~23 and ~5 million years ago. Subsequent uplift, erosion and surface water flows have removed much of the adjacent erodible basement material, leaving preserved parts of the paleo-river channels as outcropping mesas.

Similar to the other CID mesas of the Robe Valley, and based on the formations being formed as part of the same downstream extension of the Robe River paleo-channel, Mesa H comprises the same pisolite geology, with similar inter-stratigraphic features consisting of five primary layers:

- The upper hardcap layer: The Hardcap Pisolite (HTP), which is the weathered / laterized surface of the Pisolite, generally around 5 – 10 m in thickness, containing secondary soils, silica and iron. The transition between the HTP and the underlying Pisolite is gradational.
- The upper Pisolite: Pisolite (Tp / Tph) has a pisolitic texture, cemented together by a goethitic matrix, with internal interstices (relatively high porosity). This zone includes infrequent clay or hydrated / denatured pisolite zones / lenses.
- The lower Pisolite zone: Underlying the Pisolite is the Mixed / Massive Pisolite (TPM) this zone is characterised by a limonitic, denatured / massive appearance and clay is common throughout. This contact is also transitional / gradational to the underlying basal Pisolite. This zone may have been subjected to a variable palaeo-water table, which has resulted in a significant hydration effect in comparison to the overlying Tertiary Pisolite / Tertiary Pisolite Hard.
- The Pisolite Clay (TPC) is characterised by bands of predominantly clay rich material mixed throughout pisolite.
- The basal Pisolite (TPB) forms the base of the CID palaeochannel, comprising massive clay-rich limonitic pisolite with remnant pisolite textures.

The CID is incised through the Wittenoom Dolomite and Marra Mamba Iron Formation which forms the majority of the basement to the CID at Mesa H.

One of the key characteristics of the geological units known to provide habitat for troglofauna relate to the physical features, particularly the presence of fractures, cavities, vugs or interstices sufficient in size to accommodate troglofauna. Throughout the Pilbara, a range of geological formations contain, or are more likely to be pre-disposed to containing the necessary physical characteristics that have been shown to provide habitat for troglofauna. In the Proposed Change Area, the CID is considered to be the geological unit that provides primary habitat for troglofauna as it contains the necessary vugs and cavities to accommodate troglofauna. The clay pockets and lenses within the CID may also contribute to the suitability of the habitat for troglofauna as the retention of water in or on top of certain clay types may assist in maintaining high humidity levels in the subterranean environment.

The presence of potential cavities at Mesa H was assessed and compared to those at the existing Mesa A Operation using available information from drill hole data to assess whether any physical differences in troglofauna habitat between the mesas were apparent.

For comparative purposes, an analysis of the relative percentages per metre logged of potential cavities (as indicated by a change in the downhole caliper reading of greater than 17 mm) in each stratigraphic layer in Mesas A and H was undertaken (Table 7-5). The data indicate that the frequency of occurrence of cavities logged at Mesa H is greater than that at Mesa A, however the relative distribution of cavities between the strands is similar with a greater portion occurring in the TPH, and fewer in the TPC. The TPB at Mesa H also shows a relatively high portion of cavities in the lower TPB strand.

Table 7-5: Summary of the Occurrence of Potential Cavities at Mesas A and H

Strand	Mesa A Caliper > 17 mm (% of total metres logged)	Mesa H Caliper > 17 mm (% of total metres logged)
Hardcap Pisolite (HTP)	0.5%	1%
Pisolite (TPH)	1.8%	10%
Mixed/Massive Pisolite (TPM)	1.6%	6%
Pisolite Clay (TPC)	1.0%	5%
Basal Pisolite (TPB)	N/A	9%.

Mesas of the Robe Valley, including Mesa H were formed through the same broad depositional processes and therefore comprise the same geological units with similar stratigraphy, although the relative proportion of each inter-stratigraphic layer varies between the mesas. The basement and channel morphology, relative portions of clays, and secondary alteration features can vary between the mesas which can translate to variability in cavity, void and interstitial proportions, however the key propensity of the CID to host voids and cavities suitable to support troglofauna remains similar between the mesas.

At an Order level, troglofauna assemblages across the Robe Valley are also similar (Table 7-6) supporting that habitats within each mesa are similar, with a similar range of ecological niches.

Table 7-6: Order level representation of troglofauna across the Robe Valley

Troglomorphic Order	Dinner Camp	Warramboo/ Hwy/Tod Bore	Mesa A	Mesa B	Mesa C	Mesa H	Mesa K
Araneae	Y		Y	Y	Y	Y	Y
Cephalostigmata	Y						
Blattodea		Y	Y			Y	Y
Coleoptera		Y	Y	Y	Y	Y	Y
Diplura	Y	Y	Y	Y	Y	Y	
Geophilomorpha							Y
Hemiptera	Y		Y	Y			Y
Isopoda	Y	Y	Y	Y	Y	Y	Y
Opiliones					Y		Y
Polydesmida		Y	Y	Y	Y		Y
Pseudoscorpiones	Y	Y	Y	Y	Y	Y	Y
Schizomida		Y	Y	Y	Y	Y	Y
Scolopendromorpha		Y	Y	Y	Y	Y	Y
Tetramerocerata	Y						
Zygentoma	Y	Y	Y	Y	Y	Y	Y

Mining and associated troglofauna monitoring have been underway at the Mesa A Operations since 2010 and Mesa K since the 1980s. Given similar troglofauna habitat is present at other mesas within the Robe Valley, including Mesa H, results from the monitoring conducted at Mesa A and at Mesa K[6] have been used to guide the design of the Proposed Change and management actions at Mesa H as described in Section 7.4.2.2.

7.4.2.2 Results of monitoring at Mesa A and other Robe Valley locations

Multiple phases of targeted troglofauna sampling were conducted at Mesa A during 2005 and 2006 as part of the EIA for the Mesa A / Warramboo Iron Ore Project. Active mining commenced at Mesa A in February 2010 under MS 756. Monitoring conducted in accordance with the approved Mesa A Troglofauna Management Plan required under Condition 5-1 of MS 756 includes:

- biennial troglofauna sampling in the Mesa A MEZ;
- troglofauna sampling in disturbed habitats;
- subterranean habitat monitoring; and
- downhole optical image surveys.

[6] The Mesa K operations as approved under MS 776 comprises approval for remnant mining of a historical mining operation previously mined in the 1980s, prior to the first known troglofauna records. For the purposes of statistical analysis and comparison of before and after mining, Mesa A presents the only operation which allows for this type of comparative assessment.

The results of the above monitoring as they relate to the effectiveness of the Mesa A MEZ in maintaining the biological diversity of the subterranean fauna community are assessed in the Mesa A Hub Revised Proposal Environmental Review Document (Rio Tinto 2018f) and summarised below and in Table 7-7.

Troglofauna abundance in the Mesa A MEZ

The statistical power of troglofauna sampling is limited by the sampling methodology. Within the limitations presented by current troglofauna sampling methodology[7], the capture rates of troglofauna from the MEZ at Mesa A during mining were found to be similar to those recorded across Mesa A prior to commencement of mining (Rio Tinto 2018f). If capture rate is taken as a measure of abundance, then the similar range in capture rates before and during mining indicates that troglofauna abundance during mining is similar to abundances recorded prior to commencement of mining.

Troglofauna diversity in the Mesa A MEZ

Sampling at Mesa A prior to the commencement of mining was conducted across the mesa formation, while sampling during mining operations has been conducted in the MEZ. Despite the inherent limitations in sampling troglofauna, the results of the analysis confirm the persistence of a troglofauna community at Mesa A of similar general composition to that pre-mining.

In addition, a number of individuals only known from one location and excluded from the mine pit have subsequently been found in multiple other locations.

[7] Limitations include access to the subterranean environment for sampling (only via drill holes); modification of potential habitat through establishment of drill holes; trapping and scraping methodology may not be appropriate for some species depending on species preferences and mobility; sampling bias towards orebodies; difficulty in determining the specific geological strata that specimens originate from.

Table 7-7: Troglobitic and Troglomorphic Taxa Collected from Mesa A (Shown at Order level) (Rio Tinto 2018f)

Order	Pre-Mining							During mining				Combined results of orders recorded during mining
	Dec 2003*	Jan 2005	May 2005	Sep 2005	Aug 2006	Feb 2007	May 2007	Oct 2010	Jul 2012	Sep 2014	Sep 2016	Summary
Araneae			✓						✓			✓
Blattodea**								✓	✓	✓		✓
Coleoptera					✓	✓				✓	✓	✓
Diplura	✓		✓	✓			✓			✓		✓
Hemiptera**								✓			✓	✓
Isopoda				✓				✓	✓	✓		✓
Polydesmida	✓						✓	✓				✓
Pseudoscorpiones				✓	✓	✓	✓	✓	✓	✓		✓
Schizomida	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Scolopendromorpha				✓	✓							
Zygentoma			✓	✓	✓	✓						

* Sampling in 2003 was for stygofauna using haul nets; no troglofauna traps were set.

** Prior to 2010, experts considered that these groups were unlikely to contain troglobitic representatives thus no specimens were recorded during pre-mining surveys. Since 2010 a change in expert opinion has meant that potentially troglobitic Blattodea and Hemipterans are collected and retained for further assessment although there is still uncertainty whether these are truly troglobitic or simply edaphabitic (soil dwelling) species.

Troglofauna presence in disturbed habitats

The Proponent is currently undertaking further investigations into the re-colonisation of in-pit waste dumps / low grade stockpiles and utilisation of the formation beneath the waste dumps / stockpile by subterranean fauna. Troglofauna sampling (most recently Biota 2017; Appendix 10) has been undertaken in disturbed habitats at Mesas A and K to provide a preliminary assessment of the suitability and use of disturbed habitats post-impact. The limited sampling results to date are presented in Table 7-8. Schizomids, isopods, curculionid beetles and hemipterans were recorded from a formerly mined, rehabilitated pit and waste dumps at Mesa K. Pre-mining troglofaunal sampling records are not available for Mesa K as this mine was historically mined. However, all but two taxa recorded in the pits at Mesa K were also recorded outside of these impact areas. The two remaining taxa (*Curculionidae* 'sp. B01' and *Curculionidae* 'sp.B04') have not undergone complete taxonomic comparison with surrounding specimens so it is possible they have also been recorded elsewhere.

At Mesa A, limited sampling in disturbed areas has recorded three schizomid taxa (*Paradraculoides* sp. 'SCH034', *Paradraculoides anachoretus* and *Paradraculoides* sp.) from areas within the mining operation. Three schizomid specimens were collected from two drillholes (MOB03a and MOB03b) which are approximately 10 m apart in the southern part of the Mesa A pit. An additional five schizomid specimens were recorded from a drillhole (RC16MEA004) in the northern part of the Mesa A pit. Genetic analysis of these five specimens from the northern part of the pit determined the presence of two distinct lineages, equating to two species, *Paradraculoides anachoretus* and *Paradraculoides* sp. 'SCH034'. *Paradraculoides anachoretus* has been widely recorded from Mesa A, including during pre-mining baseline sampling. *Paradraculoides* sp. 'SCH034' has also been previously recorded from two sites within the Mesa A MEZ but was not identified as such during pre-mining baseline sampling.

The presence of troglofauna in disturbed in-pit areas demonstrates that potential habitat exists in or under waste dumps and under the pit during mining. However, further work is ongoing to evaluate the diversity of troglofauna present in disturbed habitats and utilisation of those habitats by troglofauna.

Due to inherent sampling difficulties, there is currently a greater level of confidence of troglofauna persistence in the retained habitat behind the escarpment MEZ at Mesa A than beneath the pit floor. This information therefore has been used to guide the approach and design of the MEZ at Mesa H.

Table 7-8: Sampling Effort (Orange Squares) in Pit and Waste Dumps at Mesa K and Mesa A Along with the Number and Taxa Collected

Site	Impact type	Sample year								
		2005	2010	2011	2012	2013	2014	2015a	2015b	2016
Mesa K										
MEKRC1721	Rehabilitated waste dump				2x Isopoda sp. 1x Chthoniidae sp. 2x Paradraculoides sp.					
MEKRC1728	Rehabilitated waste dump							1x Phaconeura `sp. OES10`		1x Paradraculoides kryptus
MEKRC1478	Rehabilitated pit floor			1x Hubbardiidae sp. 1x Paradraculoides kryptus	1x Paradraculoides kryptus	2x ?Staphylinidae sp. MesaKOES2	1x Paradraculoides kryptus			1x Phaconeura `sp. OES10` 1x Curculionidae sp. B04 2x Paradraculoides kryptus
MEKRC1486	Rehabilitated pit floor				1x Hemiptera sp. 1x Paradraculoides sp.	1x Hanoniscus `sp. MesaK1` 2x Paradraculoides kryptus	1x Curculionidae sp. OES10 1x Paradraculoides kryptus	1x Paradraculoides kryptus 1x Curculionidae sp. B01		
RC16MEK0001	Waste dump									
RC16MEK0003	Pit floor									
RC16MEK0004	Pit floor									
RC16MEK0005	Pit floor									
Mesa A										
MOB EAST PIT 4 (MOB02a)	Pit floor									
MOB WEST PIT 4 (MOB02b)	Pit floor									
MOB EAST PIT 8 (MOB03a)	Pit floor									1x Paradraculoides sp.
MOB WEST PIT 8 (MOB03b)	Pit floor									2x Paradraculoides sp.
MOB NORTH PIT 2 (MOB01a)	Pit floor									
MOB SOUTH PIT 2 (MOB01B)	Pit floor									
RC16MEA001	Pit floor									
RC16MEA002	Pit floor									

Site	Impact type	Sample year								
		2005	2010	2011	2012	2013	2014	2015a	2015b	2016
RC16MEA003	Pit floor									
RC16MEA004	Low grade waste dump[1]								3x Paradraculoides sp. 'SCH034' 1x Paradraculoides anachoretus	1x Paradraculoides sp. 'SCH034'
RC16MEA005	Pit floor									
RC16MEA006	Pit floor									
RC16MEA007	Pit floor									
Middle Robe										
M2ERC0076	Pit floor									
M2ERC0103	Pit floor									
M2ERC0095	Pit floor									

[1] This hole was drilled through the low-grade CID waste dump, but also partially into the in-situ CID bedrock geology immediately below the dump

Downhole habitat parameters in the Mesa A MEZ

Subterranean temperature and relative humidity data are collected continuously from uncased drill holes in the MEZ at Mesas A and B and in the areas remaining at Mesa K following historical mining to assess the potential effects of mining on the retained troglofauna habitat. The monitoring program was established specifically to examine potential changes in subterranean temperature and humidity in the retained habitat due to exposure of habitat at mine pit faces. The monitoring programs include potential impact sites at Mesa A (and Mesa K) as well as reference sites at Mesa B. Potential impact sites at Mesa A include sites established along several transects that run perpendicular to the pit face, across the MEZ, to the outer part of the Mesa escarpment, thus allowing assessment of potential habitat changes with increasing proximity to the pit face.

Statistical analysis of the temperature and relative humidity data collected was undertaken by Astron Environmental Services (Astron 2017a). The analysis showed proximity to the Mesa A pit edge did not influence mean down hole temperature or humidity (Astron 2017a). Increased proximity to the pit edge may result in an increase in the variability of the subterranean humidity due to increased connectivity with the surface climate. However, some of the highest variability in humidity was recorded well away (approximately 100 m) from the pit face and increases in variability in some near-pit locations are within the error margins of the humidity sensors (Astron 2017a). Variations in temperature and humidity values at Mesa A were not significantly different from those recorded from a reference (Mesa B) and an historical (and intermittently active) mining area (Mesa K) (Astron 2017a). It was, therefore, concluded that mining at Mesa A has had little discernible influence on down hole temperature and humidity in the Mesa A MEZ (Astron 2017a).

Optical image surveys have been conducted periodically in drill holes at Mesas A, B and K since 2009 to allow qualitative assessment of the extent and type of fracturing and cavities in the drill holes in retained troglofauna habitat. Comparison of the images between years show no visible changes in the shapes or sizes of voids between 2016 and 2017 (Rio Tinto 2018f).

Summary of Mesa A monitoring results

The analysis of the troglofauna sampling and habitat monitoring at Mesa A indicates that the MEZ is functioning as intended with respect to maintaining a viable troglofauna habitat. Within the inherent limitations of troglofauna sampling, the results indicate that a troglofauna community with similar abundance and diversity to the pre-mining community continues to be present at Mesa A. Downhole habitat monitoring at Mesa A shows little discernible influence of mining on subterranean temperature and humidity values with variations in temperature and humidity not significantly different from those at reference sites and proximity to the pit face showing no influence on mean temperature or humidity values. Down hole imagery shows no evidence of degradation of troglofauna habitat through collapse of cavities or generation of new fractures due to mining activities.

7.4.3 Potential impacts

7.4.3.1 Direct impacts

Potential direct impacts of the Proposed Change to troglofauna have been identified as:

- reduction in troglofauna habitat due to mine pit development; and
- loss of individuals and changes to assemblages due to mine pit development.

Reduction in troglofauna habitat due to mine pit development

The main direct impact on both troglofauna species and communities key receptors comprises habitat removal that will occur to accommodate the proposed mine pits. This will result in the loss of troglofauna habitat and the mortality of individual animals occurring within it.

The characteristics of troglofauna habitat and the modelled extent of habitat are described in Sections 7.4.1.2 and 7.4.4.1.

As discussed in Section 7.4.4, a conservative approach, considering only the areas of high prospectivity habitat, has been taken to identify and assess potential impacts to troglofauna habitat at Mesa H. This approach is based upon 3D modelling data and, therefore, allows an output as a percentage of volume, and area. Through the development of mine pits, the Proposed Change will not directly impact more than 50% of the volume of pre-mining troglofauna CID habitat at Mesa H (this is conservatively assuming no viable habitat retained below the pit floor or below waste dumps).

From a surface area extent, approximately 85% of the Mesa H Landform habitat will be retained (Table 7-9). However, conservatively, if habitat below the pit floors is excluded as viable habitat, then the troglofauna habitat extent retained via the MEZ and ex-pit is approximately 52% (Table 7-9).

Table 7-9: Potential direct impact to modelled high confidence troglofauna habitat

Habitat prospectivity for troglofauna (AWT habitat)	Current modelled habitat extent (ha)	Post-mining modelled habitat extent (ha)	% habitat by surface area remaining on Mesa H Landform
High	1,537	1,206	78 %
Medium	1,24	2,00	39 %
TOTAL	1,661	1,406	85 %
Excluding below pit habitat	1,661	Pits ~ 790 ha, = 871 ha remaining	~52%

Loss of individuals and changes to troglofauna assemblages due to mine pit development

The higher order taxonomic composition of the fauna of the Proposed Change Area is considered representative of virtually all components of the best-sampled CID (pisolitic) mesa habitats of the Robe valley (Biota 2019b).

Thirty-three potential or confirmed SRE species have been recorded from the Proposed Change Area representing nine troglofauna Orders. All nine of the troglofauna Orders recorded from the Proposed Change Area are represented in the proposed MEZ Table 7-10. Eight of these Orders are represented within the proposed mine pit footprint.

Table 7-10: Troglofauna recorded (Order level) 2011 - 2017 at Mesa H

Order	Order recorded	
	Mesa H Mine Impact area	Mesa H proposed MEZ
Araneae	✓	✓
Blattodea	✓	✓
Coleoptera	✓	✓
Diplura	✓	✓
Isopoda	✓	✓
Pseudoscorpiones	✓	✓
Schizomida	✓	✓
Scolopendromorpha	-	✓
Zygentoma	✓	✓

From the above Orders, only one potential SRE troglofauna species is currently known only from the proposed mine-pit impact area at Mesa H (Figure 7-6).

Six of the 33 potential SRE troglofauna species recorded in the Proposed Change Area, have also been recorded from outside of the Proposed Change Area and have demonstrated wider distributions. Of the remaining 27 potential SRE species known only from the Proposed Change Area, only four occur within the proposed Mesa H mine pit (i.e. within the direct impact area). Three of these taxa also occur within the MEZ leaving only one singleton species, the Diplura Japygidae sp. 'DJA011' currently only known only from the proposed mine pit impact area (Table 7-11).

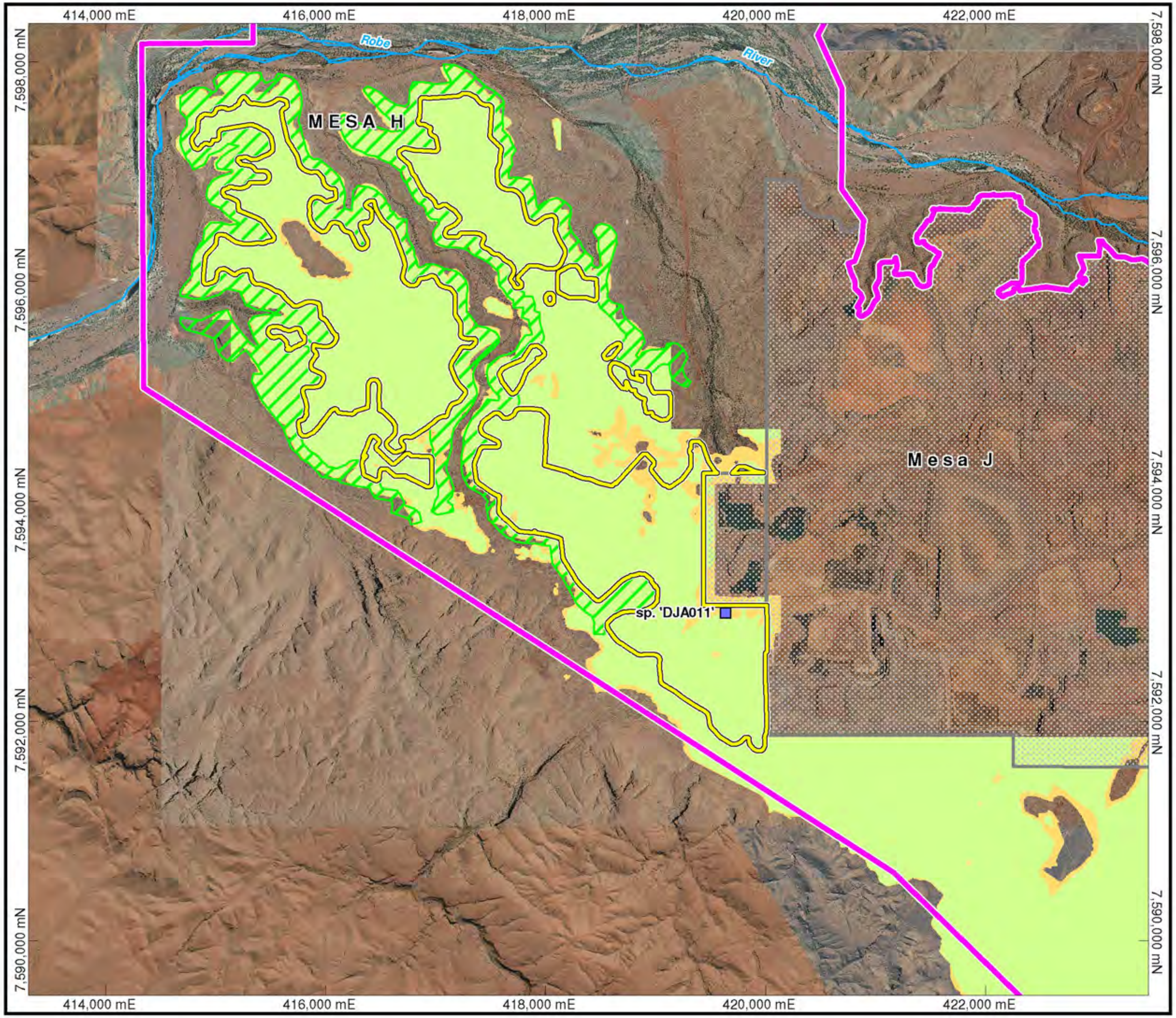
Table 7-11: Troglofauna Species Currently Known Only from within the Proposed Change Area and Their Distribution Relative to the Proposed Mine Pits (Species Shaded Grey Currently Only Known From the Mine Pits)

Species	In-pit species (Drillhole Locations)	Sites outside of Mine Pits	
		Inside MEZ (Drillhole Locations)	Other Remnant Habitat (Drillhole Locations)
Pseudoscorpiones			
Hyidae sp. 'PH017/PH027'	-	RC14MEH0252	RC16MEH0264
Hyidae sp. 'PH026'	-	RC16MEH0436	-
Olpiidae sp. 'PO008'	-	RC15MEH0302	-
Beierolpium sp. 'PO014'	-	-	RC16JIM0026
Beierolpium sp. 'PO015'	-	RC16MEH0433	-
Atemnidae sp. 'PA004'	-	RC15MEH0329	-
Chthoniidae sp. 'PC014/PC015'	GR15MEH0015 , RC15MEH0315	RC15MEH0335	-
Chthoniidae sp. 'PC055'	-	-	MEHRD0834

Species	In-pit species (Drillhole Locations)	Sites outside of Mine Pits	
		Inside MEZ (Drillhole Locations)	Other Remnant Habitat (Drillhole Locations)
Schizomida			
Paradraculoides sp. 'SCH038'	MEHRC157, RC15MEH0329	RC16MEH0433	RC16MEH0264
Paradraculoides sp. 'SCH039'	-	-	RC15MEJ0019
Scolopendromorpha			
Cryptopidae sp. 'SC018'	-	RC14MEH0388	-
Diplura			
Parajapygidae sp. 'DPA001'	-	-	RC14MEH0308
Parajapygidae sp. 'DPA009'	-	MEHRD0758	-
Projapygidae sp. 'DPR008/DPR009/DPR011'	-	RC15MEH0166	RC15MEH0261, RC15MEH0175, RC16JIM0005
Projapygidae sp. 'DPR010'	-	-	RC16JIM0005
Japygidae sp. 'DJA003'	-	RC14MEH0388	-
Japygidae sp. 'DJA011'	DD13MEH0007	-	-
Campodeidae sp. 'DCA005'	-	-	GR15MEH0032
Isopoda			
Philosciidae sp. 'ISP047'	-	-	RC15MEH0382
Philosciidae sp. 'ISP055'	-	RC15MEH0427	-
Troglarmadillo sp. 1	-	-	MEHDC0865
Troglarmadillo sp. 'ISA046'	-	-	RC15MEH0382
Coleoptera			
Curculionidae sp. 'CCU014'	RC12MEH0221, RC15MEH0302	RC14MEH0252	-
Zygentoma			
Nicoletiinae sp. 'TN019'	-	-	RC16JIM0006
Nicoletiinae sp. 'TN020'	-	RC14MEH0252	-
Araneae			
Prethopalpus sp. 'ARA052'	-	-	RC16JIM0019
Gnaphosidae sp. indet.	-	RC14MEH0270	-

At a troglofauna ecological community level, there are also two key receptors considered for this impact assessment:

- *Subterranean invertebrate communities of mesas in the Robe Valley region* (Priority 1)
- *Subterranean invertebrate community of pisolitic hills in the Pilbara* (Priority 1).



LEGEND

Development Envelope

Ministerial Statement 208

Mining Exclusion Zone

Conceptual Mine Pit

Major Watercourse

Japygidae sp.DJA011

3D Modelled habitat Prospectivity

Habitat Prospectivity: High

Habitat Prospectivity: Medium

N

SCALE

0 0.5 1 1.5 2km

1:50 000 @ A4

RioTinto

Iron Ore (WA)

Figure 7-6: Potential SRE troglofauna species currently known only from locations inside the proposed Mesa H pit area

Drawn: GIS
Date: Aug, 2018

Plan No: PDE0161846v2
Proj: MGA94 Zone50

7.4.3.2 Indirect impacts

Potential indirect impacts to troglofauna include temporary loss or degradation of habitat due to mining activities other than mine pit excavation. Mining activities that may result in indirect impacts to troglofauna include:

- Clearing of vegetation and placement of mineral waste potentially leading to a reduction in organic inputs into the subterranean environment. Reduced organic inputs may diminish the quality of troglofauna habitat.
- Seepage from the WFSF will generate a saturated zone above the groundwater table, resulting in a temporary reduction in troglofauna habitat.
- Blasting may cause voids and mesocaverns within the remnant mesa formations to collapse, resulting in a reduction in troglofauna habitat.
- Exposure of pit faces may cause changes to the temperature and humidity in the subterranean environment, potentially leading to degradation of troglofauna habitat.
- Hydrocarbon spills may result in a reduction in the quality of troglofauna habitat.

Considering only high confidence and high prospectivity habitat modelling outputs, potential indirect impacts to troglofauna habitat as a result of placement of mineral waste material from the proposed mining at Mesa H is largely related to where the mineral waste is located on retained habitat within the MEZ. As shown in Table 7-12, less than 6% of the MEZ will be impacted by the placement of mineral waste.

Table 7-12: Potential Indirect Impacts to Troglofauna Habitat at Mesa H and the MEZ From Placement of Mineral Waste

Mesa H Dump	Dump Extent	MEZ		
		Total MEZ Area (ha)	Extent of Waste on MEZ (ha)	% of MEZ
NW Dump	90	447	19.26	4.3%
SW Dump	39		7	1.6%
Total	129		26.26	5.9%

A significant change in subterranean humidity due to groundwater abstraction is not considered likely. The humidity in the subterranean environment in the Robe Valley is believed to be maintained from a combination of infiltration from rainfall through the porous CID and via fissures and bedding planes; the presence of insitu moisture content within the CID (including intra clay layers); and the presence of the groundwater table in some areas.

At Mesa H, only a limited volume of troglofauna habitat is in close contact with the water table, and the pre-mining water table does not extend below all areas of Mesa H, in particular, the proposed MEZ. Abstraction of groundwater will lower 7the groundwater table at Mesa H, however, given that only a limited volume of the troglofauna habitat is currently in close contact with the water table, and the proposed MEZ which contains all representative Orders and almost all species (bar one) of troglofauna at Mesa H and proximity to the water table has not been demonstrated to be a prerequisite for suitable troglofauna habitat, a significant change in troglofauna habitat due to groundwater abstraction is considered unlikely.

Assessment of the potential indirect impacts to troglofauna and troglofauna habitat is provided in Section 7.4.4.2.

7.4.3.3 Cumulative impacts

The below section presents the incremental impact from the Proposed Change whilst taking into account previously approved projects. Section 7.4.4.3 discusses the significance of these impacts at each location.

Overall cumulative impacts to the two troglofauna PECs in the Robe Valley are presented in Table 7-13. The calculation for the remaining extent takes into account other foreseeable proposals in the area (the Mesa A Hub Revised Proposal) as well as existing approved developments (Mesa A, Warramboo, Mesa J, Mesa K and historical Middle Robe Mining).

Table 7-13: Cumulative Direct Impacts from the Mesa H Mine Pits on Troglofauna PECs, in Context With Other Habitat Removal

PEC name	Pre-European original extent (ha)	Current extent after other habitat loss (ha)	Extent after Habitat Loss from this Proposed Change (ha)	Incremental impact (ha)
Subterranean invertebrate communities of the mesas in the Robe Valley region.	13,753.9 ha (100%)	11,773.4 ha (85.60%)	11,764.2 ha (85.53%)	9.20 ha (0.07%)
Subterranean invertebrate community of pisolitic hills in the Pilbara.	9,889.7 ha (100%)	952.3 ha (80.41%)	7,164.2 ha (72.44%)	788.1 ha (7.97%)

Assessment of the significance of the predicted cumulative impacts to troglofauna and troglofauna habitat is provided in Section 7.4.4.3.

7.4.4 Assessment of impacts

The assessment of impacts is provided in Sections 7.4.4.1 to 7.4.4.3. To enable an assessment of impacts it is relevant to consider the available information on habitats and troglofaunal records in nearby areas. This information is presented in Section 7.4.2. Comparative data from Mesa J is not available as Mesa J commenced mining in the early 1990s prior to troglofauna being discovered in the Robe Valley.

7.4.4.1 Direct impacts

Reduction in troglofauna habitat due to mine pit development

The Proposed Change will result in the direct loss of up to 50% of the volume of pre mining troglofaunal habitat at Mesa H. The Proposed Change has been designed to retain significant volumes of connected troglofauna habitat, as delineated by a MEZ. Monitoring results from the existing and geologically similar Mesa A and K mining operations have been used to guide the design of the MEZ at Mesa H and assess the likely suitability of the design.

Comparison of sampling results from the Mesa A MEZ with preliminary sampling results from disturbed habitat in waste dumps and beneath the pit floor at Mesas A and K indicates there is greater persistence of troglofauna in the retained habitat in the MEZ than beneath the pit floor. Based on the performance of the Mesa A MEZ, a MEZ has been included in the mine design for Mesa H with a focus on retaining connected habitat within the mesa periphery and escarpments, rather than beneath the pit floors.

Although habitat connectivity exists between the Mesa H CID, the Mesa J CID and the Jimmawurrada CID to the south-east the Proponent has taken a precautionary approach and has assumed that the habitat on Mesa H is limited in connectivity to Jimmawurrada, largely due to most of the high prospectively connected CID habitat in the south of Mesa J being already removed due to mining excavation. However, a corridor of connected AWT CID habitat with a width >50 m will remain and will retain a level of connectivity with the Jimmawurrada CID to the south of Mesa J (Figure 7-7). Notwithstanding this connection, the MEZ at Mesa H has been designed to retain sufficient high prospectivity habitat within Mesa H to enable the persistence of troglofaunal assemblages within the mesa.

Troglofauna capture rates vary markedly between sampling events. Table 7-14 provides detail of the overall capture rates at Mesa H and in the areas proposed as a MEZ. The range of capture rates and overall capture rate for the MEZ can be skewed by a single sampling event as seen in Phase 6 sampling. However, combined with connected CID habitat and the representation of all Orders and the majority of taxa within the MEZ (Table 7-11), the information suggests that the MEZ supports a suitable and representative habitat for troglofauna.

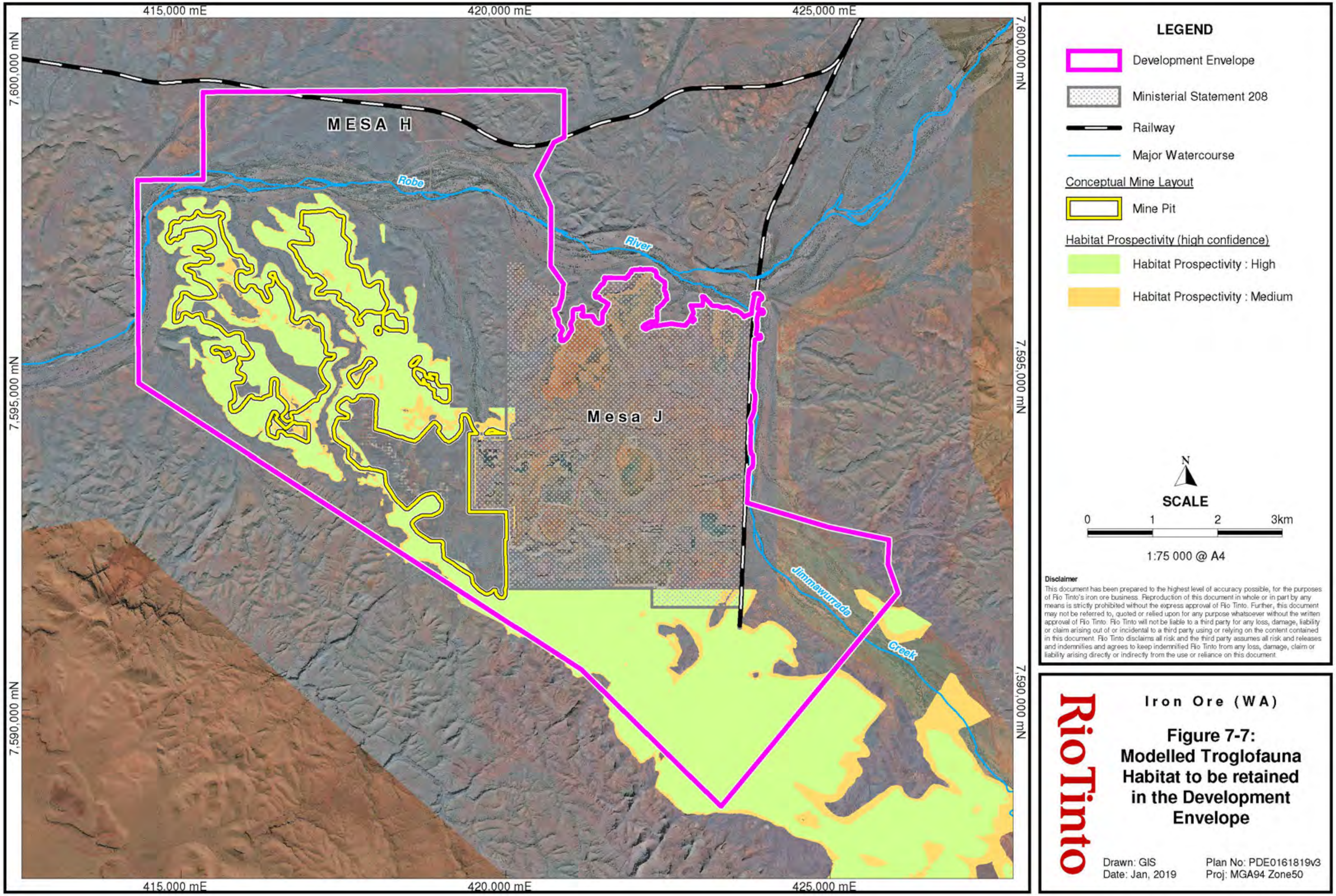
Figure 7-8 shows the thickness of CID material suitable as troglofauna habitat that is proposed for retention at Mesa H (backfill of waste material is not included in this figure). The thickness and connectivity of the retained habitat is variable, due to the variable morphology and habitat thickness of the pre-mining habitat, however retention of connected habitat of at least 5 – 15 m depth with a width of at least 50 m around the mesa plateau and a minimum of 50% by volume of the pre-mining habitat is proposed at Mesa H.

Figure 7-9 shows the habitat prospectivity within and around the Development Envelope pre-mining, during operation and following closure. This figure shows the predicted impacts and increase of the habitats during mining as a result of mine pit dewatering, and then the net habitat remaining following closure[8].

[8] The modelling is conservative and has not included consideration of backfill as additional habitat, however backfill may have the potential to provide additional troglofauna habitat.

Table 7-14: Mesa H Troglofauna Capture Rates

Mesa H	Pre-mining							
Sample collection date	2010 (21st Sep - 10th Nov)	2015 EIA Phase 1 (29th Oct - 12th Dec)	2016 EIA Phase 2 (12th Dec - 21st Jan)	2016 EIA Phase 3 (7th May - 28th Jun)	2016 EIA Phase 4 (14th Sep - 27th Oct)	2016 EIA Phase 5 (27th Oct - 14th Dec)	2017 EIA Phase 6 (14th Dec - 31st Jan)	AVERAGE
Number of trapped holes at Mesa H in MEZ.	6	7	7	16	16	16	4	
Number of trapped holes at Mesa H in pit.	17	39	39	14	27	31	10	
Number of specimens collected in MEZ.	9	5	4	3	3	3	1	
Number of specimens collected in pit.	15	18	16	5	31	5	31	
Number of specimens per 100 trapped holes in MEZ.	150.0	71.4	57.1	18.8	18.8	18.8	25.0	38.9
Number of specimens per 100 trapped holes in pit.	88.2	46.2	41.0	35.7	114.8	16.1	310.0	68.4



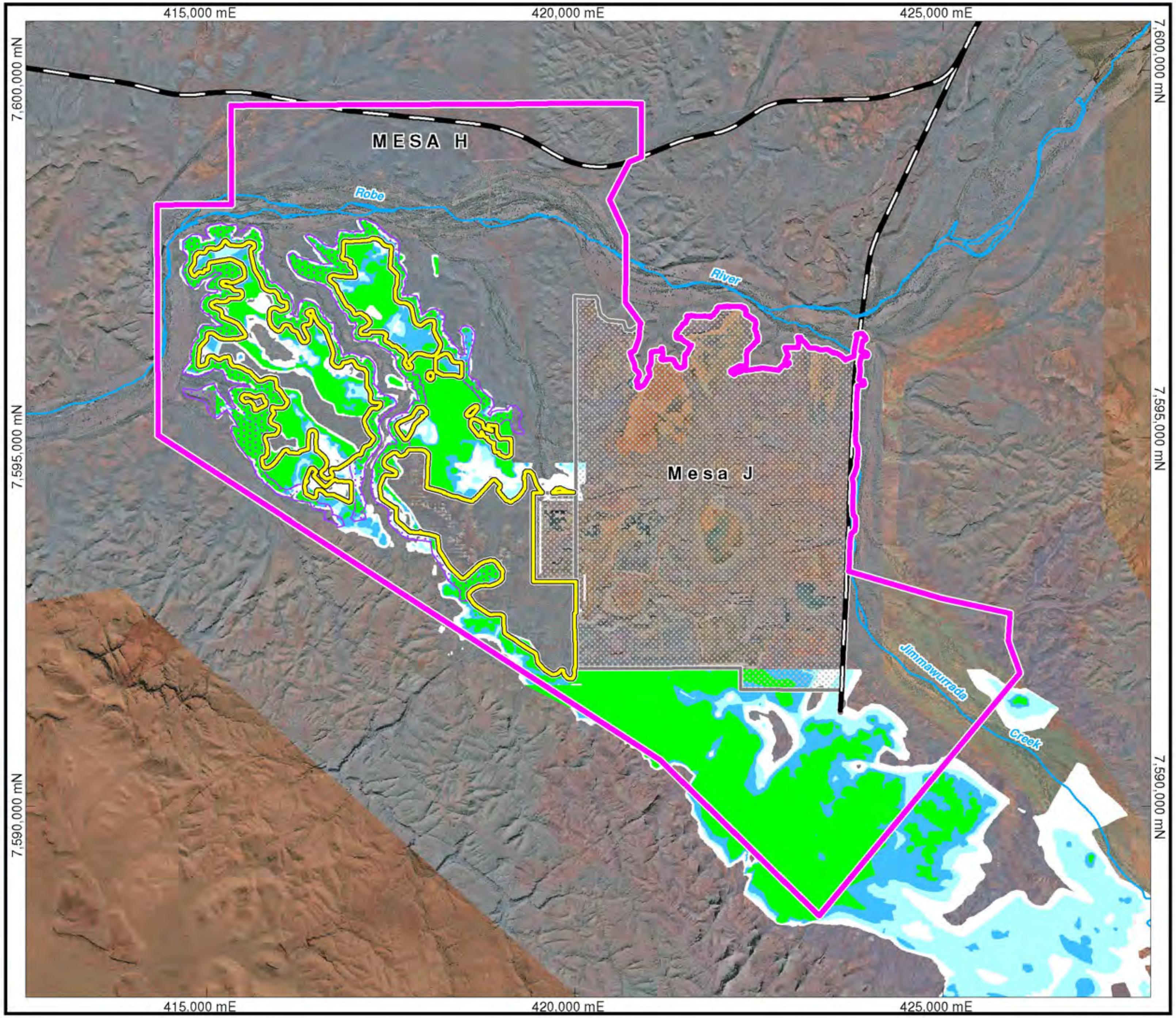
RioTinto

Iron Ore (WA)

Figure 7-7: Modelled Troglofauna Habitat to be retained in the Development Envelope

Drawn: GIS
Date: Jan, 2019

Plan No: PDE0161819v3
Proj: MGA94 Zone50



LEGEND

- Development Envelope
- Ministerial Statement 208
- Mining Exclusion Zone
- Railway
- Major Watercourse

Conceptual Mine Layout

- Mine Pit

Thickness of Troglofauna Habitat to be Retained (m)

- <5
- 5 < 10
- 10 < 15
- >= 15

N

SCALE

0 1 2 3km

1:75 000 @ A4

RioTinto

Iron Ore (WA)

Figure 7-8: Modelled extent and thickness of above water table Troglofauna habitat retained at Mesa H

Drawn: GIS
Date: Jan, 2019

Plan No: PDE0161868v6
Proj: MGA94 Zone50

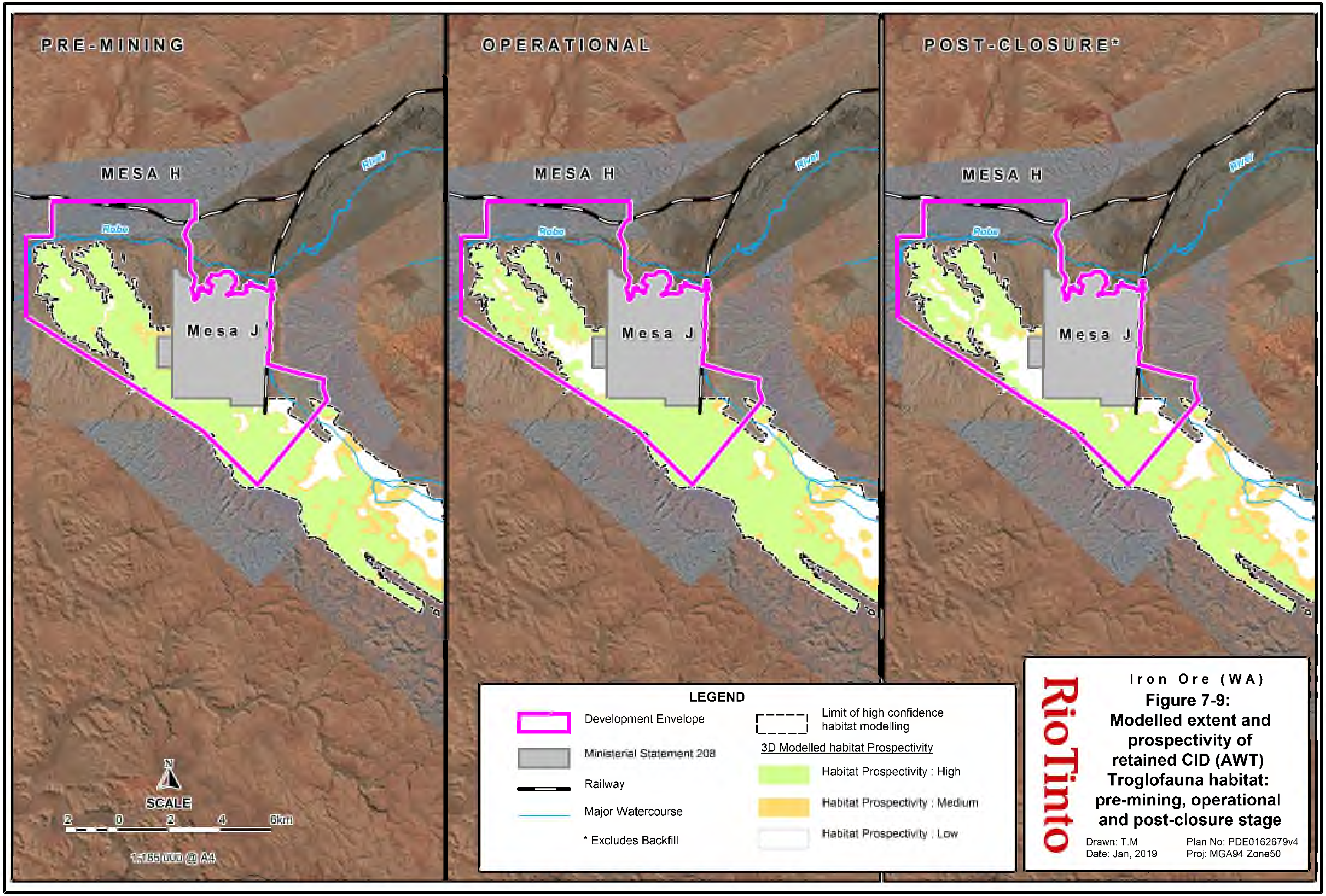


Figure 7-9: Modelled extent and prospectivity of retained CID (AWT) Troglofauna habitat: pre-mining, operational and post-closure stage

Retained habitat will be around 15 m thick with a width of at least 50 m on the mesa plateau. The width of retained habitat at the base of the mesa will be significantly greater than 50 m due to the natural slopes of the mesa escarpment and due to the construction of benches during mining (rather than a sheer face from the top to the bottom of the pit). Given that the Mesa A MEZ is providing suitable habitat, as evidenced by subterranean temperature and humidity monitoring and troglofauna sampling results; and the proposed MEZ designs for Mesa H is similar to the Mesa A MEZ and is likely to be representative of the troglofauna habitat throughout the mesa, it is considered that the Proposed Change will retain the ecological integrity of the troglofauna habitat at Mesa H.

Loss of individuals and changes to troglofauna assemblages due to mine pit development

Excavation associated with mine pit development will result in the direct loss of individuals and has the potential to change troglofauna assemblages. The avoidance of direct impact on most species occurring within the Proposed Change Area (Table 7-11) is due to the Proposed Change design, which followed an iterative process and considered troglofauna records, available habitat and likely connectivity of habitat. Potential impacts of the Proposed Change on each recorded troglofauna taxon were assessed, regardless of whether the taxon had previously been categorised as confirmed or potential SRE, or widespread in biological survey reports.

Although significant, connected troglofauna habitat is proposed to be retained at Mesa H, and the Proponent has taken a precautionary approach in relation to single location and singleton troglofauna records. The original design of the MEZ has been modified several times during the mine planning stages in order to avoid as many single location and singleton troglofaunal records as far as practicable. Consistent with the approach for Mesa A, revisions of the MEZ aimed to include at least one location in the MEZ for each taxon where practicable (Table 7-11). Results from Mesa A, have since shown singletons avoided by the delineation of the MEZ being subsequently found in numerous other locations within the retained MEZ (Rio Tinto 2018f). The current reconfigured mine plan has resulted in all Orders being represented in the MEZ (Table 7-10), and only one species being unable to be avoided (the Diplura: Japygidae sp. DJA011), which is currently known only from the mine impact area. The location of this species record occurs along the boundary between an existing mine pit at Mesa J and one of the proposed mine pits at Mesa H (Figure 7-5, Map 4) i.e. one of the mine pits at Mesa H will form an extension to an existing pit at Mesa J, and is therefore is difficult from a mining and operational perspective to avoid, particularly considering the contiguous interconnected habitat; Order level distribution and high possibility of the record being a sampling artefact. Hence a risk-based approach has been adopted in line with EPA (2016g; 2016h) as described in detail below.

Due to inherent sampling challenges, it is difficult to determine if a singleton species is truly restricted to the mine pit impact areas. In order to address the potential for wider distribution, consideration has been given to the available survey data, distributional records of all troglofauna species known from Mesa H, and the extent and configuration of interconnected troglofauna habitat in the locality.

The above water table CID landforms at Mesa H are considered to form interconnected troglofauna habitat based on the sampling records to date (Biota 2006a, 2016b, 2017, 2019a, 2019b) with over 80% of the recorded species only known to occur at Mesa H (Biota 2019b); and due to the local geology where the troglofauna habitats identified at Mesa H are bounded by major geomorphological features, with Robe River to the north, Jimmawurrada Creek to the east, and the Brockman Iron Formation ranges rising to the southwest (Section 11.1.4.3). Therefore, to assess the risk to the one species only known from within the proposed mine pit impact area, consideration needs to be given to whether such small scale and localised restrictions in species distributions could exist within the extent of troglofauna habitat mapped for Mesa H.

The key lines of evidence to support the conclusion that there is a low risk that the species at Mesa H is truly restricted to the proposed mine pits are summarised below.

Animal abundance

Numerous species recorded at Mesa H are represented by single specimens only, which makes assessing their true distribution difficult and introduces the possibility that their apparent isolation to the record sites is an artefact of ecological sampling effects. This was the case at Mesa A whereby a number of species considered ‘at risk’ from the mine pit impact area for the Mesa A – Warramboo Proposal have since been found in other locations. For example, *Lagynochthonius asema* was only known from two locations (one of which is in-pit), however is now known from eight locations (Rio Tinto 2018f).

Troglofauna habitats

The combination of surface geology habitat mapping, AWT CID thickness data, and stratigraphic cross-sections (Figure 5-11 to Figure 5-14 in Section 5.4.5), all indicate continuity and connectivity of AWT troglofauna habitats across the extent mapped within the Proposed Change Area. Therefore, it is unlikely that the habitat requirements for one species are unique and restricted.

Assemblage distribution

The EPA notes that taxa with greater known distributions may act as surrogates to infer the distributions of poorly sampled species (EPA 2016b). Other troglofauna species recorded from the same drillhole as the singleton taxa have distributions that extend beyond the direct impact areas. For example, the singleton species only known from within the proposed pit: *Japygidae* sp. ‘DJA011’ from drillhole DD13MEH0007, co-occurs in this drillhole with *Hubbardiidae* sp. ‘SCH015 / SCH016’ (Figure 7-5; Map 4 and Map 7); which is not considered a potential SRE and has been recorded both inside and outside the direct impact areas, including in habitat that will remain unmined 1.2 km to the south and other locations outside the Proposed Change Area (Biota 2019a).

At the assemblage level, there are 12 troglofauna species (not limited to potential SRE species) known to occur within the mine pit boundaries and 11 of these have wider distributions within Mesa H, with records from either the MEZ or other troglofauna habitat that will remain unmined. This species distribution pattern indicates connectivity of habitat across the extent of the landform and across the mine pit boundaries, rather than a pattern of very localised species isolation (Biota 2019b). Consistent with this, past surveys at other Robe valley mesas have shown that troglofauna species typically have distributions equivalent to at least the extent of contiguous, AWT CID landforms, once sufficient sampling has been undertaken to demonstrate this (e.g. Biota 2006b, 2007, 2016b).

The EPA acknowledges that species are unlikely to be confined to single recorded locations where there is habitat continuity and as such, endorses the use of habitat as a surrogate for species distributions at a local scale where taxa remain poorly sampled as a result of survey limitations (EPA 2016g, 2016h). Where a habitat type that supports a species is continuous then the extent of that habitat may be used to infer the likely presence of that species in the same habitat. CID with thickness >5 m is considered to represent high prospectivity troglofauna habitat. Figure 7-8 shows a plan view of the pre-mining extent and thickness of the Robe Pisolite at Mesa H in relation to the proposed mine pit outlines. Figure 7-10 shows typical cross-sections of the CID within Mesa H.

The figures show that CID is present across the mesa formation and although the central gully area comprises a reduced habitat, being the basal part of the CID formation overlying

Wittenoom Formation, preliminary troglofauna sampling has recorded the presence of troglofauna in this area, supporting that understanding the habitat is connected across this central gully. There are no other known geological barriers or faults within Mesa H that may restrict troglofauna movement.

In addition, the gradual slope of Mesa H to the southeast towards both Mesa J and Jimmawurrada in combination with the mapped continuation of the CID at Mesa H connecting to AWT CID at Jimmawurrada (Figure 7-7), also supports a broader connected habitat extent via a connected corridor south of Mesa J. This is supported by records of troglofauna in the Jimmawurrada area, albeit with lower catch rates. Hence the approach to ensuring retained troglofauna habitat at Mesa H has been conservative by largely considering Mesa H in isolation.

Figure 7-10a - Typical cross section of Mesa H

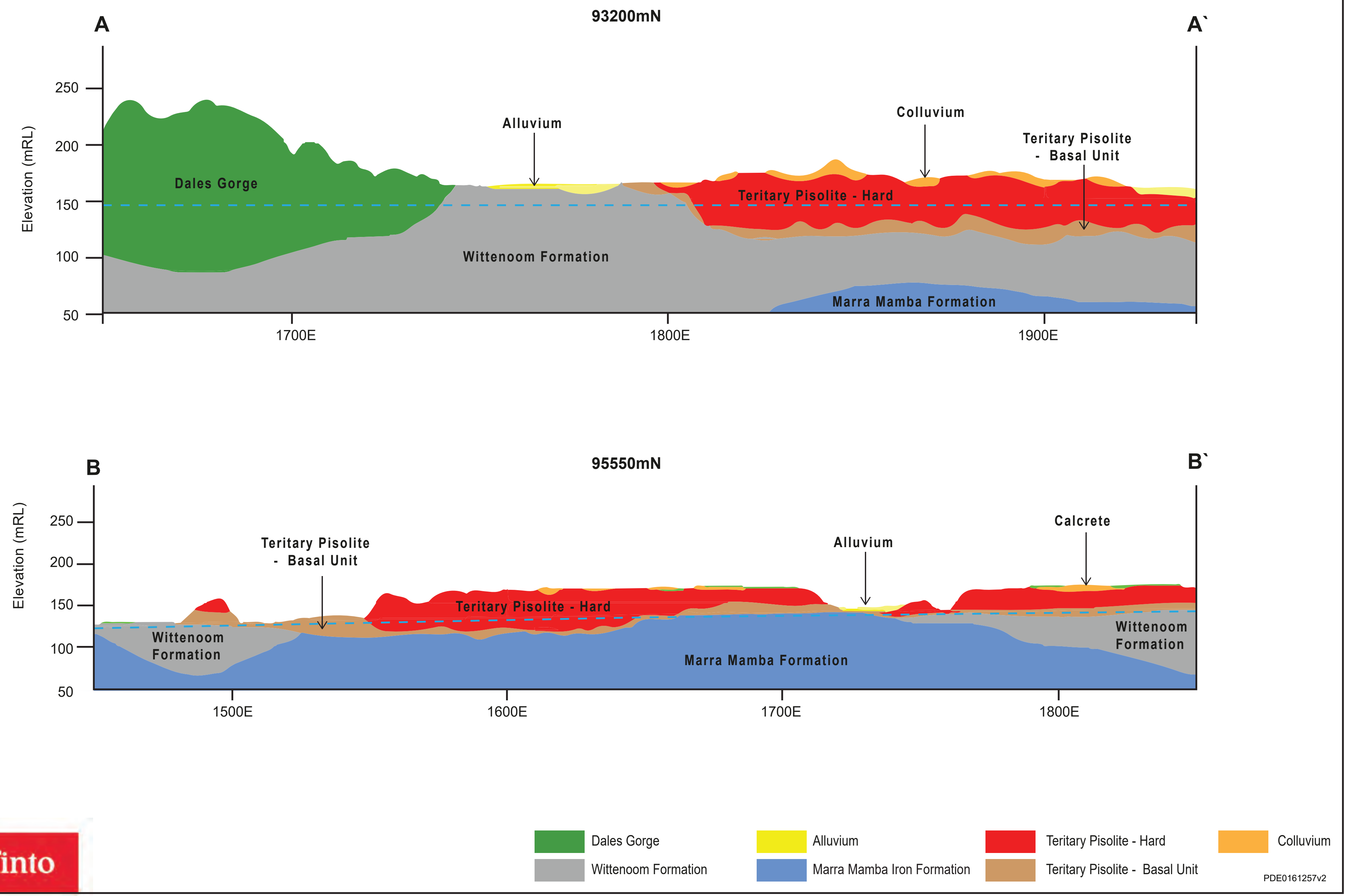
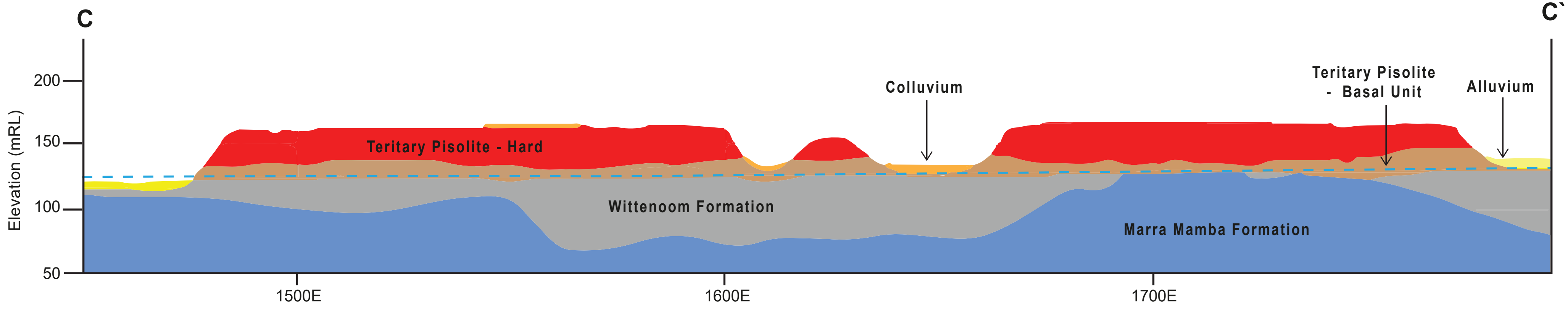
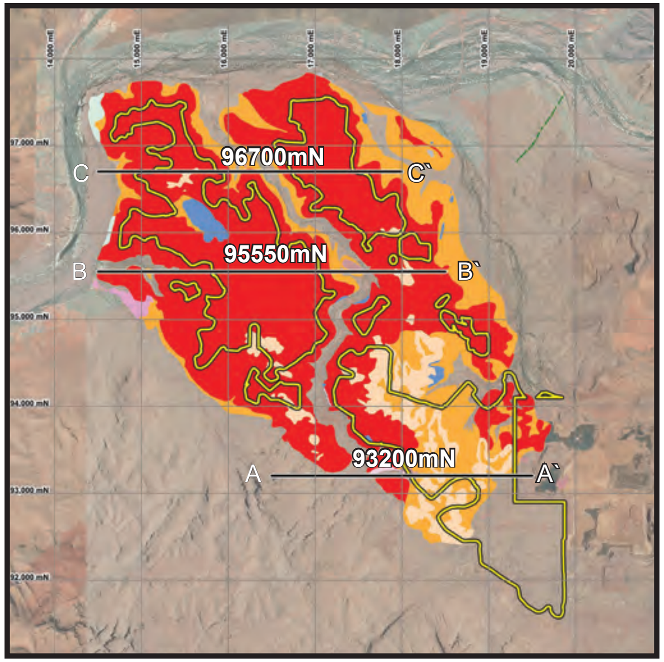


Figure 7-10b - Typical cross section of Mesa H



Witternoom Formation
Alluvium
Teritary Pisolite - Hard
Brockman Iron Formation
Calcrete
Colluvium
Marra Mamba Iron Formation
Teritary Pisolite - Basal Unit
Undifferentiated Basement



Location Map
Mesa J Local Grid

RioTinto

PDE0161257v2

The occurrence of some taxa from multiple locations within Mesa H and the absence of known geological barriers and faults indicate the level of connectivity of troglofauna habitat across Mesa H is high. It is, therefore, considered that the singleton troglofauna species currently only recorded from inside the proposed impact area is likely to have distributions that extend beyond the proposed impact area into the proposed MEZ.

Additional troglofauna sampling will be undertaken with the aim of increasing the recorded occurrences of current single location and singleton troglofauna taxa. Should additional sampling show broader distributions for current single location and singleton taxa around which the MEZs have been designed, the Proponent may seek additional approval to modify the MEZs in the future.

The physical and biological evidence as described above suggests that the one Diplura species known from only the proposed impact area is unlikely to be truly restricted to the small portions of the Mesa H landform from which it has currently been recorded. Data from other co-occurring species, and the broadly continuous nature of AWT CID habitats within Mesa H, suggest that the apparent restriction of this taxon is due to ecological sampling effects and that it occurs more widely within the local habitat extent.

Given these lines of evidence, combined with; the proposed retention of at least 50% by volume of connected pre-mining habitat at Mesa H; that the MEZ has been designed to incorporate areas with singleton records as far as practicable; and that the one singleton species recorded only from the proposed mine-pit impact area (Japygidae sp. DJA011) likely has a wider distribution that extends beyond the proposed mine-pit impact area, it is, therefore, considered that the Proposed Change can be managed such that the diversity and ecological integrity of the troglofauna assemblages at Mesa H are maintained.

7.4.4.2 Indirect impacts

Mining-related activities such as clearing of vegetation and placement of mineral waste, disposal of waste fines, blasting exposure of pit faces and hydrocarbon spills may result in temporary loss or degradation of troglofauna habitat.

Clearing of vegetation and mineral waste

Little is known about the origin of energy (i.e. organic carbon), key taxa or connectivity within the food web of subterranean systems. If energy in the subterranean system originates from the surface, clearing of vegetation and placement of mineral waste material may lead to a reduction in organic inputs and potentially a localised reduction of surface water infiltration into the subterranean environment, which may potentially result in a reduction of the quality of troglofauna habitat.

The Proposed Change has been designed to minimise clearing through placement of the WFSF in-pit at Mesa J and placement of the majority of mineral waste in mined-out pits wherever practicable, in order to minimise clearing in the MEZ. However, as described in Section 11.1, due to the limited availability of space, and constraints on locations due to avoidance of other ecological, heritage and amenity values, the Proposed Change will require placement of two of the mineral waste dumps on the periphery of Mesa H, which is within the area delineated as the MEZ. The placement of the dumps involves clearing of approximately 29.29 ha over high prospectivity habitat, representing approximately 6% of the modelled high prospectivity habitat within the MEZ. Disturbed areas will be rehabilitated once they are no longer required by the Proposed Change.

Results from troglofauna sampling in disturbed habitats (Section 7.4.2) indicate that troglofauna utilise habitat in or below mineral waste dumps. It is, therefore, likely that troglofauna will utilise habitat in or below the proposed waste dumps, although the extent of likely utilisation is not yet known. Studies of troglofauna utilisation of disturbed habitats are ongoing. As a conservative approach, although intact troglofauna habitat will be retained below the mineral waste dumps, the total volume of retained troglofauna habitat for this assessment has been calculated to ensure that the 50% by volume of high prospectivity habitat is retained, conservatively excluding habitat below the waste dumps.

Excluding the two mineral waste dumps, the Proposed Change has also been designed to limit new clearing in areas designated as MEZs to infrastructure such as tracks, utilities, telecommunications, monitoring stations and abandonment bunds; such infrastructure is variously required to access troglofauna monitoring sites, meet legal obligations or because of a lack of alternative suitable locations for essential infrastructure.

Given that disturbance will be minimised outside mining areas and rehabilitation will be undertaken, impacts from loss of vegetation are likely to be localised and temporary and are, therefore, unlikely to significantly degrade troglofauna habitat.

Waste fines storage

Waste fines generated from Mesa H are proposed to be stored in-pit at existing WFSF's at Mesa J. This approach reduces the risk to Mesa H troglofauna habitat by utilising existing facilities and confining the footprint of seepage mounding above the local groundwater table to Mesa J and therefore is unlikely to affect the long term ecological integrity of the troglofauna habitat in the Mesa H area.

Blasting activities and vibration

Blasting activities and vibration have the potential to degrade troglofauna habitat by causing voids and mesocaverns within the remnant mesa formations to collapse. Optical image surveys conducted periodically in drill holes at Mesas A, B and K since 2009 show no evidence of degradation of troglofauna habitat from collapse of cavities within the remnant mesa formations from as close as 5 m to the pit face (Section 7.4.2). Significant degradation of troglofauna habitat in proposed MEZ surrounding the proposed Mesa H pits is, therefore, considered unlikely.

Exposure of pit faces

Exposure of pit faces to surface climate may cause changes in the temperature and humidity in the subterranean environment and thereby degrade troglofauna habitat.

Subterranean temperature and relative humidity data are collected continuously from uncased drill holes in the MEZ at Mesa A, at Mesa B and in the areas remaining at Mesa K following historical mining. As discussed in Section 7.4.2, statistical analysis of down hole temperature and humidity data showed mining at Mesa A has had little discernible influence on the subterranean temperature and humidity in the Mesa A MEZ (Astron 2017a). Within the limitations presented by current troglofauna sampling methodologies, as described in Section 7.4.2, the abundance and diversity of troglofauna recorded from the MEZ behind the escarpment at Mesa A during mining appear to be similar to those recorded across Mesa A prior to commencement of mining (Section 7.4.1.3). The Proponent, therefore, considers that the Mesa A MEZ is functioning as intended and is providing habitat to maintain the biological diversity and ecological integrity of the subterranean fauna community. These results indicate that the proposed exposure of pit faces at Mesa H is unlikely to significantly degrade troglofauna habitat in the proposed MEZs.

Hydrocarbon spills

Contamination of soil or groundwater by hydrocarbon spills has the potential to reduce the quality of subterranean fauna habitat. The Proponent has well established strategies for the management of wastes at its Pilbara operations to ensure that risk of contamination of soil or groundwater is minimised. Storage will be in accordance with relevant Australian Standards and will be located at ground level, below the level of the mesa escarpments, situated off the MEZ - thus reducing the risk of contamination within the retained troglofauna habitat. Servicing and re-fuelling of plant and vehicles will not occur within the MEZ, although re-fuelling of some vehicles will occur in-pit in unsealed areas. Continued implementation of hydrocarbon and spill management procedures will mitigate the risk of hydrocarbon contamination such that hydrocarbon spills are unlikely to significantly degrade troglofauna habitat.

7.4.4.3 Cumulative impacts

Molecular evidence for some troglobitic orders indicates that there is unlikely to be continuous gene flow between the mesas of the Robe Valley. The cumulative impact to troglofauna in mesa environments, therefore, is limited to separate impacts at each mesa, however has been broadly contexted in relation to cumulative impacts to the two Priority 1 subterranean fauna PECs.

Up to 50% of the pre-mining habitat volume at Mesa H will be removed or disturbed by the proposed mining operation. The nearest existing mining operation is the Mesa J Iron Ore Development located immediately to the east and adjoining Mesa H. The Mesa J Iron Ore Development commenced mining at Mesa J in the early 1990’s prior to discovery of troglofauna in the Robe Valley. Therefore, very limited data is available for troglofauna populations and diversity at Mesa J with which to confidently context with Mesa H. The schizomid species: *Hubbardiidae* sp. ‘SCH011’ found at Mesa H is, however, also known from the escarpment on the north side of Mesa J adjacent to the Robe River), indicating some connectivity.

The nearest known or proposed (referred) mining operations are the IOH Buckland Hills Project located approximately 35 km south-east of the Development Envelope and the Mesa A Operations and Mesa A Hub Revised Proposal located approximately 40 km west of the Development Envelope. Troglofauna assemblages in areas near these existing and proposed operations differ from those in the Proposed Change Area. These operations are, therefore, unlikely to contribute to cumulative impacts on the troglofauna assemblage in the Proposed Change Area.

7.4.5 Mine closure

The Mesa J Hub Closure Plan (Rio Tinto 2018a) is an integrated closure plan encompassing the existing Mesa J and Mesa K operations, together with the inclusion of the Proposed Change, in order to optimise closure outcomes. The plan is an update to and supersedes previous closure plans for the existing Mesa J and K Operations. The Closure Plan includes the mine developments and associated infrastructure contained within the Development Envelope (Mesa J and H) and within Mesa K’s Development Envelope. A summary of the approach to closure of the Revised Proposal and how it relates to the Subterranean Fauna environmental factor is provided below.

7.4.5.1 Mining Exclusion Zones

Similar to the Mesa A / Warramboo Iron Ore Project, a MEZ has been delineated at Mesa H to retain a number of ecological and heritage values including troglofauna habitat both during and post mining operations. The Proposed Change has been designed to limit new clearing in areas designated as the MEZ as far as practicable. Disturbed areas will be rehabilitated once they are no longer required by the Proposed Change, although it is anticipated that limited rehabilitation works will be required in the MEZ (with the exception of the two mineral waste dumps) as disturbance will be minimised.

The habitat contained in the MEZ at Mesa H will be retained throughout the mining operation and upon closure. The design of the MEZ at Mesa H has focused on retention of habitat behind the periphery of the Mesa (façade). The proportion of pre-mining habitat to be retained in the MEZ at Mesa H (>50%) is similar to the total proportion of pre-mining habitat retained at the Mesa A Operations.

The predicted post closure habitat prospectivity for troglofauna is shown in Figure 7-9.

7.4.5.2 Placement of waste rock

The closure objectives include a final landform that is stable and considers ecological values. To preserve habitat post-closure, the integrity of the mesa escarpment needs to be maintained. Backfilling will be undertaken where mine scheduling allows. Some narrow areas (‘fingers’) of MEZ may protrude into the pit as a result of avoiding singleton troglofauna species; these areas will be prioritised for backfill.

The Proponent is currently undertaking further investigations into the re-colonisation of in-pit waste dumps/low grade stockpiles by subterranean fauna. Early results from Mesa A and Mesa K indicate troglofauna utilisation of disturbed habitats (Section 7.4.2). However, given only limited sampling has been completed to date in disturbed habitats; further work is required to evaluate the diversity of troglofauna present in disturbed habitats and the utilisation of those habitats by troglofauna.

7.4.6 Mitigation

7.4.6.1 Application of the mitigation hierarchy

Mitigation strategies to address the potential impacts and predicted outcomes are presented in Table 7-15.

The volume of connected habitat retained on the mesa is likely to be a key parameter in determining the ongoing suitability of the retained habitat to support a viable troglofauna population. The designs of the MEZ at Mesa H, therefore, focuses on retention of at least 50% by volume of connected pre-mining habitat, similar to the current approved Mesa A operation. Other considerations during the design of the MEZ included retention of habitat for single location and singleton troglofauna, heritage values and the geotechnical stability of the retained escarpments at closure. A 50 m minimum escarpment width has been included in the MEZ design to ensure heritage values are retained and geotechnical stability requirements are more than met. An additional minimum 30 m escarpment width has been applied where the MEZ has been modified to include single location and / or singleton troglofauna records. Troglofauna sampling and monitoring of habitat parameters at the Mesa A Operation indicate that an escarpment width of 50 m as part of a significant volume of connected habitat is providing suitable troglofauna habitat.

The MEZ designs aimed as far as practicable to retain at least one location where each troglobitic taxon has been recorded. This is consistent with the approach taken at Mesa A. Taxon originally recorded in only a limited number of locations have now been recorded in other locations in the Mesa A MEZ (Section 7.4.2).

The Mesa J Hub EMP (Appendix 6) addresses the key environmental factors which were determined by the EPA as being relevant to the appropriate management of dewatering, surface water discharge, conservation significant vegetation communities, fauna and subterranean fauna species associated with the Mesa J Hub. The EMP identifies:

- mitigation strategies proposed to minimise impacts to significant environmental values;
- the environmental criteria that the Proponent will use to monitor performance of the mitigation strategies to ensure environmental objectives are met;
- trigger criteria, threshold criteria, trigger level actions and threshold contingency actions aligned with the overall management approach; and
- the management actions that will be implemented in response to monitoring results.

The EMP for troglofauna focusses on maintaining viable and connected habitat via the MEZ, given the inherent sampling limitations in the subterranean environment. Trigger and threshold criteria, whilst recognising the practical limits to operational precision, have been structured to ensure that significant volumes of troglofauna habitat are not lost from the MEZ over the life of the mine. Volume and extent of habitat excavated is readily measurable and is part of the causal relationship between mining and impacts on troglofauna. This is supplemented by ongoing troglofauna monitoring throughout the life of mine to confirm if any changes in assemblages are apparent as a result of mining, as measured by troglofauna capture rates compared to baseline data.

Table 7-15: Mitigation Strategies and Predicted Outcomes for Troglofauna

Potential impacts	Mitigation to address potential impacts	Residual impact	Assessment of significance	Offset required?
EPA objective: *To protect subterranean fauna so that biological diversity and ecological integrity are maintained.*				
Direct Impact **Reduction in troglofauna habitat due to mine pit development** Excavation will remove up to 50% by volume of pre-mining habitat at Mesa H.	The following key management strategies will be implemented to manage impacts to troglofauna as a result of mine pit development: **Avoid:** The mine plan has been designed to retain at least 50% by volume of connected pre-mining troglofauna habitat at Mesa H by the delineation of a MEZ **Minimise:** The Proponent proposes that mine pit development be subject to a new MS (Appendix 3). The conditions of the new MS shall require the Proponent to implement an EMP (Appendix 6) to ensure suitable troglofauna habitat is retained. The Proponent proposes to backfill pits with waste rock material where mine schedules allow and to continue to monitor subterranean temperature and humidity at reference sites. The Proponent also proposes to conduct troglofauna sampling in the MEZ to verify persistence of troglofauna. **Rehabilitation:** The conditions of the new MS shall require the Proponent to implement a Closure Plan in accordance with the DMP / EPA Guidelines for Preparing	Clearing of up to 9.2 ha and 788.1 ha of the Priority 1 PECs, the *Subterranean invertebrate community of mesas in the Robe Valley region* and the *Subterranean invertebrate community of pisolitic hills in the Pilbara*. The Proposed Change will result in the loss of up to 50% by volume of pre-mining troglofaunal habitat at Mesa H.	The Proposed Change has been designed to retain at least 50% by volume of connected viable pre-mining habitat at Mesa H with thickness between 5 – 15 m through delineation of a MEZ. Data collected from Mesa A indicate that the MEZ at Mesa A is functioning as intended to provide suitable habitat for persistence of troglofauna adjacent to the active mining operation. It is, therefore, considered that the proposed MEZ at Mesa H will also continue to provide suitable troglofauna habitat and that the Proposed Change will retain the ecological integrity of the troglofauna habitat. The proponent considers that the Proposed Change can be managed to meet the EPA's objective for this factor through mitigation measures and provision of an offset.	Yes. The Proponent proposes the provision of an environmental offset at the higher offset rate ($1,500/ha) for the clearing of up to 9.2 ha and 788.1 ha of the Priority 1 PECs, the *Subterranean invertebrate community of mesas in the Robe Valley region* and the *Subterranean invertebrate community of pisolitic hills in the Pilbara*, respectively.

Potential impacts	Mitigation to address potential impacts	Residual impact	Assessment of significance	Offset required?
	Mine Closure Plans. The Closure Plan (Appendix 7) includes a closure objective to ensure the final landform is stable and considers ecological values. Pits will be backfilled against narrow areas ('fingers' of MEZ) where they occur, to ensure landform stability and potential connectivity of troglofauna habitat in the long term. **Other legislation:** The Proponent will adhere to the requirements of the BC Act (WA).			
Direct Impact **Loss of individuals and changes to troglofauna assemblages due to mine pit development** Excavation will result in the loss of individuals and has the potential to result in changes to troglofauna assemblages. The troglofauna habitat contained within the mesa H landform has conservatively been assessed as being isolated from the surrounding landscape.	The following key management strategies will be implemented to manage impacts to troglofauna as a result of mine pit development: **Avoid:** The mine plan for Mesa H has been designed to avoid as many single location and singleton troglofauna as practicable and ensure their ongoing avoidance by the retention of a MEZ. Additional sampling will be undertaken with the aim of increasing the recorded occurrences of current single location and singleton troglofauna taxa. **Minimise:** Impacts to troglofauna taxa and assemblages will be minimised through retention of connected habitat that is at least 50% by volume of the pre-mining troglofauna habitat at Mesa H through designation of a MEZ. The Proponent proposes that mine pit development be subject to a new MS (Appendix 3). The conditions of the new	The MEZ and mine pit boundaries were specifically designed to avoid troglofauna species records where feasible, which has resulted in all Orders being represented in the MEZ (Table 7-10). Only one (out of 33 recorded) species has been recorded from the mine impact area and not recorded within the MEZ or surrounding areas. This is the singleton species, the *Diplura Japygidae* sp. 'DJA011'. Habitat connectivity indicates that this species is likely to be more widespread, but this is unconfirmed.	AWT CID is present across the entirety of Mesa H, and although habitat thickness is variable and is significantly reduced in the central gully area, sampling supports connectivity with the *Diplura Projapygidae* sp. 'DPR008 / DPR009 / DPR011' occurring across either side of the central Gully, and records of troglofauna within the central gully. No other internal geological barriers or faults are known that would inhibit distribution and habitat extends beyond the proposed impact area, into the proposed MEZ. Given the evidence for connectivity of habitat beyond the proposed impact area and the retention of at least 50% by volume of the pre-mining habitat mesa, it is considered that the singleton taxa currently recorded only from inside the proposed mine-pit impact area is likely to have distributions that	No. The Proponent considers that the potential impacts can be managed, and the residual impact is not considered to be significant and therefore does not warrant the application of offsets.

Potential impacts	Mitigation to address potential impacts	Residual impact	Assessment of significance	Offset required?
	MS shall require the Proponent to implement an EMP (Appendix 6) to ensure suitable troglofauna habitat is retained. **Rehabilitation:** The conditions of the new MS shall require the Proponent to implement a Closure Plan in accordance with the DMP / EPA Guidelines for Preparing Mine Closure Plans. The Closure Plan (Appendix 7) includes a closure objective to ensure the final landform is stable and considers ecological issues. **Other legislation:** The Proponent will adhere to the requirements of the BC Act (WA).		extend beyond the proposed impact area. It is, therefore, considered that the Proposed Change can be managed such that diversity and ecological integrity of the troglofauna assemblages at Mesas H are maintained.	
Indirect Impacts **Temporary reduction in or degradation of habitat due to mining-related activities** Mining-related activities such as clearing of vegetation and placement of mineral waste, disposal of waste fines, blasting, exposure of pit faces and hydrocarbon spills may result in temporary loss or degradation of troglofauna habitat.	The following key management strategies will be implemented to manage impacts to troglofauna from activities that may result in the temporary loss or degradation of habitat. **Avoid**: Mesa J was selected as the preferred location for the WFSF rather than the alternative location of in-pit at Mesa H in order to avoid impacts to the troglofauna habitat at Mesa H. Hydrocarbon storage and servicing and re-fuelling of plant and vehicles will not occur within the MEZ. **Minimise**: Mineral waste dumps required as part of the Proposed Change will be located in-pit or in areas of the MEZ where the escarpments are less well defined, and	The assessment of potential indirect impacts does not indicate that any identified indirect impact would result in the loss of habitat outside of direct impact areas. To account for any uncertainty, the mine planning and design of the MEZ has ensured that 50% by volume of high prospectivity habitat is retained, conservatively excluding habitat below waste dumps in case of indirect impacts. Impacts from loss of vegetation and placement of mineral waste material are likely to be localised and temporary and are unlikely to	Given the area proposed for the WFSF will be located in existing facilities at Mesa J Mesa J, it is considered that the Proposed Change can be managed such that the continuity and ecological integrity of the troglofauna habitat at Mesa H is maintained. Results from troglofauna sampling in disturbed habitats indicate that troglofauna utilise habitat in or below mineral waste dumps. It is, therefore, likely that troglofauna will utilise habitat in or below the proposed waste dumps, although the extent of likely utilisation is not yet known. Monitoring results from the Mesa A and K Operations indicate that vibrations from blasting are not	No. The Proponent considers that the potential impacts can be managed, and the residual impact is not considered to be significant and therefore does not warrant the application of offsets.

Potential impacts	Mitigation to address potential impacts	Residual impact	Assessment of significance	Offset required?
	troglofauna habitat is generally thinner to minimise clearing in the MEZ. The remainder of clearing within the MEZ will be minimised and limited to infrastructure such as tracks, utilities, telecommunications, monitoring stations and abandonment bunds (if required). **Rehabilitate**: The Closure Plan (Appendix 7) includes a closure objective to ensure that final landform is stable and considers ecological values and that vegetation is self-sustaining. Progressive rehabilitation will be undertaken which may support re-establishment of nutrient flows into the subterranean environment.	significantly degrade troglofauna habitat.	resulting in significant changes to subterranean cavities in the retained habitat and MEZ (Section 7.4.2). Blasting conducted as part of the Proposed Change is, therefore, unlikely to affect the integrity of troglofauna habitat in the MEZ proposed at Mesa H. Monitoring at the Mesa A Operations indicates that mining has had little discernible influence on the subterranean temperature and humidity in the retained MEZ (Section 7.4.2). It is, therefore, considered that exposure of pit faces as part of the Proposed Change is unlikely to significantly alter the subterranean temperature and humidity in the MEZ proposed at Mesa H. Given the proposed hydrocarbon management measures, hydrocarbon spills are unlikely to significantly degrade retained troglofauna habitat. The Proponent considers that the Proposed Change can be managed to meet the EPA's objective for this factor.	

7.5 Stygofauna

7.5.1 Receiving environment

7.5.1.1 Surveys and studies

Stygal communities in WA are predominantly Crustacean (e.g. Amphipoda, Isopoda, Decapoda, Syncarida, Ostracoda and Copepoda), however Annelida (e.g. Oligochaeta), Arachnida (e.g. Hydracarina) and Platyhelminthes are also commonly collected. Three species of stygal vertebrates have been recorded from Australia. This includes two species of blind gudgeon (*Milyeringa veritas* and *M. justitia*) as well as the Blind Cave Eel, *Ophisternon candidum* (Humphreys 2001b, Department of the Environment, Water, Heritage and the Arts [DEWHA] 2008a, Foster and Humphreys 2011, Larson *et al*. 2013 in Biota 2019a).

A number of stygofauna surveys relevant to this Proposed Change have been undertaken since 2007 and are summarised in Table 7-16 and depicted in Figure 7-11. Sampling for stygofauna has been undertaken in water monitoring sites and production bores within the Proposed Change Area and in adjacent areas of modelled groundwater drawdown, including the adjacent CWSP in Bungaroo to the south-east. In addition, a desktop review of relevant existing information was undertaken in order to provide context to the assessment of stygofauna at Mesa H as summarised in Section 7.4.1.1.

A total of 53 sites were sampled for stygofauna across the five phases of investigation with the majority of sites (39) sampled on at least two separate phases. Fourteen sites were sampled only once, ten sites were sampled across three phases and one site (WB13MEJ003) was sampled across four of the five phases (Table 7-16). Eighteen of the 53 sites were located outside of the Proposed Change Area, within the predicted groundwater impact area. Stygofauna were sampled using modified plankton haul nets, constructed from 70 *µ*m plankton mesh, with 50 mm and 100 mm apertures attached to a stainless steel catch cylinder. Figure 7-11 shows the stygofauna sampling sites and records in and around the Proposed Change Area.

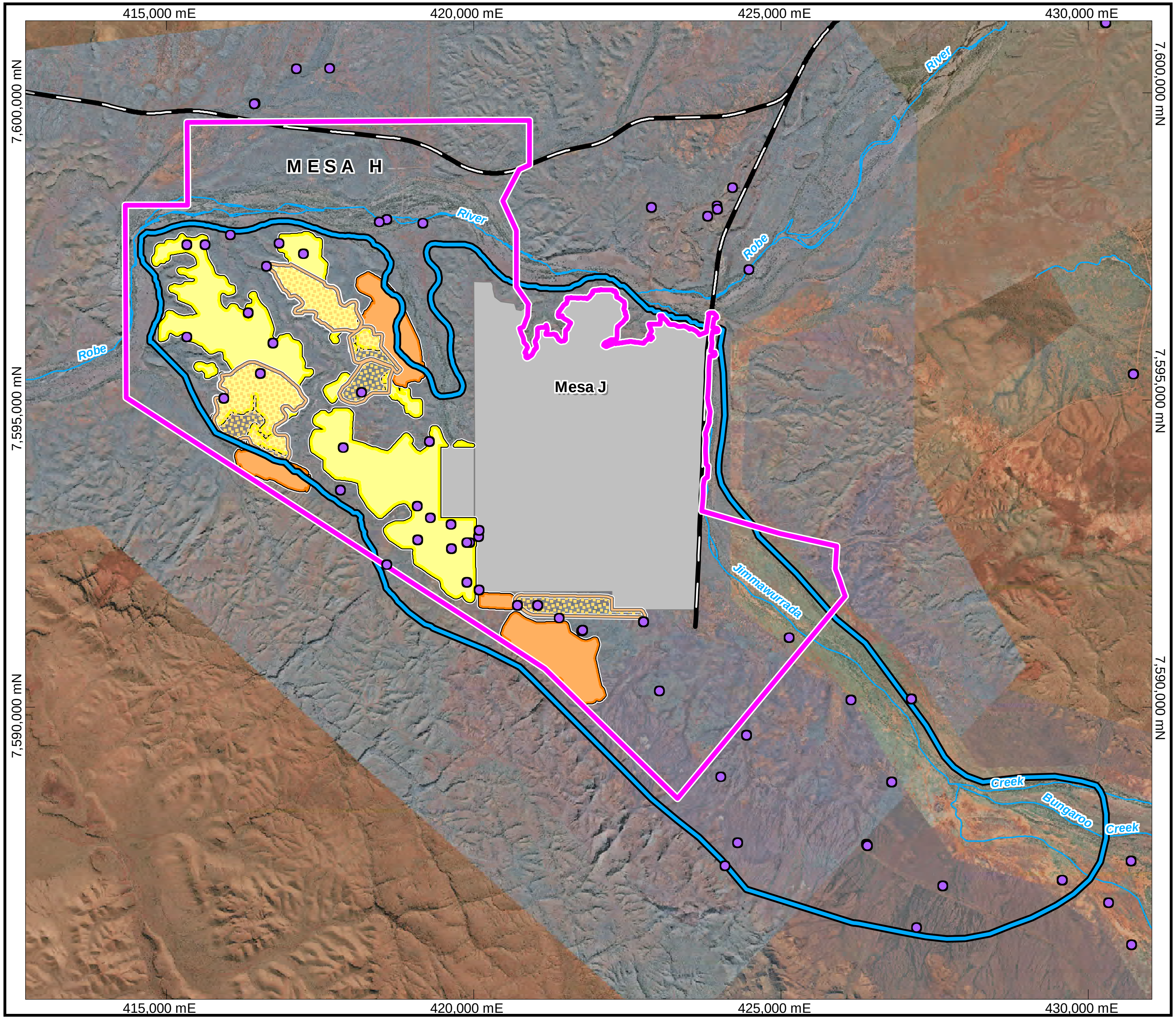
Sixteen of the bores sampled for stygofauna were also sampled for Environmental DNA (eDNA) during the December 2017 Phase 5 stygofauna sampling. The eDNA samples specifically were collected to target the Blind Cave Eel (*Ophisternon candidum*) (Section 7.5.1.3), which is not readily detectable with conventional sampling methods (Biota and Helix 2014 in Biota 2019a). This sampling methodology involves collection of a water sample from bores, to target trace amounts of fauna DNA molecules and fragments of tissues within the water column. The majority of the eDNA sampling sites were located outside of the predicted Proposed Change Area, with five sites located within the predicted impact area.

In addition, aquatic fauna surveys have been undertaken as part of the Proposed Change investigations: a baseline aquatic ecosystem survey for the Robe River and Jimmawurrada Creek in and adjacent to the Proposed Change Area (WRM 2017). Whilst these surveys do not specifically target subterranean fauna, stygofauna or more specifically, stygobites (obligate groundwater dwellers), are occasionally caught as by-catch during these surveys.

Stygofauna species recorded in and around the Proposed Change Area are shown on Figure 7-12 and described in Section 7.5.1.3, and the aquatic fauna surveys are described further in Section 8.4.2.

Table 7-16: Summary of Supporting Stygofauna Surveys

Survey Report	Survey Description / Summary	Survey Date
Mesa H Subterranean Fauna Survey Report 2018. Biota (2019a)	Six phases of troglofauna sampling and five phases of stygofauna sampling were undertaken via ten field mobilisations. This included an eDNA sampling program and qPCR and metabarcoding molecular analysis.	October 2015 and December 2017
Mesa H Subterranean Fauna habitat assessment. Biota (2019b)	Independent assessment of habitat and risk to habitat as a result of implementing the Proposed Change.	N/A
Bungaroo Coastal Waters Project Stygofauna Monitoring 2016. Biota (2016a)	Two phase stygofauna sampling survey of the Bungaroo and Jimmawurrada area. Surveys involved 28 and 25 sites respectively.	April and September 2016
Bungaroo Coastal Waters Project Stygofauna Monitoring 2015. Biota (2016b)	Two phase stygofauna sampling survey of the Bungaroo and Jimmawurrada area. Surveys involved 25 and 26 sites respectively.	May and October 2015
Bungaroo Coastal Water Supply Project Stygofauna Monitoring: 2014. Biota (2014)	Two phase stygofauna sampling survey of the Bungaroo and Jimmawurrada area. Surveys involved 27 and 23 sites respectively.	May and October 2014
Bungaroo Coastal Waters Project Stygofauna Monitoring Baseline Survey. Biota (2013a)	Single phase stygofauna sampling survey of the Bungaroo and Jimmawurrada area. Survey was conducted at 27 sites.	July 2013
Bungaroo Subterranean Fauna Collections Summary; Phases 1-11. Biota (2013b)	Summary of the 11 initial phases of stygofauna and two phases of troglofauna sampling in the Bungaroo and Jimmawurrada area. Includes a consolidated sampling effort and records.	Summary of surveys between 2003 and 2011
Bungaroo Creek Subterranean Fauna Summary Phases I – VII. Biota (2010a)	Summary of the sampling effort, catch data and species identification from the seven phases of stygofauna sampling as well as the initial phase of troglofauna sampling.	Stygo: December 2003 - November 2009 Trog: November-December 2009
Bungaroo Trial Pit Stygofauna Assessment. Biota (2007)	Initial report on three phases of stygofauna sampling in the Bungaroo area.	Sampling between 2003 and 2007



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse
- Stygofauna Sampling Site
- Groundwater Drawdown Extent

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile

N

SCALE

0 1 2 3 4km

1:90 000 @ A4

RioTinto

Iron Ore (WA)

Figure 7-11: Stygofauna sampling in or near the Development Envelope

Drawn: M.Swebbs
Date: Jan, 2019

Plan No: PDE0161246v4
Proj: MGA94 Zone50

7.5.1.2 Habitat

The likely habitats for stygobitic fauna in the study area were characterised using regional information, site-specific geological data and stygofauna survey results. The hydrogeology of the Proposed Change Area is described in detail in Section 5.

Groundwater within and adjacent to the Proposed Change Area occurs predominantly within four key aquifers:

- **Robe River alluvial aquifer**: an extensive and unconfined superficial aquifer consisting of gravelly Quaternary alluvial sediments (shingles, conglomerates and coarse sand), deposited along the Robe River with an approximate 20 m thickness and average width of 400 m.
- **Jimmawurrada Creek alluvial aquifer**: consisting of Quaternary alluvial sediments deposited along Jimmawurrada Creek, incised up to a maximum observed thickness of 40 m in the centre of the alluvial channel (thalweg).
- **CID aquifer**: an unconfined aquifer consisting of CID pisolitic sediments below Mesa H (and connected in the southeast to the Jimmawurrada and Bungaroo CID aquifers) with an average of 20-30 m thickness below the pre-mining water table.
- **Wittenoom aquifer**: a largely confined aquifer underlying the CID aquifer, consisting of weathered dolomite and dolomitic shale (Paraburdoo and Bee Gorge Member) and weathered BIF (Marra Mamba Iron Formation) with a thickness of approximately 25 m.

Pre-mining depth to groundwater within the Mesa H CID aquifer is generally between 25 and 45 m below surface within higher elevation areas, but the water table is considerably shallower in the Robe River and Jimmawurrada Creek alluvial aquifers. Depth to pre-mining groundwater in these alluvial aquifers ranges from approximately 4 – 12 m below surface along Jimmawurrada Creek, and approximately 2 – 5 m below surface along the Robe River. These groundwater levels fluctuate by up to 3 m seasonally, depending on climatic variability and rainfall patterns.

The basal Robe Pisolite (Tpb) is a 5 -10 m thick layer deposited at the base of the CID Aquifer, consisting of a variable clay-rich pisolite. While its hydraulic properties have not yet been defined, the largely impermeable physical characteristics of the unit mean that it is expected to function as a partial barrier to groundwater flow between the CID Aquifer and the underlying Wittenoom Aquifer (Rio Tinto 2019a).

The Robe River and Jimmawurrada alluvial aquifers together with the BWT CID aquifers of Mesas J, H, Jimmawurrada and Bungaroo, are the most likely to provide habitat for stygofauna, based on their physical and hydraulic characteristics. In addition to the extensive data sets that exist from sampling of equivalent aquifers in the locality, the Robe River and Jimmawurrada alluvial aquifers are the primary groundwater system that provides habitat to stygofauna in the wider locality, having yielded many stygofauna records (Biota 2019b). The Mesa H CID aquifer, while deeper and thereby likely to host less fauna is also structurally suitable as stygofauna habitat and has some existing data to confirm that stygofauna utilise the aquifer. The Mesa H CID aquifer is structurally and geologically constrained along its northern and western extents adjacent to the Robe River, and a basement high to the north-east forms an impermeable boundary adjacent to Yeera Bluff (Figure 5-11 to Figure 5-14). The CID is however continuous and connected to the Mesa J, Jimmawurrada and Bungaroo CID aquifers to the south-east, of which the latter two are overlain in places and connected to the Jimmawurrada alluvial aquifer (Figure 7-12). The Jimmawurrada Creek alluvial aquifer is also a tributary into the Robe River alluvial aquifer, which extends over 130 km from the upstream Middle Robe / Deepdale area, all the way to the Pilbara Coast. The Wittenoom Aquifer is considered unlikely to represent significant habitat for stygofauna, given its depth, confined nature, lower transmissivity host rock, and limited connectivity to more superficial systems (Biota 2019b) (Table 7-17, Table 7-18).

The aquifers that provide stygofauna habitat at Mesa H broadly correspond to the regional surface geology map units (1:250,000) and more detailed 1:10,000 local geological mapping by the Proponent, which provide a wider context to the stygofauna habitats of the dewatering extent. The units that represent High or Medium prospectivity stygofauna habitat within the dewatering extent and the wider locality are summarised in Table 7-18 and mapped in Figure 7-12. Habitat mapping was undertaken in 'Leapfrog' modelling software using downhole geological logging data combined with hydrological data including water table levels, which correlated closely with the surficial mapping data.

The mapped habitat extents show a strong spatial correlation with stygofauna record locations, with 129 of the 133 known stygofauna locations falling within units mapped as High prospectivity habitat (97%) (Biota 2019b) (Section 7.5.1.3 and Figure 7-12). The landscape setting of these units also confirms that these habitats occur as low elevation valley fill units. The stygofauna sampling results and hydrogeological data indicate that there is unlikely to be any significant physical barriers to stygofauna dispersal within the CID aquifers and alluvial aquifers in the vicinity of the Proposed Change Area and surrounds. Given the high level of validation from confirmed fauna records and 3D downhole geological modelling using Leapfrog, the regional mapping units combined with these datasets can be used to set wider context to the impacts of the Proposed Change on stygofauna habitat.

The likelihood of these geological units described above representing suitable habitat for stygofauna was categorised into Low, Moderate and High, based on the following characteristics (Biota 2019a; Table 7-17):

A. Presence of interstitial spaces or vugs.
B. Continuity and transmissivity of the local occurrence of submerged geological units.
C. The known occurrence of stygal communities recorded from equivalent rock types during previous Pilbara surveys.
D. Absence of large amounts of fine sediments such as clays, silts and sands within the geological unit description.
E. Substrate permits inflow of surface water and infiltration of nutrients.
F. Substrate is submerged below the water table.

Table 7-17: Stygofauna Habitat Prospectivity Definitions (Biota 2019b)

Prospectivity	Definition
High	Majority (five or six) of characteristics confirmed for the geological unit, including the presence of continuous, transmissive aquifer (A, B). Geology sufficiently porous to allow nutrient infiltration from surface water runoff (E). Stygofauna routinely recorded from same rock type (C) and partially or completely submerged below the water table (F).
Medium	Unit likely partially or completely submerged below the water table (F). Presence of interstitial spaces (A), low numbers of stygofauna have been recorded from this geology previously (C). Small amounts of fine sediments within the unit (D).
Low	Suitable geological unit may occur only above the water table within the study area. Rock type might have interstitial spaces (A) however may have high levels of fine sediments which reduce usability of spaces. Stygofauna not known from previous studies sampling of the same geology (C).

Of the key geological units, Alluvium, colluvium and riverine sheet floodplain (Lacustrine) and CID were categorised as high prospectivity habitat and considered likely to provide primary habitat for stygofauna where they occur BWT (Table 7-18 and Figure 7-12). Both the CID and alluvium geological units have been previously identified by the EPA as potential stygofauna habitat (Biota 2019a). The Wittenoom Formation is categorised as having low habitat prospectivity due to its lack of permeability where it occurs BWT (Biota 2019b; Table 7-18).

Table 7-18: Stygofauna Habitat Prospectivity of the Geological Units within the Study Area

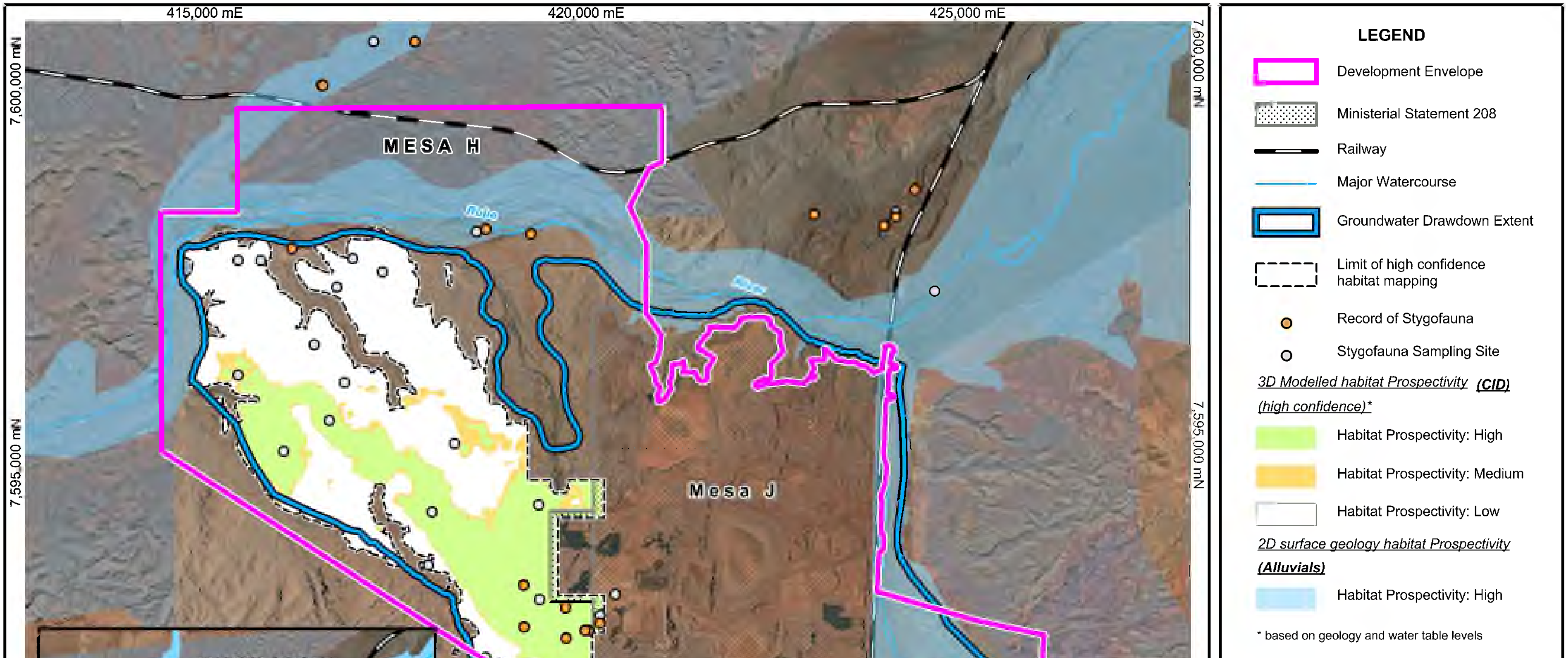
Habitat prospectivity	Geological unit	Description
High	CID (Robe Pisolite)	Pisolitic limonite deposits. Occurs along old river channels. Unit predominantly AWT within Mesa Formations and BWT at Jimmawurrada and Bungaroo Valleys.
	Alluvium[1]	Unconsolidated fluviatile deposits.
	Lacustrine Deposits[1]	Unconsolidated fluviatile and sheet flood deposits in levees and river terraces.
	Colluvium[1]	Partly consolidated valley-fill deposits; Unconsolidated to loosely consolidated slope deposits,
Low	Wittenoom Formation	Confined aquifer underlying the CID aquifer, consisting of weathered dolomite and dolomitic shale and weathered BIF.

[1] Lateral extent defined based on 2D mapping, and 3D depth defined based on available drilling data.

No TECs or Environmentally Sensitive Areas relating to stygofauna occur in the Proposed Change Area or modelled groundwater impact areas, however the Proposed Change Area and modelled groundwater impact area incorporates one PEC in the Southeast of the Proposed Change Area:

- *The Stygofauna community of the Bungaroo Aquifer, Priority 1 PEC.*

Stygofauna habitat prospectivity across the Robe Valley is shown in Figure 7-13 which also shows the location of specimen results and null records relative to the habitat prospectivity mapping.

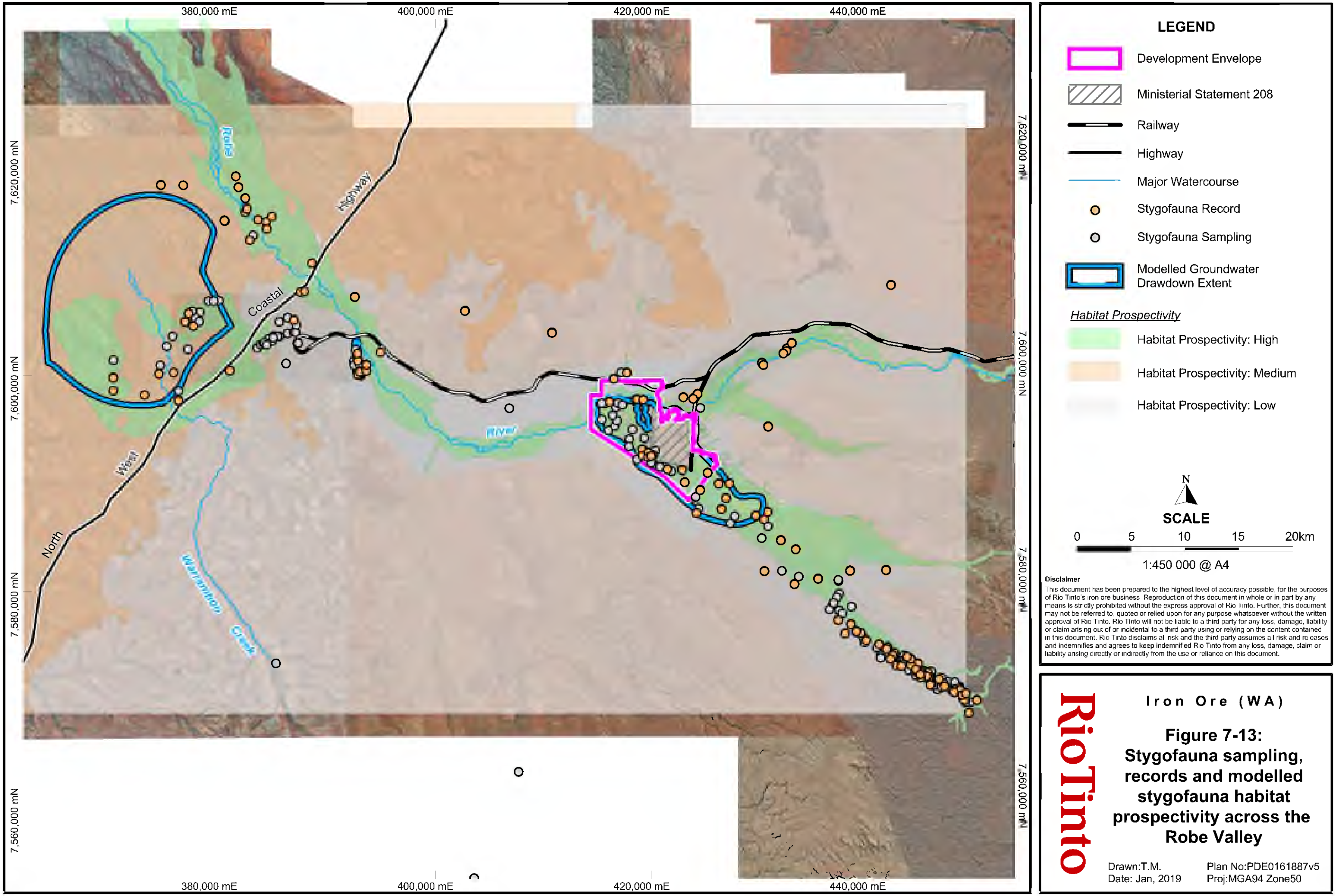


RioTinto

Iron Ore (WA)

Figure 7-12: Modelled pre-mining stygofauna habitat Prospectivity and records within or near the Development Envelope

Drawn: GIS
Date: Jan, 2019
Plan No: PDE0161817v4
Proj: MGA94 Zone50



RioTinto

Iron Ore (WA)

Figure 7-13: Stygofauna sampling, records and modelled stygofauna habitat prospectivity across the Robe Valley

Drawn:T.M.
Date: Jan, 2019

Plan No:PDE0161887v5
Proj:MGA94 Zone50

Geospatial Information and Mapping

7.5.1.3 Records

A total of 8,824 stygofauna specimens have been recorded in the broader Robe Valley, from an area spanning from the headwaters of the Bungaroo Valley to west of Warramboo between 2002 and 2016. Of these specimens, a total of 128 stygobytic taxa have been identified.

A total of 855 stygofauna specimens were recorded over the five-phase stygofauna survey completed for the Proposed Change, comprising at least 326 species-level taxa from in and around the Proposed Change Area, excluding indeterminate specimens (Biota 2019a). The recorded fauna was dominated by the Crustacea, which was represented by seven faunal groups and accounted for 98% of the specimens. Excluding indeterminate records and allowing for species already recorded during the Mesa H survey, an additional 14 species were identified as occurring during the desktop review, bringing the total known fauna to 46 species.

Whilst the BWT mine pits comprise a direct impact, the primary spatial context for the assessment of impacts on stygofauna is the wider groundwater drawdown extent (the lateral extent of the drawdown cone of depression) that will arise from the cumulative groundwater abstraction required to implement the Revised Proposal, including mine pit dewatering and water supply for operational use, and which also takes into consideration the cumulative groundwater drawdown from adjacent projects where they overlap with the drawdown extent of the Proposed Change (refer to Section 5). The predicted extent of groundwater drawdown also encompasses the area that will be directly impacted by the pits themselves. Therefore, all of the stygofauna species and communities that occur within the groundwater drawdown extent i.e. the modelled lateral extent of the groundwater drawdown cone of depression as a result of the Proposed Change are included in this assessment.

Of the known 46 species within the Proposed Change Area, the taxa recorded within the predicted extent of the groundwater impact area includes a total of 31 species, comprising:

- 13 potential SREs (half of which are amphipod taxa);
- Three conservation listed species (Nedsia hurlberti, Nedsia sculptilis and Ophisternon candidum); and
- 15 widespread species.

Conservation Significant Species

Three stygofauna species of conservation significance have been recorded within the Proposed Change Area or within the modelled area of groundwater drawdown from the Proposed Change (Biota 2019b):

- Two amphipod species (historical records) – both listed as Threatened – Vulnerable under Schedule 3 of the BC Act:
  - Nedsia hurlberti; and
  - Nedsia sculptilis.
- The Blind Cave Eel: *Ophisternon candidum* – listed as Threatened – Vulnerable under the EPBC Act and Vulnerable under Schedule 3 of the BC Act.

No additional records of the two conservation significant amphipod species were obtained during the recent surveys however, further sampling targeting this species during the recent surveys (Biota 2019a, WRM 2019 in prep, TrEnD Laboratory 2018) resulted in the detection of Blind Cave Eel DNA at five locations, both along Jimmawurrada Creek and the Robe River, including at two sites within the drawdown extent and three locations outside of the drawdown extent along the Robe River. An additional specimen was also collected during surface water alluvium sampling along the Robe River (WRM 2019 in prep), bringing the number of locations outside of the drawdown extent that physical specimens of the species has been recorded at to five (including Cape Range). The significantly improved distributional data indicate that the species occurs more widely, likely in association with the major alluvial aquifers of the Bungaroo-Jimmawurrada-Robe system.

Blind Cave Eel

The Blind Cave Eel (*Ophisternon candidum*) is a de-pigmented, subterranean fish growing up to 40 cm in length, with a long slender body, no eyes, and a thin rayless membrane around the tip of the tail (DEWHA 2008a) (Section 11.1). The Blind Cave Eel is the world's longest cave fish and one of only three vertebrate animals known from Australia that are restricted to subterranean waters (Humphreys 2001b as cited in Biota 2019a).

The Blind Cave Eel was previously collected from three sites in the Jimmawurrada-Bungaroo Creek system, within the current study area. The first specimen was recorded in 2009 at Bungaroo Creek from borehole BC186, 5.6 km southeast of the Development Envelope (Biota 2010aa), with subsequent specimens from borehole JW023 (1 km southeast of the Development Envelope) (Biota 2016 as cited in Biota 2019a) and from an adjacent borehole JW024 in 2017. Tissue from the Bungaroo specimens has been sequenced at both the CO1 mitochondrial DNA and 16S ribosomal RNA markers, showing that the Bungaroo records are less than 1% divergent from the Cape Range specimens, indicating that they are the same species (Foster and Humphreys 2011 as cited in Biota 2019a).

The species is considered to be associated with the regional alluvial aquifer of the Robe River (Biota and Helix 2014 as cited in Biota 2019a) and the alluvial aquifers of Jimmawurrada and Bungaroo Creeks.

Environmental DNA (eDNA) sampling was undertaken as part of the current study in an attempt to better understand the distribution of the species in the locality.

Environmental DNA Sampling methodology

Environmental DNA sampling of groundwater samples was undertaken on completion of stygofauna haul net sampling during Phase 5 in December 2017. The environmental samples were collected to target the Blind Cave Eel (*Ophisternon candidum*) which is not readily detectable with conventional sampling methods (Biota and Helix 2014 as cited in Biota 2019a).

Environmental DNA sample filters were analysed using two different molecular methods, each of which was undertaken independently by two separate laboratories. The objectives of both methods were to detect residual DNA from the Blind Cave Eel (*Ophisternon candidum*) in the environmental samples.

Helix Molecular Solutions analysed half of the replicate membranes from each sample site using a real-time qPCR method developed previously for the Blind Cave Eel (Biota and Helix 2014 as cited in Biota 2019a). Sequence data from past collections of the Blind Cave Eel from the Jimmawurrada and Bungaroo Creek locality was used to design a species-specific probe using the Integrated DNA Technology design tool PrimerQuest and further edited using Oligo Primer analysis software (Biota 2019a).

The matching halves of the filters from each site were also analysed by TrEnD at Curtin University. The molecular analysis undertaken by Curtin University utilised a Next Generation Sequencing approach to extract and amplify DNA fragments from the membranes and metabarcoding to simultaneously sequence the resultant eDNA (TrEnD 2018; Appendix 10).

The eDNA surveys resulted in the detection of Blind Cave Eel DNA at five locations, both along Jimmawurrada Creek and the Robe River, including at two sites within the drawdown extent and three locations outside of the drawdown extent along the Robe River (including upstream of the Revised Proposal (Figure 7-18). The results from the two eDNA methodologies produced consistent results in terms of both producing positive recordings from the same locations (Biota 2019b).

Summary

All recorded taxa are shown in Figure 7-14 (Maps 1-14) and are listed in Table 7-19. Species were considered widespread where they were recorded in multiple locations throughout the Pilbara or other locations (such as Barrow Island). These species show little geological restriction and are unlikely to represent true stygobites or SREs. As such, the 15 widespread species have been excluded from further assessment in this ERD.

Table 7-19: Stygobitic species recorded from the Proposed Change Area (Biota 2019b, WRM 2018)

Order	Species	Conservation significant/SRE	Proposed Change Area	Mesa J approved area	GW Drawdown Impact Area	Other known locations (outside impact area but within Proposed Change Area)	Other known locations (outside impact area and outside Proposed Change Area)
Amphipoda	*Nedsia hurlberti*	Conservation Significant	✓	✓	inside	-	Bungaroo, Robe River near Mesa B, Barrow Island
	Nedsia sp. 'AMM026'	Potential SRE	x	✓	inside	-	Middle Robe
	Nedsia sp. 'AMM001'	Not SRE	✓	✓	inside	RR1	Middle Robe, Warramboo, Budgie Bore, Camp Bore
	Nedsia sp. 'AMM022'	Potential SRE	x	x	outside	-	North of Mesa H (MB17MEH0007)
	Nedsia sp. 'AMM033'	Potential SRE	x	x	outside	-	North of Mesa H (MB17MEH0007, MB17MEH0009, MB17MEH0010)
	Paramelitidae sp. 'AMP003'	Potential SRE	✓	x	inside	-	-
	Paramelitidae sp. 'AMP035'	Potential SRE	✓	x	inside	RR1	-
	Chydaekata sp. 'AMP036'	Potential SRE	✓	x	outside	-	-
	Paramelitidae sp. 'AMP037'	Potential SRE	x	x	inside	-	-
	Paramelitidae sp. 'AMP038'	Potential SRE	✓	**x**	outside	RR1	Middle Robe

Order	Species	Conservation significant/SRE	Proposed Change Area	Mesa J approved area	GW Drawdown Impact Area	Other known locations (outside impact area but within Proposed Change Area)	Other known locations (outside impact area and outside Proposed Change Area)
	Neoniphargidae sp. 'B02'	Potential SRE	✓	x	inside	-	Middle Robe
	Neoniphargidae sp. 'AMN002'	Potential SRE	✓	x	outside	RR1	-
	Nedsia sculptilis	Conservation Significant	✓	✓	inside	-	Bungaroo, Barrow Island
	Wesniphargus sp. 'AMN004'	Potential SRE	x	x	inside	-	Middle Robe
Harpactacoida	*Megastygonitocrella unispinosa*	Potential SRE	✓	x	Inside	-	Robe River valley
	Parastenocaris sp. 'B28'	Potential SRE	x	x	Inside	-	-
	Abnitocrella halsei	Not SRE	x	x	Outside	-	Widespread
	Elaphoidella humphreysi	Not SRE	x	x	Outside	-	Widespread
Calanoida	*Stygoridgewayia trispinosa*	Not SRE	✓	✓	inside	RR1	Widespread
Cyclopoida	*Diacyclops cocking*	Not SRE	✓	x	Inside	RR1	Widespread
	Diacyclops humphreysi	Not SRE	✓	x	Inside	RR1	Widespread

Order	Species	Conservation significant/SRE	Proposed Change Area	Mesa J approved area	GW Drawdown Impact Area	Other known locations (outside impact area but within Proposed Change Area)	Other known locations (outside impact area and outside Proposed Change Area)
	Diacyclops sp. 'B03'	Potential SRE	x	x	Outside	-	-
	Halicyclops calm	Not SRE	x	✓	Inside	-	Widespread
	Halicyclops roachi	Not SRE	✓	x	inside	RR1	Widespread
Hypsogastropoda	*Hydrobiidae* sp. 2	Potential SRE	x	x	Inside	-	-
	Hydrobiidae sp. 'B09'	Potential SRE	x	x	Outside	-	North of Mesa H
Isopoda	*Haptolana* sp. 'B01'	Potential SRE	x	x	Inside	-	-
	Haptolana yarraloola	Potential SRE	✓	x	Outside	RR1	Yarraloola, Budgie Bore
	Kagalana tonde	Not SRE	✓	x	inside	RR1	West Pilbara, Hardey River
Podocopida	*Areacandona brookanthana*	Not SRE	x	x	Inside	-	Widespread
	Areacandona lepte	Not SRE	✓	✓	Inside	-	West Pilbara
	Areacandona sp. 'BOS1039'	Potential SRE	x	x	Inside	-	Middle Robe
	Areacandona triangulum	Not SRE	✓	✓	Inside	-	West Pilbara

Order	Species	Conservation significant/SRE	Proposed Change Area	Mesa J approved area	GW Drawdown Impact Area	Other known locations (outside impact area but within Proposed Change Area)	Other known locations (outside impact area and outside Proposed Change Area)
	Candonidae gen. nov. sp. 'BOS1037'	Potential SRE	x	x	Outside	-	North of Mesa H
	Candonidae sp. 'BOS577'	Potential SRE	x	x	Outside	RR1	-
	Candoninae sp. 'BOS541'	Potential SRE	x	x	Inside	-	-
	Gomphodella sp.	Potential SRE	✓	x	Outside	RR1	-
	Humphreyscandona fovea	Not SRE	✓	✓	Inside	-	Bungaroo, West Pilbara
	Humphreyscandona sp. 2	Not SRE	✓	✓	Inside	-	West Pilbara
	Humphreyscandona waldockae	Not SRE	✓	✓	Inside	-	West Fortescue Valley
	Pierrecandona sp. 'BOS576'	Not SRE	✓	x	Outside	RR1	Warramboo and Bungaroo
	Pilbaracandona rosa	Not SRE	✓	✓	Inside	-	West Pilbara
	Pilbaracandona sp. 'BOS526'	Potential SRE	x	x	Inside	-	Warramboo and Bungaroo
Synbranchiformes	Ophisternon candidum	Conservation Significant	✓	x		RR1,	Control, 25, RRD2, Cape Range, Exmouth

Order	Species	Conservation significant/SRE	Proposed Change Area	Mesa J approved area	GW Drawdown Impact Area	Other known locations (outside impact area but within Proposed Change Area)	Other known locations (outside impact area and outside Proposed Change Area)
Thermosbaenacea	Halosbaena tulki	Not SRE	✓	**x**	Inside	-	West Pilbara, Barrow Island
Oligochaeta	*Enchytraeus* sp. ‘AP PSS1’	Not SRE	**x**	**x**	Inside	-	Robe River Valley

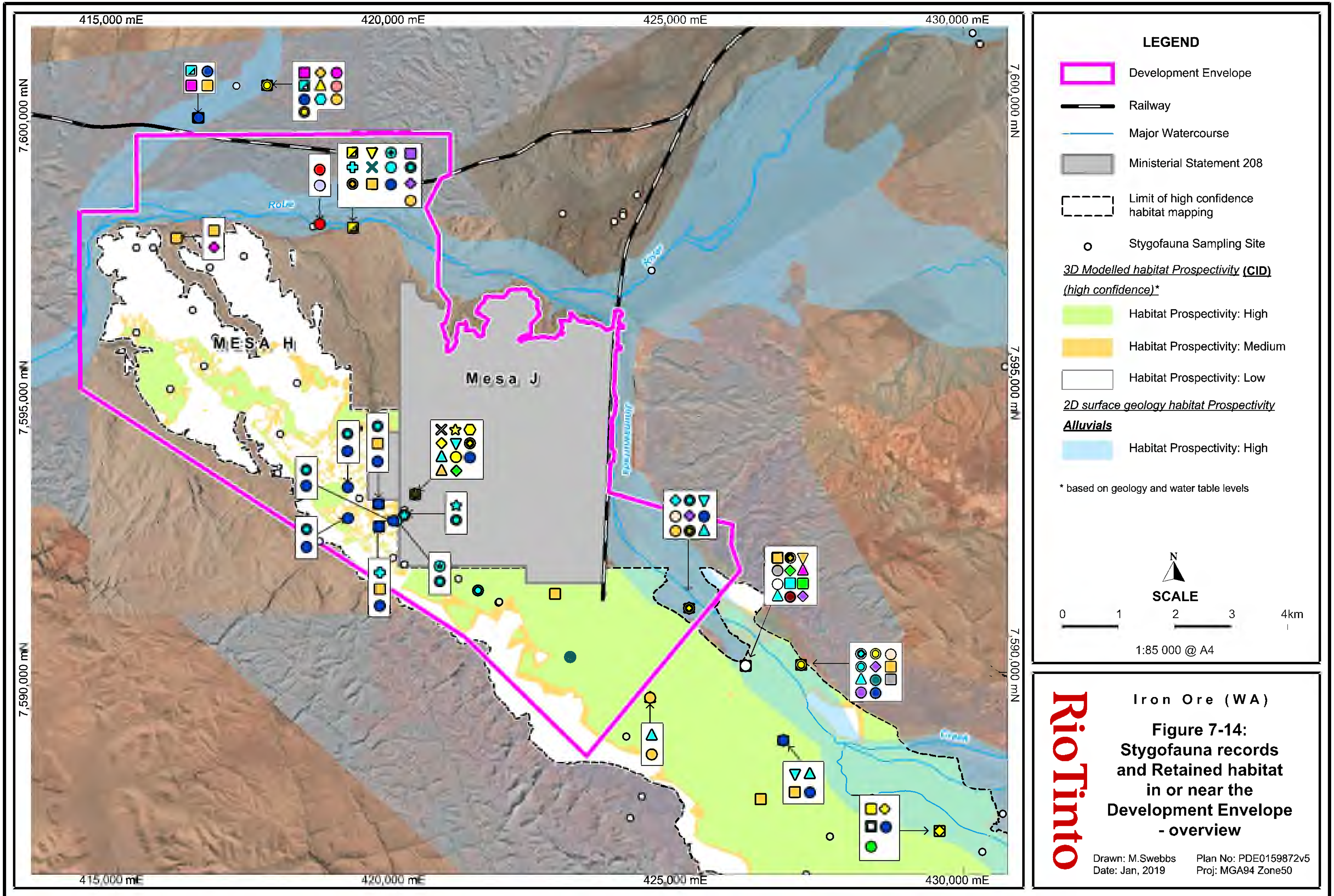


Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope - overview

Drawn: M.Swebbs
Date: Jan, 2019
Plan No: PDE0159872v5
Proj: MGA94 Zone50

Figure 7-14:
Stygofauna records and Retained habitat in or near the Development Envelope (Legend)

- Stygofauna Legend

Amphipoda

- Chydaekata sp. 'AMP036'
- Nedsia hurlberti
- Nedsia sculptilis
- Nedsia sp. 'AMM001'
- Nedsia sp. 'AMM022'
- Nedsia sp. 'AMM026'
- Nedsia sp. 'AMM033'
- Neoniphargidae sp. 'AMN002'
- Neoniphargidae sp. B02
- Paramelitidae sp. 'AMP003'
- Paramelitidae sp. 'AMP035'
- Paramelitidae sp. 'AMP037'
- Paramelitidae sp. 'AMP038'
- Wesniphargus sp. 'AMN004'

Calanoida

- Stygoridgewayia trispinosa

Cyclopoida

- Diacyclops cockingi
- Diacyclops humphreysi humphreysi
- Diacyclops sp. 'B03'
- Halicyclops calm
- Halicyclops rochai

Harpacticoida

- Abnitocrella halsei
- Elaphoidella humphreysi
- Megastygonitocrella unispinosa
- Parastenocaris sp. B28

Hypsogastropoda

- Hydrobiidae sp. 2
- Hydrobiidae sp. B09

Isopoda

- Haptolana sp. B01
- Haptolana yarraloola
- Kagalana tonde

Oligochaeta

- Enchytraeus sp. 'AP PSS1'

Podocopida

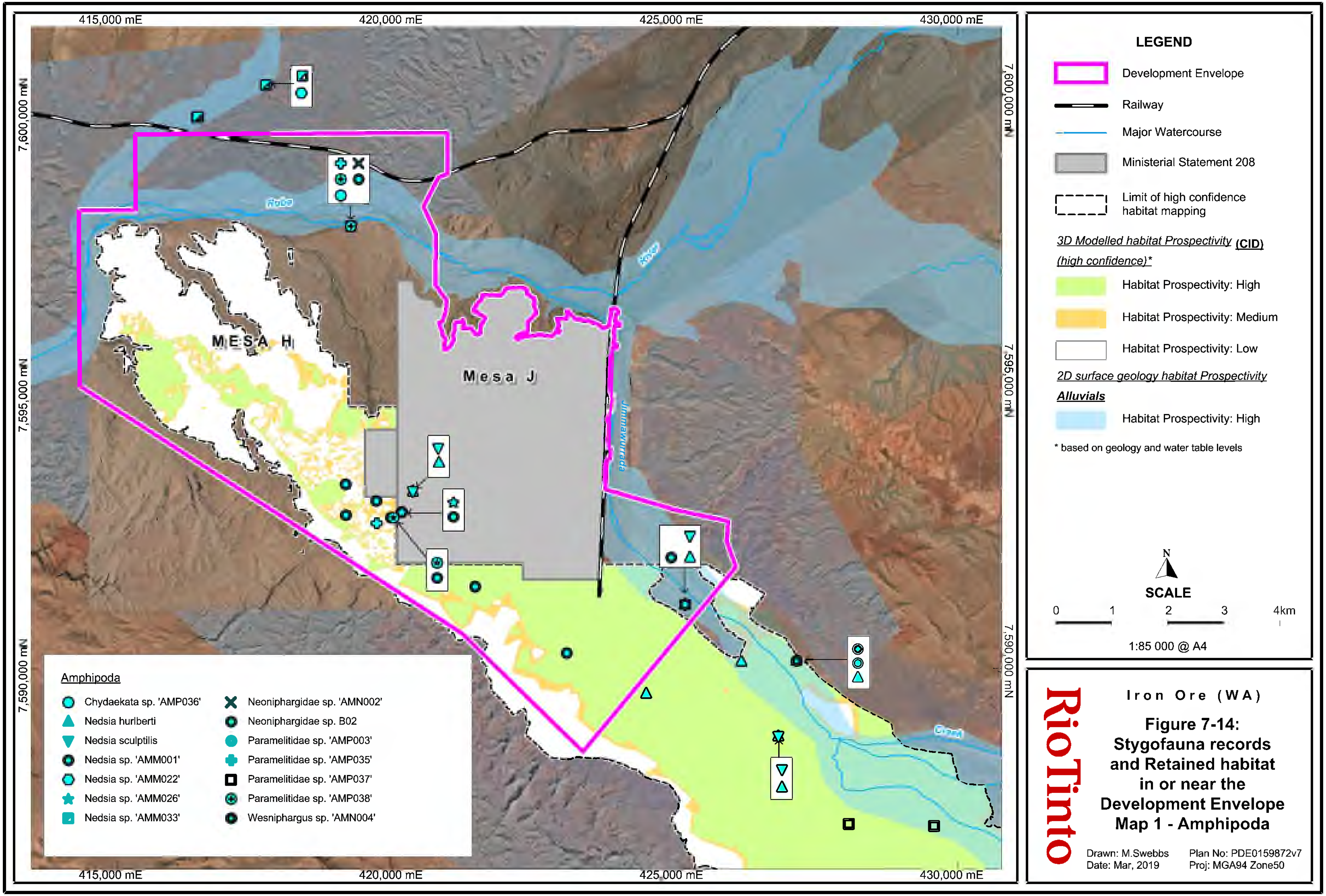
- Areacandona brookanthana
- Areacandona lepte
- Areacandona sp. 'BOS1039'
- Areacandona triangulum
- Candonidae gen. nov. sp. 'BOS1037'
- Candonidae sp. 'BOS577'
- Candoninae sp. BOS541
- Gomphodella sp.
- Humphreyscandona fovea
- Humphreyscandona sp. 2
- Humphreyscandona waldockae
- Pierrecandona sp. 'BOS576'
- Pilbaracandona rosa
- Pilbaracandona sp. 'BOS526'

Synbranchiformes

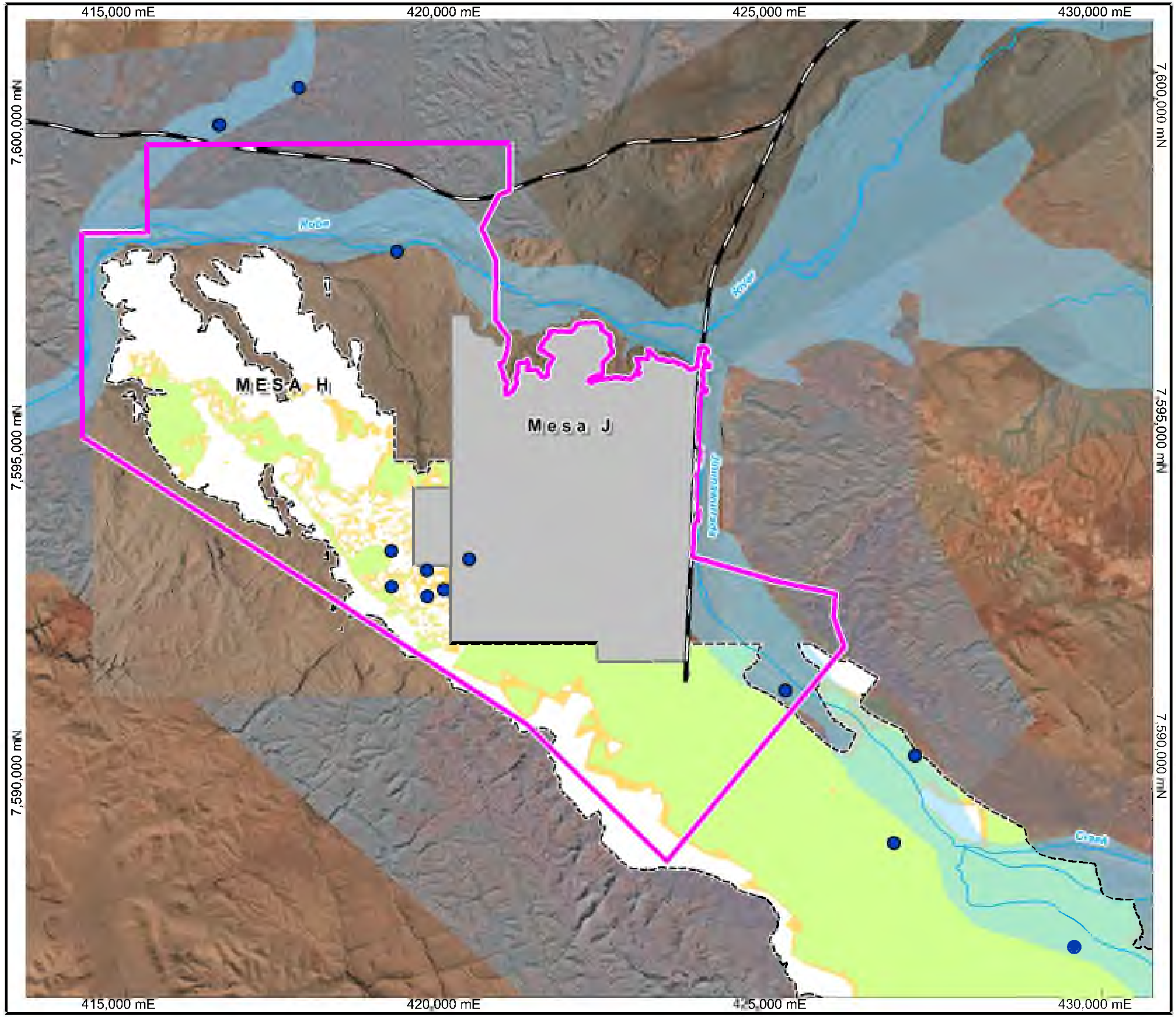
- Ophisternon candidum (eDNA)
- Ophisternon candidum (specimens)

Thermosbaenacea

- Halosbaena tulki



415,000 mE
420,000 mE
425,000 mE
430,000 mE
7,600,000 mN
7,595,000 mN
7,590,000 mN
MESA H
Mesa J
Robe
River
Jimmawurrada
Creek
Amphipoda
Chydaekata sp. 'AMP036'
Nedsia hurlberti
Nedsia sculptilis
Nedsia sp. 'AMM001'
Nedsia sp. 'AMM022'
Nedsia sp. 'AMM026'
Nedsia sp. 'AMM033'
Neoniphargidae sp. 'AMN002'
Neoniphargidae sp. B02
Paramelitidae sp. 'AMP003'
Paramelitidae sp. 'AMP035'
Paramelitidae sp. 'AMP037'
Paramelitidae sp. 'AMP038'
Wesniphargus sp. 'AMN004'
LEGEND
Development Envelope
Railway
Major Watercourse
Ministerial Statement 208
Limit of high confidence habitat mapping
3D Modelled habitat Prospectivity (CID) (high confidence)*
Habitat Prospectivity: High
Habitat Prospectivity: Medium
Habitat Prospectivity: Low
2D surface geology habitat Prospectivity
Alluvials
Habitat Prospectivity: High
* based on geology and water table levels
N
SCALE
0 1 2 3 4km
1:85 000 @ A4
RioTinto
Iron Ore (WA)
Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 1 - Amphipoda
Drawn: M.Swebbs
Date: Mar, 2019
Plan No: PDE0159872v7
Proj: MGA94 Zone50



LEGEND

Development Envelope

Railway

Major Watercourse

Ministerial Statement 208

Limit of high confidence habitat mapping

3D Modelled habitat Prospectivity **(CID)** *(high confidence)**

Habitat Prospectivity: High

Habitat Prospectivity: Medium

Habitat Prospectivity: Low

2D surface geology habitat Prospectivity

Alluvials

Habitat Prospectivity: High

* based on geology and water table levels

Calanoida

Stygoridgewayia trispinosa

N

SCALE

0 1 2 3 4km

1:85 000 @ A4

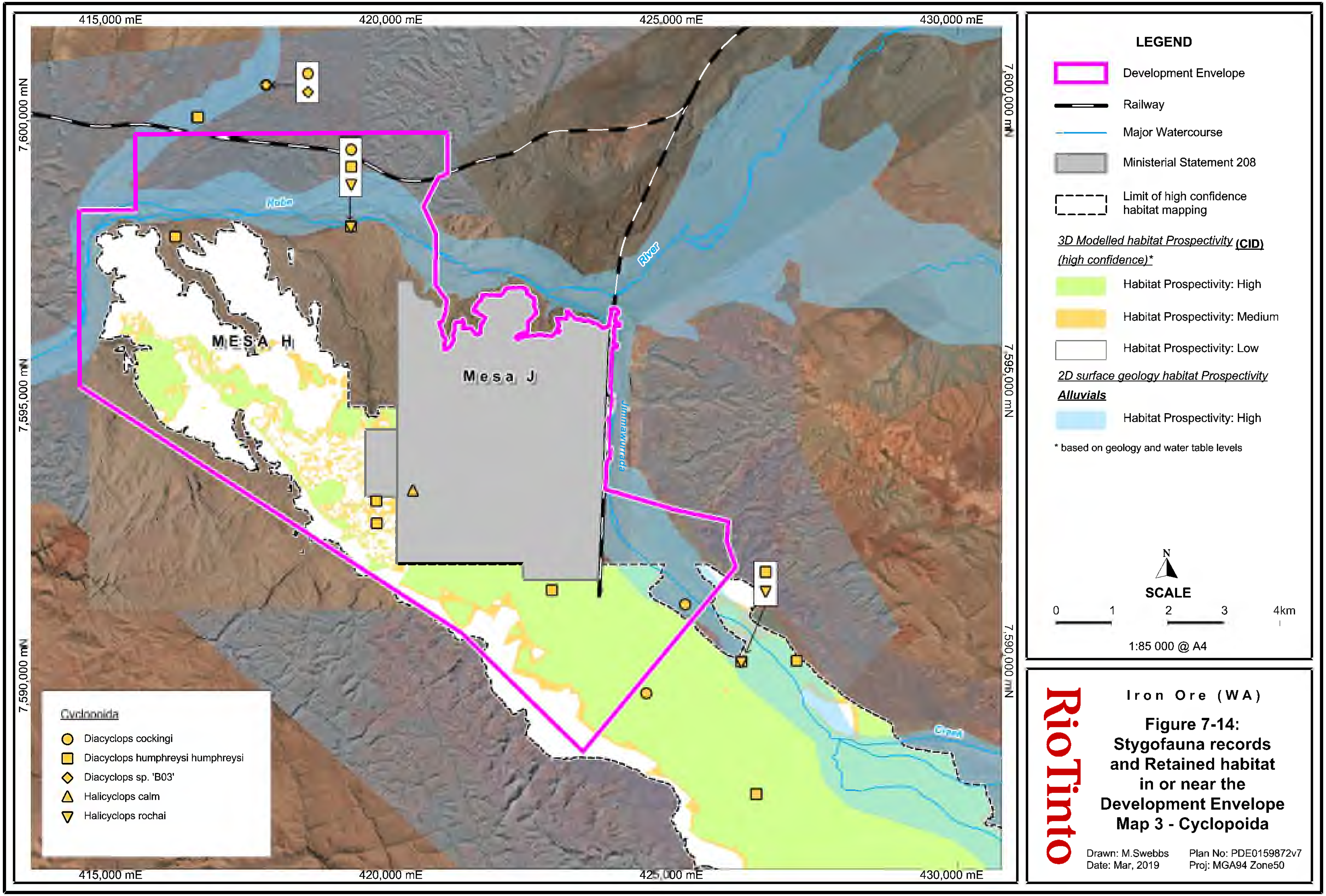
RioTinto

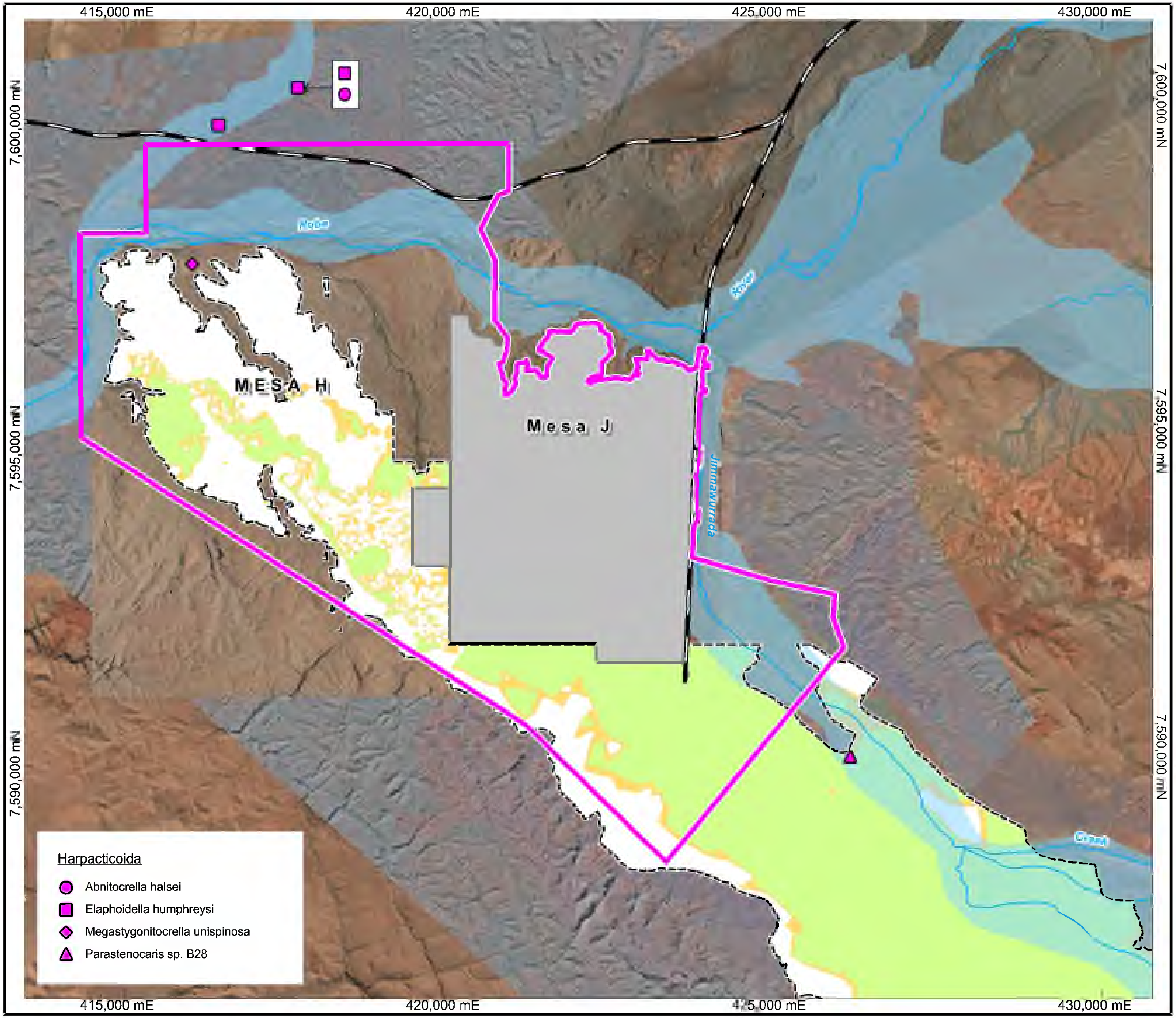
Iron Ore (WA)

Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 2 - Calanoida

Drawn: M.Swebbs
Date: Mar, 2019

Plan No: PDE0159872v7
Proj: MGA94 Zone50


415,000 mE
420,000 mE
425,000 mE
430,000 mE
7,600,000 mN
7,595,000 mN
7,590,000 mN
MESA H
Mesa J
Robe
River
LEGEND
Development Envelope
Railway
Major Watercourse
Ministerial Statement 208
Limit of high confidence habitat mapping
3D Modelled habitat Prospectivity (CID) (high confidence)*
Habitat Prospectivity: High
Habitat Prospectivity: Medium
Habitat Prospectivity: Low
2D surface geology habitat Prospectivity
Alluvials
Habitat Prospectivity: High
* based on geology and water table levels
N
SCALE
0 1 2 3 4km
1:85 000 @ A4
Cyclopoida
Diacyclops cockingi
Diacyclops humphreysi humphreysi
Diacyclops sp. 'B03'
Halicyclops calm
Halicyclops rochai
RioTinto
Iron Ore (WA)
Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 3 - Cyclopoida
Drawn: M.Swebbs
Date: Mar, 2019
Plan No: PDE0159872v7
Proj: MGA94 Zone50



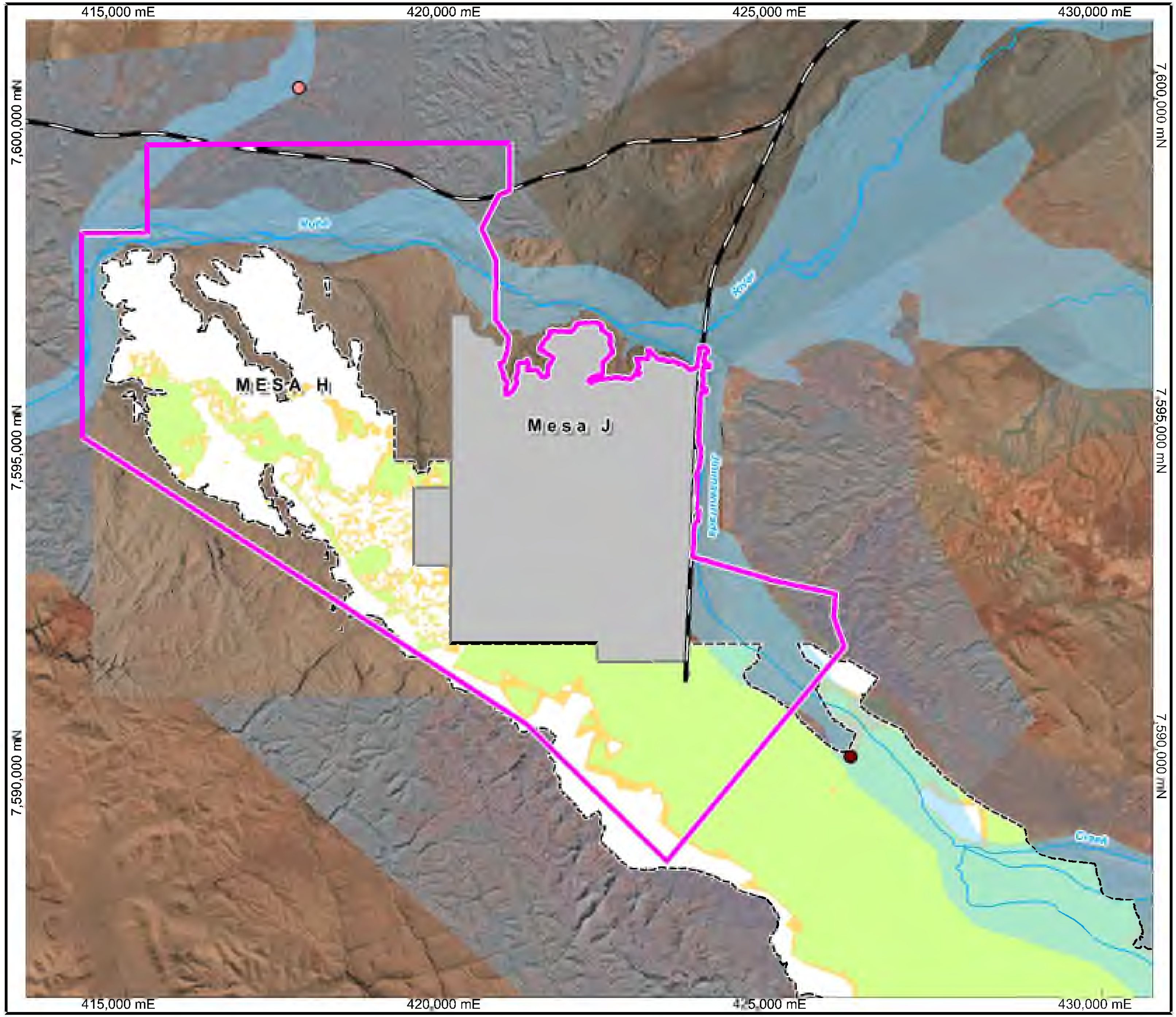
RioTinto

Iron Ore (WA)

Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 4 - Harpacticoida

Drawn: M.Swebbs
Date: Mar, 2019

Plan No: PDE0159872v7
Proj: MGA94 Zone50



Rio Tinto

Iron Ore (WA)

Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 5 - Hypsogastropoda

Drawn: M.Swebbs
Date: Mar, 2019
Plan No: PDE0159872v7
Proj: MGA94 Zone50

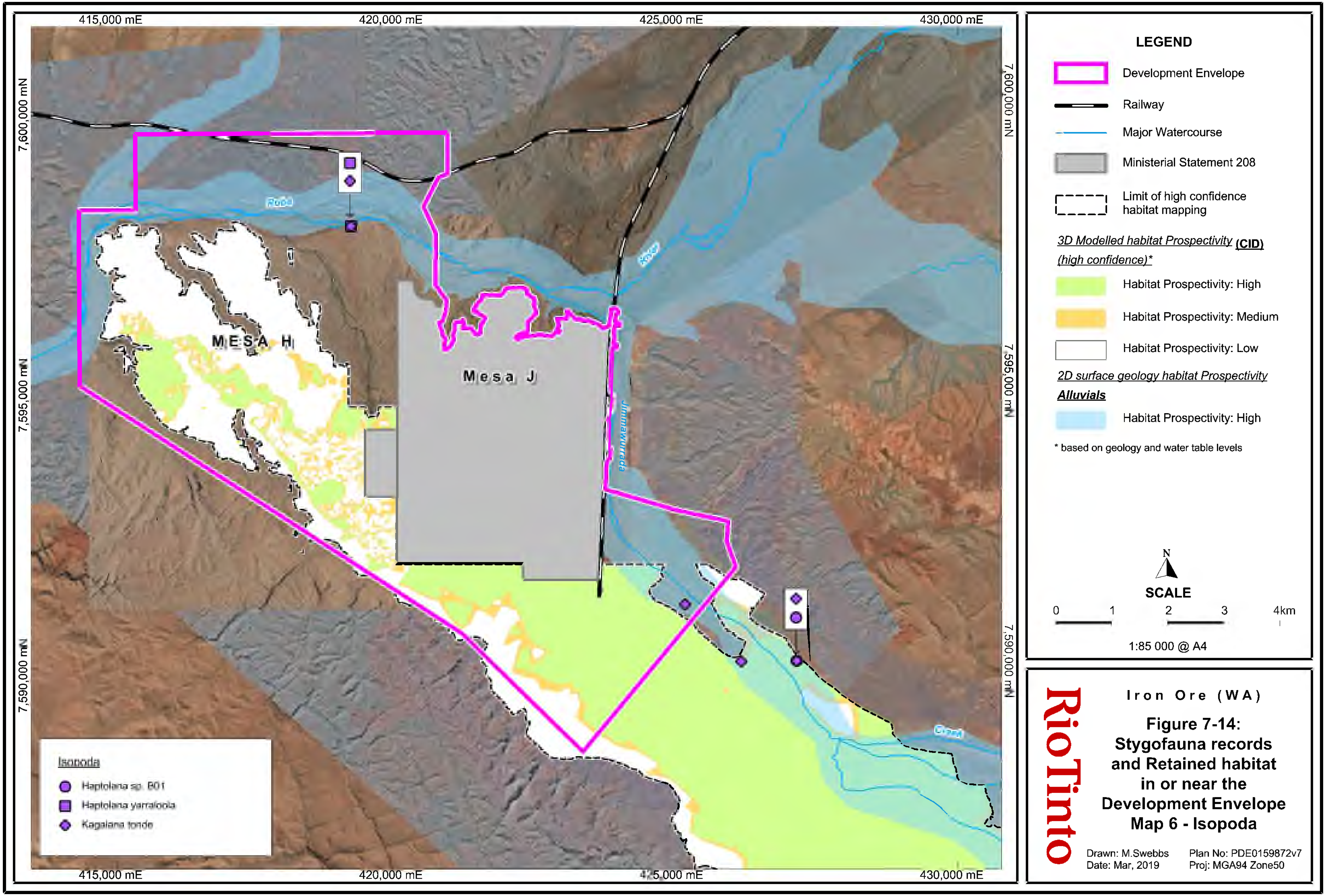
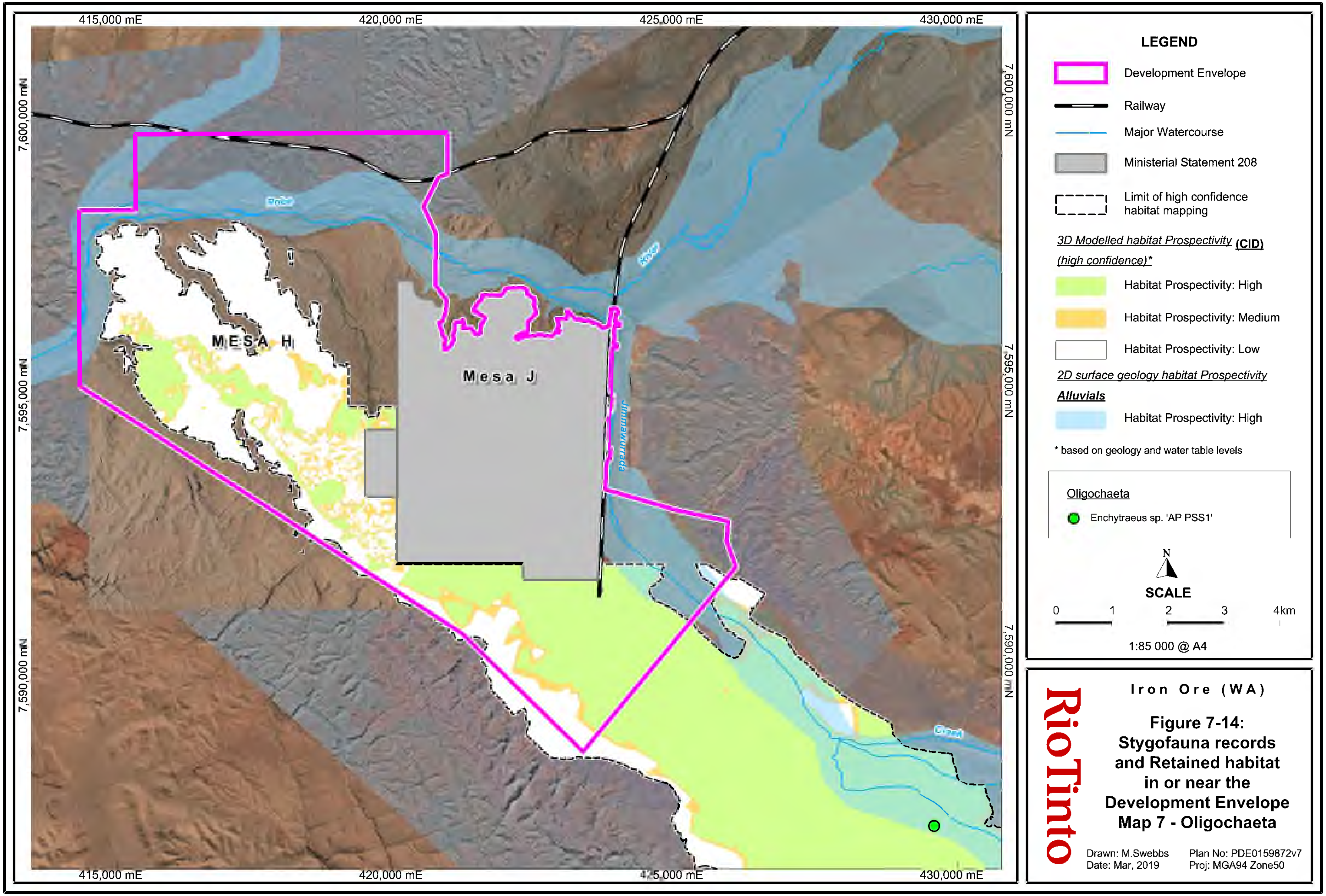
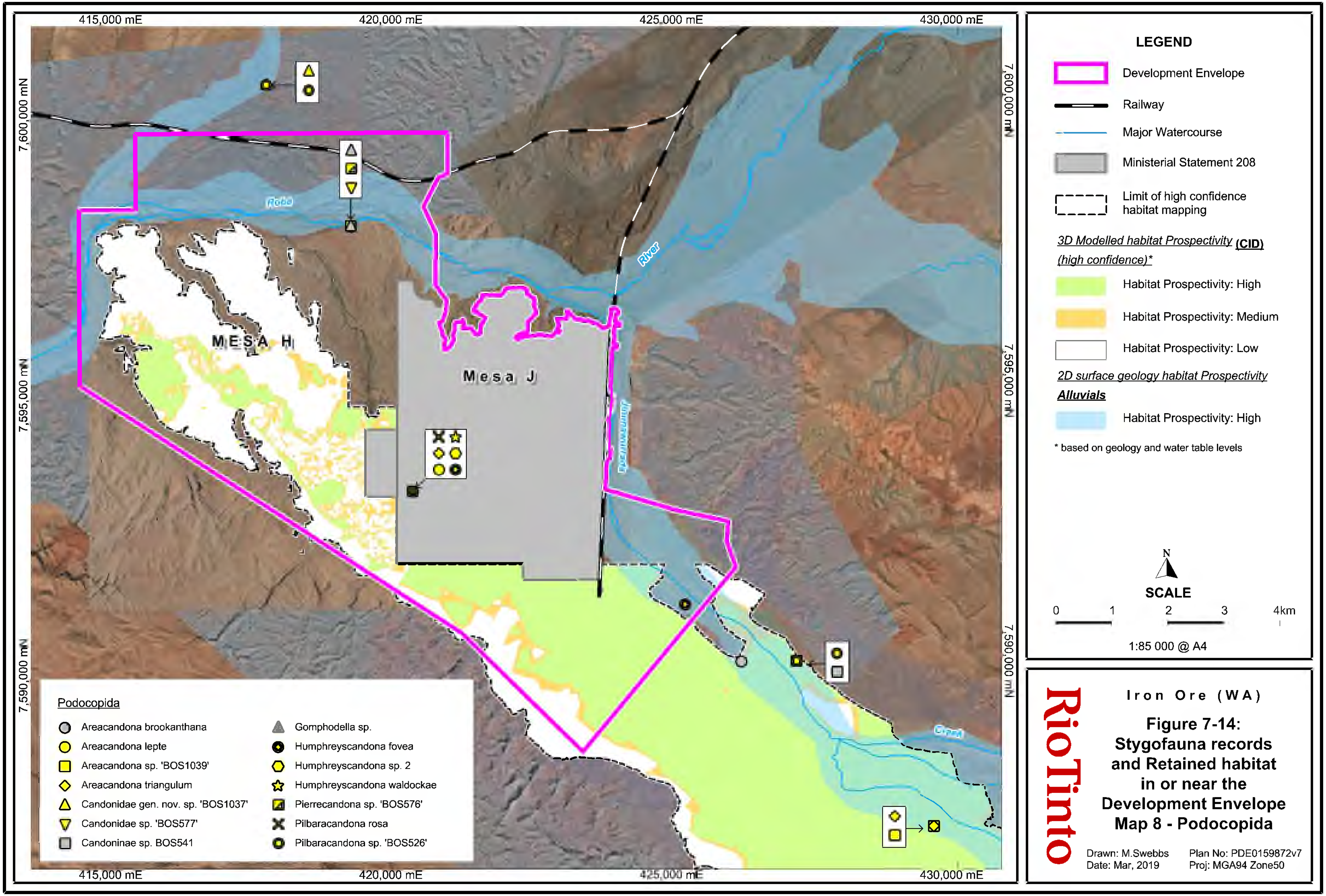
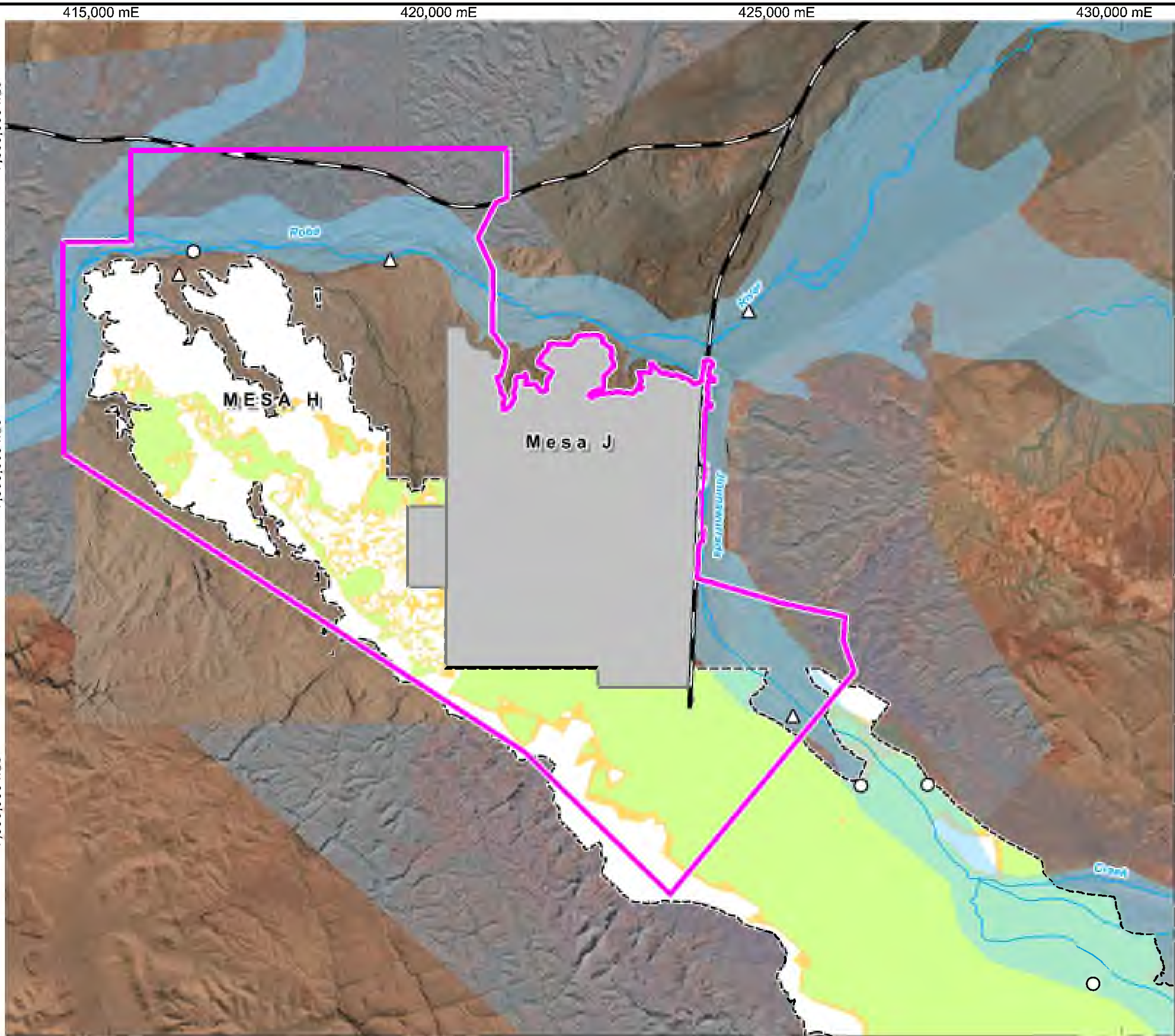


Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 6 - Isopoda


415,000 mE
420,000 mE
425,000 mE
430,000 mE
7,600,000 mN
7,595,000 mN
7,590,000 mN
MESA H
Mesa J
LEGEND
Development Envelope
Railway
Major Watercourse
Ministerial Statement 208
Limit of high confidence habitat mapping
3D Modelled habitat Prospectivity (CID) (high confidence)*
Habitat Prospectivity: High
Habitat Prospectivity: Medium
Habitat Prospectivity: Low
2D surface geology habitat Prospectivity
Alluvials
Habitat Prospectivity: High
* based on geology and water table levels
Oligochaeta
Enchytraeus sp. 'AP PSS1'
N
SCALE
0 1 2 3 4km
1:85 000 @ A4
RioTinto
Iron Ore (WA)
Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 7 - Oligochaeta
Drawn: M.Swebbs
Date: Mar, 2019
Plan No: PDE0159872v7
Proj: MGA94 Zone50



415,000 mE
420,000 mE
425,000 mE
430,000 mE
7,600,000 mN
7,595,000 mN
7,590,000 mN
Robe
River
MESA H
Mesa J
Creek
LEGEND
Development Envelope
Railway
Major Watercourse
Ministerial Statement 208
Limit of high confidence habitat mapping
3D Modelled habitat Prospectivity (CID) (high confidence)*
Habitat Prospectivity: High
Habitat Prospectivity: Medium
Habitat Prospectivity: Low
2D surface geology habitat Prospectivity
Alluvials
Habitat Prospectivity: High
* based on geology and water table levels
N
SCALE
0 1 2 3 4km
1:85 000 @ A4
Podocopida
Areacandona brookanthana
Areacandona lepte
Areacandona sp. 'BOS1039'
Areacandona triangulum
Candonidae gen. nov. sp. 'BOS1037'
Candonidae sp. 'BOS577'
Candoninae sp. BOS541
Gomphodella sp.
Humphreyscandona fovea
Humphreyscandona sp. 2
Humphreyscandona waldockae
Pierrecandona sp. 'BOS576'
Pilbaracandona rosa
Pilbaracandona sp. 'BOS526'
RioTinto
Iron Ore (WA)
Figure 7-14:
Stygofauna records and Retained habitat in or near the Development Envelope
Map 8 - Podocopida
Drawn: M.Swebbs
Date: Mar, 2019
Plan No: PDE0159872v7
Proj: MGA94 Zone50

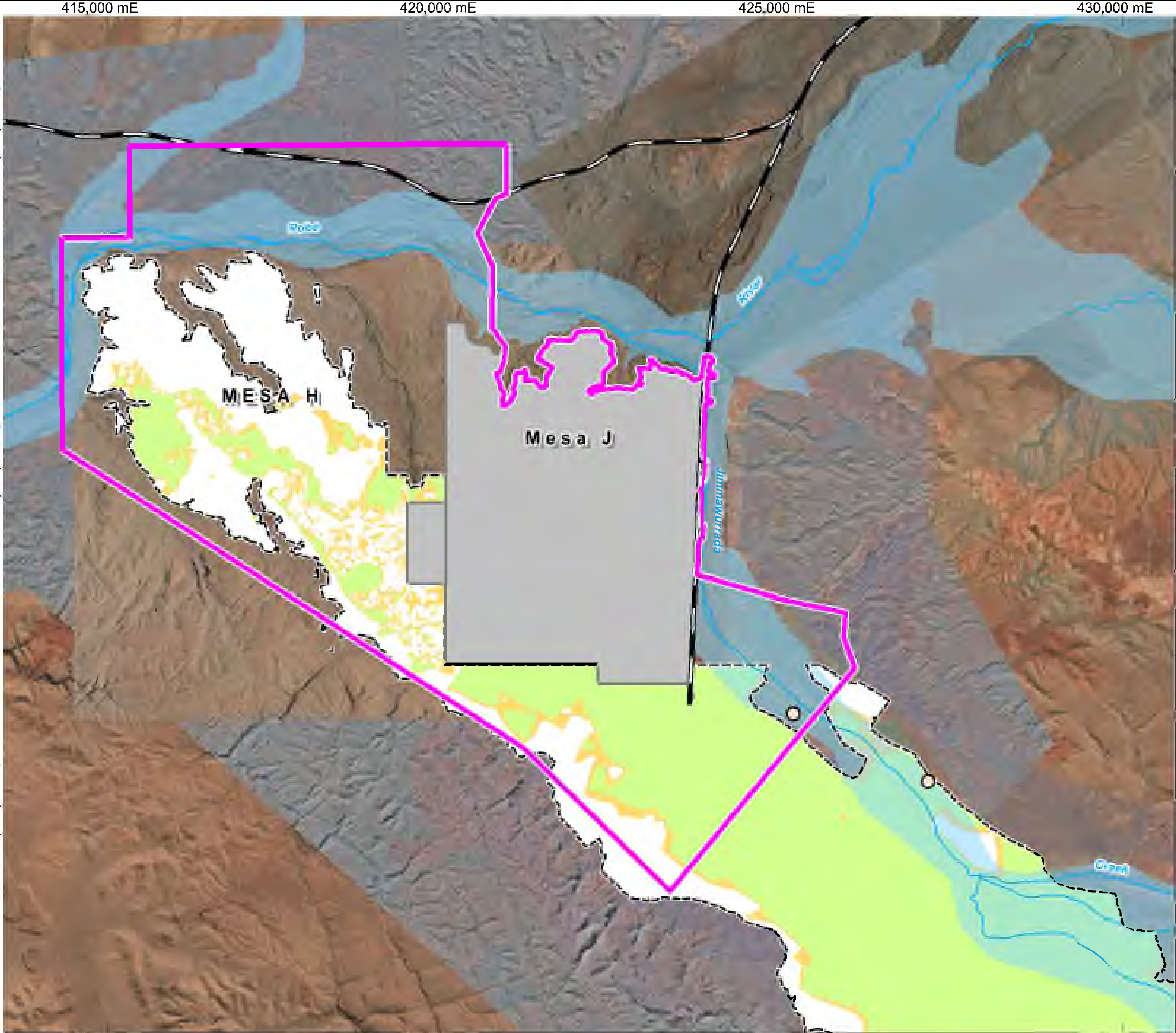


Rio Tinto

Iron Ore (WA)

Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 9 - Synbranchiformes

Drawn: M.Swebbs
Date: Mar, 2019
Plan No: PDE0159872v7
Proj: MGA94 Zone50



LEGEND

Development Envelope
Railway
Major Watercourse
Ministerial Statement 208
Limit of high confidence habitat mapping

3D Modelled habitat Prospectivity **(CID)** *(high confidence)**

Habitat Prospectivity: High
Habitat Prospectivity: Medium
Habitat Prospectivity: Low

2D surface geology habitat Prospectivity
Alluvials

Habitat Prospectivity: High

* based on geology and water table levels

Thermosbaenacea

Halosbaena tulki

N

SCALE

0 1 2 3 4km

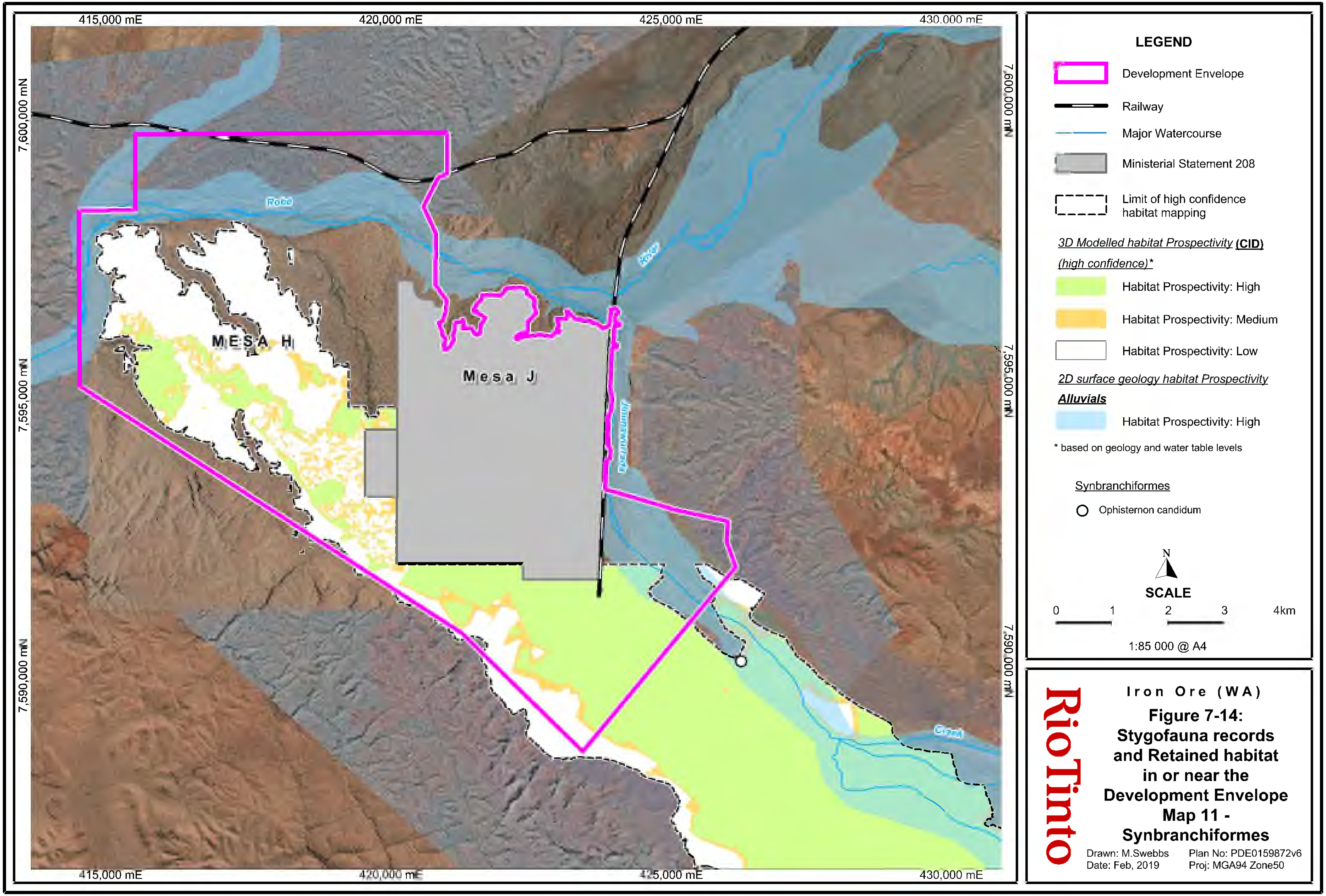
1:85 000 @ A4

Rio Tinto

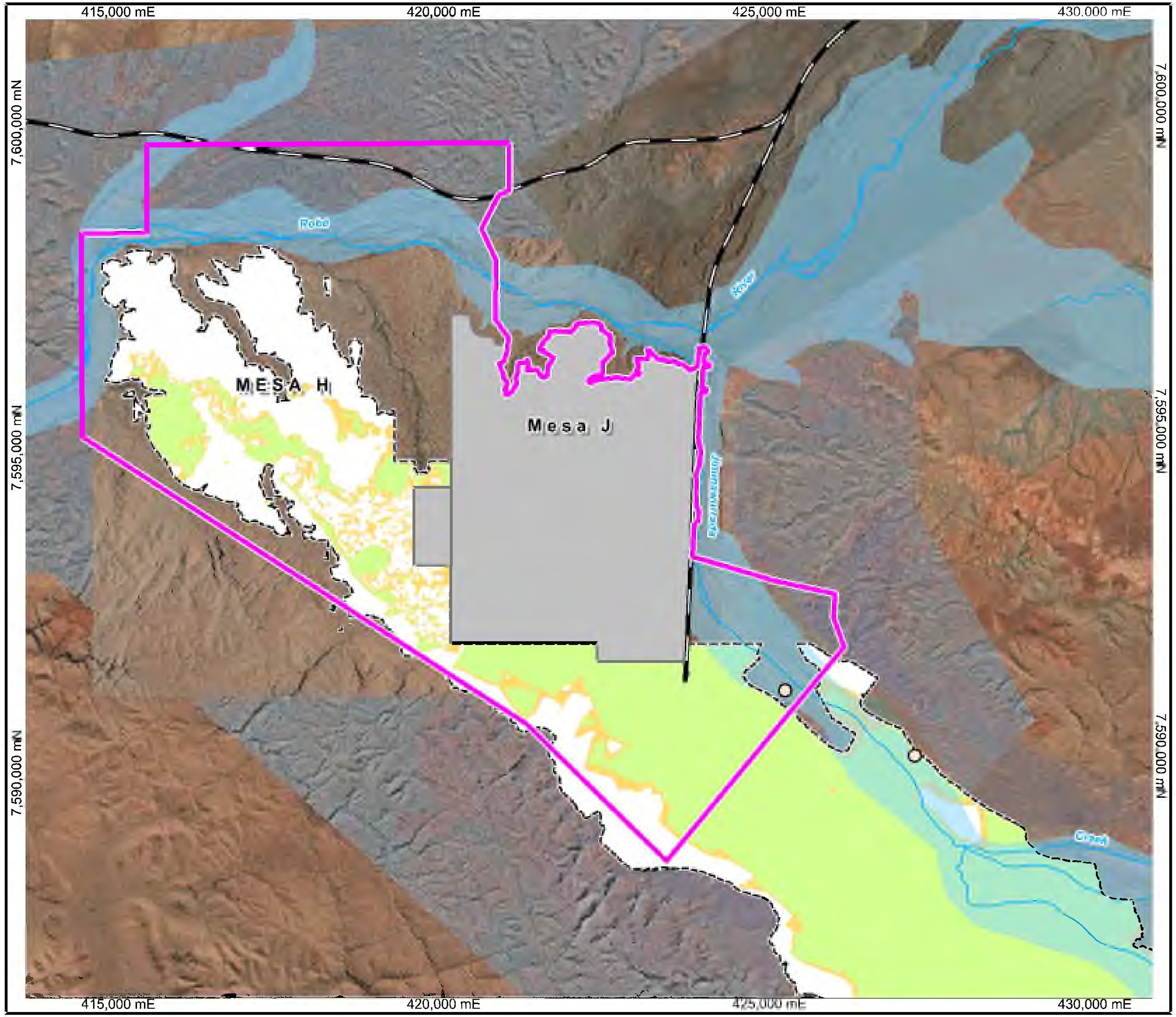
Iron Ore (WA)

Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 10 - Thermosbaenacea

Drawn: M.Swebbs
Date: Mar, 2019
Plan No: PDE0159872v7
Proj: MGA94 Zone50



415,000 mE
420,000 mE
425,000 mE
430,000 mE
7,600,000 mN
7,595,000 mN
7,590,000 mN
Robe
River
MESA H
Mesa J
Creek
LEGEND
Development Envelope
Railway
Major Watercourse
Ministerial Statement 208
Limit of high confidence habitat mapping
3D Modelled habitat Prospectivity (CID) (high confidence)*
Habitat Prospectivity: High
Habitat Prospectivity: Medium
Habitat Prospectivity: Low
2D surface geology habitat Prospectivity
Alluvials
Habitat Prospectivity: High
* based on geology and water table levels
Synbranchiformes
Ophisternon candidum
N
SCALE
0 1 2 3 4km
1:85 000 @ A4
RioTinto
Iron Ore (WA)
Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 11 - Synbranchiformes
Drawn: M.Swebbs
Date: Feb, 2019
Plan No: PDE0159872v6
Proj: MGA94 Zone50



LEGEND

- Development Envelope
- Railway
- Major Watercourse
- Ministerial Statement 208
- Limit of high confidence habitat mapping

3D Modelled habitat Prospectivity **(CID)** *(high confidence)**

- Habitat Prospectivity: High
- Habitat Prospectivity: Medium
- Habitat Prospectivity: Low

2D surface geology habitat Prospectivity
Alluvials

- Habitat Prospectivity: High

* based on geology and water table levels

Thermosbaenacea

- Halosbaena tulki

N

SCALE

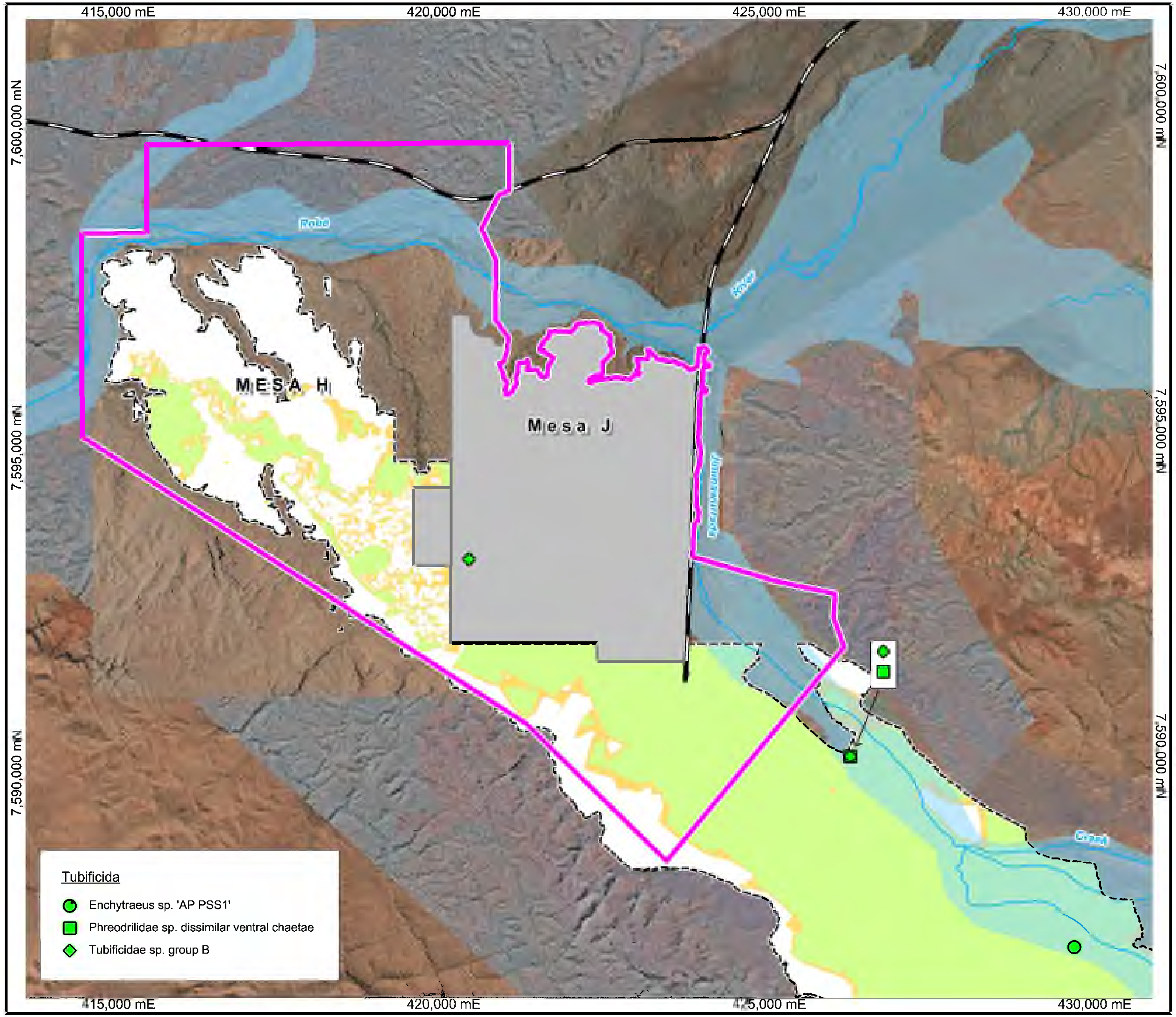
0 1 2 3 4km

1:85 000 @ A4

Iron Ore (WA)

Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 12 - Thermosbaenacea

Drawn: M.Swebbs
Date: Feb, 2019
Plan No: PDE0159872v6
Proj: MGA94 Zone50



LEGEND

Development Envelope

Railway

Major Watercourse

Ministerial Statement 208

Limit of high confidence habitat mapping

3D Modelled habitat Prospectivity **(CID)** *(high confidence)**

Habitat Prospectivity: High

Habitat Prospectivity: Medium

Habitat Prospectivity: Low

2D surface geology habitat Prospectivity

Alluvials

Habitat Prospectivity: High

* based on geology and water table levels

N

SCALE

0 1 2 3 4km

1:85 000 @ A4

RioTinto

Iron Ore (WA)

Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 13 - Tubificida

Drawn: M.Swebbs
Date: Feb, 2019

Plan No: PDE0159872v6
Proj: MGA94 Zone50

7.5.2 Potential impacts

A number of potential impacts are identified in the ESD. The potential direct, indirect and cumulative impacts identified for the Proposed Change on the basis of stygofauna surveys and assessments are described in Section 7.5.3.

7.5.2.1 Direct impacts

Direct impacts on stygofauna species comprise both habitat removal where the mine pits extend BWT and the dewatering necessary to enable this to occur.

Potential direct impacts of the Proposed Change have therefore been identified as:

- Reduction in stygofauna habitat due to BWT pit excavation at Mesa H (physical removal of habitat).
- Reduction in stygofauna habitat due to groundwater abstraction resulting in groundwater drawdown at Jimmawurrada Creek and Mesa H.
- Loss of individuals and changes to assemblages due BWT mining at Mesa H and due to groundwater abstraction at Mesa H and Jimmawurrada Creek.

Figure 7-15 shows the maximum modelled extent of groundwater drawdown at Mesa H and Jimmawurrada Creek due to the cumulative drawdown from the Revised Proposal and includes the cumulative groundwater drawdown due to Mesa J, the Southern Cutback Borefield and the CWSP in relation to modelled stygofauna habitat prospectivity. This extent also includes the direct reduction in stygofauna habitat due to BWT pit excavation at Mesa H.

Sixteen key stygofauna species, comprising 13 potential SRE species and three conservation significant species were recorded from the cumulative groundwater drawdown area. Figure 7-15 shows the distribution of these species relative to the mine pits and the maximum modelled drawdown extent for the Revised Proposal. Three species recorded from within the Proposed Change Area are also known from the Mesa J Iron Ore Development and have also been recorded from other locations outside the Development Envelope Table 7-20 summarises the sites that the 16 key species occur at and the level of predicted groundwater drawdown impact.

Table 7-20: Summary of Records of Impacted Stygofauna Key Receptors Relative to the Drawdown Extent (Reference Sites From Biota (2019a); Species Shaded Grey Known Only from the Drawdown Extent)

Species	Impact Sites	Predicted Drawdown (m)	Reference Sites; Wider Distribution
*Ophisternon candidum**	MB17MEH0015	1	RR1, 25, RRD2, Control, Cape Range.
	JW021	3	
	JW023	4	
	JW024	2	
	BC186	5	
*Nedsia hurlberti**	JW011A	20	Mesa J, Bungaroo Creek headwaters, Barrow Island.
	JW021	3	
	JW023	4	
	JW024	2	
	JIMDD080	12	
	JIMDR094	4	

Species	Impact Sites	Predicted Drawdown (m)	Reference Sites; Wider Distribution
*Nedsia sculptilis**	JW011A	20	Mesa J, Bungaroo Creek headwaters, Barrow Island.
	JW021	3	
	JIMDR094	4	
Hydrobiidae sp. 2	JW023	4	-
Areacandona sp. 'BOS1039'	BC186	5	31 (Mesa J, Middle Robe)
Megastygonitocrella unispinosa	MB17MEH0015	1	Robe River valley.
Candoninae sp. 'BOS541'	JW024	2	-
Pilbaracandona sp. 'BOS526'	JW024	2	-
Parastenocaris sp. 'B28'	JW023	4	-
Haptolana sp. 'B01'	JW024	2	-
Nedsia sp. 'AMM026'	RC13MEH0097	21	31
Paramelitidae sp. 'AMP003'	RC13MEH0041	21	-
Paramelitidae sp. 'AMP035'	RC13MEH0007	22	RR1
Paramelitidae sp. 'AMP037'	BC186	5	-
Wesniphargus sp. 'AMN004'	JW024	2	25
Neoniphargidae sp. 'B02'	JW021	3	31

* Formally listed as being of conservation significance

Nine of 16 key species have also been recorded from reference sites outside of the drawdown extent (Table 7-20). Three of these nine more widely-known species, *Ophisternon candidum*, *Nedsia hurlberti* and *Nedsia sculptilis*, are all Threatened fauna ranked Vulnerable under Schedule 3 of the BC Act, and although all three are also known from outside the drawdown extent, they are provided specific consideration in recognition of their elevated conservation status.

This leaves seven species which are currently known only from within the modelled extent of cumulative drawdown (Figure 7-15):

- the aquatic snail *Hydrobiidae* sp. 2;
- two ostracods; *Candoninae* sp. 'BOS541' and *Pilbaracandona* sp. 'BOS526';
- the copepod *Parastenocaris* sp. 'B28';
- the isopod *Haptolana* sp. 'B01'; and
- two amphipod species: *Paramelitidae* sp. 'AMP003' and *Paramelitidae* sp. 'AMP037'.

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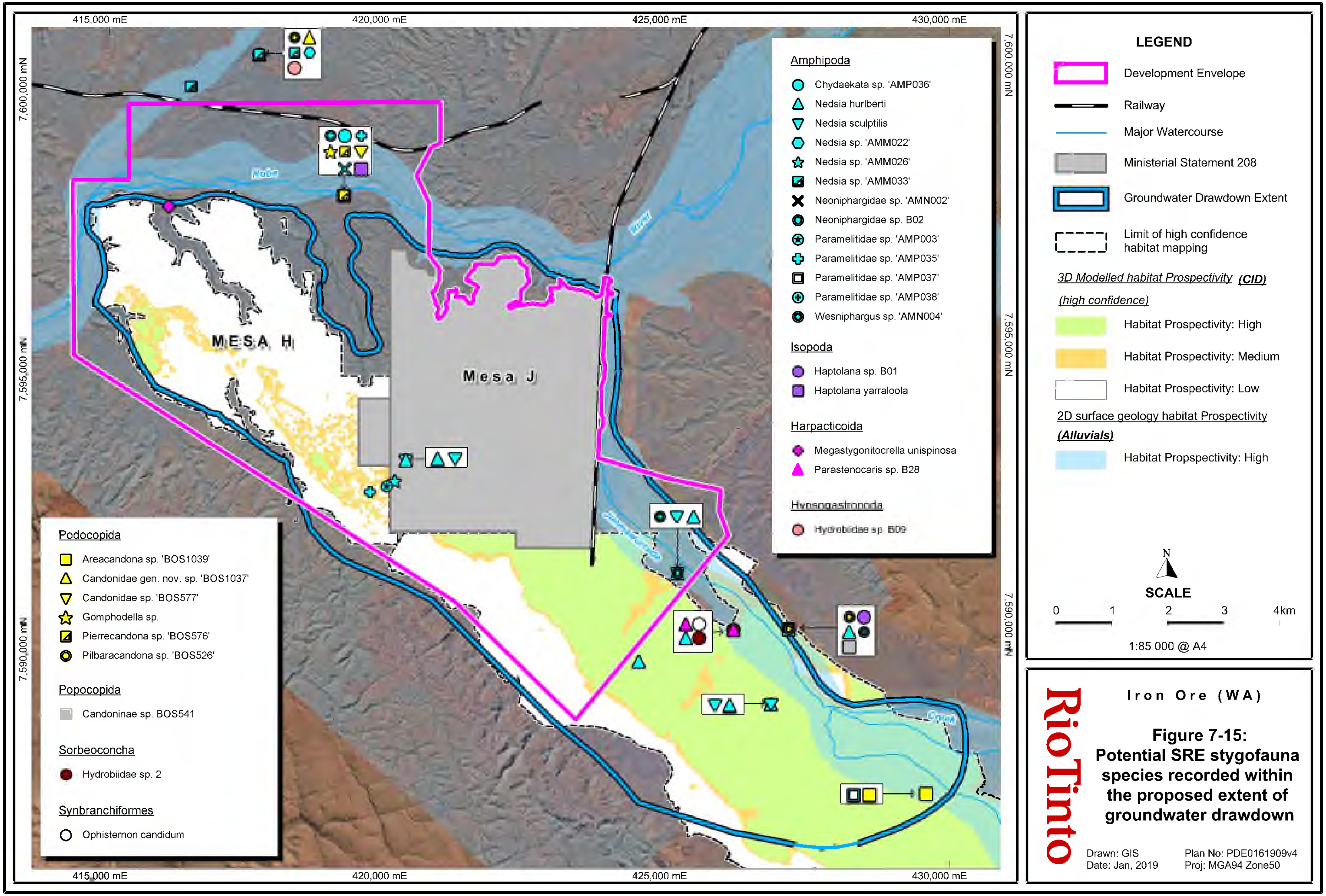


Figure 7-15: Potential SRE stygofauna species recorded within the proposed extent of groundwater drawdown

7.5.2.2 Indirect impacts

Mining activities other than mine pit excavation and groundwater abstraction which may impact stygofauna through temporary loss or degradation of habitat include:

- seepage from in-pit disposal of waste fines which has the potential to change groundwater chemistry and degrade stygofauna habitat; and
- hydrocarbon and wastewater spills which may result in a reduction in the quality of stygofauna habitat.

7.5.2.3 Cumulative impacts

Existing and foreseeable groundwater users in the vicinity of the Development Envelope are identified in Section 5 (Table 5-7) and include:

- the existing Mesa J Iron Ore Development:
  - Groundwater license allowing up to 30 GL/a to be abstracted from:
    - Southern Cutback borefield;
    - Pannawonica Town Water Supply; and
    - operational dewatering.
- the Revised Proposal;
- CWSP; and
- Yalleen Pastoral Station.

As discussed in Section 5, the operations will be integrated for Mesa J and H; abstraction from the existing Mesa J Iron Ore Development, the Southern Cutback Borefield and from the CWSP have been incorporated into the hydrological modelling, providing a cumulative hydrogeological context for impacts on stygofauna.

The abstraction rates from the pastoral station bores are likely to be negligible compared with the proposed abstraction rate for the Revised Proposal. Groundwater abstraction from the pastoral station bores are, therefore, unlikely to significantly impact stygofauna habitat.

7.5.3 Assessment of impacts

7.5.3.1 Direct impacts

Reduction in stygofauna habitat due to mine pit development and groundwater abstraction

Direct impacts on stygofauna species comprise both habitat removal where the mine pits extend BWT and the dewatering necessary to enable this to occur. While it is possible stygofauna may be able to actively respond to declining water table levels and move to habitat that remains viable, it is currently assumed that saturated habitat strata that are completely dewatered are no longer viable habitat and the individuals of species utilising those strata are conservatively considered to have been lost due to mortality. Where habitat strata have a substantial saturated thickness, and dewatering would only partially affect this; leaving connected viable habitat, the species would be likely to locally persist.

The habitat characterisation undertaken by Biota (2019b) and by the Proponent using 'Leapfrog' modelling (Figure 7-15) indicates stygofauna habitat is generally widespread within the Proposed Change Area and broader Study Area. The widespread nature of the alluvial and CID habitat and the confirmation that at least 16 of the species recorded in the drawdown impact area occur in reference sites or the wider Pilbara region, indicate that there is unlikely to be significant barriers to dispersal across the mapped high and medium habitat prospectivity areas.

Approximately 20 percent of the CID deposit at Mesa H currently lies below the water table and therefore only limited areas of the deposit provide stygofauna habitat pre-development as shown in Figure 7-12. As discussed in Section 7.5.1.2, hydrogeological test work indicates that the Mesa H CID Aquifer is in direct connection with the upstream Mesa J CID aquifer and the Jimmawurrada CID Aquifer. The Jimmawurrada CID Aquifer is also in connection with the upstream Bungaroo CID Aquifer and the overlying Jimmawurrada Alluvial Aquifer; and is recharged via throughflow from the Bungaroo valley and streamflow from the Jimmawurrada Creek during periods of high rainfall.

Figure 7-16 shows the extent and modelled prospectivity of stygofauna habitat pre-mining, during operation and post closure. The estimation of the habitat prospectivity takes into account the excavation of mine pits (permanent habitat removal) and groundwater abstraction (temporal habitat reduction). This figure shows connection of habitats is maintained throughout mining and closure.

The downstream Robe River Alluvial Aquifer is an extensive aquifer present along the length of the Robe Valley passing in close proximity to Mesa H, of which Jimmawurrada Creek is a tributary. These aquifers are considered to represent high prospectivity stygofauna habitat (Biota 2019a, Figure 7-15). Recharge from the upstream Jimmawurrada Creek alluvial aquifer and Bungaroo CID aquifer is likely to carry stygofauna with it, resulting in stygofauna potentially being deposited in the Mesa H CID Aquifer or potentially dispersing from the Mesa H CID Aquifer into the Robe River Alluvial Aquifer during periods of high rainfall and water levels.

Based on data from groundwater bores and drillholes, the Jimmawurrada Creek Alluvial Aquifer is up to 40 m deep in the centre of the channel (thalweg). The cumulative modelled drawdown of 9 m (14 mbgl) in this area, would retain a significant portion of saturated habitat. Moreover, an extended dry period (H3 'Uncertainty run 2' (Rio Tinto 2019a)), could result in a water table lowering of ~18 mbgl, which, based on the Jimmawurrada Alluvial Aquifer channel depth, would still enable retention of connected saturated habitat. Modelling using 'Leapfrog' software within the footprint of the groundwater drawdown extent estimates that volumetrically, approximately 64% of saturated Robe River – Jimmawurrada Alluvial Aquifer habitat would be retained. Even during an extended dry period, and taking into account seasonal water table lows, approximately 44% of habitat is estimated to remain (Table 7-21, Rio Tinto 2019a).

Table 7-21: Modelled Alluvium Aquifer saturated thickness within potential impact areas

Timing	Saturated Volume in m^3	% remaining saturated alluvium
Pre-mining	176,900,000	100%
Current	116,650,000	66
2030 (base case)	113,710,000	64
2030 ('uncertainty run 2', 50% reduction of groundwater inflow from Jimmawurrada Creek as a result of an extended dry period)	91,162,000	52
2030 ('uncertainty run 2' + lowest seasonal level)	77,526,000	44

Given the evidence indicating connection of the Mesa H CID Aquifer with extensive high prospectivity habitat outside of the impact area (discussed below) and the small proportion of available stygofauna habitat represented by the Mesa H CID Aquifer, it is considered that while the Proposed Change may reduce available habitat, this is unlikely to significantly affect the ecological integrity of stygofauna habitat in the Proposed Change Area.

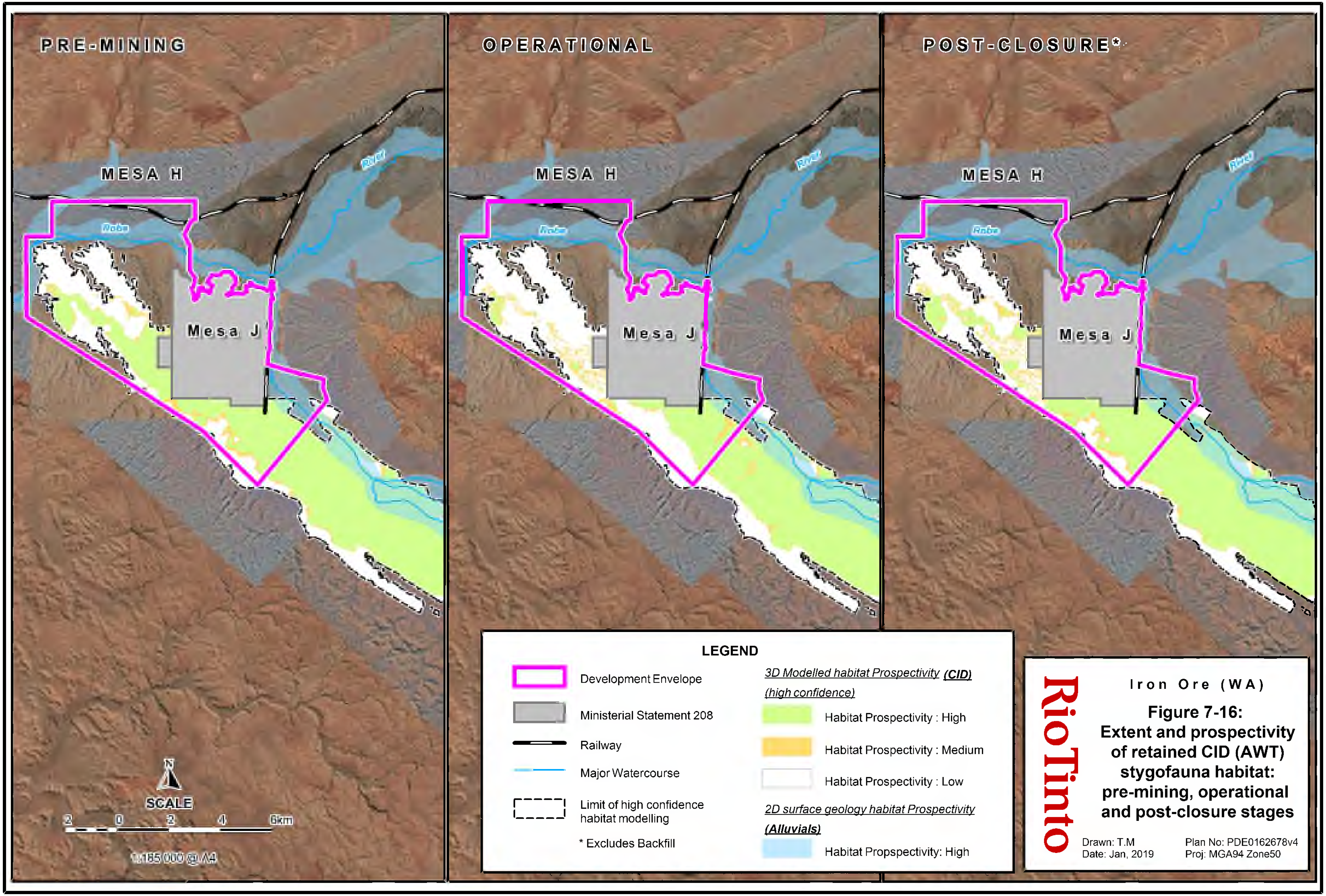


Figure 7-16: Extent and prospectivity of retained CID (AWT) stygofauna habitat: pre-mining, operational and post-closure stages

Loss of individuals and changes to assemblages due to mine pit development and groundwater abstraction

Mine pit excavation and groundwater abstraction will result in the direct loss of individuals.

Fifteen of the 31 species known to occur within the dewatering extent have been commonly recorded elsewhere within the wider Pilbara bioregion (Biota 2019b). While individuals of these species will be impacted by the mine pits and dewatering, no changes to their conservation status would be expected given their wider distributions.

There are 16 species that are either potential SRE species or of listed conservation significance. Nine of these 16 key receptors have been recorded from Reference sites outside of the drawdown extent (Table 7-20). The seven remaining species which are currently known only from within the modelled extent of cumulative drawdown include the aquatic snail *Hydrobiidae* sp. 2, two ostracods; *Candoninae* sp. 'BOS541' and *Pilbaracandona* sp. 'BOS526', the copepod *Parastenocaris* sp. 'B28', the isopod *Haptolana* sp. 'B01', and two amphipod species: *Paramelitidae* sp. 'AMP003' and *Paramelitidae* sp. 'AMP037'.

Three of these seven species (*Candoninae* sp. 'BOS541', *Pilbaracandona* sp. 'BOS526' and *Haptolana* sp. 'B01') were recorded from the same site: JW024 (Figure 7-17). The stygofauna habitat in the vicinity of JW024 comprises a sequence of saturated alluvium associated with Jimmawurruda Creek approximately 17 m in thickness from the pre-mining water table down to the underlying CID (Figure 7-17). Allowing for some uncertainty in modelling, approximately 5 – 15 m of alluvium is expected to remain saturated below watertable in the area where *Candoninae* sp. 'BOS541', *Pilbaracandona* sp. 'BOS526' and isopod *Haptolana* sp. 'B01' have been recorded (Figure 7-17). In the unlikely event that these species are restricted in distribution to this very small locality, the retention of 5 – 15 m of saturated habitat will ensure that refugia habitat remains for these species at the time of peak dewatering for the Revised Proposal. This site will also remain hydraulically connected to saturated alluvium habitat along the length of Jimmawurrada Creek (Figure 7-17). Therefore, it is considered that there is a low risk to these three potentially restricted species and they are likely to continue to persist within the remaining habitat throughout mine dewatering.

Two of the other potentially restricted species were also recorded from the same site on Jimmawurrada Creek: *Hydrobiidae* sp. 2 and *Parastenocaris* sp. 'B28', both of which are historical records from site JW023 (Table 7-20). JW023 is less than 1 km from JW024 (discussed above) and is in the same alluvial habitat setting along Jimmawurrada Creek (Figure 7-17). This habitat at JW023 will be subject to the maximum cumulative groundwater drawdown for the Revised Proposal (including the existing operations) of approximately 9 m from the pre-mining water table, however a refugial habitat of saturated alluvium of approximately 5 m thickness will still remain for the two species during the peak period of the groundwater drawdown (estimated at around 2030), which will again be hydraulically connected along the length of Jimmawurrada Creek. Again, the retention of saturated thickness at the site and the continuous connection along Jimmawurrada Creek alluvial aquifer indicates that these species are likely to continue to persist within the remaining habitat throughout mine dewatering.

This leaves the amphipod species *Paramelitidae* sp. ‘AMP003’ and *Paramelitidae* sp. ‘AMP037’ as the last two species currently known only from the drawdown extent. Both are only known from a single impact site and both may be more substantially affected by the predicted drawdown than the previously described five taxa:

- *Paramelitidae* sp. ‘AMP003’ would be the most substantially affected, having been recorded from site RC13MEH0041 within the proposed mine pit area, which will be subject to approximately 21 m drawdown in the water table (Figure 7-15, Table 7-19) and direct habitat removal from the Mesa H mine pit development. Given the location of the site beneath the Mesa H landform, it appears likely that this species occurs at least within the CID aquifer.
- *Paramelitidae* sp. ‘AMP037’ was recorded at the southeast limits of the modelled drawdown extent at site BC186, which is expected to be drawn down by approximately 5 m below the pre-mining water table (Figure 7-15, Table 7-19). This site intersects the alluvial aquifer of the Jimmawurrada – Bungaroo Creek system.

The EPA acknowledges that habitat may be used as a surrogate for inferring distributional boundaries of potentially restricted taxa (EPA 2016a and 2016b). Where a habitat type that supports a species is continuous then the extent of that habitat may be used to infer the likely presence of that species in the same habitat. The EPA also acknowledges that taxa with greater known distributions may act as surrogates to infer the distributions of poorly sampled species (EPA 2016a and 2016b).

With the exception of the singleton *Paramelitidae* sp. ‘AMP037’, every other species recorded from site BC186 is more widely distributed within the Robe River valley. As these taxa span a range of body sizes, morphologies and ecologies, their locally widespread distributions do not indicate any evidence of local barriers to fauna dispersal and gene flow for stygofauna, which by inference would also apply to *Paramelitidae* sp. ‘AMP037’ at the same site (Biota 2019b).

Direct Impacts on Conservation Significant Species

Individuals of the Threatened (Vulnerable) amphipods *Nedsia hurlberti* and *Nedsia sculptilis* will not be directly impacted by the proposed Mesa H mine pits, however will be impacted by the Revised Proposal, with approximately 20 m of groundwater drawdown predicted at JW011A where both species have been historically recorded (Table 7-20).

At site JW021 and JIMDR094 on Jimmawurrada Creek where the other records of *Nedsia hurlberti* and *Nedsia sculptilis* are located, stratigraphic cross-sections combined with hydrogeological modelling show that drawdown below pre-mining water table levels will be approximately 9 m, translating to up to 14 mbgl (or potentially up to 18 mbgl during an extended dry period). Based on the alluvial depths and extent in Jimmawurrada Creek, between 10 – 22 m of alluvium is expected to remain saturated during the period of maximum drawdown, even during an extended dry period (Figure 5-15, Figure 7-17). While the alluvial aquifer is likely to be the primary habitat for the species, the underlying Jimmawurrada CID aquifer also provides habitat for stygofauna.

While *Nedsia hurlberti* and *Nedsia sculptilis* species are listed as Threatened – Vulnerable under Schedule 3 at State level, they also occur more widely, both in the west Pilbara and as far afield as Barrow Island (Biota 2019b).

The current records of the two species from Mesa H are in addition to those used by DBCA to assign the species’ conservation listing, and the local impact on individuals arising from the Proposed Change would therefore not alter their current conservation status.

The third conservation significant species, the Blind Cave Eel (*Ophisternon candidum;* Threatened - Vulnerable), occurs along Jimmawurrada Creek (four sites) and the Robe River (Biota 2019a, 2019b and WRM 2019 in prep.), in addition to five other sites in the broader locality (Figure 7-18) (Biota 2019a). The ecology and distribution of the species is poorly understood (Biota and Helix 2014), but the surveys and related investigations completed for the Proposed Change have substantially improved the overall knowledge base for the species in the west Pilbara (Moore *et al.* 2018 as cited in Biota 2019a). Specimen records and eDNA evidence now indicate the species occurs not only within the Bungaroo Creek alluvial aquifer (Biota 2009b), but also in the Jimmawurrada Creek and Robe River alluvial aquifers, including in the hyporheic zone gravels in the Robe River (Biota 2019b; WRM 2019 in prep., TrEnD Laboratory 2018 [Figure 7-18]).

Spatially, there are five sites in the Study Area where the species has been recorded that are outside of the Revised Proposal drawdown extent (Figure 7-18). Similar to other stygofauna species, the records of the Blind Cave Eel show a high spatial correlation to the High prospectivity stygofauna habitat units. Taking account of the confirmed record locations, the distribution of this habitat suggests that suitable connected habitat for the species occurs along the length of the Robe River catchment including the Jimmawurrada Creek and Bungaroo Creek tributaries (Figure 7-18). It is notable that one of the Reference site eDNA records for the species came from the Control site sampled by Biota (2019a): this site was a surface water pool on the Robe River and consistently yielded eDNA detections for the species from multiple replicate samples (and from both the qPCR and metabarcoding eDNA methodologies). This suggests that the species utilises shallow groundwater habitats in the alluvial sequence of the Robe River, including the phreatic zone, and this could contribute to maintenance of gene flow and population connectivity within the species' overall range. This theory is consistent with the Robe River alluvium hypotheses of Moore *et al*. (2018) and is supported by the subsequent and recent collection of an additional specimen from the phreatic zone of the Robe River during aquatic fauna sampling in gravels adjacent to a surface pool in the river (WRM 2019 in prep.).

In addition, one of the Reference sites (Figure 7-18) is part of the Pannawonica town bore field, which is subject to a low level of groundwater drawdown itself, being pumped at sustainable yield for water supply (Rio Tinto 2016d). This alluvial aquifer habitat has been abstracted from since 1981 (Rio Tinto 2016d), which is indicative of both the significant recharge capacity of the Robe River alluvial aquifer and, by inference, that the *Ophisternon candidum* is at least tolerant to this level of groundwater impact in the medium term (with the borefield having been in operation for 37 years at the time the recent eDNA record was obtained; Biota 2019a).

Even within the drawdown extent, the alluvial aquifer habitat of Jimmawurrada Creek where Blind Cave Eel occurs is subject to the same predictions as those noted above for *Nedsia hurlberti* and *N. sculptilis*: that is, when considered vertically, there will be a saturated thickness remaining along the length of the creek even at the peak of groundwater drawdown for the project predicted in 2030. Figure 7-18 shows the sites where Blind Cave Eel has been recorded (both physical records and eDNA) along Jimmawurrada Creek, illustrating that a continuous and connected saturated alluvium habitat up to 40 m thick will remain within the system at the peak of dewatering. This is in addition to the underlying saturated CID, which may also provide potential refuge habitat for the species (Figure 7-17).

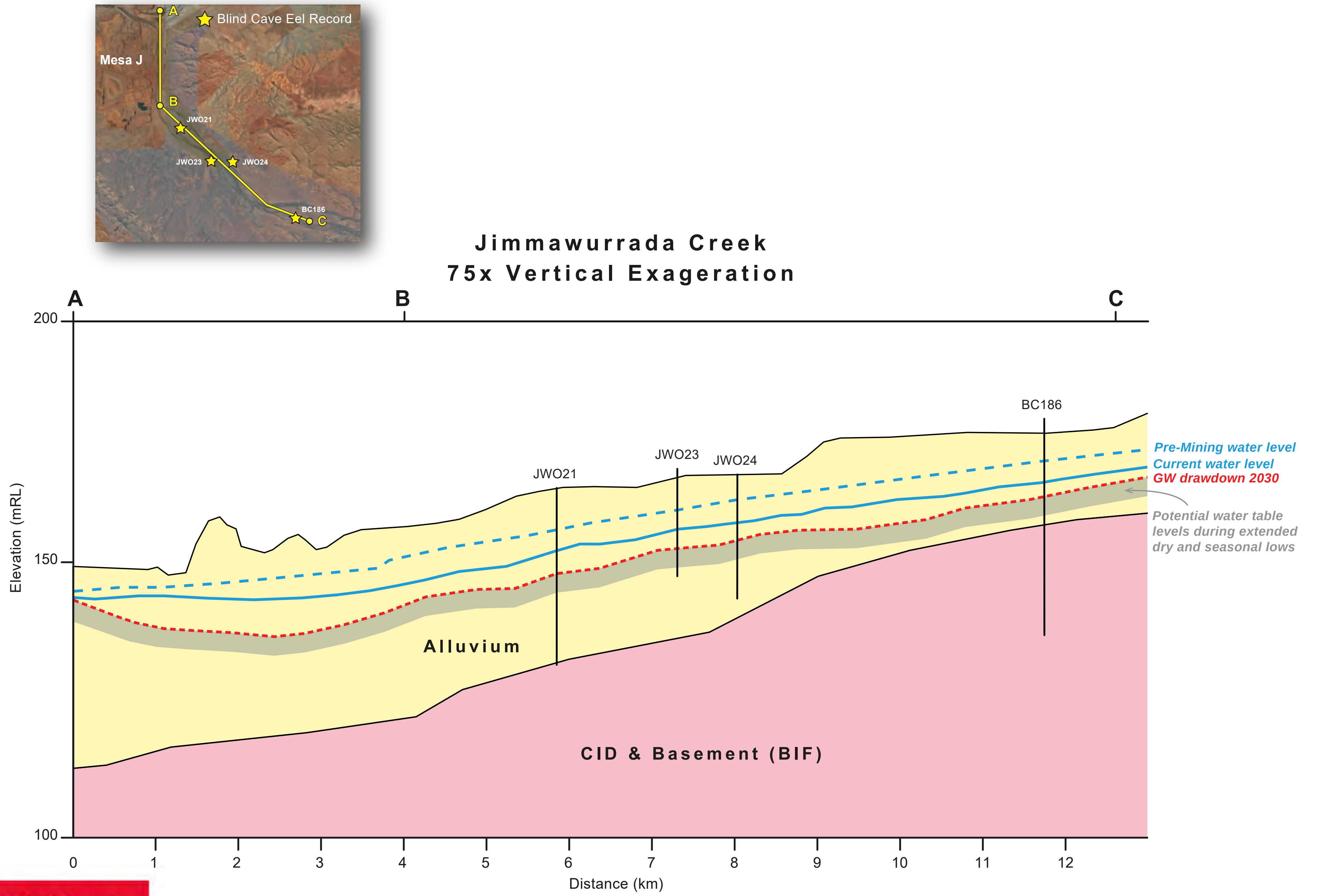
Conservatively, at the peak of groundwater drawdown, a 6.5 km section of Jimmawurrada Creek is modelled to be impacted by ~ 9 m of drawdown from the baseline water table levels (~14 m water table change from baseline during an extended dry and seasonal water table low). It is expected that even with limited saturated thickness of saturated alluvial habitat retained within this area, seasonal rainfall and larger cyclonic events will continue to enable connectivity of the aquifer and also periodically recharge water table levels.

In summary:

- Four of the known sites where *Ophisternon candidum* occurs are currently affected by groundwater drawdown, and will be subject to further groundwater drawdown of between 1 m to a temporary peak of 9 m from the current water table (~14 mbgl) in Jimmawurrada Creek. Even during an extended dry period and taking into account seasonal water table lows, an estimated 10 – 22 m of saturated alluvium in the centre of the Jimmawurrada Creek Alluvial Aquifer is expected to remain connected and provide refuge during peak drawdown (Figure 7-17).
- There are a further five known sites where the species occurs within the Robe Valley that are outside of the drawdown extent (or within the range of natural water table fluctuation), including along the Robe River.
- The species may be tolerant of groundwater abstraction based on its persistence within the aquifer that supports the Pannawonica town bore field.
- Note the distributions of the known records, and habitat mapping with a strong evidence base from the broader stygal assemblage (Section 7.4), indicate it is likely that the species is distributed more widely along the Robe River catchment alluvial aquifer (Biota 2019b) and is not restricted to the Development Envelope.

The above evidence suggest that while some individuals of the species may be directly impacted by the groundwater drawdown, the species is expected to remain locally represented within the Study Area, in addition to its possible occurrence further along the connected alluvial aquifer habitats of the Robe River and further afield at Cape Range (Biota 2019b). However, the impacts to Blind Cave Eel are considered to comprise an increased risk of temporary habitat reduction due to cumulative groundwater drawdown during operations. Given the current limited status of knowledge of this species, there is uncertainty regarding the area of risk, the degree of habitat modification and the range and sensitivity of the species. Therefore, this risk is proposed to be offset to enhance further research into the understanding of the occurrence and range of this species (Section 13.3).

Figure 7-17: Longitudinal cross-section along Jimmawurrada Creek area, showing pre-mining water table, predicted maximum drawdown from the proposal in 2030 (dashed in red) and alluvial stygofauna habitats that will remain saturated (below the red dashed line)



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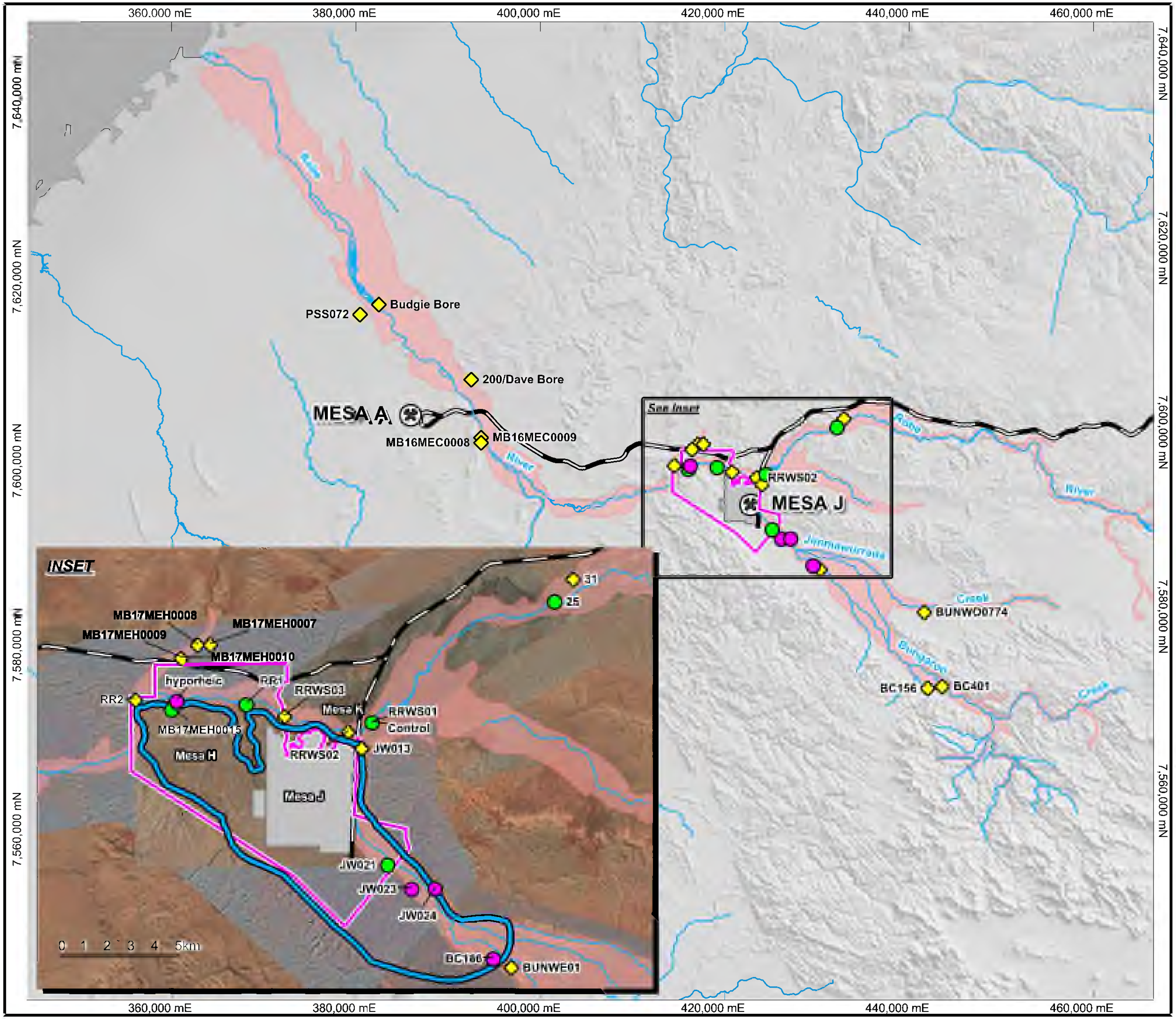


LEGEND

- Development Envelope
- Ministerial Statement 208
- Mine
- Railway
- Major Watercourse
- Blind Cave Eel eDNA
- Confirmed Eel Record
- Sample Site
- Potential Blind Cave Eel habitat

Data Source: Regional 1:250K geology GSWA - DMIRS and RTIO Mesa J Mapping 1:5000 (Nov 2003)

Groundwater Drawdown

- Drawdown Extent

N

SCALE

0 10 20 30km

1:600 000 @ A4

RioTinto

Iron Ore (WA)

Figure 7-18:
Blind Cave Eel records and potential habitat in the wider locality

Drawn: M.Swebbs
Date: Jan, 2019

Plan No: PDE0159201v5
Proj: MGA94 Zone50

Geospatial Information and Mapping

7.5.3.2 Indirect impacts

Degradation of habitat due to mining related activities

Waste fines storage

Seepage from in-pit disposal of waste fines has the potential to change the local groundwater chemistry and degrade stygofauna habitat.

Waste fines generated as a result of wet processing of Mesa H ore will be located into existing WFSF's in-pit at Mesa J. Based on results of monitoring around the Mesa J WFSF (refer Section 7.4.2) it is anticipated that the proposed additional waste fines generated from Mesa H will result in increases in analytes such as salinity, nitrogen, nitrate, NOx and zinc in the immediate vicinity of the WFSF. During operations, these changes in groundwater chemistry are likely to be mainly confined to the cone of depression generated by the production bores at Mesa J / Southern Cutback Borefield and much of the affected groundwater will be recirculated through the process plant.

Given that seepage from the WFSF will be mainly confined to the cone of depression in Mesa J from the Mesa J production bores, and the Southern Cutback Borefield during operations and that this cone of depression represents a small proportion of broader available connected stygofauna habitat, it is considered that during operations, the Proposed Change is unlikely to significantly affect the ecological integrity of the stygofauna habitat in the CID aquifer.

Additional modelling is underway to examine the fate of water seepage from the WFSF and its effect on groundwater chemistry at closure. Placement of waste fines into the WFSF will cease prior to closure. There will then be a limited period of time where seepage occurs from the waste fines until the WFSF dries out through a combination of evaporation and seepage, at which stage rehabilitation of the WFSF will be undertaken. Given the limited period of time required for 'drain-down' of the WFSF at closure and the connected stygofauna habitat available in the Proposed Change Area and surrounds, including the Jimmawurrada CID area, it is considered that at closure, the Proposed Change is unlikely to significantly affect the ecological integrity of the stygofauna habitat provided by the Jimmawurrada CID and the Jimmawurrada and Robe River Alluvial Aquifers.

Hydrocarbon and wastewater spills

The potential exists for groundwater to be degraded by spills of hydrocarbons or wastewater. Hydrocarbons will be handled, stored and disposed of in accordance with legal requirements. Hydrocarbon storage will be inspected on a regular basis to identify any maintenance requirements. Hydrocarbon and spill management procedures are expected to effectively mitigate the risk of contamination.

7.5.3.3 Cumulative impacts

The existing and foreseeable groundwater users in the vicinity of the Development Envelope are identified in Section 5.5.4. Cumulative groundwater abstraction from the Revised Proposal, and the existing operations including the Mesa J Iron Ore Development (including the Southern Cutback Borefield) and the CWSP have been integrated into the groundwater modelling for the Proposed Change and so the assessment of impacts in Section 7.5.3.1 therefore incorporates the existing and proposed impacts as described in Section 5. The pastoral station and the Pannawonica town drinking water supply bores are unlikely to significantly impact stygofauna habitat as the abstraction rates are likely to be low relative to the size of the aquifer and relative to the groundwater abstraction rates associated with the Proposed Change.

No other existing or proposed mining operations that would contribute to cumulative impacts on stygofauna occur in the vicinity of the Proposed Change Area.

7.5.4 Mine closure

The Mesa J Hub Closure Plan (Rio Tinto 2018a) is an integrated closure plan encompassing the existing Mesa J and Mesa K operations, together with the inclusion of the Proposed Change, in order to optimise closure outcomes. The plan is an update to and supersedes previous closure plans for the existing Mesa J and K Operations.

Following cessation of dewatering at Mesa H, the groundwater levels in the Mesa J and Mesa H mining areas will recover until a balance is reached between groundwater inflows and groundwater outflows. Backfilled pit voids will enable groundwater levels to eventually recover to pre-development levels. Complete aquifer recovery is predicted to take between 50 and 60 years, however, the large majority of the drawdown along the Robe River and Jimmawurrada Creek is expected to recover 90% of the drawdown after the first or second significant rainfall events (Rio Tinto 2019a). The post closure stygofauna habitat prospectivity within the Study Area is shown in Figure 7-16. A closure task has been identified to assess the potential for seepage from the WFSF from the Mesa J Iron Ore Development. This will ensure any seepage from the facility is considered in terms of any potential impact to groundwater chemistry and subterranean habitats.

7.5.5 Mitigation

Mitigation strategies to address the potential impacts and predicted outcomes are presented in Table 7-22.

The Mesa J Hub EMP (Appendix 6) addresses the key environmental factors which were determined by the EPA as being relevant to the appropriate management of dewatering, surface water discharge, conservation significant vegetation communities, fauna and subterranean fauna species associated with the Mesa J Hub. The EMP identifies:

- mitigation strategies proposed to minimise impacts to significant environmental values;
- the environmental criteria that the Proponent will use to monitor performance of the mitigation strategies to ensure environmental objectives are met;
- trigger criteria, threshold criteria, trigger level actions and threshold contingency actions aligned with the overall management approach; and
- the management actions that will be implemented in response to monitoring results.

The EMP for stygofauna focusses on maintaining viable and connected habitat via the monitoring of groundwater levels and water quality, given the inherent sampling limitations in the subterranean environment. Trigger and threshold criteria, have been developed to ensure that whilst a reduction in habitat via ground water level changes is expected, that significant areas of stygofauna habitat are still retained over the life of the mine. The ongoing persistence of connected stygofauna habitat (>44% alluvium aquifer saturated thickness) was a key consideration when defining these criteria; changes to groundwater levels are readily measurable and is part of the causal relationship between mining and impacts on stygofauna. These triggers and thresholds are supplemented by ongoing stygofauna monitoring (including specific monitoring for the Blind Cave Eel) throughout the life of mine to confirm if any changes in assemblages are apparent as a result of Proposed Change, as measured by stygofauna capture rates compared to baseline data and ongoing presence of the Blind Cave Eel.

Table 7-22: Mitigation Measures and Predicted Outcomes for Stygofauna

Potential impacts	Mitigation to address potential impacts	Residual impact	Assessment of significance	Offset required?
EPA objective: ***To protect subterranean fauna so that biological diversity and ecological integrity are maintained.***				
Direct impacts: Reduction in stygofauna habitat, loss of individuals and changes to assemblages due to mine pit development and groundwater abstraction	The following key management strategies will be implemented to manage impacts to stygofauna as a result of indirect impacts: **Avoid:** Water will be sourced from the existing Southern Cutback Borefield, within current licence limits and avoiding the requirement for a new borefield impact area. Placing waste fines in-pit at Mesa J avoids the need to disturb a previously undisturbed area and reduces seepage risk into stygofauna habitat at Mesa H. **Minimise:** Dewatering will be minimised to that required to access the BWT resource. Water from mine dewatering will be used on site where possible to minimise the requirement for additional groundwater abstraction for operational water supply. Groundwater abstraction will be within the current approved licence limits and groundwater levels will be monitored to ensure impacts remain within the predicted range of drawdown. Water levels within the semi-permanent and permanent pools of the Robe River during active mine dewatering will be monitored and the Proponent will cease dewatering below the 120 m RL in the adjacent Mesa H Pit 7 should water table levels exceed predictions during active dewatering water during dry periods and resume mining once a stream flow event occurs. The use of a thickener is proposed to be used for the WFSF, specifically to optimise water recovery and reduce the overall water demand by approximately 30% from the Southern Cutback Borefield and thus reduce cumulative drawdown in the Jimmawurrada Creek alluvial aquifer and the underlying CID aquifer.	The Proposed Change will result in impacts to stygofauna habitat and communities, including 3 conservation significant species listed as Threatened -Vulnerable under Schedule 3 of the BC Act (two Amphipods: *Nedsia hurlberti* and *Nedsia sculptilis*; and the Blind Cave Eel: *Ophisternon candidum*). *Nedsia hurlberti* and *Nedsia sculptilis* occur more widely, both in the west Pilbara and as far afield as Barrow Island and their conservation status is unlikely to be affected. The Blind Cave Eel will be impacted by a reduction in habitat through groundwater abstraction and associated groundwater drawdown.	Approximately 20 percent of the CID deposit at Mesa H currently lies below the water table and therefore only limited areas of the deposit is suitable as stygofauna habitat. The Proposed Change will result in the loss of individuals and reduction in this available habitat from the proposed groundwater drawdown and pit excavation. However, the available habitat connects to other primary stygofauna habitat comprising the Jimmawurrada CID aquifer to the south-east, which is also in connection with the overlying Jimmawurrada Creek alluvial aquifer. Given the extent and connectivity to other primary stygofauna habitat, it is unlikely the Proposed Change will significantly affect the ecological integrity of the stygofauna habitat or the diversity and ecological integrity of stygofauna assemblages in the Mesa H area. Similarly, at Jimmawurrada, the available stygofauna habitat is well connected to other extensive primary stygofauna habitat outside the impact areas. Studies indicate that the CID aquifer underlies and is connected with the Jimmawurrada Creek alluvial aquifer, and the Jimmawurrada Creek aquifer is a tributary into the Robe River alluvial aquifer. The Jimmawurrada CID aquifer is also connected to the upstream Bungaroo CID aquifer. Given this extent of available habitat and the connectivity, in particular in areas such as the Robe River Alluvial Aquifer which is not expected to be significantly impacted by the Proposed Change, it is considered that although the Proposed Change will result in the localised reduction of habitat and potential loss of individuals across a	Yes. The Proponent proposes the provision of two environmental offsets for Stygofauna. • an environmental offset at the offset rate of $1,500 per hectare for the direct impact as a result of groundwater drawdown to 'Zone 3' of the Jimmawurrada Creek alluvial aquifer within areas with other environmental values: i.e. PEC (Stygofauna community of the Bungaroo Aquifer). • Provision of $1 M of funding for further research into the occurrence and range of the Blind Cave Eel.

Potential impacts	Mitigation to address potential impacts	Residual impact	Assessment of significance	Offset required?
	Surplus water generated from mine pit dewatering will be used onsite in the first instance to supply water for operational purposes. Only surplus water exceeding the operational requirements will be discharged to local ephemeral tributaries of the Robe River, which may periodically temporarily increase habitat for stygofauna in the alluvial aquifers downstream of the discharge points. The location of surplus discharge points will be optimised to reduce the potential for impacts to significant environmental values or areas considered to be at higher risk from the effects of groundwater drawdown, including along Jimmawurrada Creek (near the Southern Cutback Borefield) and the permanent pools of the Robe River (contingency only). **Rehabilitation:** BWT pits will be backfilled enabling recovery of groundwater levels and stygofauna habitats following cessation of groundwater abstraction and to prevent the formation of pit lakes (and associated changes in water quality). Hydrocarbon storage and handling facilities will be decommissioned at closure.	The Proposed Change will result in the loss of individuals and reduction in available stygofauna habitat at Mesa H and Jimmawurrada from the proposed groundwater drawdown and pit excavation.	12 km section of Jimmawurrada CID and alluvial aquifers (greatest drawdown impact across a 6.5 km stretch), habitat connectivity will continue to be retained and it is unlikely to significantly affect the ecological integrity of stygofauna and their broader habitat and distribution. After the mitigation hierarchy has been applied, including the reduction of water abstraction by the use of a thickener and consideration of extensive, connected stygofauna habitat at Jimmawurrada, the Proponent considers that the residual impact associated with the groundwater drawdown within the Priority 1 PEC is significant for the Stygofauna component of the Subterranean Fauna factor and warrants an offset. In addition, given the current limited status of knowledge of the Blind Cave Eel, there is uncertainty regarding the area of risk of groundwater drawdown, the degree of habitat modification and the range and sensitivity of the species. Therefore, this risk is proposed to be offset to enhance further research into the understanding of the occurrence and range of this species. Given the proposed mitigation and offsets, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Subterranean Fauna.	
Indirect impacts: Degradation of habitat due to mining-related activities Seepage from in-pit disposal of waste fines and hydrocarbon spills have the potential to degrade stygofauna habitat.	The following key management strategies will be implemented to manage potential indirect impacts to stygofauna habitat: **Avoid:** Placing fines in-pit at existing Mesa J WFSF reduces seepage risk to stygofauna habitat at Mesa H. **Minimise**: Hydrocarbons will be handled, stored and disposed of in accordance with legal requirements. Hydrocarbon storage will be inspected on a regular basis to identify any	The Proposed Change will result in no new WFSF areas and seepage will mainly be captured in the cone of depression from groundwater abstraction. No significant impact on stygofauna	Based on results of monitoring around the Mesa J waste fines TSF it is anticipated that the additional waste fines from Mesa H into these facilities will result in increases in analytes such as salinity, nitrogen, nitrate, NOx and zinc in the immediate vicinity of the WFSF. During operations the seepage from the WFSF will be mainly confined to the cone of depression from the Mesa J borefield and Southern Cutback Borefiled representing disturbance to a small proportion of available stygofauna habitat.	No. The Proponent considers that the potential impacts can be managed and the residual impact is not considered to be significant and therefore does not warrant the

Potential impacts	Mitigation to address potential impacts	Residual impact	Assessment of significance	Offset required?
	maintenance requirements. Spill response procedures will be followed to contain and clean-up any hydrocarbon spills. **Rehabilitation:** Any hydrocarbon spills will be contained, and Hydrocarbon storage and handling facilities will be decommissioned at closure. **Other legislation:** Compliance with the requirements of the *Contaminated Sites Act 2003* if contamination occurs.	habitat is expected from hydrocarbon storage or handling.	Groundwater abstraction will cease prior to closure. Following cessation of groundwater abstraction, there will be a limited period of time when the TSF 'drains-down' and seepage from the WFSF will not be re-circulated through the wet processing plant. Given the extensive stygofauna habitat available around the Study Area and the limited period of time required for 'drain-down' of the WFSF at closure, it is considered that the Proposed Change is unlikely to significantly affect the ecological integrity of the stygofauna habitat provided by the alluvial aquifers. The Proponent considers that the potential impacts can be managed to meet the EPA's objective for this factor.	application of offsets.

7.6 Predicted Outcome

The key Subterranean Fauna values identified in the Development Envelopment that are considered relevant to the Proposed Change are:

- Significant troglofauna habitat:
  - the Priority 1 PEC, the *Subterranean invertebrate community of pisolitic hills in the Pilbara* occurs across Mesa H; and
  - the Priority 1 PEC, the *Subterranean invertebrate community of mesas in the Robe Valley region*, occurs across Mesa J in the Development Envelope.
- Troglofauna taxa:
  - Potential SRE troglofauna taxa.
- Significant stygofauna habitat:
  - The Priority 1 PEC Stygofauna community of the Bungaroo Aquifer.
- Stygofauna taxa:
  - potential SRE stygofauna taxa; and
  - conservation significant stygofauna species:
    - *Nedsia hurlberti* (Threatened – Vulnerable under Schedule 3 of the BC Act);
    - *Nedsia sculptilis* (Threatened – Vulnerable under Schedule 3 of the BC Act); and
    - *Ophisternon candidum,* Blind Cave Eel (Threatened - Vulnerable under the EPBC Act and Schedule 3 of the BC Act).

The key predicted outcomes for the Subterranean Fauna values outlined above are:

- Clearing of up to 9.2 ha and 788.1 ha of the Priority 1 PECs, the *Subterranean invertebrate community of mesas in the Robe Valley region* and the *Subterranean invertebrate community of pisolitic hills in the Pilbara* respectively.
- Disturbance to troglofauna habitat (conservatively including disturbance from waste dumps) at Mesa H as a result of the Proposed Change will be limited to 50% by volume of connected pre-mining habitat.
- Direct impact over a 12 km stretch of the Jimmawurrada Creek Alluvial Aquifer, with the greatest impact across a 6.5 km stretch (‘Zone3’), impacting the stygofauna PEC.
- Biological diversity and ecological integrity of the troglofauna communities are expected to be maintained given:
  - the troglofauna habitat present is connected and extends beyond the proposed impact areas; and
  - monitoring evidence also indicates that the existing MEZ at the analogous Mesa A Operations is functioning as intended, in protecting the ecological integrity of troglofauna habitat and assemblages.

- Biological diversity and ecological integrity of the stygofauna communities are expected to be maintained given:
  - o the extent and connectivity of stygofauna habitat at Mesa H and Jimmawurrada to other primary stygofauna habitat beyond the proposed impact areas, including the extensive Robe River Alluvial Aquifer and upstream CID aquifer; and
  - o the maintenance of between 10 – 22 m of saturated thickness of the Jimmawurrada Creek alluvial habitat aquifer, and >40% habitat even during peak drawdown (and including consideration of extended dry periods and seasonal water table lows) in the impact areas.

After the mitigation hierarchy has been applied (Table 7-15 and Table 7-22), including retention of connected habitat through designation of a MEZ and saturated stygofauna habitat, the Proponent considers that the residual impact associated with the clearing of the Priority 1 PECs the *Subterranean invertebrate community of mesas in the Robe Valley region,* the *Subterranean invertebrate community of pisolitic hills in the Pilbara* PEC; and cumulative, temporal drawdown impact to the Jimmawurrada Creek Alluvial Aquifer containing records of the Blind Cave Eel within the *Stygofaunal Community of the Bungaroo Aquifer* PEC are significant and warrant offsets. In addition, given the current limited status of knowledge of the Blind Cave Eel, there is uncertainty regarding the area of risk of groundwater drawdown, the degree of habitat modification and the range and sensitivity of the species. Therefore, this risk is proposed to be offset to enhance further research into the understanding of the occurrence and range of this species. The proposed offsets are discussed in Section 13.

Given the proposed mitigation and offset, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Subterranean Fauna.

8. TERRESTRIAL FAUNA

This section describes the terrestrial fauna that occur within the Proposed Change Area, provides an assessment of the potential impacts of the Proposed Change to conservation significant fauna, proposed mitigation measures and the predicted outcome for terrestrial fauna.

8.1 EPA Objective

The EPA applies the following objective from the Statement of Environmental Principles, Factors and Objectives (2018c) in its assessment of proposals that may affect terrestrial fauna:

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

8.2 Policy and Guidance

8.2.1 EPA Policy and Guidance

The following State and Commonwealth policy and guidance documents have been considered in the assessment of terrestrial fauna:

- EPA (2018c) Statement of Environmental Principles, Factors and Objectives;
- EPA (2016i) Environmental Factor Guideline: Terrestrial Fauna;
- EPA (2016j) Technical Guidance: Sampling methods for terrestrial vertebrate fauna (the content in this Technical Guidance has not yet been updated from the technical report of the EPA and the then Department of Environment and Conservation issued in September 2010 and titled ‘Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment’);
- EPA (2016k) Technical Guidance: Terrestrial Fauna Surveys (the content in this Technical Guidance has not yet been updated from EPA Guidance Statement No. 56 issued in June 2004)
- EPA (2016l) Technical Guidance: Sampling of short range endemic invertebrate fauna (the content in this Technical Guidance has not yet been updated from EPA Guidance Statement No. 20 issued in May 2009);
- EPA (2017a) Instructions on how to prepare *Environmental Protection Act 1986 Part IV* Environmental Management Plans; and
- DMP and EPA (2015) Guidelines for Preparing Mine Closure Plans.

8.2.2 Other Policy and Guidance

- Survey guidelines for Australia's threatened mammals (Department of Sustainability, Environment, Water, Population and Communities [DSEWPaC] 2011a);
- Survey guidelines for Australia's threatened reptiles (DSEWPaC 2011b);
- Survey guidelines for Australia's threatened bats (DEWHA 2010);
- Commonwealth Listing Advice on Northern Quoll (*Dasyurus hallucatus*) (Threatened Species Scientific Committee [TSSC] 2005);
- Threat abatement plan to reduce the impacts on northern Australia's biodiversity by the five listed grasses (DSEWPaC 2012a);
- Approved Conservation Advice on *Ophisternon candidum* (Blind Cave Eel) (DEWHA 2008a);
- Approved Conservation Advice on *Liasis olivaceus barroni* (Olive Python (Pilbara subspecies)) (DEWHA 2008b);
- Conservation Advice for *Macroderma gigas* (Ghost Bat). (TSSC 2016a);

- Conservation Advice for *Rhinonicteris aurantia (Pilbara form)* (Pilbara Leaf-nosed Bat) (TSSC 2016b);
- WA Environmental Offsets Policy (Government of WA 2011);
- WA Environmental Offsets Guidelines (Government of WA 2014b);
- Australian Water Quality Guidelines for Fresh and Marine Waters (ANZECC/ARMCANZ 2000);
- National Recovery Plan for the Northern Quoll (Hill and Ward 2010);
- Threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads (DSEWPaC 2011c);
- Commonwealth Listing Advice on ten species of Bats (TSSC 2001);
- Threat abatement plan for predation by the European red fox (DEWHA 2008); and
- Threat abatement plan for predation by feral cats (Department of the Environment [DoE] 2015).

8.3 Environmental Scoping Document

Table 8-1 summarises where the requirements of the ESD are addressed in this section.

Table 8-1: Requirements of the ESD for Terrestrial Fauna

Task number	Requirement of ESD	Section number
25	Provide a desktop review and analysis of all surveys of the Development Envelope undertaken in accordance with EPA Policy and Assessment, survey guidelines for Australia's threatened animals.	Section 8.4
26	The study should include: • a justification of how those surveys are relevant and representative of the Development Envelope and if they were carried out using methods consistent with the EPA policy • a comprehensive listing of vertebrate fauna and SRE invertebrate fauna known or likely to occur in the habitats present, and identification of conservation significant fauna species likely to occur in the area.	Section 8.4
27	Conduct Level 2 terrestrial fauna and SRE invertebrate surveys in areas not previously surveyed that are likely to be directly or indirectly impacted as a result of the Proposal. Surveys are to be undertaken in accordance with technical guidance statements and, where available, species-specific survey guidelines for relevant species listed under the WC Act and the EPBC Act.	Section 8.4
28	Conduct additional targeted surveys for conservation significant fauna that are known to or likely to occupy habitats in the Development Envelope if demonstrated to be required based on the results of the desktop study and Level 2 surveys.	Section 8.4
29	Specify MNES being assessed as part of the accredited assessment.	Section 8.4 and 12
30	Investigate and provide a description of any potential bat populations and habitat (including foraging habitat) in the Development Envelope, and potential impacts from the Proposal.	Section 8.4 and 8.6

Task number	Requirement of ESD	Section number
31	For each relevant conservation significant species, including MNES (Northern Quoll, Pilbara Olive Python, Pilbara Leaf-nosed Bat, and Ghost Bat) recorded or likely to occur within the Development Envelope, provide where possible: • baseline information on their distribution (including known occurrences), ecology, and habitat preferences at the site level • information on the conservation value of each habitat type from a local and regional perspective; • if a population of a conservation significant species is present on the site, its size and the importance of that population from a local and regional perspective • maps illustrating the known recorded locations of conservation significant species and short-range endemic invertebrates in relation to the proposed disturbance and areas to be impacted.	Section 8.4.5, 8.4.8 and 8.6
32	Identify the fauna habitat types within and outside the areas of impact. Consider habitat types that provide important ecological function within the Development Envelope.	Section 8.4
33	Discuss known existing threats to conservation significant species, whether or not attributable to the Proposal, with reference to relevant impacts from the Proposal (including taking into consideration any relevant guidelines, policies, plans and statutory provisions).	Section 8.5 and 8.6
34	Provide a detailed description of the potential direct, indirect and cumulative impacts to conservation significant species within the Development Envelope on a local and regional scale. Propose areas of key significance that may be considered for mine exclusion zones (including cave habitats, rocky outcrops and pools).	Section 8.5 and 8.6
35	For all conservation significant species that are not likely to be impacted by the Proposal, but for which suitable habitat is present, demonstrate that an impact on the species will not or is unlikely to occur.	Section 8.4.4
36	Discuss proposed objectives, management, monitoring and mitigation methods to be implemented demonstrating that the design of the Proposal has addressed the mitigation hierarchy to avoid and minimise impacts to terrestrial fauna.	Section 8.9
37	Develop a conservation significant fauna management plan to apply to the Proposal. The objective of the plan is to ensure the protection of threatened species that will be impacted by the Proposal and their habitat within the Development Envelope.	Appendix 6

Task number	Requirement of ESD	Section number
38	Prepare a Mine Closure Plan consistent with DMP and EPA *Guidelines for Preparing Mine Closure Plans* (2015), which addresses the need for progressive rehabilitation of habitat for conservation significant species.	Appendix 7
39	Predict the inherent and residual impacts before and after applying the mitigation hierarchy and identify whether the residual impacts are significant by applying the Significant Residual Impact Model in the WA Environmental Offsets Guideline.	Section 8.9 and 8.10
40	Quantify any significant residual impacts by completing the Offset Template, spatially defining the habitat area for each significant fauna species that will be disturbed as a result of the proposal (excluding the approved Mesa J Operation) and propose an appropriate offsets package that demonstrates application of the WA Environmental Offsets Policy and Guideline.	Section 8.9 and 8.10
41	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Section 8.9 and 8.10

8.4 Receiving Environment

8.4.1 Project setting

The Pilbara bioregion is a major centre for biodiversity within WA and provides some key habitat types for fauna. This appears to be related to the diversity of geological, altitudinal and climatic elements in the region, as well as being a function of its location (Biota 2011b). The Pilbara is located in a transitional zone between the floras of the Eyrean (central desert) and southern Torresian (tropical) bioclimatic regions, and is also an area of transition for fauna (Kendrick 2001 as cited in Biota 2011a).

The Robe Valley hosts a number of habitats important for terrestrial fauna; in particular, mesa landforms, which are prominent features in the Robe Valley landscape supporting significant terrestrial fauna habitats, including MNES. Mesa H forms escarpments to the south and east of the Robe River and lies immediately to the west of Mesa J Iron Ore Development which has retained an escarpment along its northern margin, adjacent to the Robe River, for the purposes of retaining environmental and heritage values, including important fauna habitat.

Four terrestrial MNES species have been recorded in the Proposed Change Area; Northern Quoll, Pilbara Olive Python, Ghost Bat and Pilbara Leaf-nosed Bat.

The Proposed Change Area includes the ephemeral Robe River and a portion of Jimmawurrada Creek which is a tributary of the Robe River. These watercourses provide shelter, dispersal and foraging habitat for terrestrial fauna. The Robe River also contains numerous semi-permanent pools within the Proposed Change Area, with permanent pools around Yeera Bluff occurring on the western side of the Proposed Change.

The Robe River and Jimmawurrada Creek have been affected by decades of pastoral grazing activities. Surplus water discharge from the Mesa J Iron Ore Development has been discharging into Jimmawurrada Creek and West Creek since 1993. A portion of Jimmawurrada Creek has also been exposed to groundwater drawdown in the vicinity of the Southern Cutback Borefield and the CWSP (Refer to Section 5).

The Proponent has undertaken annual biophysical and ecological monitoring of the Robe River pools since 1991. This long-term monitoring project includes aquatic fauna, channel

/ pool morphology, riparian / bank condition, weeds, water flows and water quality both upstream and downstream of the existing Mesa J Iron Ore Development. The results of the survey indicate that changes in ecological conditions of the pools are primarily the result of seasonal and annual variation in rainfall and subsequent river flows. Extreme natural events (flooding and dry spells) have been found to have an overriding influence on conditions in the watercourses (Streamtec 2017). To date, there have been no detectable changes in the aquatic ecology of the Robe River that could be attributed to mining operations, despite long term surplus water discharge programs and mining at Mesa J.

8.4.2 Terrestrial fauna studies

Systematic terrestrial fauna surveys have been undertaken in the Robe Valley area around Mesa J since 1991, progressively extending to Mesa A – Warramboo, covering an area in excess of 72,400 ha. The combined coverage of these surveys provides a considerable knowledge base of the terrestrial fauna present in the Robe Valley and provides context for the area covered by the Proposed Change Area. Surveys were also conducted specifically for this Proposed Change comprising a two-phase terrestrial fauna assessment by Astron Environmental during 2015 – 2016 and additional targeted fauna surveys (Appendix 11).

The annual monitoring of Robe River pools undertaken by Streamtec is ongoing with the most recent survey undertaken in April 2017. Results from the monitoring were consistent with previous years as no statistically significant changes to the ecology of the pool systems beyond natural variability has been detected (Streamtec 2017).

Level 2 field surveys were undertaken in accordance with the requirements of the Environmental Protection Authority (EPA) Guidelines relevant at the time of the surveys, and are considered adequate including:

- Position Statement No. 3 (EPA 2002);
- Technical Guidance - Subterranean Fauna Surveys (EPA 2016g);
- Technical Guidance - Sampling Methods for Terrestrial Fauna (Environmental Protection Authority 2016j); and
- Technical Guidance - Terrestrial Fauna Surveys (EPA 2016k).

Table 8-2 summarises the key, recent terrestrial fauna surveys most relevant to the Proposed Change and Figure 8-1 and Figure 8-2 outline their extent, as well as the extent of other historical surveys. The most recent of these studies are provided in Appendix 11. Targeted surveys for key conservation significant species (excluding the Ghost Bat) were not conducted for the reasons outlined in Section 8.4.2.1.

Table 8-2: Summary of Supporting Terrestrial Fauna Surveys

Survey report	Summary	Survey Date
Non-aquatic		
Mesa H – Targeted Night Parrot Fauna Assessment, September 2017. Astron (2017b)	A targeted, systematic field survey for the Night Parrot including autonomous recording units and motion sensitive cameras. No individual sightings, vocal calls or any other signs of the Night Parrot were recorded during the current targeted survey from 12 nights of Autonomous Recording Units recordings and eight camera trap nights.	September 2017
Mesa H – Desktop Mesa Façade Assessment October 2017. Astron (2017c)	A mesa façade ecological assessment for the Mesa H deposit, to provide data on the ecological value of mesa facades to assist in determining which facades or sections of mesa facades should be retained. The area assessed totalled 446.8 ha.	October 2017
Mesa H Ghost Bat, Macroderma gigas – Contextual Study September 2017. Astron (2017d)	Contextual analysis of Ghost Bat within the vicinity of the Mesa H survey area, to identify significant habitats for Ghost Bat and discuss habitat in a local and regional context.	September 2017
Mesa H Level 2 Fauna Assessment 2016. Astron (2017e)	A two-phase Level 2 vertebrate and SRE invertebrate fauna assessment in October 2015 and May 2016 in the Mesa H Development Envelope which is approximately 4,839 ha in size, including some adjacent areas. The survey mapped fauna habitats and recorded species present including conservation significant species, using trapping grids, avifauna surveys, motion sensitive cameras, acoustic bat surveys, active foraging, targeted searches and nocturnal spotlighting.	October 2015 and May 2016
Robe Valley Mesa A to Mesa 2405A, impact of mining on Ghost bat presence and activity, April 2017, including assessment of caves on Mesas F and G. Bat Call WA (2017a)	An assessment of the impact on Ghost bat populations of open cut iron ore mining in the Robe River valley including categorisation of the status of mesas, measurement of mesa areas and perimeters, counting of caves and lengths of facades measures, review of previous studies and detailed assessments of all identified caves and shelters on mesas B, C, F, G and H. The study was conducted in July 2016 and April 2017.	April 2017
Robe Valley Mesa H, Ghost bat roost cave assessment, April 2017. Bat Call (2017b)	A targeted assessment of bat conservation values at Mesa H including visual assessment of cave environments and an extensive search for Ghost bat presence, including roosting bat. Presence of guano and middens were recorded.	April 2017
Robe Valley Mesas Fauna Survey. Biota (2011b)	A single phase Level 2 fauna survey of a study area encompassing Mesas B, C, D, E, F, H and I to assess significant conservation significant fauna values including vertebrate and SRE fauna.	March 2011

Survey report	Summary	Survey Date
Aquatic		
Mesa H Project Baseline Aquatic Ecosystem Survey Dry Season Sampling 2016. WRM (2018)	Baseline aquatic ecosystem sampling of the Robe River system (post dry season) upstream and downstream of the Mesa H project area, including assessment of permanent pools, and assessment of water quality and sampling for micro invertebrates, hyporheic fauna, macroinvertebrates and fish.	October 2017
Aquatic Ecosystems Study - April 2017 Streamtec (2017)	An annual biophysical / ecological survey of the Robe River conducted in April 2017, as part of an on-going commitment to assess environmental impacts of mine development at Mesa J on the adjacent and downstream aquatic ecosystem of the river (largely the permanent, 'refugial' pools). This monitoring includes a long-term assessment of aquatic fauna (i.e. aquatic macroinvertebrates and fish), channel / pool morphology, riparian / bank condition, weeds, water flows and water quality, and has been conducted annually since 1991 (i.e. before mining at Mesa J).	April 2017
Mesa H Project Baseline Aquatic Ecosystem Survey Wet Season Sampling 2016. WRM (2017)	Baseline aquatic ecosystem sampling of the Robe River system (post wet season) upstream and downstream of the Mesa H project area, including assessment of permanent pools, and assessment of water quality and sampling for micro invertebrates, hyporheic fauna, macroinvertebrates and fish.	April / May 2016

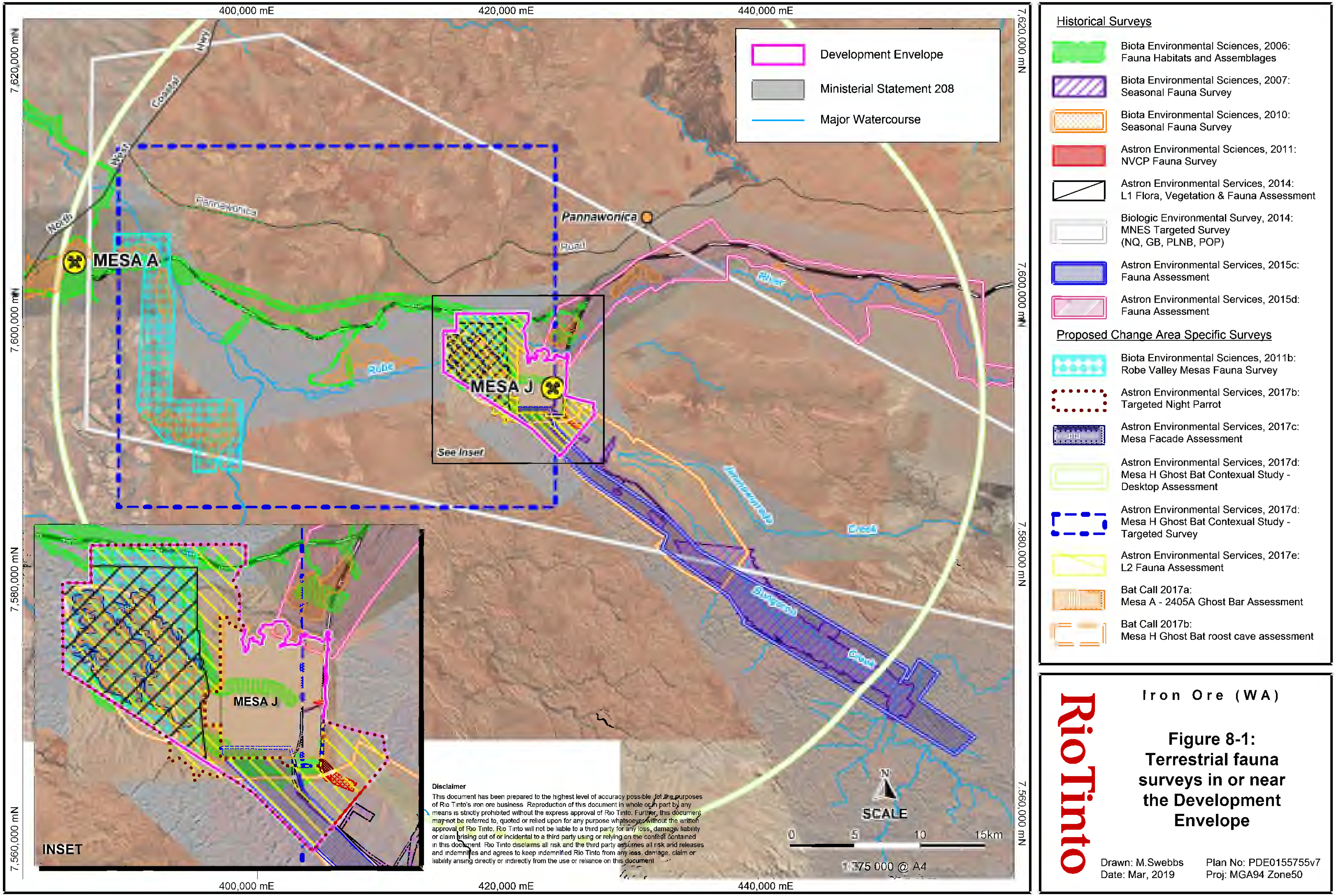
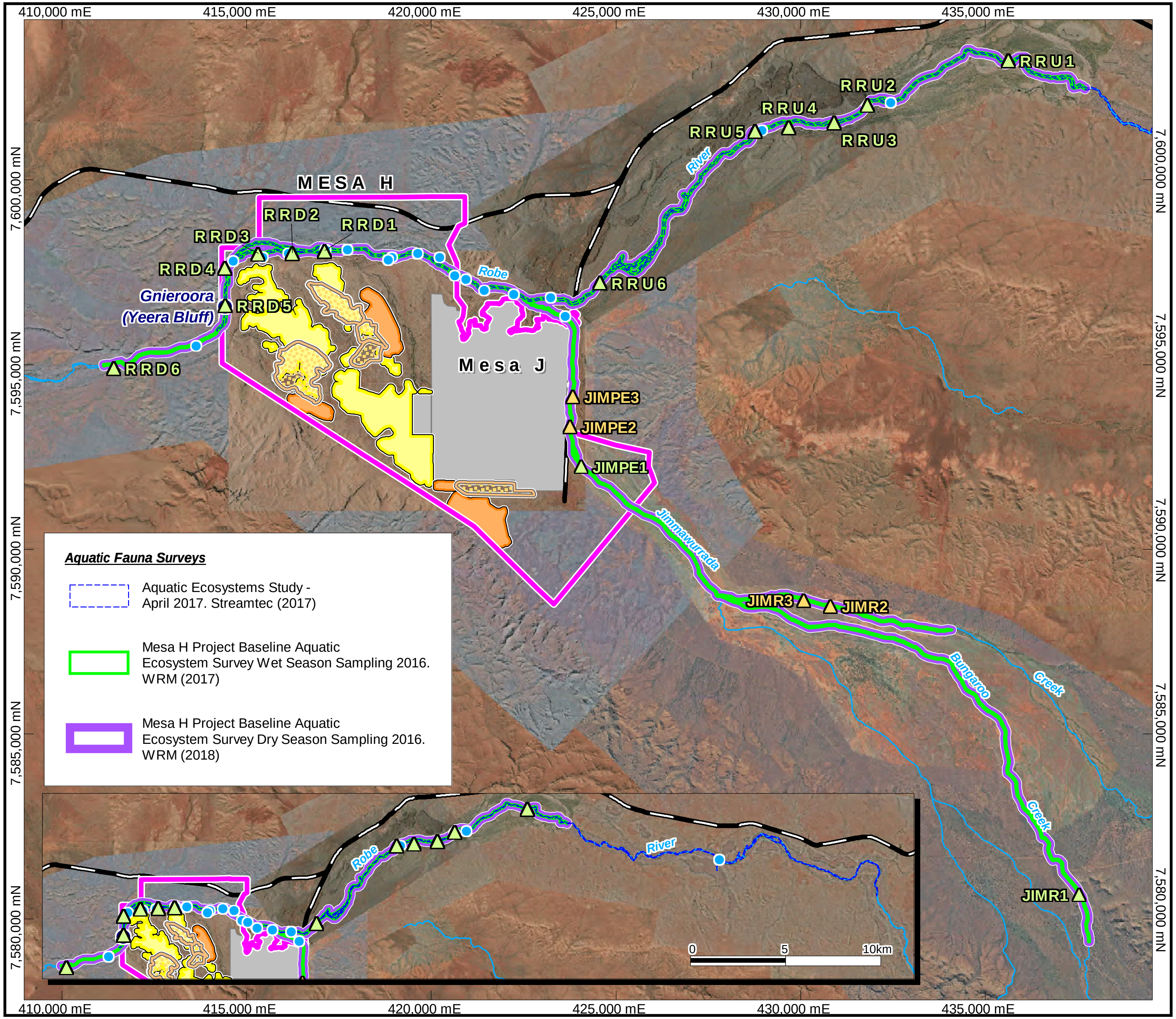


Figure 8-1: Terrestrial fauna surveys in or near the Development Envelope



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse
- Permanent Pool
- Pool
- Aquatic Fauna Sampling Site
- Dry Sediment Sampling Site

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile

N

SCALE

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Disclaimer

RioTinto

Iron Ore (WA)

Figure 8-2: Aquatic fauna surveys in or near the Development Envelope

Drawn: M.Swebbs
Date: Feb, 2019

Plan No: PDE0159427v5
Proj: MGA94 Zone50

8.4.2.1 Targeted surveys for conservation significant fauna

Specific targeted surveys have been undertaken in the Development Envelope for the Ghost Bat, given the presence of several roosts in the Proposed Change Area and throughout the Robe Valley. Northern Quoll, Pilbara Leaf-nosed Bat and Pilbara Olive Python have also been surveyed adequately, although not in specific targeted surveys, targeted techniques have been used for these species across numerous surveys which overlap with the Development Envelope as described below.

Northern Quoll

In addition to the Level 2 fauna survey for the Proposed Change (Astron 2017e), numerous surveys, comprising targeted surveys and monitoring (including ongoing monitoring) have been undertaken for the Northern Quoll within the Development Envelope and across the broader Robe Valley. These include:

- Mesa H Landform:
    - Fauna Habitats and Fauna Assemblage of the Mesa A Transport Corridor and Warramboo (Biota 2006c);
    - Mesa J Tail Track Extension Vegetation, Flora and Fauna Survey (Astron 2011);
    - Robe Valley Mesa's Fauna Survey (Biota 2011b);
    - Mesa H - Level 1 Flora, Vegetation and Fauna Assessment (Astron 2014);
    - Yarraloola - Northern Quoll, Pilbara Olive Python and Pilbara Leaf-nosed Bat Targeted Survey (Biologic 2014); and
    - Yandicoogina Threatened Species Offset Plan (TSOP) – Northern Quoll monitoring.
- Outside and overlapping with the Development Envelope:
    - Bungaroo Trial Pit and Transport Corridor to Mesa J, Near Pannawonica: Fauna Assemblage Seasonal Survey (Biota 2007c);
    - Greater Bungaroo Seasonal Fauna Survey (Biota 2010b);
    - Middle Robe and East Deepdale Level 2 Fauna Assessment (Astron 2016d); and
    - Bungaroo Iron Ore Mine and Infrastructure Project Level 2 Fauna Survey (Astron 2016e).

The Biologic (2014) survey comprised a targeted survey for the Northern Quoll, Pilbara Olive Python and Pilbara Leaf-nosed Bat, covering the entire Development Envelope as shown in Figure 8-1.

A Northern Quoll monitoring program has been established and monitoring is continuing across Yarraloola Station, as part of the Land Management Area of the Yandicoogina TSOP, undertaken in partnership with the DBCA. The Land Management Area for this program encompasses the entirety of the Mesa H landform, and a significant portion of the Proposed Change Area.

In addition to the existing Northern Quoll monitoring program as part of the TSOP, ongoing monitoring within the Development Envelope and across the Robe Valley is proposed to be implemented as part of the EMP.

Pilbara Leaf-nosed Bat

The Pilbara Leaf-nosed Bat was targeted during the Astron (2017e) survey using 14 bat SM2 detector locations in the Proposed Change Area for a total of 27 recording nights. The species was also surveyed during the Level 1 survey of Mesa H in 2014 (Astron 2014). Further monitoring for this species by Rio Tinto was undertaken at an additional 66 locations over 144 nights. Under the Commonwealth survey guidelines, a minimum of 16 detector nights from four nights is recommended. From both the Level 2 fauna surveys and an additional ongoing monitoring, a total of 171 recording nights have been conducted within the Survey Area, well beyond the minimum requirement.

The Mesa H Bat Call WA surveys and Astron (2017e) Ghost Bat targeted regional sampling included active searches of caves with some prospectivity of supporting roosts for either Ghost Bats or Pilbara Leaf-nosed Bats; if the zoologists had found Pilbara Leaf-nosed Bats or roosts then these records and roosts would have also been recorded during the targeted Ghost Bat surveys.

Pilbara Olive Python

Currently no specific referral guidelines are appropriate to this species. Under the Commonwealth survey guidelines for the Pilbara Olive Python, nocturnal road cruising and targeted searching for this species within suitable habitat is deemed appropriate. These survey methods were employed during the Level 2 fauna survey by Astron (2017e). A total of 1,800 minutes (30 hours) of nocturnal spotlighting was undertaken which is considered more than adequate in detecting this species (Astron 2017e).

8.4.3 Fauna habitats

Seven broad-scale fauna habitat types have been recorded in the Proposed Change Area (Astron 2017e) comprising a total area of 4,839 ha. These include: *Riverine, Drainage Line, Gorge, Breakaway, Rocky Hills, Low Hills and Slopes, Loamy / Stony Plain* habitats as described in Table 8-3 and depicted in Figure 8-3.

The habitat types identified within the Proposed Change Area are not restricted at the local, sub-regional or regional scale.

The following habitats are considered to be of elevated significance:

- **Gorge and Breakaway habitats** collectively comprise approximately 2% of the Proposed Change Area and are considered the most significant for fauna, in particular conservation significant fauna; and the deeply incised gorges are considered important as refugia locally (Astron 2017e).
  - Breakaway habitat is a common feature of the Pilbara but as they tend to be narrow, linear features, they represent a small proportion of the total land area (Astron 2017e). The breakaways within the Development Envelope were largely associated with the mesa facades and contain numerous crevices, caves and overhangs; which provide sheltered microhabitats for terrestrial fauna.
  - Gorge habitat is the most restricted in the survey area. Whilst gorges are a common feature of the Pilbara, they tend to be narrow, linear features, and represent a small proportion of the total land area (Astron 2017e). They also represent important shelter or roosting habitat. Deep caves and semi-permanent rock pools were recorded in this habitat type which can provide refuge for fauna during harsh dry seasonal conditions.
  - In summary, the Gorge and Breakaway habitats provide:
    - important shelter or roosting habitat for bats of conservation significance, including the Pilbara Leaf-nosed Bat and Ghost Bat
    - potential denning and foraging habitat for the Northern Quoll
    - potential breeding / denning habitat for the Pilbara Olive Python; and
    - refugia, sheltered microhabitats and food resources for vertebrate fauna assemblages in general and for invertebrate groups that support SREs.

Caves and shelters considered likely to support Ghost bats (Bat Call 2017b) are identified in Section 8.4.5.2 and further described in Section 8.6.3.

- **Riverine Habitat** is delineated along the ephemeral Robe River and comprises 143 ha of the Proposed Change Area. It is considered to be of high importance to fauna species providing a range of ecological values to a broad suite of species (Astron 2017e).
    - The habitat generally comprises narrow, linear riparian woodlands, with vegetation being denser, taller and more diverse than the adjacent Drainage Line habitat. In the Proposed Change Area, this habitat unit is dominated by *Melaleuca argentea*, *Eucalyptus camaldulensis* and *Eucalyptus victrix*.
    - A significant feature of the Riverine habitat is the presence of semi-permanent and permanent pools along the Robe River (see Figure 5-6 in Section 5.4.4).
    - In summary, the Riverine habitat provides:
        - an important source of water to fauna in a largely dry landscape; permanent and semi-permanent water bodies provide drinking opportunities for a range of species and attract prey for predators;
        - a range of micro niches for vertebrate fauna for shelter and foraging, including the Pilbara Olive Python;
        - foraging sites for Ghost Bats, Pilbara Leaf-nosed Bats, Pilbara Olive Pythons and the Northern Quoll;
        - potential ecological corridors / dispersal routes for the Northern Quoll, Pilbara Olive Python, Pilbara Leaf-nosed Bat and Ghost Bat to traverse various habitats;
        - habitat for a range of aquatic fauna; and
        - areas likely to support SREs.

The remaining habitats and habitat features recorded within the Proposed Change Area are considered to be well represented in the Robe Valley and the Pilbara bioregion and are not considered to be of elevated significance. This includes the Drainage Line habitat of Jimmawurrada Creek which contains riparian vegetation and provides:

- a seasonal source of water to fauna in a largely dry landscape;
- suitable seasonal habitat for fauna of conservation significance;
- a potential dispersal route for the Northern Quoll;
- habitat for a range of aquatic fauna; and
- areas with a moderate potential to support SREs.

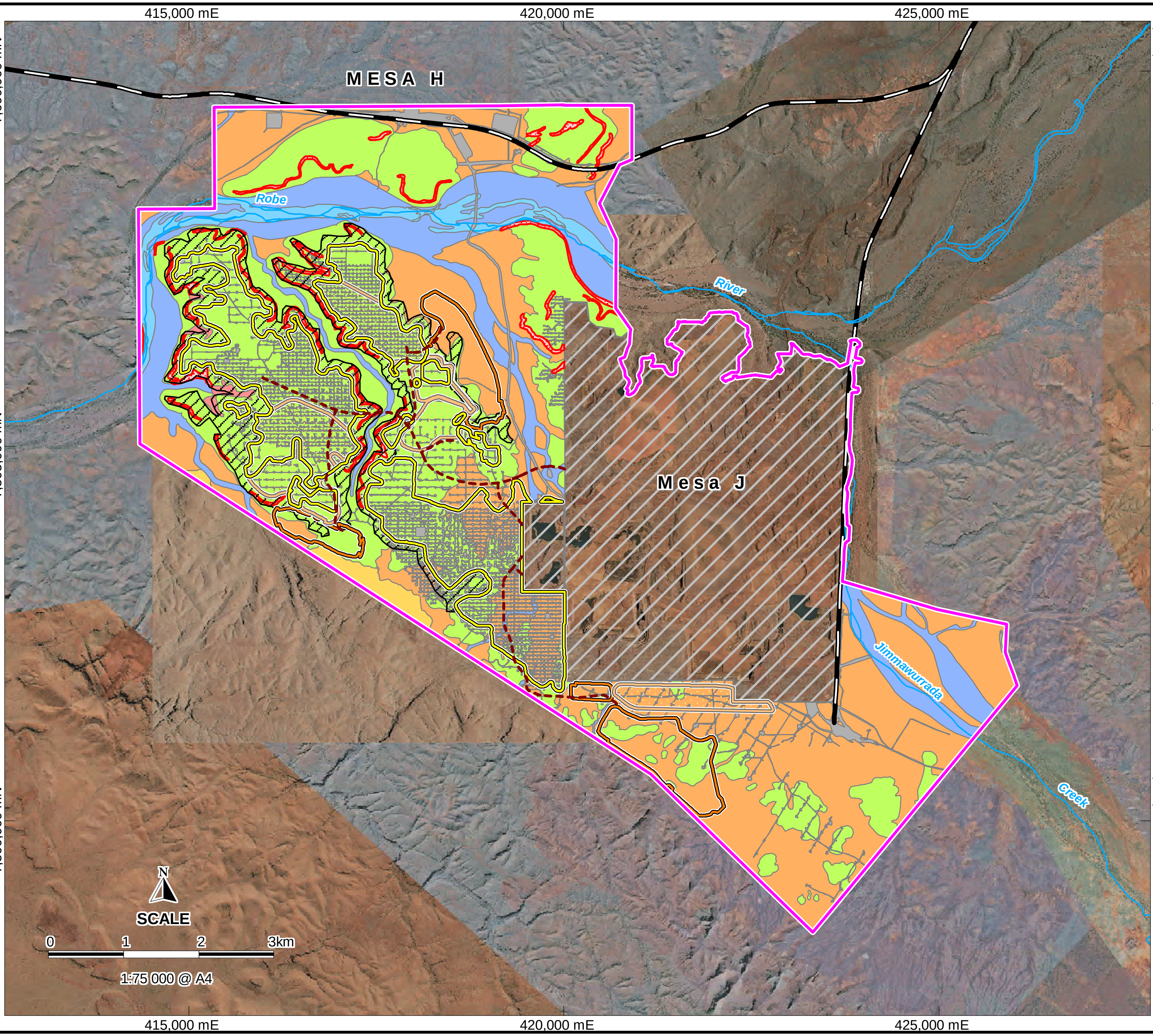
Areas of previously disturbed habitat were prevalent in the Low Slopes and Hills habitat on the mesa plateau and Loamy / Stony Plains habitat, in the form of exploration drill pads and associated tracks.

Habitat condition was assessed based on the presence of disturbances, using condition ratings suggested by Thompson and Thompson (2010). Loamy / Stony Plains habitat ranged from disturbed to very good condition, with some areas heavily affected by cattle grazing and Buffel grass. All other habitats were in good to high quality condition. Rocky Hills, Breakaway and Gorge habitats were generally in high quality condition (Astron 2017e).

The majority of Drainage Line and Riverine habitats were in poor to very good condition due to weed infestation associated with decades of pastoral activities (Astron 2017e).

Table 8-3: Fauna Habitats Mapped in the Proposed Change Area (Astron 2017e)

Habitat	Description and information	Extent in Proposed Change Area	Distribution	Potential to support fauna, including conservation significant species	Likelihood to support SREs
Riverine	Densely vegetated riparian zones of the Robe River often associated with permanent and semi-permanent water bodies on stony soils.	143 ha	Limited to linear isolated pockets of riparian vegetation adjacent to Drainage Line habitat.	High value to wide spectrum of fauna species. Moderate value to target MNES species as they are likely to forage and traverse in this habitat type.	Moderate
Drainage Line	Broad open valley floor of the Robe River on stony plains.	582 ha	Widespread. Commonly recorded in the Pilbara region.	Moderate value to wide spectrum of fauna species. Low value to target MNES species due to lack of refugia or shelter.	Moderate
Gorge	Deep often rocky gorges, sometimes with ephemeral, semi-permanent pools.	14.65 ha	A common feature in the Pilbara; however, as it occurs as narrow linear features, this habitat type represents a small proportion of the total land area. Most restricted habitat type in the Proposed Change Area.	Primary high value habitat for target MNES. Significant refugia/shelter sites. Supports diversity of fauna.	High
Breakaway	Breakaway or ridge line, usually associated with the Mesa façade, falling away to steep scree slope or drainage line.	83.5 ha	Common feature in Pilbara; however, occurs as narrow linear features, representing small proportion of land area. Associated with mesa landforms.	High value to target MNES as they are likely to roost and den within this habitat type.	High
Rocky Hills	Stony hills on high ranges with dissected valleys and gorges.	49.7 ha	Common and widespread throughout the Pilbara.	Moderate value for target MNES as they are likely to traverse and forage in this habitat type.	Moderate
Low Hills and Slopes	Low stony hills and slopes with dissected valleys and drainage on stony soils.	1,879 ha	Most common habitat type in the Proposed Change Area and widespread and common in Pilbara region.	Low value to target MNES.	Low to Moderate
Loamy / Stony Plain	Low-lying undulating loamy to stony plain within Robe valley floor.	1,712 ha	Second most common habitat in the Proposed Change Area and widespread and common in the Pilbara region.	Low value to target MNES.	Low
Disturbed	Cleared areas from mining and pastoralism activities.	372 ha	N/A	Little value as fauna habitat.	N/A
Mesa J	Existing mining operations	1,802 ha	N/A	Little value as fauna habitat	N/A



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile
- Haul Road
- Mining Exclusion Zone

Fauna Habitat

- Breakaway
- Loamy/stony plain
- Gorge
- Rocky hills
- Riverine
- Low hills and slopes
- Drainage Line
- Disturbed

Rio Tinto

Iron Ore (WA)

Figure 8-3: Fauna Habitats mapped in the Development Envelope

Drawn: M.Swebbs
Date: Feb, 2019

Plan No: PDE0152730v7
Proj: MGA94 Zone50

8.4.4 Terrestrial vertebrate fauna occurrence

Astron (2017e) recorded a total of 169 vertebrate fauna species within the Proposed Change Area during the survey, including two amphibians, 55 reptiles, 85 birds and 27 mammals (including four introduced species). The fauna species assemblage recorded during the current survey is considered typical of the Hamersley Range sub region extending from near Pannawonica to Mt Brockman as well as a subset of typical fauna assemblages across the Pilbara bioregion (Astron 2017e). The trapping effort of Astron (2017e) is shown in Figure 8-4. Survey sampling sites for the Night Parrot are shown in Figure 8-5.

Of the 169 vertebrate fauna species, six species of conservation significance were recorded, including species listed under the EPBC Act and / or the BC Act, together with species listed as Priority species by the DBCA (Table 8-4).

A desktop assessment identified one further species of conservation significance considered to have a high likelihood of occurring (Blind Snake), ten species with moderate likelihood of occurring and a further 13 with a low likelihood of occurring within the Proposed Change Area. Species considered to have a low likelihood of occurring are identified in Astron (2017e) and not addressed any further in this document.

Further detail of records and habitat preferences of conservation significant (non-aquatic) vertebrate fauna is provided in Section 8.4.5 and depicted in Figure 8-6.

It should be noted that pitfall traps for vertebrate fauna were not installed in the Breakaway habitat type for logistical reasons, owing to the lack of soil to dig pitfalls into (Astron 2017e), however this is not considered to be a limitation of the survey. The use of pitfall traps during Level 2 fauna surveys is generally designed to target small to medium ground-dwelling reptiles and mammals, particularly reptiles in the context of the Pilbara region. No conservation significant reptilian species occur within the Breakaway habitat type and specifically within the Development Envelope. To sample the Breakaway fauna habitat and record potential species of conservation significance, the site was sampled systematically through other accepted methods (i.e. wire cages traps and aluminium Elliot box traps). Two sites (site RVMP 12,252 trapping nights; site RVMP 16,518 trapping nights) combined for a total of 770 trap nights were surveyed within this habitat type (Astron 2017e).

The conservation significant mammals expected to occur within this habitat type include the Northern Quoll and potentially the Long-tailed Dunnart, which would have been captured via other accepted methods which were used (i.e. wire cages traps and aluminium Elliot box traps). In addition, other non-systematic fauna methods such as diurnal and nocturnal searching, opportunistic records and targeted searches facilitated the recording of the fauna assemblage for this habitat type and generally supplemented the species which would have been recorded through pitfall trapping (Astron 2017e).

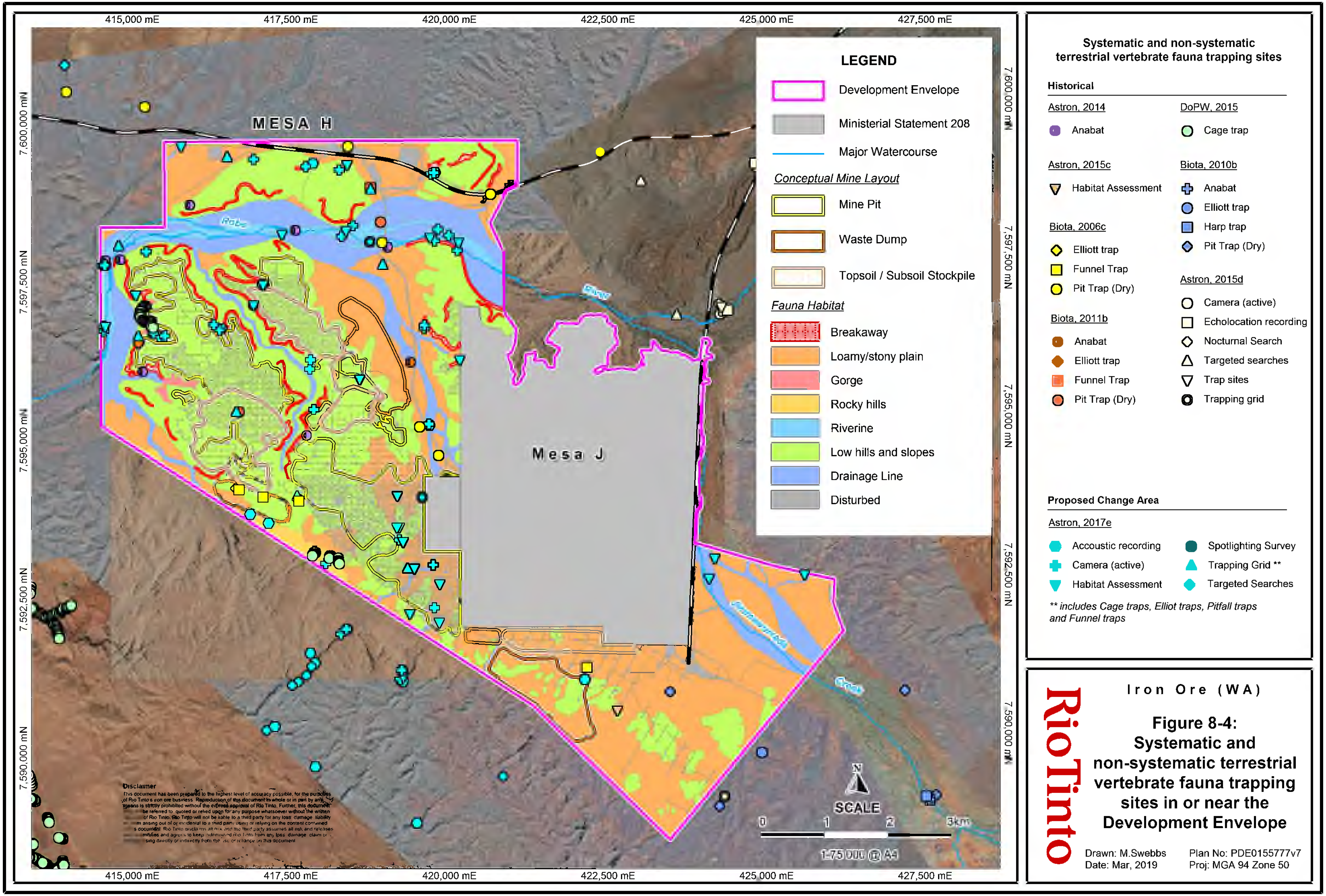
Table 8-4: Records and Likelihood of Occurrence of Conservation Significant (Non-Aquatic) Vertebrate Fauna Species

Name	Conservation status		Records within Proposed Change Area	Public database records	Preferred habitat	Habitat occurrence in the Proposed Change Area	Likelihood of occurrence
	State	Commonwealth					
Northern Quoll *Dasycercus hallucatus*	Schedule 2	Endangered	Four trap captures and 22 recorded on camera at 14 sites plus scats and tracks (Astron 2017e).	Y	Rocky hills, gorges, mesas, high and low plateaus, low slopes and stony plains with spinifex.	Y	Recorded
Pilbara Olive Python *Liasis olivaceus barroni*	Schedule 3	Vulnerable	One individual and two scats (Astron 2017e).	Y	Escarpments, deep gorges, water holes and rock piles associated with permanent pools in rocky areas.	Y	Recorded
Pilbara Leaf-nosed Bat *Rhinonicteris aurantia*	Schedule 3	Vulnerable	Multiple calls recorded in vicinity of Robe River and along southern boundary of Proposed Change Area (Astron 2017e).	Y	Deep caves with high humidity and stable temperatures, water courses, riparian vegetation, hummock grassland and sparse tree and shrub savannah.	Y	Recorded
Ghost Bat *Macroderma gigas*	Schedule 3	Vulnerable	Nine nocturnal and two diurnal roosts recorded as well as calls and scats (Astron 2017e, Bat Call 2017b).	Y	Rocky gorges and breakaways with caves and crevices.	Y	Recorded
Lined Soil-crevice Skink *Notoscincus butleri*	Priority 4	N/A	One recorded (Astron 2017e).	Y	Spinifex areas near creek and river margins.	Y	Recorded

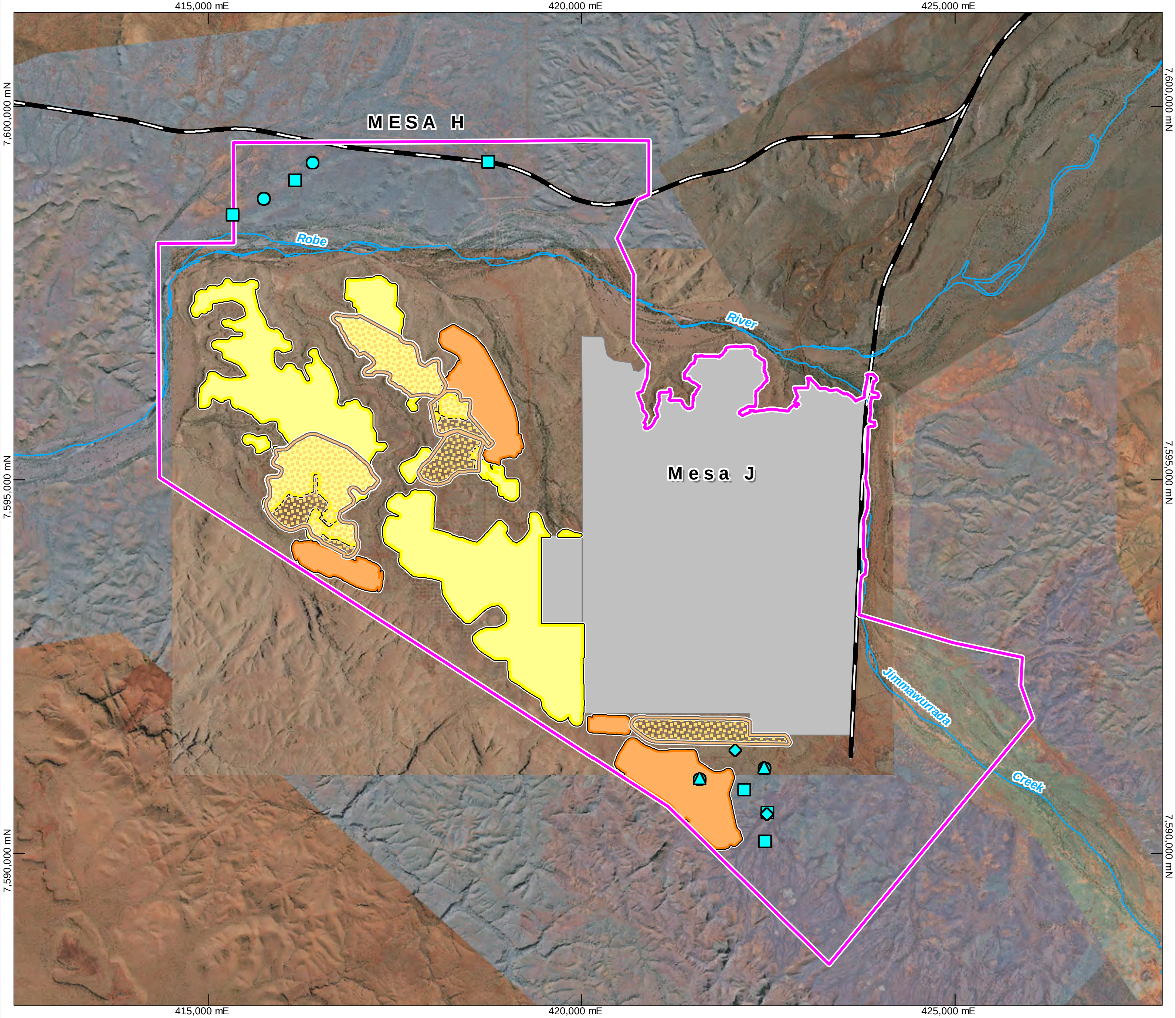
Name	Conservation status		Records within Proposed Change Area	Public database records	Preferred habitat	Habitat occurrence in the Proposed Change Area	Likelihood of occurrence
	State	Commonwealth					
Western Pebble Mound Mouse *Pseudomys chapmani*	Priority 4	N/A	Five inactive mounds (Astron 2017e). One inactive mound previously recorded by Astron (2014) and one from Biota (2006c).	Y	Gentle slopes of rocky ranges where the ground is covered by stony mulch and vegetated by hard spinifex, with sparse overstorey of eucalypts and scattered shrubs.	Y	Recorded
Blind Snake *Anilios ganei*	Priority 1	N/A	Previously recorded in vicinity of survey area (Astron 2017e)	Y	Moist gorges and gullies and potentially occurs over stony habitats.	Y	Highly likely
Fork-tailed Swift *Apus pacificus*	Schedule 5	Migratory	Nil	N	Largely aerial independent of the terrestrial environment.	Y	Moderately likely
Letter-winged Kite *Elanus scriptus*	Priority 4	N/A	Nil	Y	Arid inland regions and permanent water.	Y	Moderately likely
Australian Painted Snipe *Rostratula benghalensis (sensu lato)*	Schedule 2	Endangered	Nil	Y	Range of wetland habitats.	Y	Moderately likely
Common Sandpiper *Actitis hypoleucos*	Schedule 5	Migratory	Nil	Y	Coastline and inland areas, most common northern and western Australia.	Y	Moderately likely

Name	Conservation status		Records within Proposed Change Area	Public database records	Preferred habitat	Habitat occurrence in the Proposed Change Area	Likelihood of occurrence
	State	Commonwealth					
Sharp-tailed Sandpiper *Calidris acuminata*	Schedule 5	Migratory	Nil	Y	Fresh or brackish wetlands, most commonly in coastal areas but also occurs inland.	Y	Moderately likely
Wood Sandpiper *Tringa glareola*	Schedule 5	Migratory	Nil	Y	Well vegetated, shallow, freshwater wetlands.	Y	Moderately likely
Common Greenshank *Tringa nebularia*	Schedule 5	Migratory	Nil	Nil	Variety of inland and sheltered coastal wetland habitats.	Y	Moderately likely
Oriental Pratincole *Glareola maldivarum*	Schedule 5	Migratory	Nil	Y	Plains, floodplains, grasslands and bare areas.	Y	Moderately likely
Long-tailed Dunnart *Sminthopsis longicaudata*	Priority 4	N/A	Nil	Nil	Rocky and stony soils with hummock grasses and shrubs.	Y	Moderately likely
Short-tailed Mouse *Leggadina lakedownensis*	Priority 4	N/A		Y	Sandy soils and cracking clays.	Y	Moderately likely

* Public database records include the results of NatureMap and WA Museum database searches in a 40 km radius and the EPBC Protected Matters Search Tool in a 50 km radius. Note that 40 km is the largest possible search area for NatureMap and the WA Museum.



Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile

Night Parrot
Astron (2017b)

- Acoustic recording
- Active foraging
- Camera (active)
- Habitat Assessment

N

SCALE

0 1 2 3km

1:75 000 @ A4

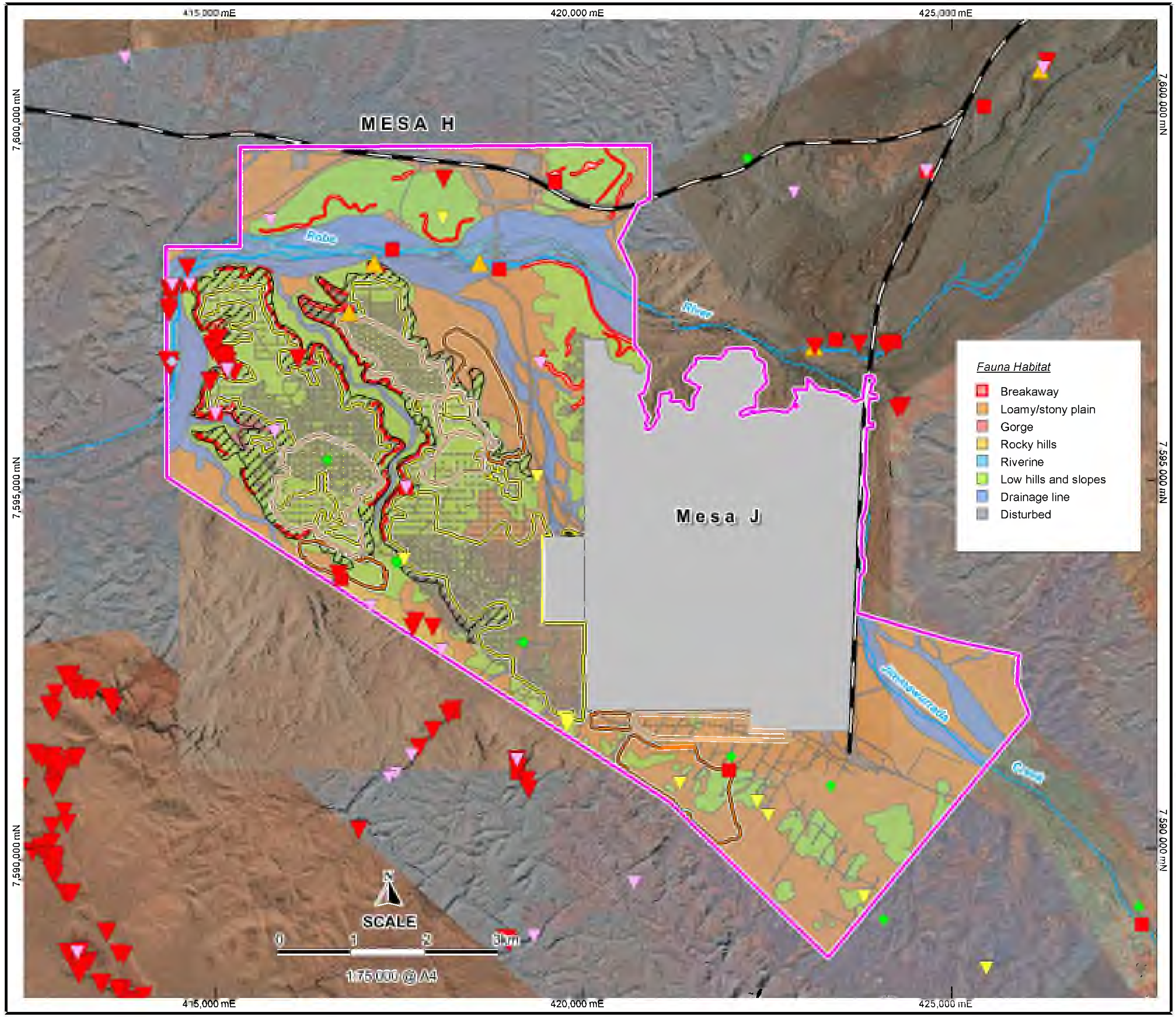
Iron Ore (WA)

Figure 8-5:
Night Parrot targeted survey sampling sites

Drawn: M.Swebbs
Date: Feb, 2019

Plan No: PDE0164867v3
Proj: MGA 94 Zone 50

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile
- Mining Exclusion Zone

Conservation listed fauna

- Ghost Bat (*Macroderma gigas S3)*
- Lined soil-crevice skink (*Notoscincus butleri P4)*
- Northern Quoll (*Dasyurus hallucatus S2)*
- Pilbara leaf-nosed bat (*Rhinonicteris aurantia S3)*
- Pilbara Olive Python (*Liasis olivaceus subsp. barroni S3)*
- Western Pebble-mound Mouse (*Pseudomys chapmani P4)*

RioTinto

Iron Ore (WA)

Figure 8-6: Conservation significant terrestrial vertebrate fauna recorded in or near the Development Envelope

Drawn: M.Swebbs Plan No: PDE0152633v10
Date: Feb, 2019 Proj: MGA 94 Zone 50

Geospatial Information and Mapping

8.4.5 Conservation significant terrestrial vertebrate (non-aquatic) fauna species

8.4.5.1 Northern Quoll (Confirmed)

The Northern Quoll is listed as Endangered under Schedule 2 of the BC Act and the EPBC Act. The Northern Quoll was originally found across northern Australia from the North-West Cape of WA to south-east Queensland; however, its abundance has significantly declined in recent years. This species is now restricted to five regional populations across Queensland, the Northern Territory and WA on both the mainland and offshore islands (DotEE 2017a).

In the Pilbara, the species is considered to favour uplands including rocky gorges, breakaways and hills. Rocky habitats adjoining drainage lines have a heightened level of importance given the close proximity of denning habitat to foraging areas. Habitat within the Northern Quoll's modelled distribution that provides shelter for breeding, refuge from fire / or predation and potential poisoning from *Rhinella marina* (Cane Toad) is considered habitat critical to the survival of the Northern Quoll (DoE 2016).

The species was recorded 32 times in the Proposed Change Area by Astron in 2016, including six captures (four confirmed separate individuals), 24 remote camera location recordings and four scats, tracks and / or trace records (Astron 2017e). The majority of records were found in Breakaway habitat with some in Riverine and Gorge habitat types; however, the species is also likely to utilise Rocky Hills habitat (Astron 2017e). Astron (2014) recorded the Northern Quoll at two locations in the survey area from scat records within the Rocky Hills habitat type. Within the first phase of the Astron (2017e) survey undertaken in 2015, the Northern Quoll was recorded at two locations in the survey area, in the Riverine habitat type and Biota (2011b) recorded this species once in the Breakaway habitat type. All previous records of this species in the survey area were from sites consistent with the preferred habitat for this species.

The Gorge, Breakaway and Riverine habitats are the most important habitats for Northern Quoll in the Development Envelope. The Gorge and Breakaway habitats contain rocky environments of high relief that are particularly important for Northern Quolls in the Pilbara as they provide denning sites for breeding and shelter and diverse microhabitats for foraging (Astron 2017e). Records of this species in the Riverine habitats and the presence of permanent water close to rocky habitats, suggest that the Riverine habitat is also an important foraging site for this species. All other habitats are considered to provide limited foraging and dispersal habitat for the Northern Quoll (Astron 2017e).

As the Northern Quoll is a MNES, this species is subject to assessment as part of the Environmental Review accredited assessment which is addressed in Section 12.

8.4.5.2 Ghost Bat (Confirmed)

The Ghost Bat is listed as Vulnerable under Schedule 3 of the BC Act and also as Vulnerable under the EPBC Act. The Ghost Bat roosts during the day in caves, rock crevices and disused mine shafts and adits. Roost sites used permanently are generally deep natural caves or disused mines with a relatively stable temperature of 23-28 ^{o}C and humidity above 50%. Individuals require a range of cave sites and move between roosts seasonally or according to weather conditions. Populations are widely dispersed when not breeding and concentrate in relatively few roost sites when breeding.

Ghost Bats forage over a wide range of habitats typically up to 2 km from their diurnal roost site and individuals generally return to the same foraging areas each night. Foraging Ghost Bats use echolocation during flight to detect prey and use passive sit-and-wait hunting techniques using eyesight to scan for prey from roosts up to 3 m above the ground, such as rocky overhangs and tree branches (MWH 2015; TSSC 2016a).

The Ghost Bat has a patchy distribution in the Pilbara. The regional Pilbara Ghost Bat population is estimated at 1,300 to 2,000 individuals, with approximately 1,500 estimated in the Chichester sub-region and approximately 350 estimated in the Hamersley sub-region, the majority of which are known from six historical mine workings; two of which appear to have disappeared (TSSC 2016a). The largest colonies are located in the Chichester sub-region and support up to several hundred individuals (Bat Call 2016). The smaller colonies of the Hamersley sub-region typically support less than ten (TSSC 2016a), but potentially up to around 25 individuals in local groups (Bat Call 2016). To persist, these groups need roost complex including at least one deep cave with characteristics of a maternity roost, multiple caves/shelters and overhangs in close proximity offering nocturnal and refuge opportunities, productive set of gullies and gorges locally and productive foraging with a 5 - 10 km radius, which usually includes a good riparian line and protection from human interference (Bat Call 2016).

The Ghost Bat is common in the Robe Valley, often occurring in groups of up to 20 individuals (MWH 2015). Astron completed a fauna survey of the Robe Valley to the east of Mesa J (including assessment of potential Ghost Bat roosts) (Astron 2015c) and a contextual Ghost Bat habitat assessment of the Robe Valley from Mesa B to Mesa J (Astron 2017d). Potential diurnal Ghost Bat roosts sites were identified at Mesas B, C, F, G, H and in the Middle Robe region approximately 60 km east of the Development Envelope. The contextual assessment also identified high quality habitat along the Buckland Hills to the south of Mesa H (Astron 2017d). The contextual analysis notes that the Ghost Bat tends to occur in fewer locations but greater numbers in the Chichester sub region when compared to occurrence in the Hamersley sub region where the species is known from more locations, but occurs in smaller numbers. Observations to date in the Robe Valley indicate that the Robe Valley Ghost Bats are moving through the landscape opportunistically and possibly seasonally and are taking advantage of all of the foraging and roosting opportunities provided by the valley of the river, its tributaries and the various caves available (B. Bullen, Bat Call WA, pers. comm. 2019).

The most important habitat types for Ghost Bat within the Proposed Change Area includes Gorge and Breakaway habitat for their cave forming characteristics providing potential shelter and foraging habitat, representing 2% of the Proposed Change Area; and Riverine habitat for foraging and dispersal, representing 16% of the Proposed Change Area.

A total of 13 records, 2 diurnal roosts / possible maternal roosts and, nine nocturnal feeding roosts have been identified in the Proposed Change Area (Figure 8-7). Twelve of the records were from the Astron (2014) survey, comprising four acoustic recordings and eight scat/visual sighting/remains locations. The additional one record was from the most recent survey (Astron 2017e) comprising scats. Four acoustic recordings of the Ghost Bat were also detected during the Astron (2017e) survey at one location outside of the Proposed Change Area approximately 900 m to the south-west (Figure 8-7). Table 8-5 summarises the surveys which deployed acoustic bat detectors for Ghost Bats within the Development Envelope and the resulting acoustic records.

Table 8-5: Acoustic Bat Detector Deployments in the Development Envelope for the Ghost Bat and Resultant Records

Survey	Acoustic recorder Site ID	Ghost Bat recorded Y/N
Astron (2014)	Anabat 1	Y
	Anabat 10	N
	Anabat 11b	N
	Anabat 4	N
	Anabat 5	N
	Anabat 6	Y
	Anabat 7	Y
	Anabat 8	Y
	Anabat 9	N
Astron (2017e)	ARU1_MesaH	N
	ARU2_Mesa H	N
	ARU3	N
	ARU4	N
	BAT02	N
	BAT03	N
	BAT04	N
	BAT07	N
	BAT13	N
Rio Tinto Internal Data - Regional Pilbara Leaf-nosed Bat data collected in 2016	Mesa J March17-003	N
Biota (2011b)	RVMBat01	N

An assessment of the conservation value of caves associated with Ghost Bats at Mesa H indicated that Ghost Bat presence at the mesa is intermittent, with the mesa being used for nocturnal foraging and occasional diurnal roosting (Bat Call 2017b). The Ghost Bats at Mesa H likely originate from Buckland Hills to the south, Yeera Bluff between Mesas G and H or the Three Peak hills to the north-west (Bat Call 2017b).

A further assessment of the impact of mining on Ghost Bat in the Robe River system identified 20 of the 34 mesas that have recent Ghost Bat records, and a further five sites within 10 km that have Ghost Bat activity. The total estimated population of these mesas is approximately 150 individuals in an estimated 400 shelters and caves in the lower and mid Robe river valley, noting that the population likely varies depending on the quality of the wet season (Bat Call 2017a).

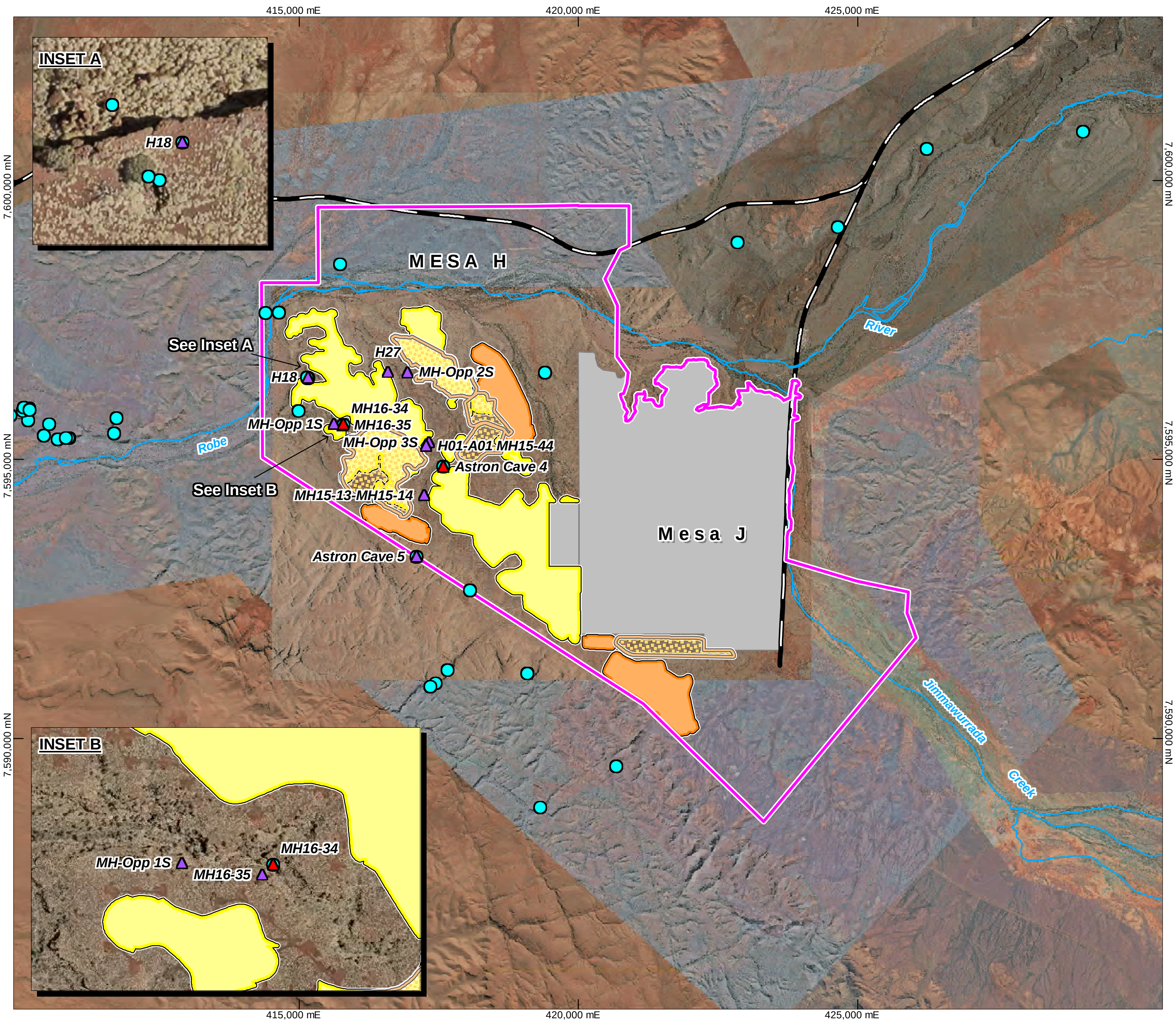
As the Ghost Bat is a MNES, this species is subject to assessment as part of the Environmental Review accredited assessment which is addressed in Section 11.1.

Table 8-6 summarises the morphology of each of the caves recorded at Mesa H.

Table 8-6: Characteristics of Caves and Shelters with Evidence of Ghost Bat Use

Cave name	Type	Approximate depth[1] (m)	Maximum internal height (m)	Entrance orientation	Internal temperature/ humidity
H01-A01_MH15_44	Nocturnal feeding roost	8	2.5	south	ambient
Astron Cave 3 (H18)	Nocturnal feeding roost	19	2.5	north	ambient
H27	Nocturnal feeding roost	10.5	1.8	North-east	ambient
MH15_13_MH15_14	Nocturnal feeding roost	9	5.5	west	ambient
Astron Cave 1 (MH16-34)	Diurnal roost. Possible maternal roost	30	5	South-west	ambient
MH16_35	Nocturnal feeding roost	5	1.5	North-west	ambient
Astron Cave 4	Diurnal roost. Possible maternal roost	30	3.9	north-east	ambient
Astron Cave 5	Nocturnal feeding roost	18	1.5	South-east	ambient
MH-Opp 1S	Nocturnal feeding roost	16	1.5	north	ambient
MH-Opp 2S	Nocturnal feeding roost	3	3.5	west	ambient
MH-Opp 3S	Nocturnal feeding roost	4	2	South-east	ambient

[1] The lateral extent (cave depth) was measured using a hand-held laser wherever possible



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile
- Ghost Bat Roost (Nocturnal Feeding)
- Ghost Bat Roost (Diurnal/ potential maternal)
- Ghost Bat Record

N

SCALE

0 1 2 3 4 5km

1:100 000 @ A4

RioTinto

Iron Ore (WA)

Figure 8-7: Ghost Bat records and roosts

Drawn: M.Swebbs
Date: Jan, 2019

Plan No: PDE0152731v5
Proj: MGA 94 (Zone 50)

8.4.5.3 Pilbara Leaf-nosed Bat (Confirmed)

The Pilbara Leaf-nosed Bat is listed as Vulnerable under Schedule 3 of the BC Act and also as Vulnerable under the EPBC Act. The Pilbara Leaf-nosed Bat roosts during the day in caves and mine adits (horizontal tunnels) with stable, warm and humid microclimates. The species is thought to be restricted to such environments because it has a limited ability to maintain its heat and water balance (DotEE 2017b). These underground diurnal and breeding roosts are considered 'habitat critical to the survival' of the Pilbara Leaf-nosed Bat (TSSC 2016a).

The Pilbara Leaf-nosed Bat is known to have a typical dry season foraging range up to 20 km from its primary roost caves (Bat Call 2016) but may forage at greater distances if suitable water sources are available. The Pilbara Leaf-nosed Bat is most commonly encountered over small pools of water in rocky gullies and gorges, but has been observed foraging in a variety of habitats including *Triodia* hummock grasslands covering low rolling hills and shallow gullies, with scattered *Eucalyptus camaldulensis* along the creeks; over small watercourses amongst granite boulder terrain; over pools and low shrubs in ironstone gorges; and above low shrubs and around pools in gravelly watercourses with *Melaleuca leucodendron* (DotEE 2017b).

The Pilbara Leaf-nosed Bat has been recorded 11 times in the Proposed Change Area. The species was recorded at five of the 11 acoustic bat detector locations in the Proposed Change Area by Astron (2017e). The species was recorded opportunistically (e.g. scats or visual recordings) a further six times in the Proposed Change Area during the earlier Level 1 survey of Mesa H (Astron 2014) (Figure 8-8). Table 8-7 summarises the surveys which deployed acoustic bat detectors for the Pilbara Leaf-nosed Bat within the Development Envelope and the resulting acoustic records.

Table 8-7: Acoustic Bat Detector Deployments in the Development Envelope for the Pilbara Leaf-nosed Bat and Resultant Records

Survey	Acoustic recorder Site ID	Ghost Bat recorded Y/N
Astron (2017e)	ARU1_MesaH	N
	ARU2_Mesa H	N
	ARU3	N
	ARU4	N
	BAT01	Y
	BAT02	N
	BAT03	N
	BAT04	Y
	BAT07	N
	BAT08	Y
	BAT11	Y
	BAT12	Y
	BAT13	N
Astron	Anabat 1	N
	Anabat 10	N
	Anabat 11b	N
	Anabat 4	N

Survey	Acoustic recorder Site ID	Ghost Bat recorded Y/N
	Anabat 5	N
	Anabat 6	N
	Anabat 7	N
	Anabat 8	N
	Anabat 9	N
	RVMBat01	N
	Mesa J March17-003	N

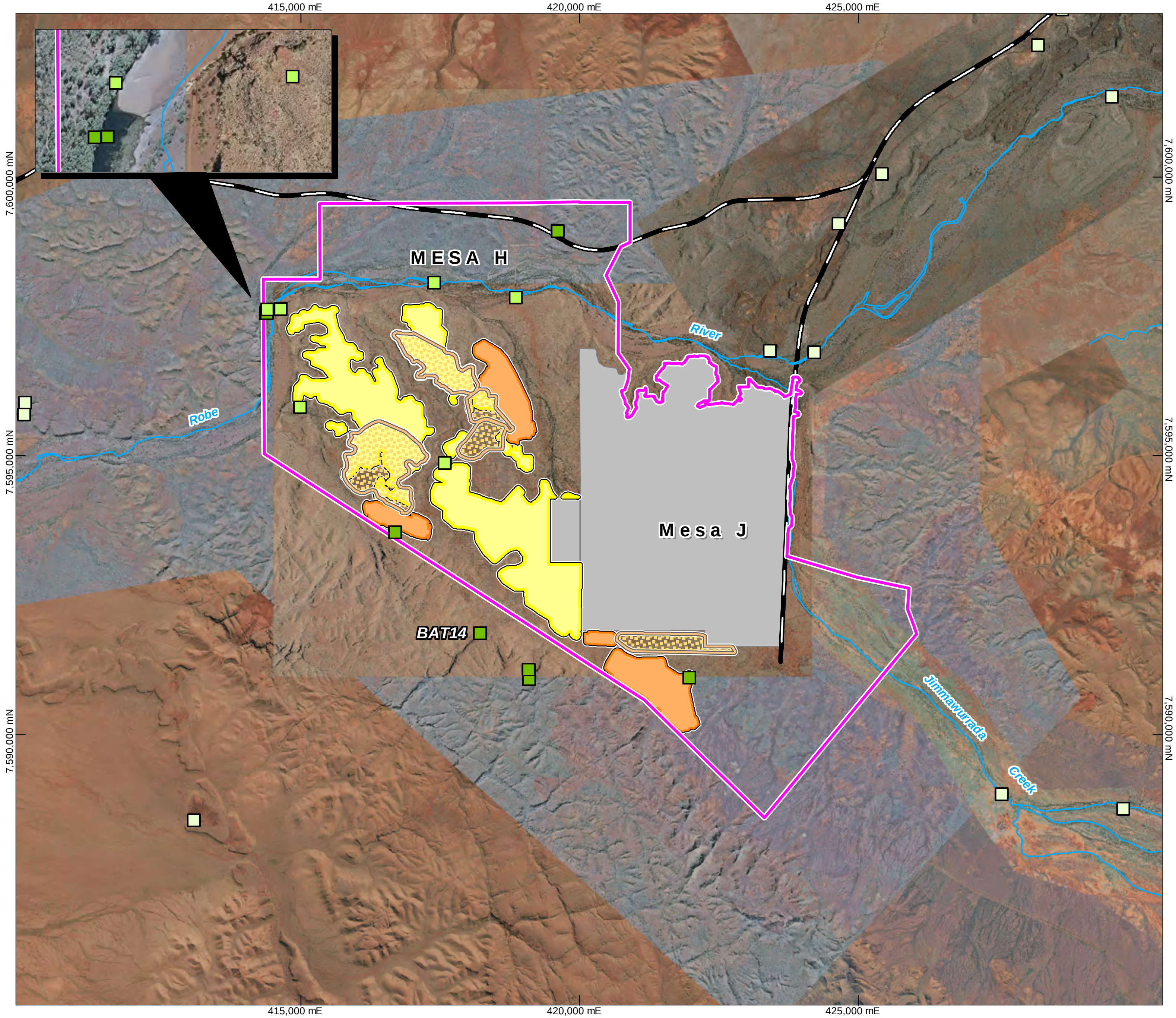
In the Astron (2017e) survey, seven locations yielded low activity levels, while one location (BAT 14) recorded high activity levels with 257 calls (Astron 2017e). BAT 14 was located at the entrance to a large gorge system, which occurs south of the Proposed Change Area (Figure 8-8). Four bat detectors were subsequently placed along the gorge system for a period of five days in June 2016, following completion of the main survey and results indicate that individuals likely originate from a known roost site approximately 10 km south of the survey area (Astron 2017e).

No caves within the Proposed Change Area match the depth, temperature and humidity criteria to be classified as diurnal roost sites for this species. The deeper caves in the Gorge habitat (representing 0.3 %) of the Proposed Change Area have dimensions suitable to be considered potential nocturnal refuges (Astron 2017e).

Additional monitoring for the species was undertaken by Rio Tinto across the broader Robe Valley involving deployment of bat detectors at 66 locations over 144 nights from 2015 to 2017. The program failed to identify a roost at Mesa A, B, C, D, E or F (Rio Tinto 2017e). Based on the Pilbara Leaf-nosed Bat's expected patterns of movement from a roost, typical dispersal flight speed of 20 km per hour and the frequency and location of calls, the mesas of the Robe Valley are considered to form part of a larger home range for local populations, with the Robe River providing an important foraging source (Rio Tinto 2017e).

The most important habitats for this species within the Proposed Change Area likely include the foraging habitat comprising Gorge, Breakaway, Riverine (and to a lesser extent; Drainage Line) habitats. The remaining habitats of the Proposed Change Area are considered to provide limited foraging and dispersal habitat (Astron 2017e).

An assessment of the ecological value of mesa facades (Astron 2017e) found ten sites rated as having high ecological value (based on rarity, variety, integrity and ecological importance) within the two main gorges on the western façade along the Robe River and a small section of façade along the northern section near the Robe River. As the Pilbara Leaf-nosed Bat is a MNES, this species is subject to assessment as part of the Environmental Review accredited assessment which is addressed in Section 11.1.



LEGEND

Development Envelope

Ministerial Statement 208

Railway

Major Watercourse

Conceptual Mine Layout

Mine Pit

Waste Dump

Topsoil / Subsoil Stockpile

Pilbara Leaf-nosed Bat Record

Astron, 2014

Astron, 2017

Other Historical Record

N

SCALE

0 1 2 3 4 5km

1:100 000 @ A4

Iron Ore (WA)

Figure 8-8: Pilbara Leaf-nosed Bat records and roosts

Drawn: M.Swebbs
Date: Feb, 2019

Plan No: PDE0164868v2
Proj: MGA 94 (Zone 50)

8.4.5.4 Pilbara Olive Python (Confirmed)

The Pilbara Olive Python is listed as Vulnerable under Schedule 3 of the BC Act and as Vulnerable under the EPBC Act.

This species prefers escarpments, deep gorges, water holes and rock piles associated with permanent pools in rocky areas in ranges of the Pilbara (Astron 2017e; DotEE 2017c). It is widespread in the region and occurs as scattered populations. This species is known to occur at more than 60 locations across the Pilbara (G. Humphreys, Biota Environmental Sciences, pers. comm. 2012) including populations at Pannawonica, Millstream, Tom Price and the Burrup Peninsula. It also occurs within the Rangelands (WA) Natural Resource Management Region and part of the species' habitat is conserved in Karijini National Park. Individuals occupy distinct home ranges and males can travel distances of up to 4 km during the breeding season (June to August) to locate females (DotEE 2017c).

Individuals spend the cooler winter months hiding in caves and rock crevices away from water sources, and the warmer summer months moving around widely, usually close to water and rock outcrops. The species uses waterholes to hunt and ambushes prey on animal trails or by striking from a submerged position in water holes (DEWHA 2008b). Individuals occupy distinct home ranges, estimated to range from approximately 87 ha to 449 ha (DotEE 2017c based on one study by Tutt *et al.* 2004) and males can travel distances of up to 4 km during the breeding season (June to August) to locate females.

The species has been recorded 23 times across the Robe Valley outside the Development Envelope. A single juvenile was recorded at a pool of the Robe River (Japanese Pool) within the Riverine habitat in the Proposed Change Area; and scats were recorded on two further occasions in Breakaway habitat, in proximity to the Robe River. This species likely inhabits Gorge, Breakaway and Riverine habitats (representing 5% of the Proposed Change Area) particularly where semi-permanent and permanent water is present. The Rocky Hills and Drainage line habitat, where associated with adjacent Gorge and Riverine habitats (representing 13% of the Proposed Change Area) also provides dispersal opportunities.

As the Pilbara Olive Python is a MNES, this species is subject to assessment as part of the Environmental Review accredited assessment which is addressed in Section 11.1.

8.4.5.5 Lined Soil Crevice Skink (Confirmed)

This Priority 4 species is endemic to WA, restricted to the arid north-west of the Pilbara bioregion and occurs in spinifex dominated areas near creek and river margins. The Lined Soil-crevice Skink was captured on five occasions during the survey in three trapping grids in Loamy / Stony Plains habitat and Low Hills and Slopes habitat of the Proposed Change Area (Astron 2017e).

8.4.5.6 Western Pebble mound Mouse (Confirmed)

This Priority 4 species occurs in colonies in gentle rocky slopes of rocky ranges where ground is covered by stony mulch and vegetated by hard spinifex, often with sparse over-storey of eucalypts and scattered shrubs.

Evidence of the Western Pebble-mound Mouse was recorded in the Proposed Change Area during the first phase of the Astron (2017e) survey undertaken in 2015, comprising five inactive mounds recorded in Low Hills and Slopes habitat.

8.4.5.7 Blind snake (Highly likely)

The Blind Snake, *Anilios ganei*, is generally poorly collected in fauna surveys but is known from the Pannawonica local area. It is associated with moist gorges and gullies and occurs over a range of stony habitats. This species likely occupies the Gorge, Breakaway and Rocky Hills habitats in the survey area (Astron 2017e).

8.4.5.8 Fork-tailed Swift (Moderately likely)

The Fork-tailed Swift is listed as Migratory under the EPBC Act and is a non-breeding visitor to all states and territories of Australia. In north and north-west WA, the Fork-tailed Swift is known to arrive around October and generally depart around April the following year (DotEE 2017d). They will often appear ahead of cyclones or tropical storms (Johnstone *et al*. 2013). Numbers are highly variable, usually appearing in small flocks of up to 50 birds, but occasionally seen in large flocks. This species is highly mobile, almost entirely aerial, flying predominantly over dry or open habitats including inland plains, foothills and coastal areas (DotEE 2017d).

Given the presence of vast open habitat in and near the Development Envelope, it is moderately likely that this species occurs as a visitor in the months between October and April. This species is addressed as part of the accredited assessment.

8.4.5.9 Letter-winged Kite (Moderately likely)

This Priority 4 species occurs predominantly in central and eastern Australia and exhibits sudden population fluctuations directly related to prey abundance (Birds in Backyards 2017). The species has been known to expand its distribution into other arid parts of Australia at times of drought when prey is scarce, or when the population booms as a result of increased prey abundance (Johnstone *et al.* 2013). It inhabits grasslands in arid and semi-arid areas, near tree-lined streams or water courses (Birds in Backyards 2017). This species may occur as an itinerant visitor in the Loamy / Stony Plains or Riverine habitat types of the Proposed Change Area during times of drought in eastern Australia.

8.4.5.10 Australian Painted Snipe (Moderately likely)

The Australian Painted Snipe is a wading bird listed as Endangered under Schedule 2 of the BC Act and Endangered under the EPBC Act and is addressed in this section as part of the accredited assessment.

It occurs in wetlands across Australia; however, is more common in eastern Australia. It occurs less frequently in WA. It inhabits shallow terrestrial freshwater wetlands, including temporary and permanent lakes, swamps and claypans (DSEWPaC 2013). It has the potential to occur as an itinerant visitor to Riverine habitat, in particular areas of semi-permanent and permanent water, in the Proposed Change Area.

8.4.5.11 Common Sandpiper, Sharp-tailed Sandpiper, Wood Sandpiper, Common Greenshank, Oriental Pratincole (Moderately likely)

These five species are migratory shorebirds listed as Migratory under the EPBC Act and are listed under Schedule 5 of the BC Act as Migratory birds, protected under an international agreement.

These species inhabit a variety of wetland habitats including estuaries, permanent and semi-permanent wetlands on floodplains of inland and coastal rivers, sheltered coastal habitats (DoE 2015b). They are addressed as part of the accredited assessment.

These species potentially occur as migrating visitors to Riverine habitat, in particular permanent and semi-permanent pools along the Robe River within the Proposed Change Area.

8.4.5.12 Long-tailed Dunnart (Moderately likely)

The Long-tailed Dunnart is a Priority 4 species which occurs in the Gibson Desert, southern Carnarvon Basin, Rangelands and Pilbara in WA. It also occurs in the Northern Territory. It inhabits exposed rock and stony soils with hummock grasslands and shrubs, flat-topped hills, lateritic plateaus, sandstone ranges and breakaways and sparse mulga over spinifex (WAM 2017).

It has the potential to occur in Breakaway, Rocky Hills, Low Hills and Slopes and Loamy / Stony Plains habitats within the Proposed Change Area.

8.4.5.13 Short-tailed Mouse (Moderately likely)

This Priority 4 species occurs across northern Australia from Cape York to the Pilbara. In WA, it inhabits sandy soils and cracking clays (DEC 2012). It has the potential to occur in Loamy / Stony Plains habitat within the Proposed Change Area.

8.4.6 Invertebrate fauna and potential Short-Range Endemic species

SRE species are those that display restricted distributions (less than 10,000 km^2; (Harvey 2002) and are therefore generally at greater risk of changes in conservation status and / or local population or taxon extinctions than other, more widely distributed taxa (EPA 2016l). Taxa that exhibit short-range endemism are generally characterised by poor dispersal powers, low fecundity levels, confinement to discontinuous habitats and highly seasonal activity patterns, with many species active only during cooler and wetter periods (Harvey 2002). Some better known SRE species have been listed under State or Commonwealth legislation, or as Priority species by the DBCA; however, the majority of SRE species have not been listed under legislation, often due to lack of knowledge.

In the Pilbara region, SRE species currently listed as Threatened or Priority fauna species include 16 arachnics, 19 crustaceans, four millipedes, three insects, one polychaete and one snail species. Of these 44 Threatened or Priority fauna species, only two dragonfly species are surface dwelling species with no specimens ever found from the vicinity of the Proposed Change Area and are unlikely to occur locally. The other species are all subterranean and were not part of the Level 2 terrestrial fauna survey, or do not occur in the vicinity of the survey area (Astron 2017e).

Targeted and systematic searches have been undertaken for SREs during various surveys conducted in the Proposed Change Area (Figure 8-9). During the Astron (2017e) survey, a total of 20 systematic sampling sites were sampled for SRE fauna. This included the vertebrate fauna trap sites and the nine SRE specific sample sites (leaf litter sieving and active foraging) (Figure 8-9). A total of 800 minutes (over 13 hours) was spent searching the 20 sample sites for SRE species (Astron 2017e). Figure C.1.A to C.1.C of Astron (2017e) depict the spatial spread of all sample sites including specific SRE sites conducted during the survey area. The sampling design for SRE species is considered adequate and no major limitations were highlighted by Astron (2017e).

A total of 36 invertebrate fauna specimens were collected within the Proposed Change Area belonging to at least 14 morphospecies (Astron 2017e). Scorpions were the most diverse group with seven species and 12 specimens, followed by slaters (three species, 16 specimens), pseudoscorpions (two species, four specimens) and spiders (two species, four specimens). No centipedes, harvestmen, millipedes or snails (aquatic or terrestrial) were collected. No conservation significant invertebrate species or confirmed SRE species were recorded; however, four species were considered potential SRE's, including two scorpions, one spider and one slater species. This number is lower compared to 19 (Phoenix Environmental 2014b as cited in Astron 2017e) and 10 (Biota Environmental Sciences 2010 as cited in Astron 2017e) potential SRE species recorded within the wider Pannawonica region. However, this is more than likely a function in differing sampling designs, survey timing and specifically an increased knowledge of species taxonomy and distributions of Pilbara invertebrate fauna over time (Astron 2017e). In addition, the diversity of landforms in the survey area is lower than in some of the previously surveyed areas and may account for some of the differences (Astron 2017e).

Potential SRE species collected within the Proposed Change Area are identified in Table 8-8 and shown on Figure 8-10.

Table 8-8: Potential SRE Collected in the Proposed Change Area

Species	Number of sites	Habitat types	Survey code	SRE status	Occurrence outside Proposed Change Area	Likely to be widespread ?
Scorpions						
Lychas 'sp. nov. 1'	2	Riverine; Loamy / Stony Plains.	WAM Category D - Molecular evidence.	Potential SRE.	Unknown	Y
Lychas 'sp. nov. 2'	2	Riverine; Loamy/Stony Plains.	WAM Category D – Molecular evidence.	Potential SRE.	Unknown	Y
Slaters						
Buddelundia '61'*	2	Breakaway and Gorge, Loamy / Stony Plain.	WAM Category E – Research and Expertise.	Potential SRE.	Jimmawurrada, Bungaroo	Unknown
Spiders						
Karaops feedtime	1	Disturbed.	WAM Category A – Data Deficient.	Potential SRE.	Likely	Y

The two scorpions, *Lychas* 'sp. nov. 1' ad *Lychas* 'sp. nov. 2' were collected from Riverine habitat and Loamy / Stony Plains habitats respectively and identified using DNA sequencing. They were treated as potential SREs because there were no matching DNA sequences in the WA Museum database and the distribution range is currently not known. However, it is likely that these scorpions are more widespread due to the nature of the habitat types in which they were collected being more widely distributed and specimens with similar morphology have been collected from other areas of the Western Pilbara.

The spider specimen was a juvenile, identified using DNA sequence. *Karaops feedtime* is a potential SRE collected from a disturbed site and is considered more widespread. An additional spider; *Karaops* sp. indet. is a potential SRE and was collected from one location outside the Development Envelope in Breakaway habitat during the Astron (2017e) survey. However, genetically similar specimens have been collected from three other localities outside the Development Envelope supporting that the species is more widespread (Astron 2017e). *Karaops* specimens have also been collected previously during fauna surveys in the broader Robe Valley at Bungaroo and Middle Robe/East Deepdale (Astron Environmental Services 2016a, 2016b as cited in Astron 2017e) and they may belong to this species (Astron 2017e). As this species is considered to be widespread and was recorded outside the Development Envelope only, it is not considered further in this ERD.

Overall, only a relatively small number of potential SRE species were collected in the survey area (Astron 2017e). Of the four potential SREs, four were collected from habitats which are known to be widespread and extend well beyond the survey area, with no obvious barriers for the dispersal of fauna within these habitats (Astron 2017e).

The survey locations and locations of potential SRE records in the Proposed Change Area are depicted in Figure 8-9 and Figure 8-10.

The remaining eight invertebrate species recorded in the Proposed Change Area are considered unlikely to represent SRE species as they were collected from habitats that were widespread, well connected and lacked microhabitats. These eight species are not discussed further.

The Astron (2017e) desktop assessment of SRE species revealed at least 137 potential or confirmed SRE species, belonging to eight SRE groups that have been collected within a 100 km radius of the Development Envelope. Total estimates comprised of 36 terrestrial slaters, 32 mygalomorph spiders, 19 non-marine snails, 15 pseudoscorpions, 13 araneomorph spiders, ten scorpions, eight millipedes, three centipedes and one harvestman. Many species known from the desktop assessment to potentially occur within the survey area were not collected during the on-ground survey, including mygalomorph spider species such as *Missulena* sp. (Actinopodidae) and *Synothele* sp. (Barychelidae). These species have been recorded in similar habitats nearby. Although there was a comprehensive survey effort, it is not known whether these species were not recorded as they are absent locally, were present but not collected, or have ranges that do not coincide with the survey area (Astron 2017e).

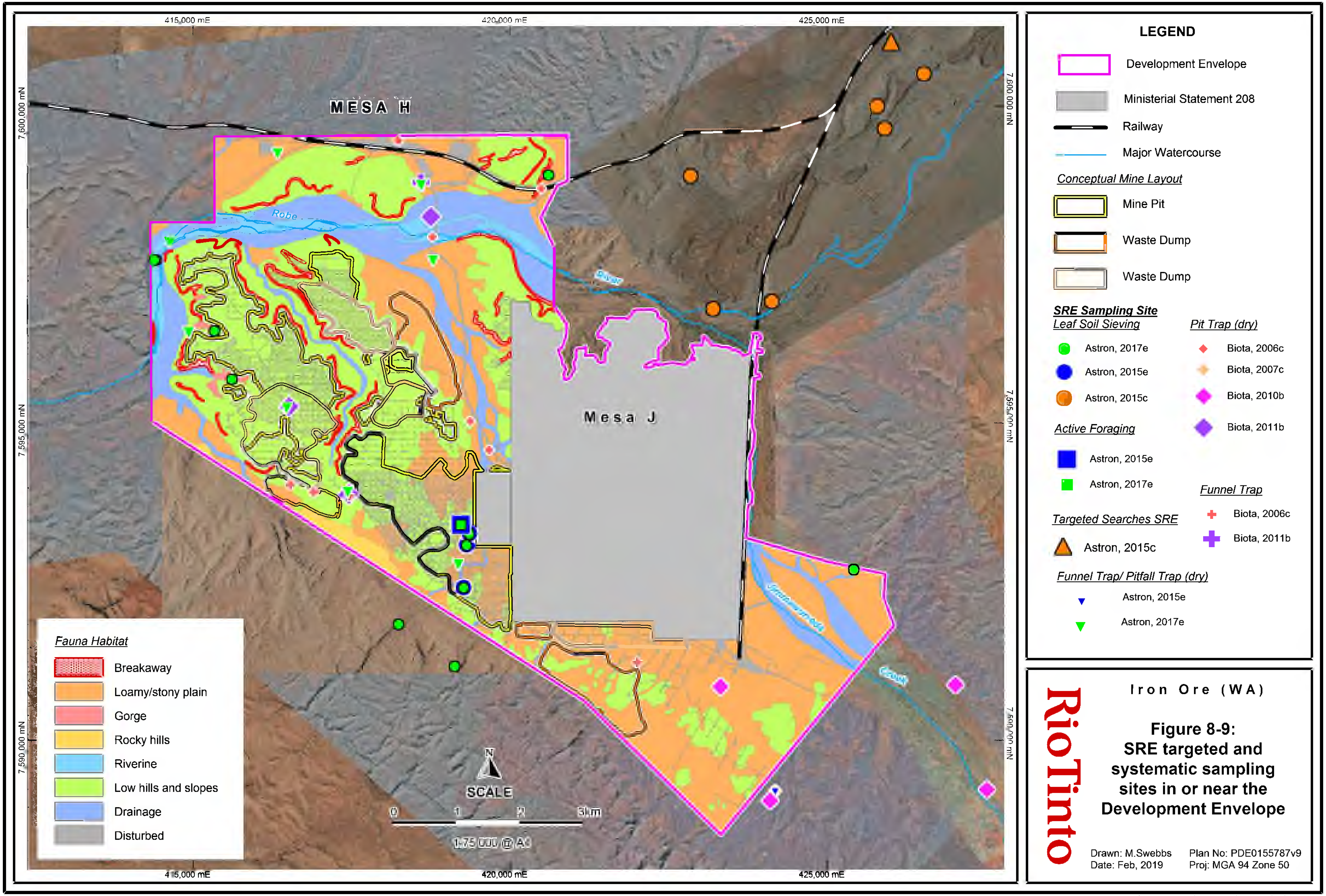


Figure 8-9: SRE targeted and systematic sampling sites in or near the Development Envelope

Geospatial Information and Mapping

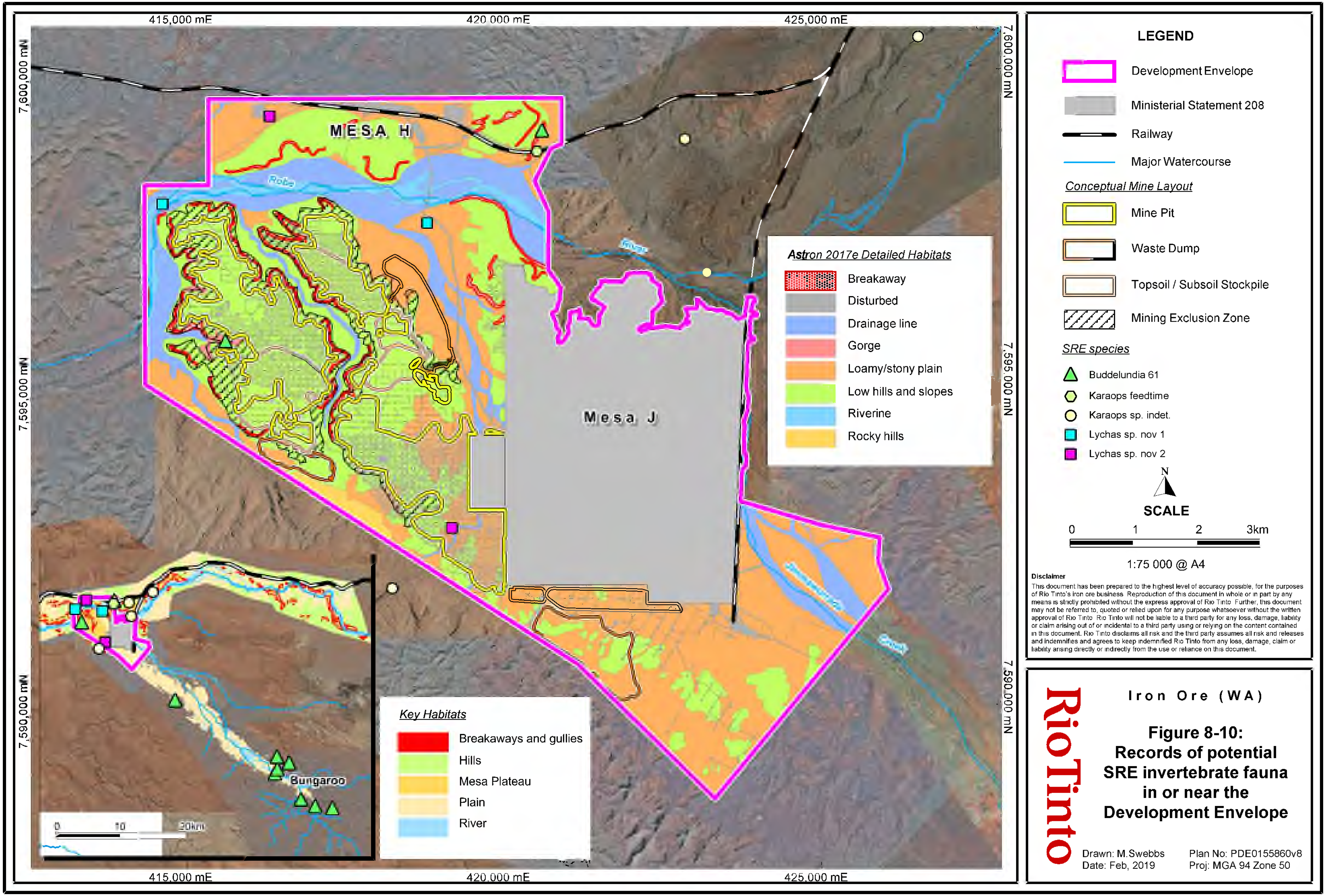


Figure 8-10: Records of potential SRE invertebrate fauna in or near the Development Envelope

8.4.7 Aquatic fauna occurrence

8.4.7.1 Micro-invertebrates

WRM's (2017) post-wet season aquatic fauna survey included sampling of 12 sites both upstream and downstream of the Proposed Change Area (including the Robe River and upper Robe River) and identified 81 micro-invertebrate taxa, including specimens which could not be identified to species level due to unresolved taxonomy or juvenile specimens. Micro-invertebrates included Protista, Rotifera, Copepoda, Cladocera and Ostracoda, with Rotifera dominant at each sample site. Additional post-dry season sampling during 2017 (WRM 2018) also sampled six upstream sediment samples within Jimmawurrada Creek.

The micro-invertebrate assemblage was considered typical of that commonly recorded from tropical / sub-tropical freshwater systems. Most species were common, ubiquitous species with Australasian or cosmopolitan distributions; however, one species, the calanoid copepod *Eodiaptomus lumholtzi* is listed on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species as Vulnerable. Since listing in 1996, this species has been recorded from many localities across Australasia and across the Pilbara region and also Papua New Guinea, and hence its conservation listing may require revision.

8.4.7.2 Hyporheic invertebrates

Hyporheic invertebrates are generally small invertebrates which inhabit the saturated zone beneath the stream or river bed. There are two main categories, including temporary hyporheic invertebrates which occupy the hyporheic zone after flash flooding or heavy rains, while permanent hyporheic invertebrates are specialised in this zone. A total of 59 taxa were recorded from the hyporheic zone of pools in the Proposed Change Area by WRM (2017). These included:

- 54% are considered stygoxene, meaning they are not specifically adapted to subterranean habitats that occur in groundwater;
- 8% were stygobitic meaning they are obligate groundwater inhabitants with morphological adaptations to survive these conditions;
- 31% were occasional hyporheic stygophiles meaning they use the hyporheic zone seasonally or during early life stages; and
- 2% were possible hyporheic taxa and 5% were unable to be classified (WRM 2017).

One species collected, *Nedsia* sp. is considered likely to be a potential SRE species. The specimens could not be identified to species level due to lack of taxonomic resolution (WRM 2017).

No other species collected and identified are of conservation significance (WRM 2017).

8.4.7.3 Macro-invertebrates

A total of 148 macro-invertebrate taxa were recorded from the broader Study Area including some which could not be identified to species level. The assemblage included Cnidaria, Mollusca, Oligochaeta, Crustacea, Acarina, Collembolla, Odonata, Ephemeroptera, Hemiptera, Coleoptera, Diptera, Trichoptera and Lepidoptera. The composition is considered typical of freshwater systems and there was no significant difference in composition between upstream and downstream sampling sites (WRM 2017).

One species, *Eurysticta coolawanyah* (Pilbara pin damselfly) is endemic to the Pilbara region and is currently listed as Near Threatened on the IUCN Red List of Threatened Species (Hawking 2009). It was recorded from two sites, both downstream of the Jimmawurrada-Robe confluence in the Drainage Line habitat. This species is known from over 40 locations across the Pilbara (WRM 2017).

The 2017 annual monitoring undertaken by Streamtec (2017) recorded 67 macro-invertebrate fauna species from five pool sites both upstream and downstream of the Revised Proposal including the upper Robe River and the Robe River adjacent to the Proposed Change. No species was considered rare or locally restricted.

8.4.7.4 Fish

The history of isolation of river systems of the Pilbara results in a low biodiversity of freshwater fish being recorded from the Pilbara (12 species) (Allen *et al*. 2002 cited in Streamtec 2017). A total of ten species have been recorded in the Robe River during aquatic surveys since 1991 (Streamtec 2017).

The baseline aquatic survey in 2016 (WRM 2017) recorded a total of 3,515 fish in the Proposed Change Area including seven true freshwater taxa. There was no significant difference in abundance of fish upstream and downstream of the Jimmawurrada-Robe confluence; however, there was a significant difference in mean species richness between upstream and downstream, with significantly higher richness downstream of the Jimmawurrada-Robe confluence, adjacent to the existing Mesa J Iron Ore Development and the Proposed Change.

Western Rainbowfish was the most abundant species captured and was present at all sampling sites. Fortescue Grunter and Spangled Perch were the next most abundant species (WRM 2017). Survey locations and records of aquatic fauna are listed Table 8-9.

Two conservation significant aquatic species were identified, and these are identified in Table 8-10 and are further described in Section 8.4.8. Survey locations and records of aquatic fauna are depicted in Figure 8-11 and Figure 8-12.

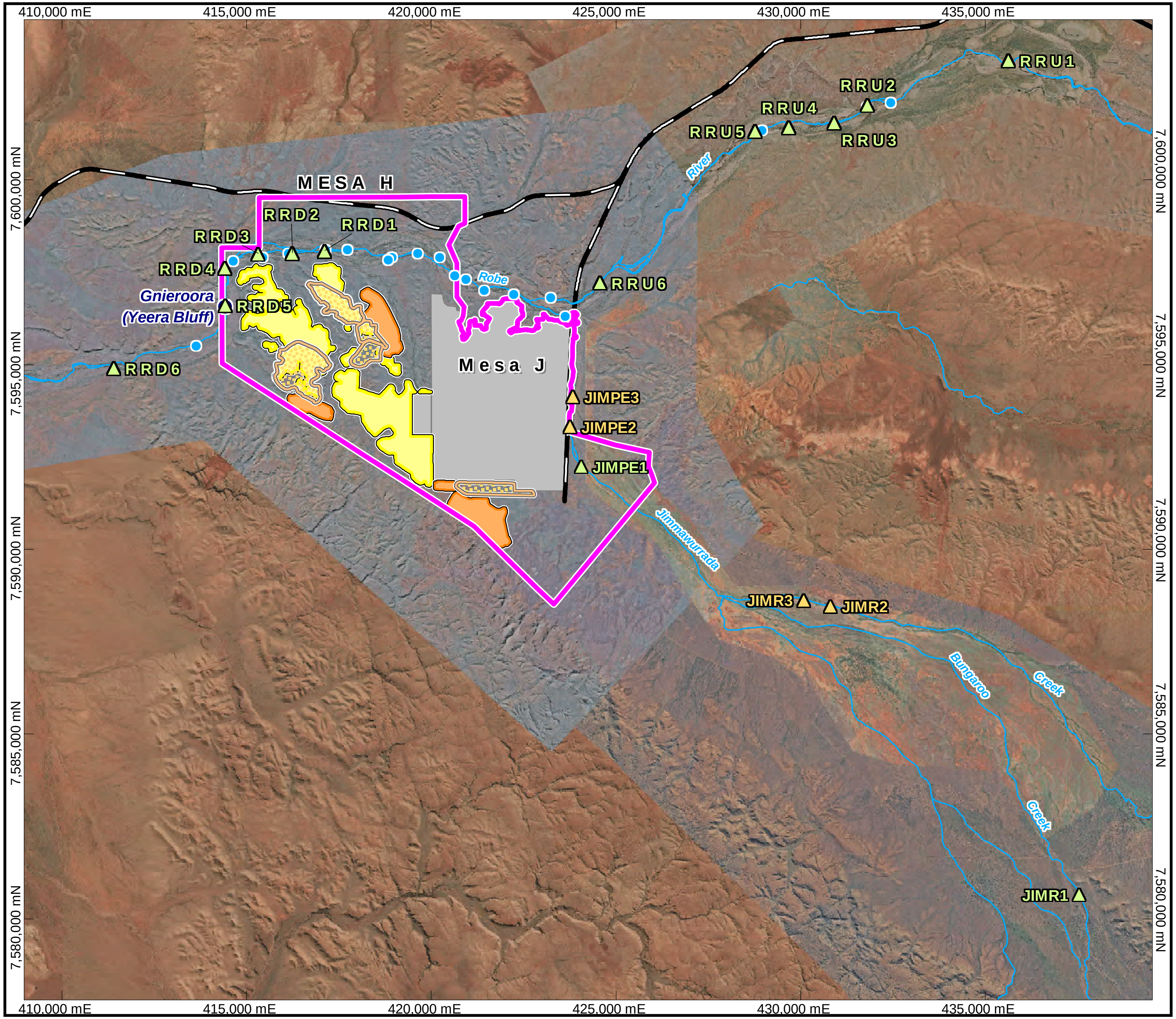
No introduced species have been recorded in the Robe River (Streamtec 2017).

Table 8-9: Summary of Other Fish Species Recorded in the Proposed Change Area

Origin	Species	Record location in relation to Jimmawurrada - Robe confluence	
		Downstream	Upstream
Freshwater	Western rainbowfish *Melanotaenia australis*	✓	✓
	Pilbara tanda *Neosilurus* sp.	✓	✓
	Spangled perch *Leipotherapon unicolor*	✓	✓
	Fortescue grunter *Leipotherapon aheneus*	✓	✓
	Barred grunter *Amniataba percoides*	✓	✓
	Grunter hybrid *Terapontidae* sp.	✓	✓
	Bony bream *Nematolosa erebi*		✓
Estuarine/marine	Milkfish *Chanos chanos*	✓	
	Tarpon / ox-eye herring *Megalops cyprinoides*	✓	✓
	Mullet *Mugil* sp.	✓	✓
	Banded scat / striped butterfish *Selenotoca multifasciata*	✓	

Table 8-10: Records and Likelihood of Occurrence of Conservation Significant Aquatic Fauna Species in the Proposed Change Area

Name	Conservation status		Records within Proposed Change Area	Public database records	Rio Tinto regional records within 50 km of centre of Development Envelope*	Preferred habitat	Habitat occurrence in the Proposed Change Area	Likelihood of occurrence
	State	Commonwealth						
Blind Cave Eel *Ophisternon candidum*	N/A	Vulnerable	Four records within the Proposed Change Area (Biota 2019a): • one physical record in the hyporheic zone within the Robe River • three eDNA records within Jimmawurrada Creek and Robe River alluvial aquifers (Biota 2019a).	Y	Nine records: • Four records within the Proposed Change Area • Five records in the broader study area (Biota 2019a): o Three physical records between 1 km and 5 km east of Development Envelope in Jimmawurrada Creek alluvial aquifer o Two eDNA records 4 & 12 km upstream of the Development Envelope within a pool and alluvial aquifer of the Robe River.	Caves and groundwater systems in subterranean caves, fissures and wells, alluvial aquifer.	Y	Recorded
Fortescue Grunter *Leipotherapon aheneus*	Priority 4	N/A	Recorded both upstream and downstream of the Jimmawurrada – Robe confluence.	Y	36 records. Records in Dobbs and Davies 2009; Morgan *et al.* 2003.	Occurs in the Fortescue, Ashburton and Robe Rivers. In the Robe River, this species is highly dependent on pools.	Y	Recorded



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse
- Permanent Pool
- Pool
- Aquatic Fauna Sampling Site
- Dry Sediment Sampling Site

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile

N

SCALE

0 2 4 6km

1:150 000 @ A4

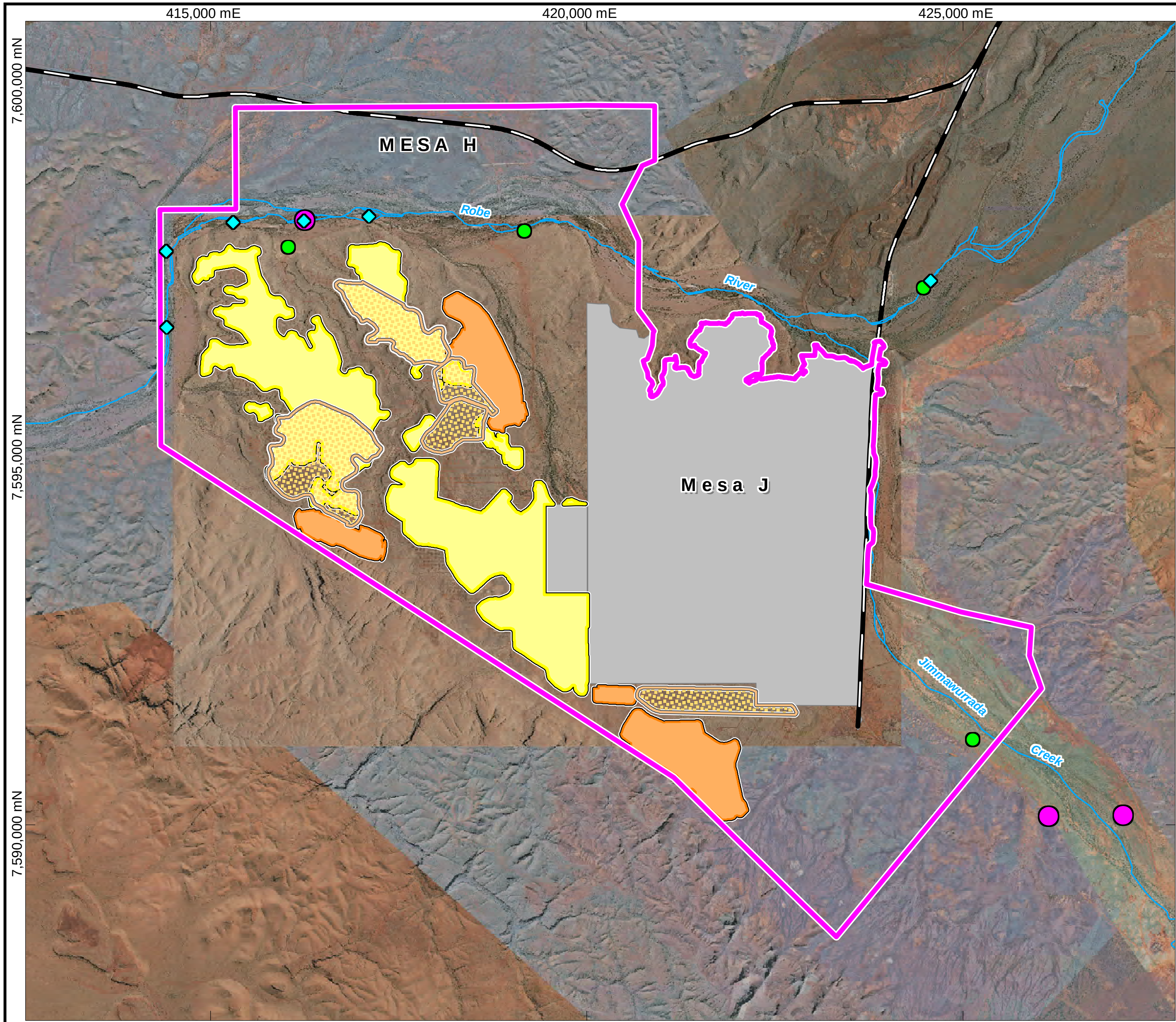
RioTinto

Iron Ore (WA)

Figure 8-11: Location of aquatic fauna sampling sites in or near the Development Envelope

Drawn: M.Swebbs
Date: Jan, 2019

Plan No: PDE0159431v4
Proj: MGA94 Zone50



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile

Priority 4 Aquatic Fauna

- ***Leiopotherapon aheneus (Fortescue Grunter)***

Blind Cave Eel Record

- Blind Cave Eel eDNA
- Confirmed Eel Record

N

SCALE

0 1 2 3km

1:75 000 @ A4

Disclaimer

RioTinto

Iron Ore (WA)

Figure 8-12: Conservation significant aquatic fauna located in or near the Development Envelope

Drawn: M.Swebbs
Date: Feb, 2019

Plan No: PDE0159432v5
Proj: MGA94 Zone50

8.4.8 Conservation significant aquatic fauna

8.4.8.1 Fortescue Grunter

One fish species of conservation significance was recorded in the Proposed Change Area; the Fortescue Grunter, which was the second most abundant fish species recorded in the Study Area and recorded at all sites upstream and downstream of the Jimmawurrada – Robe confluence. This species is endemic to the Pilbara and is listed on the IUCN Red List of Threatened Species as Lower Risk / Near Threatened and is Priority 4 listed. It is known only from the Fortescue, Robe and Ashburton Rivers; however, is common within its range (WRM 2017).

8.4.8.2 Blind Cave Eel (Confirmed)

The Blind Cave Eel is listed as Vulnerable under the EPBC Act. The species is also listed as Threatened – Vulnerable under Schedule 3 of the WA BC Act.

The Blind Cave Eel is a pure white fish growing up to 40cm, with an eel-like body, no eyes and a thin rayless membrane around the tip of the tail (DEWHA 2008a). The species is the world's longest cavefish and one of only two vertebrate animals known from Australia that are restricted to subterranean waters (DEWHA 2008a).

This species inhabits caves and groundwater systems in subterranean caves, transmissive geological formations and fissures and wells, utilising cave floor pool sediments, karst aquifers and alluvial aquifers in the western Pilbara. It tolerates a range of salinities from fresh to seawater (DEWHA 2008a). It is known to occur in the Cape Range approximately 225 km west of Mesa H and has been physically recorded from the hyporheic zone in the Robe River within the Proposed Change Area and from three bores located between 1 km and 5 km east and upstream of the Proposed Change Area in Jimmawurrada / Bungaroo Creek alluvial aquifers (Biota 2019b). In addition, the Eel has been recorded via eDNA in a further five locations in the Robe River and Jimmawurrada Creek alluvial aquifers and a pool, both upstream and within the Proposed Change Area.

Further details are provided in Section 7. As the Blind Cave Eel is a MNES, this species is subject to assessment as part of the Environmental Review accredited assessment which is addressed in Section 11.1.

8.5 Potential Impacts

A number of potential direct and indirect impacts are identified in the ESD. On the basis of surveys completed to date, the following are considered key issues relevant to the Proposed Change and are addressed in Section 8.6 and 0.

8.5.1 Direct impacts

The potential direct impacts of the Proposed Change on Terrestrial Fauna have been identified as:

- loss or fragmentation of fauna habitat including breeding, foraging and dispersal habitat due to clearing; and
- loss of individuals from increased vehicle strikes, collisions with fencing and construction activities.

The Proposed Change involves clearing of up to 2,200 ha of native vegetation across seven mapped terrestrial fauna habitats within the Proposed Change Area which are described in Section 8.4.2.1. The predicted direct impacts to these fauna habitats and an assessment of potential impacts to these habitats is provided in Section 8.5 and Section 8.6.

Vehicular movements will increase in the Development Envelope as a result of construction and operation activities and may result in an increase in vehicle collisions with wildlife.

Vehicle strike of terrestrial fauna species (including conservation listed species) has the potential to decrease local fauna abundance, particularly species which are attracted to roads for basking or foraging activities. Fencing within mining areas of the Development Envelope also poses a risk to some terrestrial fauna species, particularly bat species which may collide with and become entangled in fencing.

8.5.2 Indirect Impacts

The potential direct impacts of the Proposed Change on Terrestrial Fauna have been identified as:

- alteration of fauna habitat due to altered hydrology arising from groundwater abstraction and increased temporal availability of surface water from discharge of surplus water;
- loss or degradation of habitat due to noise and vibration;
- degradation of habitat due to dust and light emissions;
- degradation of habitat due to altered fire regime, introduction or spread of weeds and changes to feral animal populations; and
- degradation of aquatic fauna habitat due to changes in water chemistry as a result discharge of surplus water.

Groundwater abstraction for pit dewatering will result in localised groundwater drawdown in the Mesa H CID aquifer, which has some connectivity to the Robe River alluvial aquifer. The modelling indicates the potential for a reduction in water levels in the Robe River alluvial aquifer and the Robe River semi-permanent and permanent pools up to 1 m. The key impact on fauna habitat will be a small reduction in the length of time semi-permanent pools persist after rainfall recharge events and a reduction in the lateral extent of the pools.

Groundwater abstraction for water supply from the existing Southern Cutback Borefield, in combination with the upstream CWSP, and abstraction from the Mesa J Iron Ore Development, will increase existing groundwater drawdown below Jimmawurrada Creek and extend the timeframe for the predicted groundwater recovery once water abstraction ceases. Cumulatively, with the existing Mesa J abstraction and the Coastal Water Supply, this may result in localised changes to the canopy cover of riparian vegetation and associated fauna habitat values in the Jimmawurrada area, predominantly within a 6.5 km stretch of Jimmawurrada Creek. Substantial drawdowns are expected within this stretch ('Zone 3') where drawdowns of up to 9 m (14 mbgl, based on the Central Case) may occur from the cumulative drawdown effects. No semi-permanent or permanent pools occur in the Jimmawurrada area.

Due to the shape of the mesa, most of the CID contained within the MEZ is not located directly above the groundwater table and therefore the Ghost Bat roosts are not in direct connection with the groundwater table. A change in groundwater level is, therefore, not expected to result in changes to the relative humidity in roost caves at Mesa H. Periodic discharge of surplus water via existing discharge outlets in Jimmawurrada Creek and / or West Creek, maintaining similar volumes as currently discharged from the existing Mesa J Iron Ore Development will maintain the temporal availability of water in these systems and alter the seasonality of available surface water in the Robe River tributaries; Jimmawurrada Creek and / or West Creek, up to 8 km downstream of the discharge point, periodically, for the duration of discharge.

8.5.3 Cumulative impacts

Detailed fauna habitat mapping has been completed for the Proposed Change Area. Detailed mapping at the scale undertaken for the Proposed Change Area is not broadly available for the Pilbara region. Identification and assessment of potential cumulative impacts to fauna habitat, therefore, requires broader mapping completed across a greater area.

The seven terrestrial fauna habitat types mapped in the Proposed Change Area have been grouped into five habitat types:

- Mesa Plateau; equivalent to Low Hills and Slopes;
- Breakaways and Gullies; amalgamated Breakaway and Gorge habitat types;
- Hills; equivalent to Rocky Hills;
- Plains; equivalent to Loamy / Stony Plains; and
- River; amalgamated Drainage Line and River habitat types.

These five habitat types have been mapped for the entire Robe Valley to enable an assessment of the cumulative habitat loss from existing and reasonably foreseeable projects in the region (Figure 8-13). These projects include:

- Existing and historical mining projects:
  - o proponent mining operations: Mesa J, Mesa A, Warramboo, Mesa K;
  - o proponent historical mining projects: East Deepdale and Middle Robe; and
  - o existing clearing from other infrastructure: Mesa J and Mesa A Railways, borrow pits, power lines, roads and tracks.
- Reasonably foreseeable projects (referred):
  - o proponent: Mesa H Revised Proposal and Mesa A Hub Revised Proposal (currently being assessed); and
  - o Buckland Project, Iron Ore Holdings Pty Ltd approved in February 2014 but not yet implemented.

Exploration impacts have not been included in the cumulative impact calculations as these are temporary in nature and are required to be rehabilitated within six months.

Table 8-11: Cumulative Impacts on Fauna Habitat Types within the Robe Valley

MNES Habitat	Pre-European extent (ha)	Historical clearing %	Mesa H Clearing (ha)	Mesa H Clearing % pre-European extent	Total cumulative clearing (historical + proposed + reasonably foreseeable) (ha)	Total cumulative clearing % pre-European extent
Hills	17,676	3.1	0.5	<0.1	752	4.3
Breakaway and Gullies	1,009	8.4	3.5	0.4	97	9.6
Mesa Plateau	7,471	42.3	1,071	14.3	4,529	60.6
River	8,062	0.9	23.2	0.3	80.4	1.0
Plains	53,081	4.5	1,102	2.1	6,150.1	12

8.6 Assessment of Impacts to Terrestrial (Non-Aquatic) Fauna

Assessment of impacts to each fauna habitat and to each conservation significant species are assessed below. Where species utilise similar habitats, these species have been grouped.

8.6.1 Fauna habitat

8.6.1.1 Direct impacts

Clearing for the Proposed Change will result in clearing of up to 2,200 ha of fauna habitat. All known bat roost caves in the Proposed Change Area will be avoided. None of the recorded fauna habitats are restricted to the Proposed Change Area and are not restricted at the local, sub-regional or regional scale (Astron 2017e).

The most significant terrestrial habitats in the Proposed Change Area comprise the Breakaway, Gorge and Riverine habitats.

During planning for the Proposed Change, the placement of key infrastructure, including haul roads, external topsoil stockpiles, and waste dumps have been considered and preferred options have been selected to meet project requirements whilst minimising clearing of significant fauna habitats, and balanced with minimising impacts to other identified environmental values within the Proposed Change Area. In particular, haul road routes have been modified and designed to avoid direct disturbance and indirect disturbance (dust and noise) to a diurnal / potential maternal Ghost Bat roost. Similarly, the waste dumps have been located on areas that are considered low value habitat, where the mesa is devoid of breakaway and gorge habitats.

The proposed clearing of fauna habitats is presented in Table 8-12.

Table 8-12: Potential Direct Impact to Terrestrial Fauna Habitats

Habitat	Extent within Proposed Change Area (ha)	Proposed extent of disturbance (ha)	Proposed extent of disturbance (% in Proposed Change Area)
Riverine	143	1.3	<1%
Drainage Line	583	22	4%
Gorge	15	0.1	<1%
Breakaway	84	3.4	4%
Rocky Hills	50	0.5	1%
Low Hills and Slopes	1,879	1,071	57%
Loamy/Stony Plain	1,712	1,102	64%
Disturbed	372	N/A	N/A

Riverine

Clearing for the Proposed Change will clear up to 1.3 ha of Riverine habitat required for the widening of an existing access road to enable access to the Proposed Change. This represents less than 1% of the Riverine habitat mapped in the Proposed Change Area. This habitat type is of moderate value to conservation significant species as they are likely to forage and traverse this habitat type and moderate value to SRE. The proposed disturbance is not considered a significant loss to terrestrial fauna species at a local or regional scale.

Drainage Line

The Proposed Change will result in clearing of up to 22 ha of Drainage Line habitat. This represents approximately 4% of the mapped Drainage Line habitat within the Proposed Change Area. Given Draina7ge Line habitat is of low value to conservation significant species due to a lack of refugia or shelter, and moderate value to SRE, the proposed disturbance is not considered a significant loss to terrestrial fauna species at a local or regional scale.

Gorge

Clearing for the Proposed Change will result in loss of up to 0.1 ha of Gorge habitat, which represents approximately 0.4% of the mapped Gorge habitat within the Proposed Change Area. Given the high value of this habitat type for conservation significant species due to significant refugia and shelter sites and SRE, the Proposed Change has been designed to minimise clearing of this habitat type. The proposed disturbance is not considered a significant loss to terrestrial fauna species at a local or regional scale.

Breakaway

The Proposed Change will result in impact to 3.4 ha of Breakaway habitat, which represents approximately 4% of the available Breakaway habitat within the Proposed Change Area. Given this habitat type is of high value to conservation significant fauna and SRE, the Proposed Change has been designed to minimise clearing and disturbance of this habitat type. The proposed disturbance of up to 3.4 ha is not considered a significant loss to terrestrial fauna species at a local or regional scale.

Rocky Hills

The Proposed Change will result in clearing of up to 0.5 ha of Rocky Hills habitat, which represents approximately 1% of the available Rocky Hills habitat within the Proposed Change Area.

This habitat type is considered of moderate value to conservation significant species as they are likely to traverse and forage in this habitat type. This habitat type is considered to have moderate value to SRE. The Proposed Change has been designed to minimise clearing and disturbance of this habitat type. The proposed disturbance is not considered a significant loss to terrestrial fauna species at a local or regional scale.

Low Hills and Slopes

The Proposed Change will result in clearing of up to approximately 1,071 ha or 57% of the Low Hills and Slopes habitat in the Proposed Change Area. Given the widespread availability of this habitat type within the local vicinity and regional expanse and low value to both conservation significant species and SRE, the proposed disturbance is not considered to be significant.

Loamy / Stony Plain

The Proposed Change will result in clearing of up to approximately 1,102 ha or 64% Loamy / Stony Plain habitat, within the Proposed Change Area. Given the widespread availability of this habitat type and low value to both conservation significant species and SRE, this proposed disturbance is not considered to be significant locally or regionally.

8.6.1.2 Indirect impacts

Groundwater abstraction for pit dewatering will result in localised groundwater drawdown in the Mesa H CID aquifer, which has some connectivity to the Robe River alluvial aquifer. There is some uncertainty regarding the level of hydraulic connection between the alluvial aquifer and the CID aquifer and therefore the modelling and this impact assessment has been based on the worst-case scenario that there is a connection and that the basement underlying the alluvial aquifer is permeable. Under this scenario, the modelling indicates the potential for a reduction in water levels in the Robe River alluvial aquifer and the Robe River semi-permanent and permanent pools up to 1 m. This is not anticipated to change the permanent or semi-permanent nature of any of the pools or change riparian vegetation which provides fauna habitat, as the water will still be accessible to root systems. The permanent pool (Gnieora at Yeera Bluff) in the section of the Robe River adjacent to Mesa H is approximately 3-4 m deep. This pool will continue to be permanent, but the area and depth of this pool may be reduced during dry periods. The key impact on fauna habitat will be a small reduction in the length of time semi-permanent pools persist after rainfall recharge events and a reduction in the lateral extent of the pools. Shallower pools such as Duck Pool may dry out more quickly during extended dry periods than would currently be the case. The temporary habitat values that these semi-permanent pools provide include drinking water, associated foraging habitat (both vegetation and prey availability) and shelter. As the size of the pools contract and understorey wetland vegetation cover reduces during dry periods, these habitat values will be reduced more quickly due to groundwater abstraction.

The majority of water in the Robe River alluvial aquifer derives from streamflow recharge and throughflow from upstream within the alluvial aquifer. Therefore, the potential for discernible drawdown impact is limited to dry conditions. Monitoring in the Robe River alluvial aquifer has shown natural water level fluctuations of up to 3 m. The EWRs for the Robe River (DoW 2012) were developed using an approach that allows for the highly variable water conditions experienced in the Pilbara. The EWRs for drought conditions in the Robe River are to maintain phreatophytic vegetation and permanent pools as refuges for fauna. These EWRs are expected to be met during implementation of the Proposed Change.

The level of hydraulic connection between the alluvial aquifer and the CID aquifer is outlined in Section 5.5.2.1. No measurable impact on water levels in the Robe River alluvial aquifer or pool water levels has been found to date as a result of historical dewatering at Mesa J (Streamtec 2017).

In the event that surface water levels in pools of the Robe River reduce more than the predicted range as a result of mine dewatering from the Revised Proposal, these will be mitigated with an adaptive management approach that may include discharge of surplus abstracted groundwater from Mesa H dewatering directly into permanent pools; or avoidance of BWT mining below 120 m RL in the pit closest to the Robe River in order to avoid or mitigate the impact. Groundwater abstraction in the Southern Cutback Borefield for water supply will remain within existing licence limits for the Mesa J Iron Ore Development. Mesa H will utilise some water from this Borefield for wet processing when dewatering is not sufficient. The cumulative impacts of the existing Mesa J Iron Ore Development dewatering, Mesa H water supply and the adjacent CWSP abstraction will extend the depth and extent of groundwater drawdown below Jimmawurrada Creek and the timeframe to groundwater recovery. This combined abstraction may result in localised changes to the canopy cover of riparian vegetation and associated fauna habitat values in the Jimmawurrada area, predominantly within a 6.5 km stretch of Jimmawurrada Creek. Substantial drawdowns are expected within this stretch (‘Zone 3’) where drawdowns of up to 9 m (14 mbgl) may occur from the cumulative drawdown effects. However, if natural recharge in Jimmawurrada Creek is reduced by 50% due to an extended dry period (H3 numerical model ‘Uncertainty Run 2’ (Rio Tinto 2019a)), the water table levels could be lowered by almost 3 m in addition to the historical seasonal fluctuations; this would translate to localised changes in water table depths of up to 14 m from pre-mining conditions, or ~18 mbgl by 2030. No semi-permanent or permanent pools occur in the Jimmawurrada area, affected by groundwater drawdown associated with the Proposed Change and hence changes to the surface water regime are predicted to be limited to potential decreased persistence of ephemeral pools following large rainfall events.

The footprint of the periodic surplus water discharge will overlap with areas subject to groundwater drawdown including along the Robe River and sections of Jimmawurrada Creek and thus may partially mitigate the potential impact from groundwater drawdown in these areas.

The predicted potential impacts to fauna habitat as a result of groundwater drawdown as a result of abstraction for mine pit dewatering and for water supply from the Southern Cutback Borefield (in combination with the upstream CWSP, and abstraction from the Mesa J Iron Ore Development) for the Revised Proposal are outlined in Table 8-13. More detailed description of the predicted changes to vegetation as a result of drawdown is presented in section 6.6.3.

Table 8-13: Potential Impacts to Creek and Riverine Fauna Habitats

Zone	Fauna habitat	Extent of potential indirect impact (km)	Potential impact to fauna habitat
Jimma 1 - 3	Drainage Line	12	Minor to moderate reduction in cover and understorey vegetation affecting shelter and foraging opportunities for ground dwelling mammals and reptiles. No semi-permanent or permanent pools occur. Vegetation already affected by cattle grazing.
Robe 1, 1a, 2, 2b	Riverine	14	Reduction in water levels in the Robe River alluvial aquifer and the Robe River semi-permanent and permanent pools up to 1 m. This is not anticipated to change the permanent or semi-permanent nature of any of the pools. The area and depth of pools could be reduced. There may also be a small reduction in the length of time semi-permanent pools persist after rainfall which would affect the availability of aquatic habitats. During dry periods the reduced time of persistence and size of pools within this stretch of Robe River will reduce the availability of water and associated food sources. This may affect avifauna (birds and bats), aquatic fauna and ground dwelling fauna. Minor changes to cover and understorey vegetation – affecting cover and foraging opportunities for ground dwelling mammals and reptiles. Vegetation already affected by cattle grazing.

Surplus water will be periodically discharged into Jimmawurrada Creek and / or West Creek via existing discharge outlets. The discharge will maintain similar volumes to that currently discharged from the existing Mesa J Iron Ore Development. Discharges will alter the seasonality of available surface water in the Robe River tributaries; Jimmawurrada Creek and / or West Creek up to 8 km downstream of the discharge point, periodically, for the duration of discharge as summarised in Table 8-14.

Table 8-14: Potential Indirect Impacts From Surplus Water Discharge

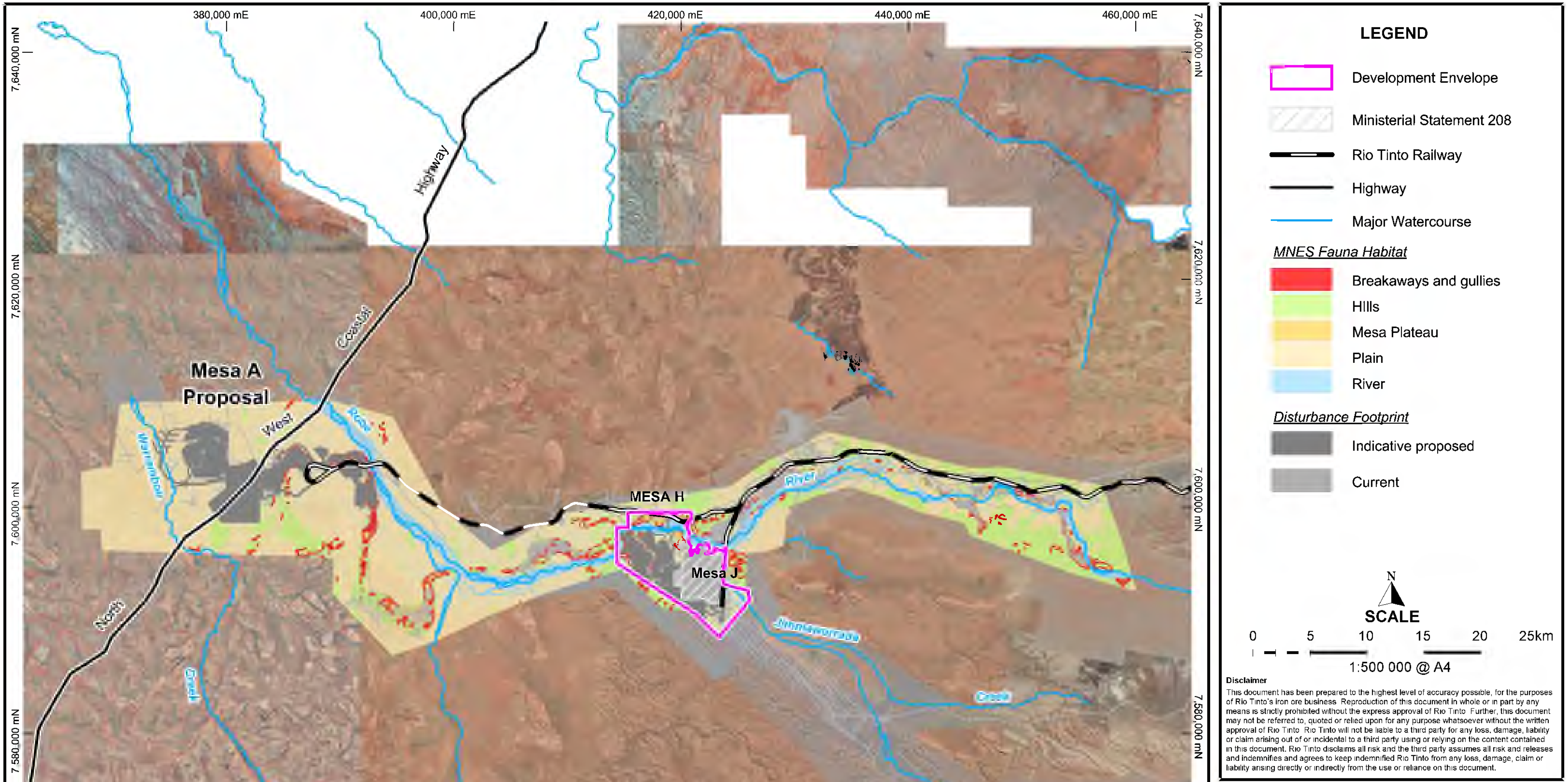
Component	Modelled discharge rate (GL/a)	Extent of potential impact to fauna habitat	Predicted potential impact to fauna habitat
Discharge to Jimmawurrada and or West Creek.	Up to ten (average three).	Up to 8 km downstream from the discharge points.	Temporary, localised changes to fauna habitat as currently affected by Mesa J Iron Ore Development.

Assessment of impacts to fauna habitat from all indirect impacts to conservation significant fauna is provided in the indirect impacts section relating to each species as appropriate.

8.6.1.3 Cumulative impacts to fauna habitat

The Proposed Change will increase cumulative loss of fauna habitat in the Robe Valley. However, approximately 90% of the pre-European extent of the habitat types identified as most significant to conservation significant fauna (i.e. Breakaway and Gullies habitat and Riverine habitat) will be retained within the Robe Valley following the proposed and reasonably foreseeable mining developments (Table 8-11).

The habitat type most affected by clearing in the Robe Valley is the Low Hills and Slopes habitat unit which is referred to as the Mesa Plateau habitat type in the Robe Valley mapping. Approximately 42% of the Mesa Plateau habitat unit has been cleared to date. Cumulative impacts from reasonably foreseeable projects is predicted to increase clearing of this habitat type to 61% of pre-European extent, however the habitat loss within the habitat unit is predominantly limited to the plateau itself, which is considered to be of lower habitat value (particularly for conservation listed terrestrial fauna species) than the mesa escarpment which has the highest habitat value; particularly for the Pilbara Leaf-nosed Bat, Ghost Bat and Northern Quoll. The retention of the landscape elements with the highest biodiversity value (i.e. the mesa escarpments) in Mesa H, Mesa J and the Mesa A Hub Revised Proposal is likely to effectively minimise the impact of cumulative clearing associated with mining these mesas on biodiversity and threatened species.



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Iron Ore (WA)

Figure 8-13: Cumulative impacts to fauna habitat across the Robe Valley

Drawn: M.Swebbs
Date: Jan, 2019

Plan No: PDE0159458v3
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping

8.6.2 Northern Quoll

8.6.2.1 Policy and Guidance

A National Recovery Plan is in place for Northern Quoll (Hill and Ward 2010) which describes the species' distribution, habitat and population and identifies known threats to the species.

In addition, the EPBC Act referral guidelines (DoE 2016) define the requirements for EPBC referral of proposals likely to significantly impact the species, describes the spatial distribution of the species, and defines habitat critical to the survival of the species and populations important for the long-term survival of the species.

Populations important for the long-term survival of the Northern Quoll are defined by DoE (2016) as:

- High density quoll populations occurring in refuge-rich habitat critical to the survival of the species, including where cane toads are present. High density populations are characterised by numerous camera triggers of multiple individuals across multiple cameras and/or traps on the site. Conversely, a low-density population is defined as infrequent captures of one or two individuals confined to one or two traps or where no trapping has identified an individual but latrine evidence is present.
- Populations occurring in habitat that is free of cane toads and unlikely to support cane toads upon arrival i.e. granite habitats in WA, populations surrounded by desert and without permanent water.
- Subject to ongoing conservation or research actions i.e. populations being monitored by government agencies or universities or subject to reintroductions or translocation.

The Northern Quoll population recorded in the Proposed Change Area is classifiable as a 'population important for the long-term survival' of the species as defined by DoE (2016) as it is characterised by numerous camera triggers of multiple individuals across multiple cameras and or traps on the site (DoE 2016) occurring in refuge-rich habitat. A full description of this species' current status and distribution in Australia as well as discussion of records of this species in the Development Envelope and broader Robe Valley is provided in Section 12.3.3.

All habitat that provides shelter for breeding, refuge from fire/or predation and potential poisoning from the Cane Toad, (*Rhinella marina*) is considered to be 'habitat critical to the survival' of the species and usually occurs in the form of (DoE 2016):

- Rocky habitats such as ranges, escarpments, mesas, ranges, gorges, breakaways, boulder fields, major drainage lines or treed creek lines.
- Structurally diverse woodland or forest areas containing large diameter trees, termite mounds or hollow logs.
- Offshore islands where the Northern Quoll is known to exist.

Rocky habitats adjoining drainage lines have a heightened level of importance given the close proximity of denning habitat to foraging and dispersal areas. The majority of the Proposed Change Area is connected to the shelter habitats of the breakaways and rivers and therefore fits the broad definition of 'habitat critical to the survival of the species. However, habitat defined as critical to the survival of the Northern Quoll (DoE 2016) includes all habitat within the modelled distribution of the species which provides shelter/breeding and/or dispersal and foraging habitat associated with or connecting populations important for the long-term survival of the species. This definition is highly inclusive and could be considered to include all foraging/dispersal habitat in the vicinity of multiple records of Northern Quoll. The local population of Northern Quoll has a strong association with the Breakaway, Gorge and Riverine habitat. Based on the evidence from the location of Northern Quoll records from the Robe Valley and the Development Envelope

(Section 12.3.3), the critical habitat locally is considered to comprise the these three habitat types. In particular the Breakaway habitat contains rocky environments of high relief that are especially important for Northern Quolls in the Pilbara as they provide denning sites for breeding and shelter and diverse microhabitats for foraging. Other foraging and dispersal habitat within the Development Envelope is considered widespread and low value and not considered critical to the survival of the species. The foraging and dispersal values of the Plains, Mesa plateau, lower order Drainage lines and Low Hills and Slopes are considered low. Northern Quoll (particularly breeding age males) may utilise all of these habitats but these values are common and widespread.

The majority of the Proposed Change Area is connected to the shelter habitats of the breakaways and rivers and therefore fits the broad definition of 'habitat critical to the survival of the species'. However, the most important habitats in the Proposed Change Area for the Northern Quoll are considered to be the Breakaway, Gorge and Riverine habitat, which provide high value denning / shelter habitats associated with caves and rocky overhangs and/or enhanced foraging opportunities due to the availability of water (MWH 2015).

8.6.2.2 Assessment of potential direct impacts

Loss of habitat

With consideration of the policy and guidance for Northern Quoll, and survey results, the most valuable habitat for the species in the Proposed Change Area are Gorge and Breakaways, which provide suitable denning habitat and Riverine and Rocky Hills habitats which support foraging and dispersal (Astron 2017e).

The local population is considered a high-density population important for the long-term survival of the species. This is based on the number of records, including multiple camera recordings of multiple individuals.

The Proposed Change has been designed to avoid and minimise impact to high value denning habitat including Gorge and Breakaways. The Proposed Change will require the construction of two cuttings of approximately 100 m width each to enable access across the incised central section of the mesa. These cuttings are required for haul road access and cannot be avoided. The cuts will be located 3 km away from the most valuable denning habitat which was mapped as high priority for retention by Astron (2017e). A small amount of disturbance may also be required for a water mitigation strategy during groundwater drawdown, which would involve installation of layflat pipe over the edge of the mesa; however, this does not require clearing. Up to 3.5 ha of potential denning habitat, comprising Gorge and Breakaway habitats, will be impacted by the Proposed Change, which represents approximately 4% of suitable denning habitat in the Proposed Change Area.

As the majority of the mesa escarpments which provide denning habitat for Northern Quoll will be retained by the Proposed Change and escarpment cuts will avoid high value denning habitat, the disturbance to the escarpments is unlikely to directly reduce the local availability of denning habitat.

Habitat defined as critical to the survival of the Northern Quoll (DoE 2016) is discussed in detail in Section 12.3.3 and includes all habitat within the modelled distribution of the Northern Quoll which provides shelter/breeding and/or dispersal and foraging habitat associated with or connecting populations important for the long-term survival of the Northern Quoll. The habitats referred to in Section 12.3.3 are the MNES habitats; Breakaways and Gullies (equivalent to Breakaway and Gorge habitat) and River (equivalent to Riverine habitat). Given the number of records of Northern Quoll locally and their strong association with Breakaways and Gullies habitat (Breakaway and Gorge) (80% of records are either within Breakaways and Gullies (Breakaway and Gorge) habitat or within 10 m of it, or in River habitat), it is proposed that an appropriate definition of critical habitat locally is the Breakaways and Gullies habitat (Breakaway and Gorge) and portions of the River habitat (Riverine). This is consistent with the conclusion of Astron (2017e) that the Breakaways and Gullies habitat in particular contains rocky environments of high relief that are particularly important for Northern Quolls in the Pilbara as they provide denning sites for breeding and shelter and diverse microhabitats for foraging. Other foraging and dispersal habitat within the Development Envelope is considered widespread and low value and not considered critical to the survival of the species.

The Proposed Change will clear foraging and dispersal habitat within the Proposed Change Area however, no clearing is proposed in areas around permanent pools of the Robe River. Larger areas of foraging and dispersal habitat within the Low Hills and Slopes habitat, including the mesa plateaus, will also be cleared. Given the extent of available foraging and dispersal habitat outside of the Proposed Change Area and that this habitat is not considered critical to the survival of the species, this is unlikely to significantly disrupt foraging or dispersal activities.

The Proposed Change has been designed to limit disturbance to critical habitat locally and will impact 4% of Breakaway habitat and less than 1% of Gorge and Riverine habitat. The proposed loss of habitat is unlikely to fragment the local population, nor is it likely to disrupt foraging activities or affect the survival of the species locally or regionally.

Northern Quoll have been recorded in historical mining areas in the Robe Valley, particularly where mesa escarpments are largely intact. Astron (2016e) recorded the Northern Quoll numerous times during a survey in the East Deepdale and Middle Robe region approximately 60 km east of the Development Envelope. The majority of these records were from the Breakaway habitat type (45 records), with some records from the Riverine (13), Stony Hills and Slopes (two) and Mesa (seven) fauna habitats. The Breakaway habitat was, therefore, considered highly suitable for the Northern Quoll while the Mesa, Riverine and Drainage habitats that act as ecological linkage corridors and may provide refuge and foraging opportunities were considered to be areas of moderate suitability (Astron 2016e). Overall the results of the survey indicate Northern Quoll are utilising intact escarpments around previously impacted sites (Astron 2016e).

There are 4,153 records of Northern Quoll from the Pilbara (DBCA 2018). The majority of these are recent records; only 315 records date back further than 2009. The Northern Quoll is known to have a boom and bust population cycle. The study modelled likelihood of occurrence in the Pilbara and identified high likelihood of occurrence on the western edge of the Hamersley Range, the Chichester Range, the granite outcrops of the Abydos Plain and low likelihood of occurrence in the Fortescue River catchment, the alluvial coastal Plain (Roeburne Plain) of the Pilbara and southern areas of the Hamersley Range.

With consideration of the likely occurrence of the species, and availability of suitable habitat outside the Development Envelope, the Proposed Change is considered unlikely to significantly impact the availability of habitat for the species at a regional scale. The Proposed Change will therefore, not reduce the area of occupancy of this species.

Loss of habitat through clearing is unlikely to fragment habitat or the local population. Northern Quolls are known to move over installed linear infrastructure such as roads. The mine pits in the mesa plateaus are unlikely to fragment populations or create barriers to movement, as the mesa plateaus do not provide preferred habitat for the species.

Breakaway and Gorge and Riverine habitats are considered of high importance to Northern Quoll and the Proposed Change has been designed to largely avoid these habitats. However, the direct impact to core habitat for Northern Quoll; 3.5 ha of Breakaway and Gorge habitat (equivalent to Breakaways and Gullies MNES habitat), 3.8 ha of habitat within 10 m of Breakaway and Gorge habitat and 1.3 ha of Riverine habitat is considered to be a significant residual impact and is proposed to be offset (Section 13).

Loss of individuals due to fauna strike

Vehicle movements for construction and operation of the mine may result in fauna strike, causing injury or death of individuals. Vehicle speed limits on access roads will be imposed to minimise the risk of fauna strike. There have been no recorded incidents of vehicle collision with Northern Quoll at the existing Mesa J Iron Ore Development.

8.6.2.3 Assessment of potential indirect impacts

Alteration of surface water and groundwater hydrology

The potential increase in water availability in the tributaries of the Robe River (Jimmawurrada Creek and West Creek) and in the Robe River due to surplus water discharge may locally increase available foraging habitat for the duration of the discharge(s).

Groundwater abstraction for pit dewatering will result in localised groundwater drawdown in the Mesa H CID aquifer that has some connectivity to the Robe River alluvial aquifer. This may affect Riverine habitat which provides dispersal and foraging habitat for Northern Quoll. Modelling indicates the potential for a short-term reduction in water levels in the Robe River alluvial aquifer and the Robe River semi-permanent and permanent pools of less than 1 m. This is not anticipated to change the permanent or semi-permanent nature of any of the pools. The key impact on fauna habitat will be a small reduction in the length of time semi-permanent pools exist following rainfall and a temporal reduction in the lateral extent of the pools. These impacts are not expected to significantly affect the quality of foraging habitats for Northern Quoll along Robe River.

The EWRs for the Robe River (DoW 2012) were developed using an approach that allows for the highly variable water conditions experienced in the Pilbara. The EWRs for drought conditions in the Robe River are to maintain phreatophytic vegetation and permanent pools as refuges for fauna. These EWRs and their significance for Northern Quolls in maintenance of foraging habitat are expected to be met during implementation of the Proposed Change.

Groundwater abstraction for water supply from the existing Southern Cutback Borefield, in combination with the upstream CWSP, and abstraction from the Mesa J Iron Ore Development, will increase groundwater drawdown below a 12 km stretch of Jimmawurrada Creek and extend the timeframe for the predicted groundwater recovery once water abstraction ceases. This may result in localised changes to the canopy cover of riparian vegetation in the Jimmawurrada Creek area predominantly over a 6.5 km stretch (‘Zone 3’) during dry conditions. This impact may be exacerbated taking into consideration an extended dry period combined with seasonal water table lows. No semi-permanent or permanent pools occur in the Jimmawurrada area and the creek ecosystem function is expected to be maintained. Any changes to groundwater levels beneath Jimmawurrada Creek are considered unlikely to significantly impact Northern Quoll foraging habitat.

Noise and vibration

The indirect impact of noise and vibration emissions are considered unlikely to impact Northern Quoll. Viable populations of Northern Quoll have remained at Mesa A and adjacent to Mesa J Iron Ore Development despite current mining activities. Populations also remain at Process Minerals’ Poondano West Project despite excavation over large areas of potential foraging habitat. The relative lack of change in the population of Northern Quoll across the Poondano project area, demonstrates resilience to noise and vibration emissions arising from that project (Astron 2015f).

Lighting

Temporary mobile lighting in areas of active pit excavation may result in temporal and localised areas of light spill to the mesa escarpments, similar to current operations at Mesa

A and Mesa J; however, this is not expected to significantly interfere with nocturnal foraging activities.

Invasive species

The Cane Toad is considered to be the main invasive species that poses a threat to Northern Quoll. While the Pilbara was once thought likely to provide a refuge for the Northern Quoll from the Cane Toad, recent modelling suggests that Cane Toads will invade the region (Cramer *et al.* 2016). Intermittent discharge of surplus water to Jimmawurrada Creek and the West Creek tributary into the Robe River via the existing Mesa J discharge outlets may increase the availability of surface water. This may locally increase suitable habitat for Cane Toads for the duration of discharge activities; however, water is available year-round in the semi-permanent and permanent pools which are already present in the Robe River, and surplus water discharge from Mesa H will be discharged at the same locations that have been used for Mesa J surface water discharge since 1993. The Proposed Change will not, therefore, alter the possibility of Cane toads becoming established in the area.

Feral cats are also a threat to the Northern Quoll. There is little opportunity for the Proposed Change to result in increases to the feral cat population. Feral cat control is currently undertaken and will continue to be undertaken in areas where the Proponent operates.

The invasion of Gamba Grass (*Andropogon gayanus*) and other introduced grasses are recognised threats to this species as they out-compete native grasses and increase fuel loads, which can contribute to intense, late dry season fires. These fires can cause direct loss of Northern Quoll or cause predation following fire due to reduction in the availability of shelter (DotEE 2017a). The Riverine and Drainage habitats are currently subject to extensive weed invasion by Buffel Grass due to decades of pastoral activities including sheep and cattle grazing. The Proponent will undertake weed inspection and control in priority weed management areas which will include both manual and chemical control measures. Areas of high priority for weed management include Jimmawurrada Creek, Robe River permanent pools and river crossings, MEZs and topsoil stockpiles.

8.6.2.4 Cumulative impacts

The current Proposed Change is adjacent to the existing Mesa J Iron Ore Development which includes a mine footprint of approximately 1,800 ha (BBG 1991). The Mesa J Iron Ore Development utilises open cut mining modifying the mesa plateau to a basin and has largely avoided impacts to the highest value habitat around the mesa escarpment including breakaways and gullies; in particular the northern escarpment which abuts the Robe River. No systematic surveys were historically undertaken for the Mesa J Iron Ore Development, so it is not known if Northern Quoll were present; however, given the characteristics of the mesa landforms, it is considered likely that suitable habitat for the species was present within the Mesa J footprint.

In the downstream end of the Robe Valley, approximately 30 km away, the existing Mesa A operation has retained the majority of its mesa escarpment, including the northern gorge on the eastern escarpment of Mesa. The Mesa A operation includes a 150 m wide cut on the middle of the eastern escarpment. The remaining extent of the façade has been retained in a MEZ, protected from mining activities. This project had no impact on the Robe River which is also considered suitable habitat for the species. It was predicted that the Mesa A operation may result in loss of some individuals (Strategen 2006).

The new activities of the Mesa A Hub Revised Proposal will clear up to 3,000 ha which includes suitable denning and foraging habitat for Northern Quoll. The Mesa A Hub Revised Proposal will retain the majority of the mesa facades, with the exception of small scale cuts to allow access into the mesas. Escarpment cuts at Mesas B and C will be up to 200 m wide and the existing cut at Mesa A will be increased by approximately 100 m to enable widening of the haul road.

The cumulative clearing across the Robe Valley (including historical, approved and reasonably foreseeable projects) will result in the loss of up to 10% of Breakaways and Gullies habitat which provides potential denning habitat and up to 1% of River habitat which supports foraging (Table 8-11 and Figure 8-13). On this basis, the impact from the Proposed Change is unlikely to result in significant cumulative impacts on the Northern Quoll.

8.6.2.5 Outcome

The Proposed Change Area avoids disturbance to the higher value parts (the more incised gullies and rockiest areas) of the Breakaway and Gorge habitat types but may result in disturbance of lower value sections of the Breakaway and Gorge habitat and less than 2 ha of the Riverine habitat in the Proposed Change Area. Breakaway and Gorge and Riverine habitats are considered of high importance to Northern Quoll and the Proposed Change has been designed to largely avoid these habitats. However, the direct impact to core habitat for Northern Quoll; 3.5 ha of Breakaway and Gorge habitat (equivalent to Breakaways and Gullies MNES habitat), 3.8 ha of habitat within 10 m of Breakaway and Gorge habitat and 1.3 ha of Riverine habitat is considered to be a significant residual impact and is proposed to be offset (Section 13).

8.6.3 Ghost Bat

8.6.3.1 Policy and Guidance

Approved conservation advice for this species was published in 2016 (TSSC 2016a) and defines the species' distribution, biology and ecology, identifies key threats, assigns threat ratings and identifies conservation and management actions.

The advice identifies the consequence rating of habitat loss as severe and disturbance of breeding sites, modification to foraging habitat and collision with fences as moderate.

8.6.3.2 Direct impacts

Loss of habitat

The most important habitat types for Ghost bats in the Proposed Change Area are Gorge and Breakaway habitats, which provide suitable roost habitat. In addition, Riverine, Drainage Line and Breakaway habitats also provide foraging and dispersal habitat (Astron 2017e). For the purposes of identifying the extent of impact, Breakaway habitat is included in this assessment as potential roost habitat.

The Proposed Change will avoid direct impacts to all Ghost bat roosts in the Proposed Change Area, comprising the two diurnal / potential maternal roosts at Mesa H and the nine recorded nocturnal feeding roosts. MEZs and vibration thresholds will be established around the diurnal / potential maternal roosts and nocturnal roosts, to prevent rock fall or instability of roosts (Figure 8-14). The MEZ has been designed to ensure that mine pits are set back from recorded diurnal/maternity roosts by a minimum of 40 m from the lateral extent (recorded back) of the cave and from nocturnal roosts by a minimum of 50 m from the entrance to the cave. The nearest Ghost Bat roosts to the proposed mine pits are a nocturnal roost at 65 m and a diurnal roost at 90 m. These measures are expected to effectively avoid impacts to roosts.

The Mesa formations of the Robe Valley comprise competent Robe Pisolite (CID) and are highly resistant to erosion relative to the surrounding formations, demonstrated by nature of their current topographic form as outcropping mesa formations in the landscape (as described further in Section 11.1). The understanding of the local geology and geological features in the vicinity of the diurnal / potential maternal caves is supported by both surface geological information (2D) and downhole geological and geophysical data from drill holes

(3D), including diamond drill holes which provide in-situ geological cores and structural information. Based on the nearest diamond drill hole data, the geology at Mesa H behind the diurnal / potential maternal caves comprises Robe Pisolite with multiple vugs; interstitial clay, clay pods / bands; and occasional small <10 cm cavities (largest cavity recorded <30 cm). No key structural features were noted in the geological logging that might reduce geotechnical stability. A geotechnical assessment of the diurnal caves (Rio Tinto 2017g) noted an absence of large continuous structures that could lead to collapse of the caves.

Geotechnical analysis of both the diurnal/potential maternal roost sites and the mesa formations has been completed. The geotechnical analysis of the roost complexes surrounding the diurnal/potential roost sites determined the geotechnical sensitivity for all of these caves to be 'low' (Rio Tinto 2017g). The geotechnical analysis of the mesa formations was specifically undertaken to understand and support the geotechnical stability requirements to ensure key environmental and heritage values contained within the mesa escarpments, including bat roosts, are maintained. Rio Tinto (2017d) concluded that a minimum of 30 m is required to maintain the geotechnical stability of an open face of Robe Pisolite, hence a 40 m buffer proposed from the lateral extent (back) of the diurnal/potential maternal roost sites to the proposed pits is more than sufficient to meet this geotechnical stability criterion. In addition, the geotechnical stability of pit walls will be monitored as mining progresses as part of operational and safety protocols and the proposed blast management measures.

The Proponent regularly establishes successful vibration control and management projects to protect sensitive sites; vibration control may apply to only a small number of blasts in the mine plan or may apply across a large mining area over a number of years. The Proponent has successfully applied vibration control to blasting near sensitive sites such as culturally sensitive sites, sensitive infrastructure (e.g. high pressure gas pipeline, communications tower) and environmentally sensitive sites (e.g. troglofauna habitat and Ghost Bat roosts) (Rio Tinto 2013). The Proponent's Blast management framework takes a risk-based approach in relation to diurnal/potential maternal roost sites. This approach assumes all diurnal / potential maternal roost sites are sensitive receptors requiring the highest level of blast control. As such, a very conservative blast threshold (peak particle velocity (PPV)) trigger criterion has been set, as detailed in the EMP, to ensure no structural damage to the caves occurs. Typical steps involved in ensuring the trigger PPV criterion is not exceeded at a sensitive site include:

- Calculation of the likelihood that the blast will reach or exceed the set trigger PPV based on a conservative generic set of ground condition parameters.
- If the trigger is likely to be reached:
    - conducting site specific tests to establish site specific ground condition parameters and re-calculation of the vibration levels; and/or
    - revision of the blast design.

The design of the blast can be altered in a number of ways to reduce the PPV. For example, distance from the blast to the sensitive site may be increased, drill hole sizes and charge weights may be reduced, blast timing (the layout and delays between firing successive holes) may be modified or high frequency blasting techniques may be used. Based on the Proponent's experience and monitoring from mining operations at other mesa formations throughout the Robe Valley, the Proponent is able to demonstrate the effectiveness of current blast management techniques.

A study of historically mined mesas in the Robe Valley, Bat Call WA (2017a) indicates, 'For current and future mining operations retaining a perimeter of greater than 20 m around the mesa perimeters and providing particular protection to significant diurnal/maternal roost caves will result in no further loss of Ghost Bats in the Robe Valley due to roost destruction'. The proposed buffers of 40 m from the lateral extent of the diurnal/potential maternal roosts and 50 m from the entrance to the nocturnal roosts exceed the recommendation of 20 m and, together with implementation of the proposed blast management techniques, provide particular protection to diurnal/maternal roosts.

Given the competent nature of the formation surrounding the caves, the operational checks of geotechnical stability and the Proponent's use of, and demonstrated experience in applying, blast management techniques, the Proponent considers the proposed setbacks between the pit boundaries and the diurnal/potential maternal and nocturnal roost sites are appropriate to ensure direct disturbance to the caves is avoided and the integrity of the caves is not compromised by the Revised Proposal.

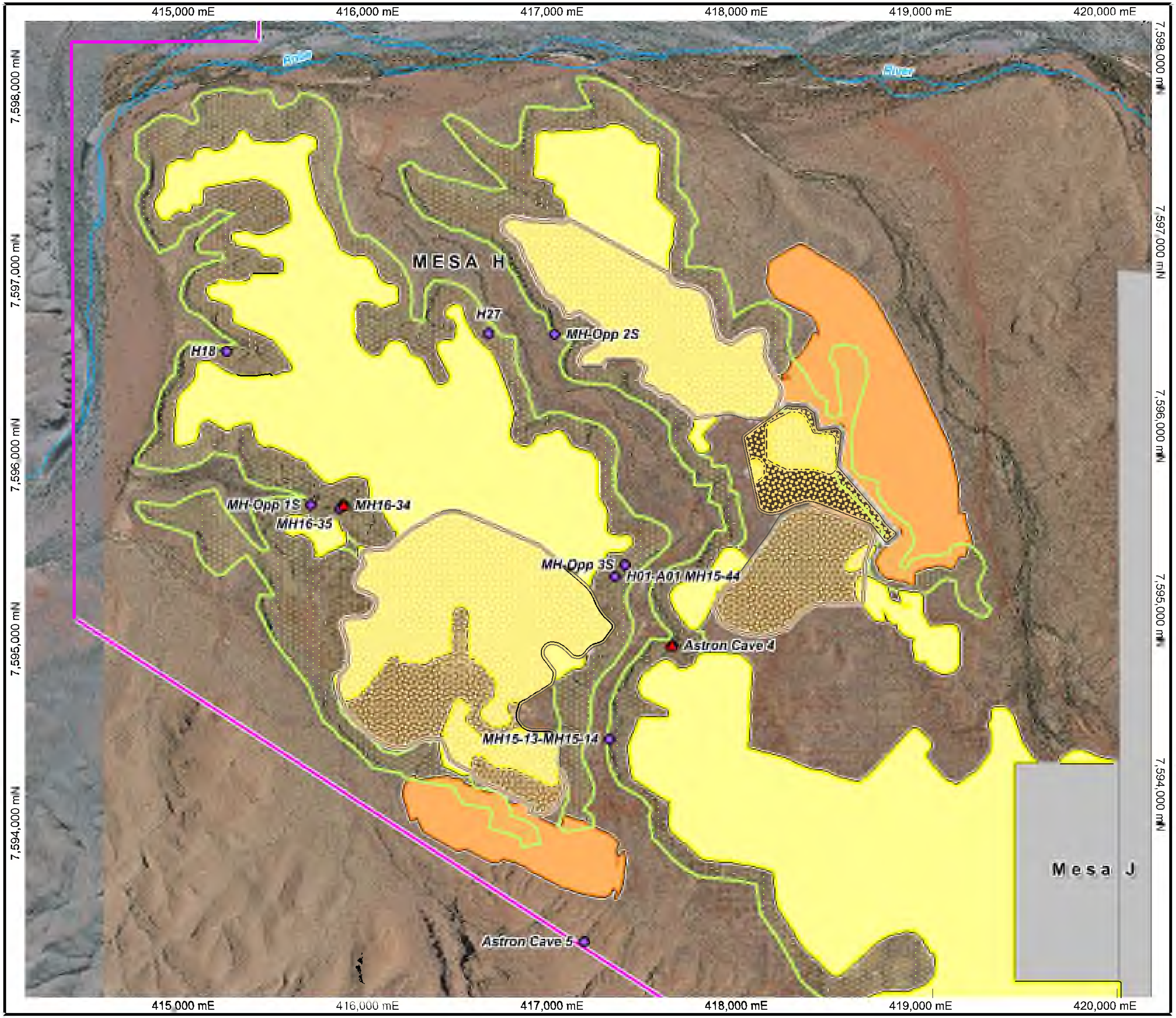
Up to 3.5 ha of potential roost habitat, comprising Gorge and Breakaway habitats, will be impacted, which represents approximately 4% of the available roost habitat in the Proposed Change Area. There are no caves within the area of disturbance. In addition, up to 24 ha of foraging and dispersal habitat including Riverine and Drainage Line habitat types will be directly impacted by the Proposed Change. This represents up to 4% of available foraging and dispersal habitat in the Proposed Change Area.

Given the mobility of the species and retention of the majority of roost habitat, the Proposed Change is unlikely to fragment the local population or habitat.

Loss of individuals

Individual Ghost Bats can be impacted by installation of barbed wire fencing, causing collisions during flight. The Proponent will install non-barbed wire fencing, except where legislated. Where barbed wire fencing is required for legislative compliance, reflectors will be attached to make fencing more visible and to reduce the risk of fauna injury or mortality due to entanglement with fencing. This approach has been applied elsewhere in the Pilbara and appears to be effective.

Vehicle movements for construction and operation of the mine may result in fauna strike, causing injury or death of individuals. However, vehicle movements at night (when Ghost Bats are foraging) are at a much lower frequency than during the day and are generally limited to in-pit operations. Vehicle movements for the Proposed Change are considered unlikely to result in a long-term decrease in the Ghost Bat population.



LEGEND

Development Envelope

Ministerial Statement 208

Major Watercourse

Conceptual Mine Layout

Mine Pit

Waste Dump

Topsoil / Subsoil Stockpile

Mining Exclusion Zone

Ghost Bat Roost (Nocturnal Feeding)

Ghost Bat Roost (Diurnal/ potential maternal)

N

SCALE

0 0.25 0.5 0.75 1km

1:30 000 @ A4

RioTinto

Iron Ore (WA)

Figure 8-14: Ghost Bat roosts retained in the Mining Exclusion Zone

Drawn: M.Swebbs
Date: Jan, 2019

Plan No: PDE0165465v1
Proj: MGA 94 (Zone 50)

8.6.3.3 Indirect impacts

Invasive species

The Cane Toad is a known threat to the Ghost Bat, if ingested (TSSC 2016a). Cane Toads are not currently established in the Pilbara, and the Proposed Change is considered unlikely to increase the opportunity for Cane Toads to become established.

The Feral Cat is also a threat to the Ghost Bat as they may compete for prey. There is little opportunity for the Proposed Change to cause an increase in the Feral Cat population. Feral Cat control will continue to be undertaken as needed in areas where the Proponent operates.

Vehicle movements for clearing and construction may introduce or spread weeds within the Development Envelope and reduce the quality of foraging habitat. The Riverine and Drainage habitats are currently subject to extensive weed invasion by Buffel Grass due to decades of former and current pastoral activities including cattle grazing. Increased weed spread may also elevate fire risk which may result in increased fire frequency or fire intensity and impact fauna habitat. The Proponent will undertake weed inspection and control in weed management areas which will include both manual and chemical control measures. Areas of high priority for weed management include Jimmawurrada Creek, Robe River permanent pools and river crossings, MEZs and topsoil stockpiles.

Loss of Habitat

The potential increase in water availability in the Robe River due to surplus water discharge may temporarily and locally increase available foraging habitat for the duration of the discharge.

Groundwater abstraction for pit dewatering will result in localised groundwater drawdown in the Mesa H CID aquifer that has some connectivity to the Robe River alluvial aquifer. This may affect Riverine habitat which provides foraging habitat for Ghost Bats. Modelling indicates the potential for a reduction in water levels in the Robe River alluvial aquifer and the Robe River semi-permanent and permanent pools of less than 1 m. This is not anticipated to change the permanent or semi-permanent nature of any of the pools. The key impact on fauna habitat will be a small reduction in the length of time semi-permanent pools exist following rainfall and a temporal reduction in the lateral extent of the pools. These impacts are not expected to significantly affect the quality of foraging habitats for Ghost Bats along Robe River.

Groundwater abstraction for water supply from the existing Southern Cutback Borefield, in combination with the upstream CWSP, and abstraction from the Mesa J Iron Ore Development, will increase groundwater drawdown below Jimmawurrada Creek and extend the timeframe for the predicted groundwater recovery once water abstraction ceases. This may result in localised changes to the canopy cover of riparian vegetation in the Jimmawurrada area, predominantly over a 6.5 km stretch (‘Zone 3’) during dry conditions. This impact may be exacerbated taking into consideration an extended dry period combined with seasonal water table lows. No semi-permanent or permanent pools occur in the Jimmawurrada area and the creek ecosystem function is expected to be maintained. Any changes to groundwater levels beneath Jimmawurrada Creek are considered unlikely to significantly impact Ghost Bat foraging habitat.

Noise and vibration

Noise and vibration from construction and operation may disturb Ghost Bats and cause individuals to abandon roosts. If these disturbances occur during the breeding season or while pups remain in the roost, this may impact the breeding cycle of the local Ghost Bat population. However, fauna monitoring at Process Minerals’ Poondano project, near Port Hedland, reported the continued presence of a colony of Ghost Bats despite mining. This suggests that blast management measures, such as implementation of MEZs around caves, and application of vibration thresholds are effective in preventing disturbance to bats and damage to caves (Astron 2015f).

Ghost Bat monitoring at West Angelas mine (Biologic 2015) has been undertaken since 2012. Monitoring in one cave located 70 m from the mine pit has shown evidence of Ghost Bat activity in every year until 2014, with a lack of activity in that year, and a subsequent return of activity recorded in the 2015 survey. Another cave located 90 m from the mine pit showed sporadic use over the monitoring period. The data suggests no significant impact on the size of the local population from mining (Biologic 2015).

Ghost Bats have been found to be roosting at Mesa H despite adjacent mining operations at Mesa J. It is possible that Ghost Bats which may be roosting immediately adjacent to an active mine pit may vacate roosts due to blasting and vibration, however, are expected to re-locate to alternate nearby roosts (B. Bullen pers comm 2018). Records of recent occupancy of Ghost Bat roosts in historic mining areas in the Robe Valley (Bat Call 2017a) emphasise the importance of maintaining the structural integrity and microclimates of the roosts to facilitate return of Ghost Bats.

Studies on sound and vibration transmissivity through Robe Pisolite as a result of blasting have been undertaken at Mesa A Operations and focussed on vibration propagation through the pit walls (Robe Pisolite). The studies indicated that blast vibrations were attenuated in the CID over a distance of less than 50 m from the blast site, without any specific blast management or trim shots being employed to reduce vibration. As blast management, including trim shots is proposed for mining at Mesa H (as described in Section 8.6.3.2and Section 8.9), the potential for vibration impacts will be further reduced.

The mine design incorporates a 40 m setback distance between the back of each potential diurnal/maternal roost cave and the proposed mine pit and 50 m from the entry to nocturnal roosts to protect the integrity of the diurnal / maternal roosts and to minimise the impact of noise and vibration on bats. In addition, the openings of recorded roosts are orientated away from the mine pit, which is expected to reduce the potential for noise impacts.

Blasting at the existing Mesa J Iron Ore Development occurs on average up to five times per week, with each blast lasting from two to ten seconds. A similar approach is expected to be adopted for this Proposed Change. The sporadic and brief nature of blasting means that blasting related vibrations may, at most, disrupt the local population for very brief periods of time.

A geotechnical assessment of the caves identified as potential diurnal / maternal Ghost Bat roosts (and associated complex) has also determined that the geotechnical sensitivity of these roosts to structural instability is considered to be low (Rio Tinto 2017g), however, a conservative approach has been adopted for setting vibration limits for blasting levels.

Ghost Bats are known to move between a number of caves seasonally or as influenced by weather conditions and utilise a number of caves (TSSC 2016a). The Ghost bat is an obligate cave roosting bat that is widespread across the Pilbara in general including the Robe valley (McKenzie and Bullen 2009; Bat Call 2017a). It has been the subject of detailed observations for many years and more recently of mid and long term monitoring programs. These have shown that Ghost Bats are constantly moving between available caves (B. Bullen,Bat Call WA, pers. Comm. 2019). Observations to date in the Robe Valley also indicate that the Robe Valley Ghost Bats are moving through the landscape opportunistically and possibly seasonally and are taking advantage of all of the foraging and roosting opportunities provided by the valley of the river, its tributaries and the various caves available (B. Bullen,Bat Call WA, pers. Comm. 2019).

Studies undertaken by Biologic indicate that groups of Ghost Bats move about within a local area and that multiple groups may use a cave (Biologic 2016). Biologic (2016) note that there generally isn't a continuous presence of Ghost Bats in any one cave and that it is rare to encounter a maternity group despite visiting the most suitable recorded caves in an area across a number of breeding seasons. In 2015 a maternity group was encountered in a small cave in the east Pilbara that had previously shown little evidence of Ghost Bat occupancy (Biologic 2016). Ghost Bat monitoring at the West Angelas mine site has been undertaken since 2012 (Biologic 2015). Monitoring in one cave located 70 m from the mine pit has shown evidence of Ghost Bat activity in every year until 2014, with a lack of activity in that year, and a subsequent return of activity recorded in the 2015 survey. Another cave located 90 m from the mine pit showed sporadic use over the monitoring period. The field observations thus indicate that Ghost Bats naturally move between a number of caves and that maternity groups may also use different roosts across different seasons. Hormone analysis supports these findings with scats from numerous caves in the same locality containing progesterone levels indicating pregnancy (Biologic 2016).

A study conducted by Bat Call WA (2017a) assessing habitat on all mesas in the Robe Valley from Mesa A to Mesa 2405A, approximately 40 km east of Mesa H (see Figure 11-5 in Section 11.1.4.5), showed Ghost Bat use of caves in historical mining areas. Thirteen mesas that have been historically mined were assessed. Of these, three have had their escarpments completely removed. No evidence of current Ghost Bat usage on these three mesas was found, although it is possible that occasional foraging visits are made. The percentage of retained perimeter on the remaining ten mesas, varies from 16% on Mesa 2402E to 93% on Mesa 2403D. Six of the ten mesas with retained escarpments had been recently surveyed; all contained evidence of current Ghost Bat usage and a possible diurnal roost was recorded on Mesa 2400E. This result shows that retained mesa escarpments at historically mined sites remain as Ghost Bat habitat and the protected caves and deep shelters on the escarpments continue to offer nocturnal and diurnal roost opportunities for the species (Bat Call WA 2017b).

Given the likely irregular presence of Ghost Bats at Mesa H, the retention of the two recorded diurnal and all nocturnal roosts in the Proposed Change Area, the natural movement of Ghost Bats between roosts, the availability of roosts outside the Development Envelope (Section 8.4.5.2), the use of caves in historically mine areas and the use of roosts by multiple Ghost Bat groups it is considered likely that there is opportunity for individuals to avoid any temporary indirect impacts and safely move to other caves within the species' range in the event that disturbance causes Ghost Bats to vacate a cave.

Lighting and dust

Temporary mobile lighting in areas of construction may result in some light spill to the mesa escarpments; however, this is not expected to significantly interfere with nocturnal foraging activities. Lighting will be directed inwards towards mine activities, and away from the mesa escarpments which contain Gorge and Breakaway habitat suitable for Ghost bat.

Dust management will be implemented; however, dust emissions are not expected to affect the diurnal / maternal roosts due to the protection afforded by distance of the known roosts from pit boundaries (diurnal roost AC04 is 95 m from the pit boundary and diurnal roost MH16-34 is 97 m from the pit boundary), and the caves face outwards from the active pits.

8.6.3.4 Cumulative impacts

The Proposed Change adds to previous impacts to Ghost Bat habitat from the existing Mesa J and Mesa A operations. Ghost Bats were recorded in the northern gorge on the eastern escarpment of Mesa A (Strategen 2006). The majority of the Mesa A escarpment was retained, with the exception of a cut of up to 50 m in the middle of the eastern escarpment. The remaining escarpment was retained in a MEZ, such that the direct impact to potential Ghost Bat habitat was minimised. In addition, a blast management framework applies, to minimise the vibration emissions and prevent rockfall or instability in Ghost Bat roosts.

Mesa H is immediately adjacent to the existing Mesa J Iron Ore Development. No systematic fauna survey was historically conducted at Mesa J prior to commencement and it is therefore not known if Ghost Bat inhabited the mesa escarpments prior to disturbance.

Mesa J includes approval to clear up to 1,800 ha of native vegetation, dewatering and discharge of surplus groundwater to the Robe River (BBG 1991). Given the characteristics of mesa landforms, it is possible that the Mesa J footprint supported suitable roost habitat for Ghost Bat and foraging habitat, however Mesa J includes retention of its main northern escarpment adjacent to the Robe River which contains what is likely to be viable Ghost Bat roost habitat.

The cumulative clearing across the Robe Valley (including historical, approved and reasonably foreseeable projects) will result in the loss of up to 10% of Breakaways and Gullies habitat which provides potential roost habitat and up to 1% of River habitat which supports foraging (Table 8-11 and Figure 8-13). On this basis, the impact from the Proposed Change is unlikely to result in significant cumulative impacts on the Ghost Bat.

8.6.3.5 Outcome

Given the setback distances and blast management to be applied to maintain the integrity of the recorded potential diurnal/maternal roost caves, the avoidance of direct impacts to all roost caves, the natural movement of Ghost Bats between roosts, the use of historically mined areas, the diverse foraging habitat of the Ghost Bat and the availability of foraging habitat outside the Development Envelope; the predicted loss of potential foraging habitat through clearing is unlikely to significantly impact the local population and is unlikely to affect the conservation status of the species. In addition, the connection of the cave habitat in the mesa façade (MEZ) will be maintained to preserve the direct access to the Robe River and connected foraging habitat for the species.

8.6.4 Pilbara Leaf-nosed Bat

8.6.4.1 Policy and Guidance

The Australian Government Species Profile and Threats Database provides the following advice regarding the importance of roosts (DotEE 2017b):

- Permanent diurnal roosts are occupied year round and are likely the focus for some part of the nine month breeding cycle and are considered critical habitat that is essential for daily survival.
- Non-permanent breeding roosts are used during some part of the nine month breeding cycle but are not occupied year round and are considered critical habitat for daily and long term survival.
- Transitory diurnal roosts are occupied for part of the year only outside of the breeding season and which could facilitate long distance dispersal in the region, and are critical habitat that is essential for daily and long-term survival.
- Nocturnal refuges are occupied or entered at night for resting, feeding or other purposes, with perching not a requirement. They are not considered critical habitat but are important for persistence in local areas.

Approved conservation advice for the species was published in 2016 (TSSC 2016b) and identifies populations and habitat critical to the survival of the species, national conservation objectives and priority conservation actions.

The type and quality of potential foraging habitat surrounding known or suspected roost sites can be critical to the survival of the Pilbara Leaf-nosed Bat. The Conservation Advice for the species (TSSC 2016b) lists the types of habitat that are used for foraging and their relative priority but also indicates that assessment of significance of habitat removal would include assessment of "the relative proportion of identified foraging habitats to be removed (e.g. within a surrounding 10 km radius from the roost)". The conservation advice states that actions are:

- highly likely to have a significant impact on Pilbara Leaf-nosed bats if an action causes the loss of confirmed or even potential roost sites; and
- may have a significant impact on Pilbara Leaf-nosed bats if an action disrupts breeding or removes a significant proportion of foraging habitat within proximity (e.g. 10 km radius from the roost).

There is currently no recovery plan for this species.

8.6.4.2 Direct Impacts

Loss of habitat

There are no known Pilbara Leaf-nosed Bat diurnal and/or breeding roosts present in the Proposed Change Area, however, a high level of activity was recorded in the Gorge habitat immediately to the south of the Proposed Change Area (Figure 8-8) and deep caves recorded within the Gorge habitat have dimensions suitable to be nocturnal refuges (Astron 2017e). The timing and location of calls recorded during the surveys indicate that the bats originate from a diurnal roost outside the Development Envelope (Bat Call 2017b).

The most important habitats within the Proposed Change Area for Pilbara Leaf-nosed Bat are Gorges, Breakaways, Riverine habitats and to a lesser extent; Drainage Line habitats (Astron 2017e).

The Proposed Change has been designed to avoid or limit direct disturbance to these key habitats as far as possible however they will be impacted by clearing associated with the Proposed Change (Section 8.6.1.1).

However, as these habitats are more than 10 km from the nearest roost site, this habitat is considered of low importance with regard to the Pilbara Leaf-nosed Bat ongoing viability.

Therefore, the direct impacts on foraging habitat as a result of the Proposed Change is not expected to have a significant residual impact on Pilbara Leaf-nosed Bats.

Loss of individuals

This species is known to display a curiosity for light sources (DotEE 2017b). Temporary mobile lighting in areas of active excavation may result in temporal and localised areas of light spill on to the mesa escarpments, similar to current operations at Mesa A and Mesa J; however, this is not expected to significantly interfere with nocturnal foraging. Attraction to light sources may also give rise to collisions with vehicles. Lighting will be directed inwards to the mining operations.

8.6.4.3 Indirect Impacts

Invasive species

The potential for increased weed occurrence in the Development Envelope is discussed in Section 6.6.3.4. The Proposed Change may introduce and spread weed species within and in the vicinity of disturbance. Weed species have the potential to spread further downstream with altered hydrological regimes, specifically, discharge to Jimmawurrada and West Creeks, which are tributaries into the Robe River.

The majority of Drainage Line and Riverine habitats are already subject to extensive weed invasion by Buffel Grass due to former and current pastoral activities including cattle grazing.

The Proponent has well established strategies for the management of weeds at its Pilbara operations to minimise the risk of the spread of weeds. The Proponent will undertake weed inspection and control in priority weed management areas which will include both manual and chemical control measures. Areas of high priority for weed management include Jimmawurrada Creek, Robe River permanent pools and river crossings, MEZs and topsoil stockpiles. It is unlikely that the Proposed Change will significantly impact vegetation or fauna habitat through the introduction and spread of weed species

Alteration of surface water and groundwater hydrology

The presence of Pilbara Leaf-nosed Bat in the Development Envelope confirms the area has foraging and dispersal habitat value. However, as the nearest roost is 10 km to the south-east of the Proposed Change Area, the potential foraging habitat within the Proposed Change Area, although utilised by the bats, is not considered important to the preservation of the population.

The potential increase in water availability in the Robe River due to surplus water discharge may locally and periodically increase available foraging habitat for the duration of the discharge.

Groundwater abstraction for pit dewatering will result in localised groundwater drawdown in the Mesa H CID aquifer that has some connectivity to the Robe River alluvial aquifer. This may affect Riverine habitat which provides foraging habitat for Pilbara Leaf-nosed Bats. Modelling indicates the potential for a reduction in water levels in the Robe River alluvial aquifer and the Robe River semi-permanent and permanent pools may be up to 1 m which is within the range of natural variability. This is not anticipated to change the permanent or semi-permanent nature of any of the pools. The key impact on fauna habitat will be a small reduction in the length of time semi-permanent pools exist following rainfall and a potential reduction in riparian vegetation canopy cover during drought conditions. Neither of these impacts are expected to significantly affect the quality of foraging habitats for Pilbara Leaf-nosed Bats along Robe River.

Groundwater abstraction for water supply from the existing Southern Cutback Borefield, in combination with the upstream CWSP, and abstraction from the Mesa J Iron Ore Development, will increase groundwater drawdown below a 12 km section of

Jimmawurrada Creek (Drainage Line habitat) and extend the timeframe for the predicted groundwater recovery once water abstraction ceases. This may result in localised changes to the canopy cover of riparian vegetation in the Jimmawurrada Creek area predominantly over a 6.5 km stretch where drawdowns of up to 9 m (14 mbgl) may occur from the cumulative drawdown effects. This impact may be exacerbated taking into consideration an extended dry period combined with seasonal water table lows, and is likely to result in localised riparian canopy decline and increased tree mortality. No semi-permanent or permanent pools occur in the Jimmawurrada area affected by groundwater drawdown and the overall creek ecosystem function is expected to be maintained.

The area most affected by groundwater drawdown along Jimmawurrada Creek ('Zone 3') is within a 10 km radius of the known Pilbara Leaf-nosed Bat roost, and occupies 319 ha, which is 1.02% of the area within the 10 km radius. Therefore, the temporary impacts expected to this portion of the habitat within 10 km of the known roost will affect only a small proportion of the total foraging habitat available within the radius.

Any changes to groundwater levels beneath Jimmawurrada Creek are therefore considered unlikely to significantly impact foraging habitat for Pilbara Leaf-nosed Bats.

Noise and vibration

Noise and vibration impacts associated with machinery use and in particular blasting, may disturb Pilbara Leaf-nosed Bat individuals foraging in the Development Envelope, such that they may temporarily avoid areas of suitable foraging or nocturnal roost habitat. However, these impacts are anticipated to be temporary with no long-term changes in the species' use of retained habitat.

In addition, there are currently four Pilbara Leaf-nosed Bat permanent roost caves in reasonably close proximity to other active large scale Pilbara open cut mining operations where monitoring has confirmed the persistence of the species despite operation of the mines; all four caves have remained viable diurnal roosts for the species and remain maternity roost candidates (B. Bullen,Bat Call WA, pers. Comm. 2019). Section 12.5.1 provides further description of these findings.

8.6.4.4 Cumulative impacts

The Proposed Change will add to the existing Mesa J and Mesa A operations in the Robe Valley. The Pilbara Leaf-nosed Bat was not recorded in the existing Mesa A operation project area and it is considered unlikely that this operation has had an impact on the species.

No systematic fauna surveys were undertaken of the Mesa J Iron Ore Development area prior to commencement, consequently it is not known if the species was present prior to disturbance.

The Pilbara Leaf-nosed Bat has been recorded in the broader Mesa A Hub Revised Development Envelope; however, no roosts have been identified. It is likely that the species forages in the area, including over Warramboo Creek. Proposed surplus groundwater discharge into Warramboo Creek may result in temporary changes to foraging habitat for this species, while noise and vibration impacts may cause individuals to temporarily avoid affected areas. It is unlikely that the Mesa A Hub Proposal will significantly impact this species and in turn, it is unlikely that this Proposed Change will contribute to significant cumulative impacts to the species.

The cumulative clearing across the Robe Valley (including historical, approved and reasonably foreseeable projects) will result in the loss of up to 10% of Breakaways and Gullies habitat which provides potential roost habitat and up to 1% of River habitat which supports foraging (Table 8-11 and Figure 8-13). On this basis, the impact from the Proposed Change is unlikely to result in significant cumulative impacts on the Pilbara Leaf-nosed Bat.

8.6.4.5 Outcome

Potential impacts of the Proposed Change on Pilbara Leaf-nosed Bat are limited to loss of foraging habitat which is not in proximity to a known roost, temporary reduction in quality of foraging habitat along Jimmawurrada Creek that is within 10 km of a known roost, and the potential for minor indirect impacts from light, noise and vibration. Given the lack of identified diurnal roosts in the Proposed Change Area and the presence of extensive foraging habitat along the Robe River and in the vicinity of the Proposed Change Area, the Proposed Change is not expected to adversely affect the local population or the conservation status of the Pilbara Leaf-nosed Bat.

8.6.5 Pilbara Olive Python

8.6.5.1 Policy and Guidance

Conservation advice for Pilbara Olive Python was published in 2008 (DEWHA 2008b) which describes distribution and habitat, recognised threats and regional and local priority actions. Priority actions relevant to habitat loss, disturbance and modification include:

- identify populations of high conservation priority;
- ensure road widening, maintenance activities, and gas infrastructure development (or development activities) in areas where the Olive Python (Pilbara subspecies) occurs do not adversely impact on known populations;
- manage any changes to hydrology which may result in changes to the water table levels, increased run-off, sedimentation or pollution; and
- investigate further formal conservation arrangements such as the use of covenants, conservation agreements or inclusion in reserve tenure.

The conservation advice for Pilbara Olive Python does not define critical habitat for the species or important populations for the long-term survival of the species.

8.6.5.2 Direct impacts

Loss of habitat

The most important habitat types in the Proposed Change Area for the Pilbara Olive Python, based on known habitat preferences are Breakaway and Gorge habitats which are likely to support denning, and Riverine, Rocky Hills and Drainage Line habitats which provide suitable habitat for hunting, foraging and dispersal (Astron 2017e).

In total, the proposed clearing will affect 3.5 ha of potential denning habitat for the construction of two cuttings to the mesa, to enable access to the incised central section of the mesa. These cuttings are required for haul road access and cannot be avoided; however, will be located away from the most valuable denning habitat. This clearing represents approximately 4% of suitable denning habitat in the Proposed Change Area.

Up to 24 ha of hunting, foraging and dispersal habitat will be cleared as a result of the Proposed Change. This represents approximately 3% of the available hunting, foraging and dispersal habitat in the Proposed Change Area.

A small amount of disturbance may also be required for a water mitigation management strategy during groundwater drawdown, which would comprise installation of layflat pipe over the mesa edge; however, this does not require clearing and is unlikely to create physical barriers to the movement of Pilbara Olive Pythons.

Fauna strike

Vehicle movements for construction and operation of the mine may result in fauna strike, causing injury or death of individuals. Vehicle speed limits will be imposed on access roads to minimise the risk of fauna strike. There have been no recorded incidents of vehicle collision with Pilbara Olive Pythons at the existing Mesa J Iron Ore Development.

8.6.5.3 Indirect impacts

Alteration of surface water and groundwater hydrology

The potential increase in water availability in the Robe River due to surplus water discharge may locally and periodically increase available foraging habitat for the duration of the discharge.

Groundwater abstraction for pit dewatering will result in localised groundwater drawdown in the Mesa H CID aquifer that has some connectivity to the Robe River alluvial aquifer. This may affect Riverine habitat along the Robe River which provides dispersal and foraging habitat for Pilbara Olive Pythons. Hydrogeological modelling indicates the potential for a reduction in water levels in the Robe River alluvial aquifer and the Robe River semi-permanent and permanent pools of less than 1 m. This is not anticipated to change the permanent or semi-permanent nature of any of the pools. The key impact for Pilbara Olive Pythons will be a small reduction in the length of time semi-permanent pools exist following rainfall events and a temporal reduction in the lateral extent of the pools. GDV is not expected to be significantly affected as the groundwater table will continue to be within the root zones of phreatophytes. Neither of these impacts are expected to significantly affect the quality of foraging habitats for Pilbara Olive Pythons along Robe River.

Groundwater abstraction for water supply from the existing Southern Cutback Borefield, combined with the cumulative drawdown effects of the upstream CWSP will increase groundwater drawdown below a 12 km section of Jimmawurrada Creek (Drainage Line habitat) and extend the timeframe for the predicted groundwater recovery once groundwater abstraction ceases. This may result in localised changes to the canopy cover of riparian vegetation and losses in vegetation biomass in the Jimmawurrada Creek area predominantly over a 6.5 km stretch ('Zone 3'). However, no semi-permanent or permanent pools occur in the Jimmawurrada area affected by groundwater drawdown associated with the Proposed Change. As the creek system is topped up during rainfall events and groundwater levels re-set during cyclonic rainfall events, no significant long term impact on potential Pilbara Olive Python habitat in this area is expected.

Noise and vibration

Snakes use the inner ear to identify prey and avoid predators by detecting ground vibrations. Blasting for the existing Mesa A operation has been done on average three times per week, with each blast lasting for two to ten seconds. A similar approach is expected to be adopted for this Proposed Change. The sporadic and brief nature of blasting means that blasting related vibrations are unlikely to interfere with the Pilbara Olive Python's ability to detect prey and avoid predators.

Invasive species

Feral cats are listed as a threat to the Pilbara Olive Python (DEWHA 2008b), particularly juvenile pythons. There is little opportunity for the Proposed Change to cause an increase in the feral cat population. Feral cat control will continue to be undertaken as required in areas where the Proponent operates.

Whilst Cane Toads pose a potential threat to the Pilbara Olive Python due to potential for poisoning from ingestion, current evidence indicates that adults do not eat Cane Toads (Turvey 2013). There is potential for poisoning from secondary consumption. Additional research is required to more clearly establish the threat the Cane Toad potentially poses to the Pilbara Olive Python. The Cane Toad is not currently established in the Pilbara and the Proposed Change is unlikely to increase the opportunity for the Cane Toad to become established in the area.

8.6.5.4 Cumulative impacts

The Proposed Change will add to the existing Mesa J and Mesa A operations in the Robe Valley. Mesa J includes approved clearing of up to 1,800 ha and includes dewatering to enable BWT mining and a borefield for water supply. Surplus dewater is discharged into Jimmawurrada Creek and West Creek which are tributaries of the Robe River. This operation has altered the baseline hydrology of the local area, which may have impacted the availability and quality of habitat for Pilbara Olive Python. No systematic fauna surveys were undertaken of the Mesa J Iron Ore Development area prior to commencement, consequently it is not known if the species was present prior to disturbance.

The Mesa J Iron Ore Development has avoided mining of the northern mesa escarpment, abutting the Robe River, which likely provides suitable habitat for the species.

The existing Mesa A operation retained the majority of the mesa escarpment, with the exception of cuts to the mesas. The Mesa A Hub Revised Proposal will extend the existing Mesa A operation and enable BWT mining, proposed dewatering and pumping for water supply, and discharge of surplus water into Warramboo Creek. This may result in increased levels and seasonal availability of surface water, resulting in temporary changes to foraging habitat for this species.

The cumulative clearing across the Robe Valley (including historical, approved and reasonably foreseeable projects) will result in the loss of up to 10% of Breakaways and Gullies habitat which provides potential for denning and up to 1% of River habitat which supports foraging (Table 8-11 and Figure 8-13). On this basis, the impact from the Proposed Change is unlikely to result in significant cumulative impacts on the Pilbara Olive Python.

8.6.5.5 Outcome

Given the retention of suitable denning and foraging habitat within the Proposed Change Area, the wider presence of denning and foraging habitat and populations outside of the Development Envelope in the Robe Valley and elsewhere in the Pilbara including Karijini National Park, Pannawonica, Millstream, Tom Price, Burrup Peninsula and Rangelands Natural Resource Management Region (DotEE 2017c; DEWHA 2008b), the limited loss of potential denning and foraging habitat via clearing is not expected to adversely impact the conservation status of the Pilbara Olive Python. Indirect impacts are not expected to be significant.

8.6.6 Lined Soil-crevice Skink

There is no conservation advice or recovery plan for this species. The most suitable habitat for this species in the Proposed Change Area includes Loamy / Stony Plains and Low Hills and Slopes habitat types which are widespread within the Proposed Change Area and conceptual mine layout. The Proposed Change may result in the direct loss of individuals.

Given the retention of at least 50% of suitable habitat within the Proposed Change Area, the Proposed Change is unlikely to contribute to cumulative impacts or significantly impact any individuals occurring in the local area, or the conservation status of the species.

8.6.7 Western Pebble-mound Mouse

There is no conservation advice or recovery plan for this species. The most suitable habitat for this species in the Proposed Change Area includes Low Hills and Slopes habitat.

Clearing will directly impact up to approximately 50% of Low Hills and Slopes habitat, within the Proposed Change Area. This may include direct disturbance to mounds. Low Hills and Slopes habitat is widespread and common in the Pilbara region. Given the lack of individuals recorded in the Proposed Change Area, and widespread availability of suitable habitat in the region, the proposed disturbance is not expected to adversely affect a local population or the conservation status of the species.

8.6.8 Blind snake

There is no conservation advice or recovery plan for the Blind Snake, *Anilios ganei*.

Clearing will impact up to 4 ha of Gorge, Breakaway and Rocky Hills habitat which represents approximately 3% of the mapped extent of habitat in the Proposed Change Area. This is considered unlikely to affect a local population or the conservation status of the species.

8.6.9 Letter-winged Kite

There is no conservation advice or recovery plan for this species.

The Proposed Change will directly impact up to 1.3 ha of Riverine habitat which likely provides suitable habitat for this species. This represents less than 1% of the mapped extent of Riverine habitat in the Proposed Change Area.

Given the species likely only occurs as an itinerant visitor to the Development Envelope during times of population increases, and the availability of this habitat type outside of the Development Envelope, the proposed disturbance is considered unlikely to impact any itinerant visitors or the conservation status of the species.

8.6.10 Australian Painted Snipe

Approved conservation advice for the Australian Painted Snipe was published in 2013 (DSEWPaC 2013). The advice identifies key threats as loss and degradation of wetlands, through drainage, surface water diversion and agriculture, weed invasion, fire, reducing rainfall as a result of climate change, and potential predation by foxes and feral cats.

The Proposed Change will directly impact up to 1.3 ha of Riverine habitat which is likely suitable habitat for the species. This represents less than 1% of the mapped extent of Riverine habitat in the Proposed Change Area.

The discharge of surplus water may increase the level and availability of surface waters within the Proposed Change Area for the duration of discharge activities. This may be temporarily beneficial to the species.

Given the species' wide distribution and availability of habitat outside of the Development Envelope, the proposed disturbance is considered unlikely to impact any itinerant visitors to the area or the conservation status of the species.

8.6.11 Common Sandpiper, Sharp-tailed Sandpiper, Wood Sandpiper, Common Greenshank, Oriental Pratincole

A Wildlife Conservation Plan (DoE 2015b) applies to these five migratory shorebirds. This plan aims to protect important habitats for migratory shorebirds, including wetland habitats and to address information gaps relating to shorebird ecology. The plan defines nationally important habitat for these species as habitat that supports the following:

- 0.1% of the flyway population of a single species of migratory shorebird; or
- 2,000 migratory shorebirds; or
- 15 migratory shorebird species.

These species have the potential to occur as migrant non-breeding visitors to the area; however, none have been recorded in the Proposed Change Area. On this basis, the Proposed Change Area does not support nationally important habitat for these species.

The Proposed Change will directly impact up to 1.3 ha of Riverine habitat which is likely to be suitable habitat for these species. This represents less than 1% of the mapped extent of Riverine habitat in the Proposed Change Area.

The discharge of surplus water may increase the level and availability of surface waters within the Proposed Change Area for the duration of discharge activities. This may be beneficial to these species in temporarily increasing habitat availability, However, the predicted change in the level and availability of surface water will result in the same discharge footprint / duration as current operations and will only occur intermittently and mostly after wet seasons.

Given the limited impact to suitable habitat and lack of records of these species in the Proposed Change Area, the proposed disturbance is considered unlikely to impact the conservation status of these species.

8.6.12 Long-tailed Dunnart

There is no conservation advice or recovery plan for this species.

The Proposed Change will impact Breakaway, Rocky Hills, Low Hills and Slopes and Loamy / Stony Plains habitats, which likely provides suitable habitat for the Long-tailed Dunnart.

The majority of the impact will occur in the Low Hills and Slopes and Loamy / Stony Plains fauna habitat types.

Given the lack of records of this species in the Proposed Change Area and retention of the majority of suitable habitat within the Proposed Change Area, the proposed disturbance is considered unlikely to affect the conservation status of this species.

8.6.13 Short-tailed Mouse

There is no conservation advice or recovery plan for this species.

The Proposed Change will directly impact up to approximately 64% of Loamy / Stony Plains habitat within the Proposed Change Area. This habitat type is widespread and common in the Pilbara region.

Given the lack of records of the species in the Proposed Change Area, limited impact and widespread availability of suitable habitat, the proposed disturbance is considered unlikely to significantly impact a local population if present, or the conservation status of the species.

8.6.14 Potential SREs

No known SRE species were recorded in the Proposed Change Area; however, four potential SRE species were recorded in a number of habitat types including Riverine, Loamy / Stony Plains, Breakaway, Gorge habitats and disturbed areas. The status of potential SREs is often unclear and the data available is insufficient to establish SRE status with certainty. In these cases, the WAM assigns the following categories:

A. Data Deficient – insufficient data to determine SRE status

B. Habitat indicators – where habitat is known to be associated with SRE taxa

C. Morphology Indicators – morphological characteristics that are characteristic of SRE taxa

D. Molecular evidence – if molecular work is done it may reveal patterns congruent or incongruent with SRE status

E. Research and Expertise – previous research and / or WAM elucidates taxon SRE status.

The slater, *Buddelundia* ‘61’ was recorded from multiple habitats (Breakaway and Gorge) that extend far beyond the survey area (Astron 2017e). Buddelundia ‘61’ has been recorded at Bungaroo 12 times, with the nearest record located approximately 26 km south-east of the Development Envelope. These records occurred in habitat similar to that occurring in the Proposed Change Area. This species is considered to be widespread and is a habitat generalist (Astron 2017c). While it is considered unlikely to be restricted to the Proposed Change Area, it is a potential SRE in the category ‘Research and Expertise’. The Proposed Change will directly impact up to 3.5 ha of Breakaway and Gorge habitats within the Proposed Change Area, which represents approximately 3% of the mapped extent in the Proposed Change Area; however, it will avoid the one recorded location of this species in the Proposed Change Area. This is considered unlikely to significantly impact the species.

The scorpions *Lychas* ‘sp. nov. 1’ and *Lychas* ‘sp. nov. 2’ are both considered potential SREs in the category ‘Molecular Evidence’ due to lack of matching DNA sequences in the WA Museum database.

Lychas ‘sp. nov. 1’ was recorded in Riverine habitat which extends beyond the Proposed Change Area. It is possible that this species has a wider distribution; however, further field surveys and DNA sequencing is required (Astron 2017e). The two recorded locations of *Lychas* ‘sp. nov. 1’ will be avoided by the Proposed Change.

Lychas ‘sp. nov. 2’ was collected from two locations in the widespread and common Loamy / Stony Plains habitat which may suggest wider distribution of this species; however, further field work would be required to confirm this. Based on morphology, the specimens could possibly be conspecific with *Lychas* ‘gracilimanus’ which is an informally described species by Erich Volschenk but no DNA sequences are available in the WAM database for this species. *Lychas* ‘gracilimanus’ is also considered a potential SRE by Erich Volschenk but has been previously collected during fauna surveys in the Pilbara, including a location north-east of Mile Camp and Bonney Downs Homestead approximately 290 km east of the survey area (Astron 2017e).

One recorded location of *Lychas* ‘sp. nov. 2’ will be impacted by the Proposed Change, as it occurs within the footprint of the proposed mine pit; however, given the widespread and common distribution of the Loamy / Stony Plains habitat type, it is possible that this species occurs elsewhere.

The remaining three recorded locations of *Lychas* ‘sp. nov. 1’ and *Lychas* ‘sp. nov. 2’ will be avoided by the Proposed Change.

Approximately 36% of the Loamy / Stony Plains habitat mapped in the Proposed Change Area will be retained.

The juvenile spider identified as *Karaops feedtime* produced inconclusive genetic data. The specimen may potentially represent a new species that is genetically and morphologically similar to *Karaops feedtime*. Given this uncertainty, this specimen is considered a potential SRE in the category ‘Data Deficient’, but is referred to here as *Karaops feedtime* to avoid confusion. The Proposed Change will avoid the recorded location of this species within the Proposed Change Area and therefore is considered unlikely to significantly impact the species. An additional spider; *Karaops* sp. indet. is a potential SRE that was collected from one location outside the Development Envelope. Genetically similar specimens have been collected from three other locations outside the Development Envelope. This spider is considered to be widespread and won’t be impacted by the Proposed Change and is therefore not considered further in this assessment as described in Section 8.4.6.

On the basis of habitat retention, the Proposed Change may impact one potential SRE, *Lychas* ‘sp. nov. 2’; however, it is considered unlikely to significantly impact the remaining four potential SREs.

8.7 Assessment of Impacts to Aquatic Fauna

8.7.1 Direct impacts

The Proposed Change will directly impact up to 1.3 ha of Riverine habitat which includes permanent and semi-permanent pools along Robe River, which support aquatic fauna. This represents less than 1% of the available Riverine habitat within the Proposed Change Area; however, this habitat type extends beyond the Proposed Change Area.

8.7.2 Assessment of potential indirect impacts

Groundwater abstraction for pit dewatering will result in localised groundwater drawdown in the Mesa H CID aquifer that has some connectivity to the Robe River alluvial aquifer. Modelling indicates the potential for a reduction in water levels in the Robe River alluvial aquifer and the Robe River semi-permanent and permanent pools may be up to 1 m. This is not anticipated to change the permanent or semi-permanent nature of any of the pools. The key impact on aquatic fauna habitat will be a small reduction in the length of time semi-permanent pools exist following rainfall and a temporal reduction in the lateral extent of the pools. The continued existence of permanent pools will ensure that critical refuges for fish and other aquatic fauna are maintained.

Discharge of surplus abstracted groundwater into the Robe River will likely increase the levels and seasonal availability of surface water for the duration of discharge activities, and across the predicted discharge extent of up to 8 km. Discharge will also likely alter surface water quality, particularly during natural no-flow conditions. During the wet season or when the Robe River is in flood, surplus groundwater will be diluted by natural surface water flow. Discharge will cease upon closure.

Groundwater chemistry data for samples collected from bores most likely to represent the proposed surplus water discharge were compared with data from surface water samples collected from. The groundwater chemistry of the surplus water proposed for discharged has a neutral to mildly alkaline pH and is considered fresh. The mean groundwater electrical conductivity value and mean concentrations of nitrogen and dissolved silver, boron, cobalt and copper were elevated compared with background levels in surface water collected from the Robe River. Electrical conductivity and nitrate values were typically an order of magnitude greater than recorded for surface water in the Robe River. Occasional elevated concentrations of arsenic, silver, cadmium and zinc have also been recorded in some bores. Under natural no-flow conditions, discharged surplus water has the potential to change sediment quality and water chemistry in an 8 km section of the Robe River tributaries; Jimmawurrada Creek and / or West Creek, potentially causing temporary vegetation stress and impacts to aquatic fauna for the duration of discharge.

Based on the available data, potential risks to aquatic fauna from surplus water discharge are considered to be osmotic shock due to elevated electrical conductivity, metal toxicity, nitrate toxicity and eutrophication effects due to nitrogen enrichment. Risk will be greatest during natural recessional or no-flow periods when discharge constitutes a greater proportion of flow in the creek, and the diluting effect of rainfall is low. Elevated levels in groundwater do not automatically imply that these are the levels to which creek biota will be exposed. For nitrate, eutrophication and toxicity effects will depend on the biogeochemical capacity of the creek to recycle nitrate through the ecosystem via microbial denitrification in the soil. For dissolved metals, toxicity will be strongly dependent on the form of the metal and the degree to which it is bioavailable. Many metals also readily bind to organic matter and clays and precipitate out of the water column, making them unavailable for direct uptake by plants and fauna and hence of low toxic risk. Levels of dissolved organic matter in most surface waters are often sufficient to remove silver, cadmium, copper and zinc toxicity (ANZECC/ARMCANZ 2000).

The potential impacts to aquatic fauna are described below.

8.7.3 Micro-invertebrates

E. lumholtzi is the only identified micro-invertebrate species of significance. Any potential indirect impact to the local *E. lumholtzi* population as a result of changes to surface water quality in the Robe River is likely to be temporary, lasting for the duration of discharge activities, and seasonal, limited to times of natural no-flow conditions. The altered hydrology and potential impact to surface water quality is unlikely to adversely affect the species' known wider population (C. Hofmeester, Wetland Research and Management, pers. comm. 2017).

8.7.4 Macro-invertebrates

The lowering of surface water levels in permanent and semi-permanent pools of the Robe River has the potential to indirectly reduce the local availability of habitat for macro-invertebrates. Although the area of habitat may be reduced, the continued existence of permanent pools will ensure that critical refuges for aquatic fauna are maintained.

Discharge of surplus abstracted groundwater into the Robe River may potentially impact the *Nedsia* sp. which is considered likely to be a potential SRE species. Alteration in surface water quality during natural no-flow conditions may impact this species downstream of the discharge point under natural no flow conditions; however, during natural flow conditions, surplus groundwater will be diluted and is unlikely to impact aquatic fauna. The Proposed Change is considered unlikely to significantly impact the species regionally.

8.7.5 Fish

The potential lowering of surface water levels in permanent and semi-permanent pools of the Robe River has the potential to directly reduce the local availability of habitat for the Fortescue Grunter. Although the area of habitat may be reduced, the continued existence of permanent pools will ensure that critical refuges for fish are maintained. Annual monitoring of fish in the Robe River pools from 1991 to 2017 has shown no evidence of impacts to fish species as a result of implementation of the Mesa J Project (Streamtec 2017). The patterns of fish species distribution are unrelated to the position of sites in relation to Mesa J (e.g. similar patterns upstream and downstream) (Streamtec 2017).

8.7.5.1 Fortescue Grunter

Changes to surface water quality from discharge activities have the potential to indirectly impact the size and health of the local population of Fortescue Grunter. However, no impact on the species has been recorded to date from Mesa J discharges and the species exists in an environment with a naturally high variability in surface water quality which varies significantly with rainfall and concentration from evaporation during dry periods.

8.7.5.2 Blind Cave Eel

Approved conservation advice for the Blind Cave Eel was published in 2008 (DEWHA 2008a). This advice identifies key threats to the species including mining, canal development, water abstraction, pollution and landfill.

Groundwater abstraction for water supply from the existing Southern Cutback Borefield combined with drawdown from the Mesa J Iron Ore Development and drawdown from the upstream CWSP will increase groundwater drawdown below a 12 km section of Jimmawurrada Creek (Drainage Line habitat) and extend the timeframe for the predicted groundwater recovery once water abstraction ceases. This may result in localised changes to the canopy cover of riparian vegetation in the Jimmawurrada Creek area predominantly over a 6.5 km stretch ('Zone 3') where drawdowns of up to 9 m (14 mbgl) may occur from the cumulative drawdown effects. This impact may be exacerbated taking into consideration an extended dry period combined with seasonal water table lows.

This drawdown will occur within an area that contains a known Blind Cave Eel record (located 1.1 km from the Proposed Change Area). No semi-permanent or permanent pools occur in the Jimmawurrada area and the creek ecosystem function is expected to be maintained. The subterranean habitat below Jimmawurrada Creek will be affected by groundwater drawdown which will reduce the aquifer thickness and stygofauna habitat available. Wet season flows are expected to continue to provide seasonal recharge and connectivity of the alluvial habitat through this creek system. Therefore, any localised impact on groundwater levels below Jimmawurrada Creek is likely to be seasonal and impact subterranean habitat for the Blind Cave Eel during the dry season only. This impact is not expected to permanently fragment any Blind Cave Eel habitat or populations, or significantly affect the distribution of the Blind Cave Eel.

Potential impacts to the Blind Cave Eel are addressed in more detail as part of the subterranean fauna assessment in Section 7.

Given the current limited status of knowledge of this species, there is uncertainty regarding the area of risk, the degree of habitat modification and the range and sensitivity of the Blind Cave Eel. Therefore, this risk is proposed to be offset to enhance further research into the understanding of the occurrence and range of this species (Section 13).

8.8 Closure

The Mesa J Hub Closure Plan (Rio Tinto 2018a) is an integrated closure plan encompassing the existing Mesa J and Mesa K operations, together with the inclusion of the Proposed Change, in order to optimise closure outcomes. The plan is an update to and supersedes previous closure plans for the existing Mesa J and K Operations. The Closure Plan includes the mine developments and associated infrastructure contained within the Development Envelope (Mesa J and H) and within Mesa K's Development Envelope. A summary of the approach to closure in the Revised Proposal and how it relates to the terrestrial fauna factor is provided below.

The majority of high value habitat for MNES recorded in the Proposed Change Area including Northern Quoll, Ghost Bat, Pilbara Leaf-nosed Bat, Pilbara Olive Python, and the Blind Cave Eel will be retained by the Proposed Change. Upon closure, the Proponent commits to rehabilitating the area to a safe, stable and self-sustaining native ecosystem that may provide opportunity for suitable fauna habitat. The intent is to create habitats and landforms in appropriate locations to encourage natural migration of fauna species into rehabilitated areas. Habitat elements considered as part of the final landform design include:

- vegetation known to provide food or shelter;
- retaining and replacing woody debris;
- generation and retention of leaf litter using small scale topography;
- introducing or leaving rocky features such as oversized waste burden or scree slopes;
- returning soil to allow opportunities for burrowing fauna;
- managing feral predators and herbivores across both reference and rehabilitated areas; and
- backfilling of the MEZ in locations to allow fauna habitat continuation.

In addition, work will be undertaken to determine the best strategy for reducing surplus water discharge, to minimise impact to native fauna which may have adapted to the altered regime.

8.9 Mitigation

Mitigation strategies to address the potential impacts and predicted outcomes in relation to potential impacts are presented in Table 8-15.

The Mesa J Hub EMP (Appendix 6) includes Mesa H and addresses the key environmental factors which were determined by the EPA as being relevant to the appropriate management of dewatering, surface water discharge, conservation significant vegetation communities and fauna species associated with the Proposed Change. The EMP identifies:

- Mitigation strategies proposed to minimise impacts to significant environmental values.
- The environmental criteria that the Proponent will use to monitor performance of the mitigation strategies to ensure environmental objectives are met.
- Trigger criteria, threshold criteria, trigger level actions and threshold contingency actions aligned with the overall management approach.
- The management actions that will be implemented in response to monitoring results.

Table 8-15: Mitigation measures and predicted outcomes for terrestrial fauna

Inherent impact	Mitigation	Residual impacts	Assessment of significance[9]	Offset required?
EPA Objective: To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.				
Potential direct impacts				
Loss or fragmentation of fauna habitat as a result of clearing: Clearing will reduce the available extent of fauna habitat including Riverine, Drainage Line, Gorge, Breakaway and Rocky Hills, which provide suitable habitat for conservation listed species recorded in the region.	**Avoid**: The Proposed Change has been designed with a MEZ around the perimeter of Mesa H which will permanently sterilise ore in this part of the mesa. This is designed to avoid impact to the majority of the significant Gorge, Breakaway and Rocky Hills habitats. The MEZ enables avoidance of all direct disturbance of recorded potential diurnal/maternal roost caves and nocturnal roosts for Ghost Bats and protects the integrity of the habitat values of these caves. The mine design incorporates a 40 m setback distance between the back of each diurnal / potential maternal roost cave and the proposed mine pit and >50 m from the entry to nocturnal roosts to minimise the impact of blasting and associated vibration on the structure and quality of roosts. The Proposed Change avoids direct impacts to Riverine habitat except for <2 ha of clearing required to widen an existing road and avoids direct impacts to all semi-permanent and permanent pools. The Proposed Change avoids fragmentation of habitat between the mesa escarpment and the Robe River. **Minimise**: The total mine footprint has been minimised through the utilisation of existing Mesa J	The Proposed Change will result in the loss of up to 2,200 ha of fauna habitat (including habitats for conservation significant fauna species) including: High value fauna habitat, including: • 0.5 ha Rocky Hills habitat • 0.1 ha Gorge habitat • 3.4 ha Breakaway habitat. Moderate value fauna habitat: • 1.3 ha Riverine habitat Low value fauna habitat: • Drainage Line habitat • Low Hills and Slopes habitat • Loamy / Stony Plain habitat • previously disturbed habitat. The most significant habitats are largely protected through establishment of the MEZ and through infrastructure planning. None of the habitats recorded are restricted to the Proposed Change Area. The fauna habitats occur throughout the Robe Valley. The proposed habitat loss is treated as a permanent habitat loss due to the long duration of disturbance and the level of uncertainty regarding the timing and extent of re-establishment of habitat values following rehabilitation and closure. However, rehabilitation will be undertaken	The Proponent considers that the Proposed Change meets the EPA objective for this factor; the proposed loss of habitat is not expected to cause any loss of biological diversity at the local or regional scale and the ecological integrity of the area surrounding the footprint is expected to be maintained. Given the proposed avoidance via the creation of a MEZ and minimisation of disturbance to significant habitats; and the widespread distribution and/or low value to terrestrial fauna of the other habitats, the loss of habitat is not expected to adversely affect the conservation status of species (including species of elevated conservation significance) or affect the availability or quality of significant habitat for a species. After the mitigation hierarchy has been applied, including avoidance of direct impacts to key habitat and key habitat features, the Proponent considers that the direct impact to core habitat for the Northern Quoll; 3.5 ha of Breakaway and Gorge habitat (equivalent to Breakaways and Gullies MNES habitat), 3.8 ha of habitat within 10 m	Yes. The proposed offset for the significant residual impact is the contribution of $3,000 per ha of direct impacts to 8.6 ha of core habitat or an alternative but equivalent resourcing of an offset project that will provide direct benefits to Northern Quoll in the Pilbara.

[9] Assessed in accordance with the residual impact significance model (EPA 2014)

Inherent impact	Mitigation	Residual impacts	Assessment of significance[9]	Offset required?
	infrastructure, processing facilities and rail facilities. In addition, Mesa J mine pits will be used for disposal of waste fines rather than requiring clearing of additional habitat to develop an external WFSF. The width of the haul road access points to the mesa have been designed to minimise disturbance to the escarpments and the locations were optimised to avoid disturbance to the highest value areas (Astron 2017c). A five year study of Ghost Bat utilisation of high value habitat in the Robe Valley will be undertaken with the objective to improve knowledge of the Ghost Bat population and utilisation of high value habitat in the Robe Valley in order to assist in maintaining biological diversity and ecological integrity. This will involve bi-annual collection and analysis (genetic and hormone) of scat samples from across the broader Robe Valley and measurement of temperature and humidity in Ghost Bat roost caves (see EMP in Appendix 6). After a period of five years the monitoring frequency and type will be reviewed. **Rehabilitate:** The Mesa J Hub Closure Plan (Appendix 7) includes a closure objective to ensure that vegetation on rehabilitated land is self-sustaining and compatible with the final land use. The conditions of the new MS will require the Proponent to implement a Closure Plan in accordance with the DMP / EPA Guidelines for Preparing Mine Closure Plans. The initial Mine Closure Plan is provided in Appendix 7.	which will re-establish some fauna values following closure. The habitat types that are most significant to conservation significant fauna (i.e. Breakaways and Gullies habitat (Breakaway and Gorge) and River habitat) will have more than 90% of their pre-European extent remaining within the Robe Valley after the cumulative impacts of all historical and reasonably foreseeably projects have been considered. The habitat type most affected by clearing in the Robe Valley are the Mesa Plateaus which have had 42.3% cleared to date and cumulative impacts from reasonably foreseeable projects will increase clearing to 61% of pre-European extent. The habitat loss within the Mesa Plateau habitat unit is predominantly of the plateau itself rather than the mesa escarpment which has the highest habitat value; particularly for bats and Northern Quolls (in addition to other environmental factor values). The Proposed Change will directly impact core habitat for the Northern Quoll; 3.5 ha of Breakaway and Gorge habitat, 3.8 ha of habitat within 10 m of Breakaway and Gorge habitat and 1.3 ha of Riverine habitat.	of Breakaway and Gorge habitat and 1.3 ha of Riverine habitat, is considered to be a significant residual impact for the Northern Quoll and requires offsetting. Given the proposed mitigation and offset, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Terrestrial Fauna.	
Potential indirect impacts				
Loss of individuals from increased vehicle	The following management strategies will be implemented to manage the potential loss of	The Proposed Change will result in the loss of approximately 0.4% of Gorge habitat and approximately 4% of Breakaways habitat	Given the avoidance of high value habitat (for both conservation significant and other fauna species),	No. The Proponent considers that the

Inherent impact	Mitigation	Residual impacts	Assessment of significance[9]	Offset required?
strikes, collisions with fencing and construction activities: Construction and operation has the potential to result in the loss of some individuals of the following conservation significant fauna species: EPBC listed fauna • Northern Quoll • Pilbara Olive Python • Pilbara Leaf-nosed Bat • Ghost Bat. BC Act listed fauna: • Lined Soil-crevice Skink • Western Pebble-mound Mouse. Potential SRE: • *Buddelundia* '61' • *Lychas* 'sp. nov. 1' • *Lychas* 'sp. nov. 2' • *Karaops feedtime* •	individuals (including individuals of conservation significance): **Avoid**: The Proposed Change has been designed with a MEZ around the perimeter of the mesa which will permanently sterilise ore in this part of the mesa. This avoids impact to the majority of the significant Gorge, Breakaway and Rocky Hills habitats and avoiding impact to these habitats will also avoid direct impact to those fauna individuals that utilise them. **Minimise:** The Proponent will limit clearing to up to 2,200 ha and will retain approximately 99% of the Riverine habitat, 99% of Gorge habitat and 95% of Breakaways habitat. The Proponent will undertake annual monitoring of the Ghost Bat population in the Development Envelope to detect any potential declining trend. In the event that populations decline as a result of implementation of the Proposed Change, the Proponent will implement mitigation measures. In the event that active dens or nests of conservation significant fauna species are identified within the proposed footprints and disturbance cannot be avoided, licensed wildlife handlers will capture and translocate individuals to suitable nearby habitat in consultation with the DBCA. Direct impacts to fauna from vehicle strikes will be minimised through the use of speed limits and strict management of access outside of the active mining area. The Proponent will install non-barbed wire fencing, except where legislated. Where barbed wire fencing is required for legislative compliance, reflectors will be attached to make fencing more	which support Northern Quoll denning, potential denning for Pilbara Olive Python and Ghost Bat roosts and foraging for Pilbara Leaf-nosed Bat. The Proposed Change will avoid recorded Northern Quoll dens and Ghost Bat diurnal / potential maternity roosts.	the potential loss of individuals will be minimised and is not expected to be significant. The Proponent considers that the Proposed Change can be managed to meet the EPA's objective for terrestrial fauna. No significant residual impact to areas of high conservation significance or unusually high biological diversity is expected.	potential impacts can be managed and the residual impact is not considered to be significant and therefore does not warrant the application of offsets.

Inherent impact	Mitigation	Residual impacts	Assessment of significance[9]	Offset required?
	visible and to reduce the risk of fauna injury or mortality due to entanglement with fencing. This approach has been applied elsewhere in the Pilbara and appears to be effective. **Rehabilitate**: The conditions of the MS shall require the Proponent to implement a Closure Plan in accordance with the DMP / EPA Guidelines for Preparing Mine Closure Plans. The Closure Plan (Appendix 7) includes a closure objective to ensure that final landform is stable and considers ecological issues. Further detail regarding MNES species is provided in Section 11.1.			

Inherent impact	Mitigation	Residual impacts	Assessment of significance[9]	Offset required?
Alteration of fauna habitat due to altered hydrology arising from groundwater abstraction. Lowering of groundwater levels as a result of groundwater abstraction, may impact the quality of foraging habitat for Ghost Bat, Pilbara Leaf-nosed Bat and Pilbara Olive Python and the availability of habitat for the Blind Cave Eel and aquatic fauna including the *Nedsia* sp. and the Fortescue Grunter.	The following management strategies will be implemented to manage the potential loss of fauna habitat from groundwater abstraction: **Avoid:** The Proposed Change will utilise an existing water supply borefield and therefore avoid creating a new drawdown area for groundwater supply. **Minimise:** The Proponent will utilise mine water from mine pit dewatering for water supply as far as practicable. The Proponent will abstract groundwater within the existing licence limits regulated under the RIWI Act and monitor groundwater levels to ensure impact remains within the predicted range of impact. The Proposed Change also capitalises on existing lowered groundwater levels as a result of the Mesa J Iron Ore Development which reduces the volume of additional groundwater required to be abstracted and reduces surplus discharge requirements. The impacts of groundwater drawdown on fauna habitat will be minimised through the use of the existing Southern Cutback Borefield rather than the creation of a new water supply. **Rehabilitate**: In the unlikely event that groundwater abstraction reduces surface water levels in Robe River pools greater than the predicted extent, groundwater may be discharged directly into the Robe River, to mitigate this impact.	Groundwater drawdown as a result of abstraction for water supply is expected to increase groundwater drawdown below Jimmawurrada Creek. This may result in localised changes to canopy cover of riparian vegetation along a 6.5 km section of Jimmawurrada Creek under drought conditions. This impact may be exacerbated taking into consideration an extended dry period combined with seasonal water table lows. No semi-permanent of permanent pools occur in the Jimmawurrada area and the creek ecosystem function is expected to be maintained. Groundwater drawdown below the creek may locally and seasonally affect the availability and connectivity of suitable subterranean habitat for the Blind Cave Eel. This is considered a direct significant residual impact associated with the Subterranean Fauna factor and is proposed to be offset (see Section 7.5 and Section 13). Groundwater abstraction for pit dewatering may result in localised drawdown of water levels in the Robe River alluvial aquifer and associated pools. There will be no change in the permanence status of any of the Robe River pools which will maintain the ecological function of the permanent pools in the naturally variable Pilbara environment. There may be a small reduction in the length of time semi-permanent pools persist following rainfall.	Given the limited potential impact to surface water levels and riparian vegetation, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for terrestrial fauna, in relation to groundwater abstraction. No significant residual impact on terrestrial fauna is anticipated.	No. The Proponent considers that the potential impacts can be managed or mitigated and the residual impact is not considered to be significant and therefore does not warrant the application of offsets. The direct significant residual impact to the Blind Cave Eel is proposed to be offset and is addressed under the Subterranean Fauna factor (Sections 7.5 and 13).

Inherent impact	Mitigation	Residual impacts	Assessment of significance[9]	Offset required?
Alteration of surface water regime and quality in Jimmawurrada Creek and the Robe River from discharge of surplus abstracted groundwater, may impact fauna habitat for Pilbara Olive Python and aquatic fauna, for the duration of discharge activities, during natural no-flow conditions.	The following key management measures will be implemented to manage the potential impacts to fauna habitat from groundwater discharge: **Minimise:** Surplus groundwater will be utilised on site for mine operations and ore processing, where practicable. Surplus water will only be discharged when dewatering supply exceeds demand, for the duration of abstraction activities only and will cease upon closure. Surplus water will be discharged at a rate unlikely to cause erosion impacts. Existing discharge infrastructure will be considered as potential discharge locations which would reduce the additional impact from new discharge sites. The footprint of the periodic surplus water discharge will overlap with areas subject to groundwater drawdown including along the Robe River and sections of Jimmawurrada Creek and thus may partially mitigate the potential impact from groundwater drawdown in these areas. **Rehabilitate:** Fauna habitat impacted by discharge is expected to naturally revert back to an ephemeral system upon closure.	Potential impacts to Riverine habitat from discharge of surplus groundwater are expected to extend up to approximately 8 km (Rio Tinto 2019a) from the discharge outlets in either Jimmawurrada Creek or West Creek. However, the discharge will be temporary and intermittent, lasting for the duration of discharge activities, which is anticipated to be substantially less than the LOM. Given the temporary nature of the discharge to a system that is adapted to highly variable flow conditions, it is unlikely that there will be any significant residual impact on fauna habitat values. During natural flow conditions, the discharge of surplus water is unlikely to impact surface water quality.	Given the limited potential impact to surface water levels and riparian vegetation, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for terrestrial fauna, in relation to surface water discharge. No significant residual impact on terrestrial fauna is anticipated.	No. The Proponent considers that the potential impacts can be managed and the residual impact is not considered to be significant and therefore does not warrant the application of offsets.

Inherent impact	Mitigation	Residual impacts	Assessment of significance[9]	Offset required?
Loss or degradation of habitat due to noise and vibration. Noise and vibration emissions may disturb Ghost Bat individuals and roosts, and may cause Pilbara Leaf-nosed Bat individuals to avoid foraging habitat. Vibration may affect stability of the mesa facades.	The following key management strategies will be implemented to manage the potential impact to fauna from noise and vibration emissions: **Avoid:** The mine design incorporates a 40 m setback distance between the back of each diurnal / potential maternal roost cave and the proposed mine pit and >50 m from the entry to nocturnal roosts to minimise the impact of blasting and associated vibration on the structure and quality of roosts. **Minimise:** Blasting may be undertaken on a daily basis, lasting from two to ten seconds for each blast. In addition, the Proponent will implement a Blast Management Framework to ensure blast vibration levels at the identified diurnal/potential maternal Ghost Bat roosts remain below the trigger level PPV set in the EMP (see EMP in Appendix 6). Measures that may be used to achieve the required blast control are discussed in Section 8.6.3.2. Blasting may be undertaken on a daily basis for periods of time, with blasts lasting from two to ten seconds. Consequently, the time over which fauna may experience vibrations is very short.	Noise and vibration emissions are unlikely to significantly reduce the quality of fauna habitat, or cause conservation significant fauna to permanently avoid areas of suitable habitat. The implementation of a vibration threshold as part of the operational Blast Management Framework will minimise impact.	The Proponent considers that the Proposed Change can be managed to meet the EPA's objective for this factor. No significant residual impact on terrestrial fauna is anticipated.	No The Proponent considers that the potential impacts can be managed and the residual impact is not considered to be significant and therefore does not warrant the application of offsets.
Degradation of habitat due to dust and light emissions. Light may disrupt nocturnal foraging behaviour of the Northern Quoll, Ghost Bat and Pilbara Leaf-nosed Bat.	The following key management measures will be implemented to manage the potential disturbance to fauna from light emissions. **Minimise:** Temporary mobile lighting will be installed in active mine pits and active operational areas, similar to the existing Mesa J Iron Ore Development. Lights will be directed inwards towards mine activities to minimise lighting effects on fauna in adjacent areas.	The impact of lighting on Ghost Bat roosts is expected to be minimal as the roost caves face away from operational areas. Night time lighting may result in some limited changes to nocturnal foraging of Northern Quoll, Ghost Bat and Pilbara Leaf-nosed Bat, in proximity to operational areas. These are not expected to be significant. The potential impact of dust emissions on fauna habitat quality are expected to be limited to retained vegetation in proximity to mining and unsealed roads. Potential	The Proponent considers that the Proposed Change can be managed to meet the EPA objective for terrestrial fauna. No significant residual impact on fauna is anticipated.	No The Proponent considers that the potential impacts can be managed and the residual impact is not considered to be significant and therefore does not warrant the

Inherent impact	Mitigation	Residual impacts	Assessment of significance[9]	Offset required?
	Dust emissions will be managed through application of dust suppression methods including water sprays, where applicable.	impacts are likely to be seasonal (limited to the dry season) and temporary, lasting for the duration of the Proposed Change.		application of offsets.
Degradation of habitat due to altered fire regime, introduction or spread of weeds and changes to feral animal populations.	The following key management measures will be implemented to manage the potential impacts of dust on fauna habitat quality: **Minimise**: Weed inspection and control will be undertaken in weed management areas which will include both manual and chemical control measures. Areas of high priority for weed management include Jimmawurrada Creek, Robe River semi-permanent and permanent pools and river crossings, MEZs and topsoil stockpiles. Feral cat control is currently undertaken and will continue to be undertaken in areas where the Proponent operates.	The Proponent is experienced in managing weeds, fire and feral animals throughout their areas of operation. No significant change in fire regime, weed cover or feral animal populations are expected.	The Proponent considers that the Proposed Change can be managed to meet the EPA objective for terrestrial fauna. No significant residual impact on terrestrial fauna is anticipated.	No The Proponent considers that the potential impacts can be managed and the residual impact is not considered to be significant and therefore does not warrant the application of offsets.

8.10 Predicted Outcome

The Terrestrial Fauna values identified in the Proposed Change Area that are considered relevant to the Proposed Change include:

- Significant fauna habitat:
  - Breakaway and Gorge habitat, including denning and foraging habitat for the Northern Quoll and Pilbara Olive Python, roosting habitat for the Ghost Bat and potential habitat for SREs.
  - Riverine habitat, including denning / shelter habitat and a dispersal route for Northern Quoll and Pilbara Olive Python and foraging habitat for the Pilbara Leaf-nosed Bat and Ghost Bat.
- Conservation significant fauna:
  - **Confirmed Presence** in the Proposed Change Area:
    - Northern Quoll;
    - Pilbara Leaf-nosed Bat;
    - Ghost Bat;
    - Pilbara Olive Python;
    - Western Pebble-mound Mouse; and
    - Lined Soil-crevice Skink.
  - **Very likely to occur** in the Proposed Change Area:
    - Blind Snake.
  - **Moderately likely to occur** in the Proposed Change Area:
    - Long-tailed Dunnart;
    - Short-tailed Mouse;
    - Letter-winged Kite;
    - Australian Painted snipe; and
    - Common Sandpiper, Sharp-tailed Sandpiper, Wood Sandpiper, Common Greenshank, Oriental Pratincole.
- Potential SRE invertebrate fauna:
  - Scorpions*:* *Lychas* 'sp. nov. 1' and *Lychas* 'sp. nov. 2';
  - Slaters: *Buddelundia* '61'; and
  - Spiders: Karaops feedtime.
- Aquatic fauna:
  - Fortescue Grunter; and
  - Blind Cave Eel[10].

The Proponent considers that the Proposed Change meets the EPA objective for this factor; the proposed loss of habitat is not expected to cause any loss of biological diversity at the local or regional scale and the ecological integrity of the area surrounding the footprint is expected to be maintained. The Proposed Change is also not considered to be inconsistent with any relevant policy, guidance, Recovery Plan or Threat Abatement Plan considered in this assessment (Section 8.2).

Given the proposed avoidance via the creation of a MEZ and minimisation of disturbance to significant habitats; and the widespread distribution and / or low value to terrestrial fauna of the other habitats, for the majority of MNES the loss of habitat is not expected to adversely affect the conservation status of species or affect the availability or quality of

[10] Blind Cave Eel is further addressed in Chapter 7Subterranean Fauna

significant habitat for a species. Offsets are proposed for the loss of Breakaway and Gorge (equivalent to Breakaways and Gullies MNES habitat) and Riverine habitats and for the increased risk of temporary habitat reduction for the Blind Cave Eel due to cumulative groundwater drawdown during operations (Section 13).

After the mitigation hierarchy has been applied (Table 8-15), including avoidance of direct impacts to key habitat and key habitat features, implementation of the EMP and application of the proposed offsets the Proponent considers that the Proposed Change is not expected to have a significant impact on terrestrial fauna.

9. SOCIAL SURROUNDINGS

This section describes the social surroundings of the Proposed Change Area and provides an assessment of the potential direct, indirect and cumulative impacts of the Proposed Change to the social values of the Proposed Change Area and surrounds, proposed mitigation measures and the predicted outcome for this key environmental factor.

9.1 EPA Objective

The EPA applies the following objective in its assessment of proposals that may affect Social Surroundings:

- To protect social surroundings from significant harm**.**

9.2 Policy and Guidance

9.2.1 EPA Policy and Guidance

The following EPA guidelines and guidance have been considered in the assessment of social surroundings with respect the above EPA objective:

- EPA (2016m) Environmental Factor Guideline: Social Surroundings;
- EPA (2018c) Statement of Environmental Principles, Factors and Objectives;
- DMP and EPA (2015) Guidelines for Preparing Mine Closure Plans;
- EPA (2018b) Instructions on how to prepare an Environmental Review Document; and
- EPA (2016c) Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans.

9.2.2 Other Policy and Guidance

The following policies relevant to the protection of social surroundings have also been considered:

- Department of Aboriginal Affairs (DAA) and Department of Premier and Cabinet (DPC) (2013). *Due Diligence Guidelines, Version 3.0*.

9.3 Environmental Scoping Document

Table 9-1 summarises where the requirements of the ESD are addressed in this section.

Table 9-1: Requirements of the ESD for Social Surroundings

Task number	Requirement of ESD	Section number
52	Characterise the heritage and cultural values of proposed disturbance areas and any other areas that may be indirectly impacted to identify sites of significance and their relevance within a wider regional context.	Section 9.4
53	Conduct Aboriginal heritage surveys in conjunction with the native title determination (WC2016/006) holders Kuruma Marthudunera and other local people to identify Aboriginal sites of significance and identify concerns regarding impacts from proposed mining operations.	Section 9.4
54	Provide a description of the heritage values within the Development Envelope and proposed disturbance.	Section 9.4.3, 9.5 and 9.6 Figure 9-2

Task number	Requirement of ESD	Section number
55	Assess the impacts of the proposal on heritage sites and/or cultural associations as a result of implementation of the Proposal, including those arising from changes to the environment which may impact on ethnographic and archaeological heritage significance.	Section 9.6
56	Demonstrate application of the mitigation hierarchy to avoid and minimise impacts to social surroundings.	Section 9.8
57	Provide detail on consultation that will be undertaken with Traditional Owners in preparing the Mine Closure Plan, particularly in relation to water management.	Section 9.7 and Appendix 7
58	Prepare a Mine Closure Plan consistent with DMP and EPA Guidelines for Preparing Mine Closure Plans (2015), which addresses the need to protect the social surrounds from significant harm post closure.	Section 9.7 and Appendix 7
59	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Section 9.9

9.4 Receiving Environment

The Revised Proposal lies within the Robe River Kuruma People's native title determined country (WCD2018/003). The Robe River Kuruma People were formerly known as the Kuruma Marthudunera People prior to the Native Title determination in April 2018. The Proponent has a Participation Agreement and Indigenous Land Use Agreement with the Robe River Kuruma People that includes an established consultation framework and ongoing engagement on relevant aspects of the Proponent's operations. These Agreements set obligations for processes such as land access, tenure acquisition, heritage surveys, environmental management, mining benefit payments, and reporting, consultation and communication between the parties. The agreements commit the Proponent and the Robe River Kuruma People to work together to manage and maintain the areas in which the Proponent operates.

9.4.1 Social surroundings studies

Extensive archaeological and ethnographic surveys have been conducted across the Proposed Change Area and immediate surrounds with the involvement of the Robe River Kuruma People which have helped to inform the heritage values of the area. In line with statutory requirements and internal heritage management standards, archaeological and ethnographic surveys have been completed for the majority of the Proposed Change Area, which comprises approximately 17 km stretch of the Robe River, and the proposed general footprint of the Mesa H Mine.

Ethnographic consultations regarding specific sites that will be impacted by the project are ongoing. Should regulatory consent be granted to impact these sites, an archaeological excavation and salvage program will be required. This heritage work, and any future assessments or clearances required will be conducted in collaboration with the Robe River Kuruma People in alignment with the Heritage Protocol as set out in the Native Title Agreements.

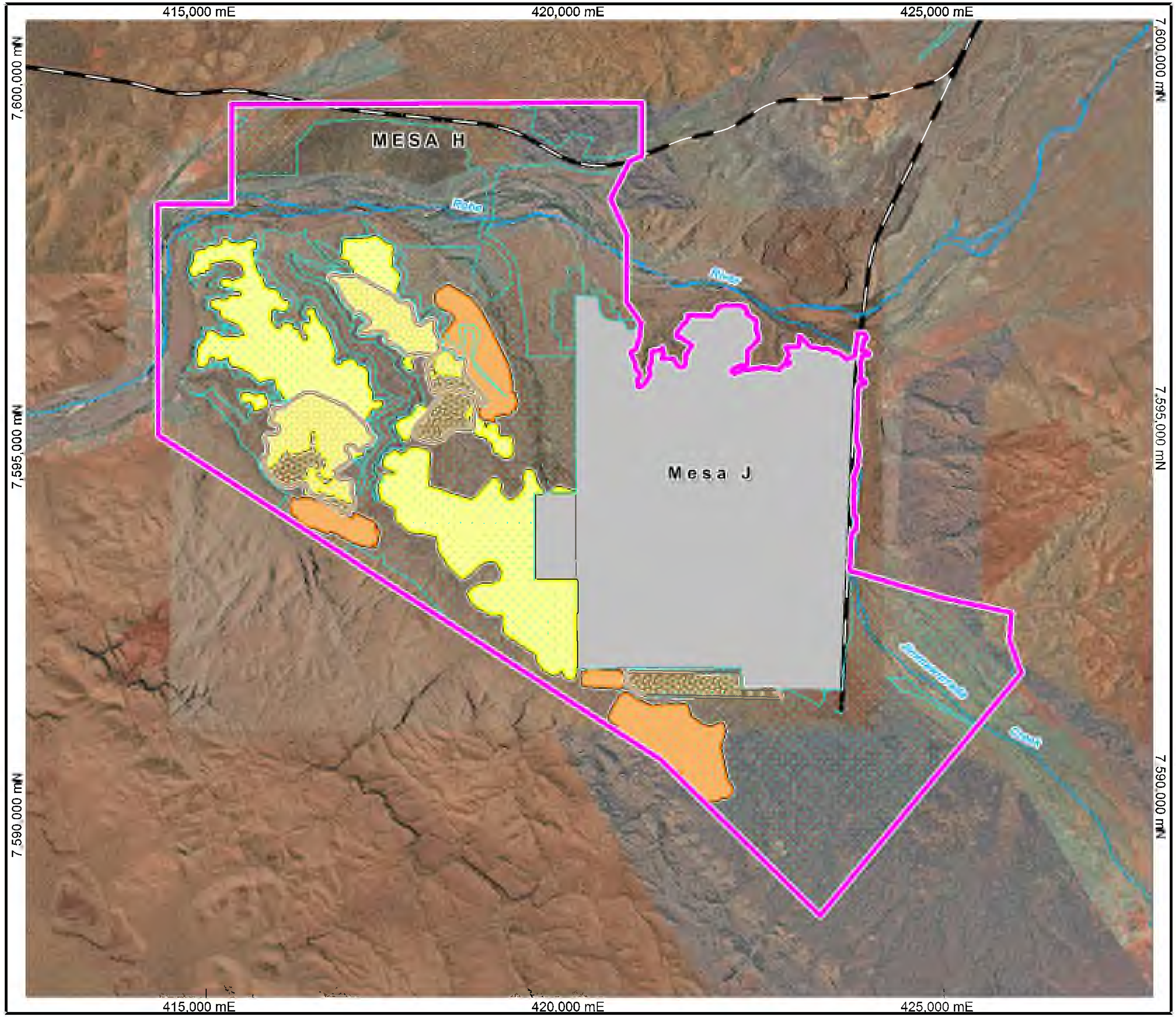
Many of the reports contain information which is of a sensitive nature to the Robe River Kuruma People; copies have therefore not been appended to this ERD. Instead, the location and scope of these studies are summarised in Figure 9-1 and Table 9-2.

Previous studies in the Robe Valley area have documented evidence of concentrated Aboriginal occupation in the valleys along the Robe River in proximity to permanent pools, frequent yet ephemeral use of mesa tops and preferential use of shelters depending on aspect and accessibility (VWHC 2012). The largest heritage sites, containing the highest density and greatest diversity of artefacts, occur on alluvial terraces along the Robe River (VWHC 2012).

Table 9-2: Summary of Social Surroundings studies

Report	Summary	Survey Date
Draft Report on an Ethnographic Site Assessment of sites within the Mesa H and J Project Areas and an Ethnographic Site Avoidance of AR-17-14410 with the Kuruma and Marthudunera Traditional Owners and Terra Rosa Consulting for Kuruma Marthudunera Aboriginal Corporation, and prepared for RTIO Terra Rosa (in Prep) 2018	Ethnographic Site Assessments at Mesa H of previously identified archaeological sites & Ethnographic Site Avoidance survey in the Jimmawurrada area	October 2017
Final Report of a Kuruma Marthudunera Ethnographic Site Assessments at Mesa H in the West Pilbara. Robin Stevens (2018)	Ethnographic Site Assessments at Mesa H of previously identified archaeological sites.	April 2018
Report on an Ethnographic Site Avoidance & Site Assessment Surveys Mesa H, Pilbara, Western Australia. Edward M. McDonald (in prep) 2018	Ethnographic Site Avoidance survey of areas at Mesa H & Ethnographic Site Assessments at Mesa H of previously identified archaeological sites.	May 2017
Report of an Aboriginal Archaeological Site Location and Assessment Recording Level 1 survey of identified rockshelter sites located on the escarpment of Mesa H, Pilbara, Western Australia - Vol 1. Ian Ryan, Tegan Raines and David Walshe (2017a)	Archaeological Site Location and Assessment Recording Level 1 survey of identified rockshelter sites located on the escarpment of Mesa H.	May to September 2016
Report of an Aboriginal Archaeological Site Location and Assessment Recording Level 1 survey of identified rockshelter sites located on the escarpment of Mesa H, Pilbara, Western Australia - Vol 2. Ian Ryan, Tegan Raines and David Walshe (2017b)	Archaeological Site Location and Assessment Recording Level 1 survey of identified rockshelter sites located on the escarpment of Mesa H.	May to September 2016
Report of an Aboriginal Archaeological Site Location and Assessment Recording Level 1 survey of identified rockshelter sites located on the escarpment of Mesa H, Pilbara, Western Australia - Vol 3. Ian Ryan and David Walshe (2017c)	Archaeological Site Location and Assessment Recording Level 1 survey of identified rockshelter sites located on the escarpment of Mesa H.	May to September 2016
A report of the Aboriginal Archaeological Site Bypass and Site Location & Assessment Recording Level 1 Survey within the Jimmawurrada and Mesa H Surrounds Project Areas, Pilbara, Western Australia.	Archaeological Site Bypass and Site Location & Assessment Recording Level 1 Survey within the Jimmawurrada and Mesa H Areas.	July 2015

Report	Summary	Survey Date
David Walshe, Emer Larkin and Michelle Smyth (2017)		
Report on an ethnographic site assessment of sites within the Mesa H Project Areas, conducted by the Kuruma and Marthudunera Traditional Owners and Terra Rosa Consulting and Kuruma Marthudunera Aboriginal Corporation and prepared for Rio Tinto. Terra Rosa 2017a	Ethnographic Site Assessments at Mesa H of previously identified archaeological sites.	July 2017
Report on an ethnographic site assessment of sites within the Mesa H Project Areas, conducted by the Kuruma and Marthudunera Traditional Owners and Terra Rosa Consulting and Kuruma Marthudunera Aboriginal Corporation and prepared for Rio Tinto. Terra Rosa 2017b	Ethnographic Site Assessments at Mesa H of previously identified archaeological sites.	September 2017
A Report of the Aboriginal Archaeological Site Location and Assessment Recording Level 1 Survey, including Six Previously Recorded Sites, within the Mesa B, Mesa C, Mesa H and Warramboo Areas, Pilbara, Western Australia. GJCRM (2016)	An archaeological survey undertaken at Mesas B, C, H and Warramboo areas in April 2016. Level of Recording: Site location and Assessment level 1.	April 2016
A Report of the Aboriginal Archaeological Site Location and Assessment Recording Level 1 Survey of the Proposed Robe Valley Evaluation Drilling Mesa H, Pilbara, Western Australia. J.J. McDermott, Michelle Smyth and Emer Larkin (2015)	Archaeological Site Location and Assessment Recording Level 1 Survey of the Proposed 2015 Robe Valley Evaluation Drilling program at Mesa H.	October 2015
A Report of the Salvage of 36 Indigenous Archaeological Sites within the Mesa A – J Rail Corridor, near Pannawonica, Western Pilbara. Archae-Aus (2012)	Salvage of 36 Aboriginal heritage sites as part of the original development of Mesa A and Warramboo and associated rail transport corridor from June 2007 to January 2009.	June 2007 to January 2009
Results of a Kuruma Marthudunera Ethnographic Heritage Survey of the Mesa A to Mesa J Transport Corridor Robe Valley, West Pilbara. Pilbara Native Title Service (2006)	An ethnographic survey conducted about the proposed Mesa A to Mesa J Transport Corridor in September 2006. Level of recording: Site avoidance.	September 2006



LEGEND

- Development Envelope
- Ministerial Statement 208
- Heritage Survey Area
- Railway
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile

N

SCALE

0 1 2 3km

1:75 000 @ A4

RioTinto

Iron Ore (WA)

Figure 9-1: Location of Heritage surveys within the Development Envelope

Drawn: M.Swebbs
Date: August, 2018

Plan No: PDE0159433v3
Proj: MGA94 Zone50

9.4.2 Local context

A number of heritage sites and places or features with cultural value and significance have been identified within and adjacent to the Proposed Change Area. Heritage sites are protected by law under the *Aboriginal Heritage Act 1972* (WA) (AH Act) and should any proposed development affect the heritage values of these places, a Section 16 and / or Section 18 notice will need to be submitted under the AH Act seeking ministerial consent to impact the sites. The Robe River Kuruma People value all of their heritage, as they are a part of 'the country' and a direct link to their ancestors and their past. The Proponent respects and values the heritage and culture of its host communities and impacts to heritage sites will be avoided wherever reasonably practicable. This is particularly the case with areas marked for infrastructure which allow some flexibility in design. In accordance with the Participation Agreement, the Proponent will develop the necessary Section 16 and / or Section 18 notices in consultation with Robe River Kuruma People for those sites deemed unavoidable.

All cultural heritage work and consultation is conducted in alignment with the agreement between the Proponent and the Robe River Kuruma People and is embedded into the Proponent's Cultural Heritage Management System. Rio Tinto's cultural heritage work is conducted to meet all regulatory requirements. Rio Tinto continues to consult with the Robe River Kuruma People through regular established forums as well as on the ground during project specific survey work.

9.4.3 Social surroundings values

Based on ongoing consultation, archaeological and ethnographic surveys with the Robe River Kuruma People, and a separate on-country consultation specifically to discuss and understand heritage values of the Proposed Change Area in August 2017, the areas of heritage significance that fall within or adjacent to the Proposed Change Area can generally be described as falling within three broad categories: Heritage Sites, Water, and Mesa Facades, as discussed in the following sections and shown on Figure 9-2 (excluding Heritage Sites).

9.4.3.1 Heritage sites

A number of heritage sites of extremely high significance to Robe River Kuruma People have been identified within ~800 m of Mesa H, including the old Deepdale station homestead which has an associated burial, two Law grounds (one with an associated pool in the Robe River), and another named pool in the Robe River; one significant ethnographic (mythological) site (Jirtiwi Thalu), a burial (Deepdale Burial), a gender restricted quarry (MJ04-09), and a Rockhole in the adjacent Mesa J escarpment.

9.4.3.2 Water

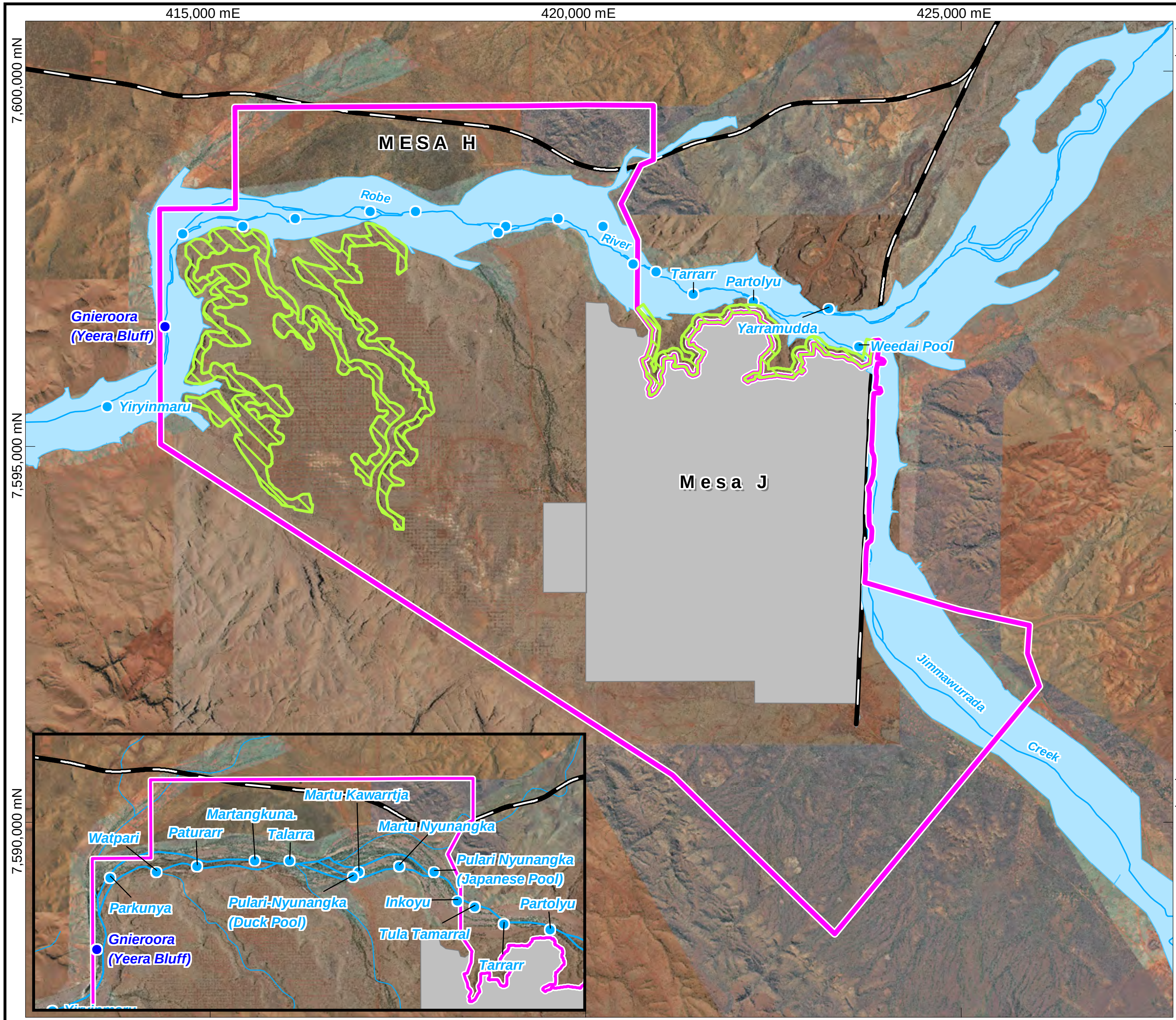
The Robe River Kuruma People have very strong links with waterways within their country and water in general, features prominently in the Robe River Kuruma People's traditional culture.

The high level of knowledge about and continuing usage of locations along the creek and river systems for camping, fishing and hunting as a communal exercise, reinforces the cultural importance to the Robe River Kuruma People of water and sites related to water. The Robe River holds particular importance to the Robe River Kuruma People, and this is reflected in the way that they identify themselves as "Robe River People". There are several named pools (Figure 5-6) located in the Robe River to the west, north, and northeast of Mesa H, that range between permanent, near-permanent and seasonal, as well as the Robe River (Gadjiwura) itself being a registered site with the DPLH. These named pools (ethnographic sites) include Nyithura or Gnieroora (KM-RR16 – Also known as Yeera Bluff pool), Martu Kawarrtja (DPLH 6428 – Also known as Duck pool), Paturarr (DPLH 6396), Parkunya (DPLH 6433), Watpari (DPLH 6432), Martangkuna (DPLH 6395), Talarra (DPLH 6394), Martu Nyunangka (DPLH 6429), Pulari Nunangka (DPLH 6430), Inkoyu (DPLH 6435), Tula Tamarral (DPLH 6436), Tarrarr (DPLH 6437), Partolyu (DPLH 6438), Yarramudda (DPLH 6439), Weedayi (DPLH 6389) and Nyirinmaru (DPLH 6434).

9.4.3.3 Mesa facades

The mesa profile is also a very important feature to the Traditional Owners, as the whole of the landscape (Mesas, plains, rivers, waterholes etc.) are viewed as a combined entity and their reference to each operates as a geographical locator. When the Robe River Kuruma People were travelling through the countryside in past times, predominantly using the Robe River as their main corridor, each individually shaped mesa was used as a landmark, which could then indicate to a person where they were, and what other natural or cultural features were therefore nearby. In current times, this way of navigating is still in use by the Robe River Kuruma People, with many descriptions of places being in direct reference to the location of another place or places.

In recognition of the value of the Mesa landforms to the Robe River Kuruma People and as part of the development approach for mining operations in the Robe Valley since the early 1990's, the Proponent has committed to protecting the cultural (and associated biological) values of the mesa landform by retaining the mesa escarpments (facades) and adjusting the mine plans to enable the creation of a MEZ over the mesa escarpment. The Proposed Change will continue the same approach of maintaining a MEZ, to ensure retention and protection of the significant values associated with of the mesa escarpment.



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway

Landscape Scale Values

- Watercourses (and associated ecosystems including aquatic fauna)
- Gnieroora (Yeera Bluff)
- Pools (and associated ecosystems)
- Riparian Vegetation
- Mesa Escarpments (including caves)

Also: Not depicted, fauna habitats, bush tucker and medicine plants

N

SCALE

0 1 2 3km

1:75 000 @ A4

RioTinto

Iron Ore (WA)

Figure 9-2: Location of Landscape Scale Physical and Biological related Heritage Values (not including heritage sites)

Drawn: T.M.
Date: Sept, 2018

Plan No: PDE0162041v3
Proj: MGA94 Zone50

9.5 Potential Impacts

A number of potential impacts are identified in the ERD. On the basis of surveys and assessments relating to social surroundings completed to date, the following are considered the key issues and are addressed in Section 9.6:

- Direct disturbance of sites and places of cultural significance (via clearing, excavation and infrastructure placement).
- Indirect disturbance to sites and places of cultural significance via changes to the physical and biological attributes of the environment (via dewatering, surplus water discharge, and blast vibrations).
- Prevention or reduction of access to a site.

9.5.1 Direct impacts

Clearing for the Proposed Change of up to 2,200 ha of native vegetation may also impact a number of heritage sites.

Based on current pit and infrastructure designs, the Proposed Change footprint will directly impact 18 archaeological sites comprising 17 artefact scatters (including one with a scarred tree with its boundary), and one quarry (non-gender restricted). Section 18 consent under the AH Act will be required for all of these sites.

9.5.2 Indirect impacts

There are 74 rockshelter sites located in the escarpments of the Proposed Change which whilst will not be directly impacted, have the potential to be indirectly impacted by blasting vibrations, depending on their geotechnical sensitivity.

Hydrogeological modelling predicts that mine pit dewatering to access the 20% of ore below the current water table for the Proposed Change may impact water levels in the Robe River alluvial aquifer and associated pools, however the drawdown is predicted to be within the range of seasonal variation, with a short-term maximum groundwater drawdown of less than 1 m.

Additional water supply is proposed to be abstracted from the Southern Cutback Borefield in order to meet operational water demand (particularly for wet ore processing) until additional water is available from surplus mine dewatering. The groundwater drawdown cone of depression from abstraction from the Southern Cutback Borefield is modelled to extend beneath Jimmawurrada Creek, with drawdown up to 9 m, taking into consideration of the combination of Mesa J mine pit dewatering and the CWSP. Water table levels may be further reduced as a result of an extended dry period and seasonal water table lows, which could result in a water table as low as 18 mbgl.

Surplus water will be discharged to Jimmawurrada and / or West creek, both tributaries of the Robe River, adopting the same approach as the current Mesa J Iron Ore Development. It is estimated that the wetting footprint resulting from surplus water discharge may extend up to 8 km downstream of the discharge point(s) under natural no-flow conditions. Surplus water discharge will be fresh with a chemical signature reflecting the local groundwater chemistry.

9.5.3 Cumulative impacts

One hundred and fifty-five known archaeological sites are recorded within the Proposed Change Area, including 56 artefact scatters, (one which also includes a scarred tree), 91 rockshelter sites (several incorporating two or more individual rockshelters within the one site, and several including stone features), one stone feature, one scarred tree, one grinding patch and five quarries (three of which are gender restricted). Of the 155 known sites, 92 are likely to be impacted either directly or indirectly.

Hydrogeological modelling predicts that dewatering and discharge for the Revised Proposal may impact water levels in the Robe River alluvial aquifer and associated pools within the range of seasonal variation (<1 m).

Groundwater abstraction for water supply from the Southern Cutback Borefield, combined with abstraction from the existing Mesa J Iron Ore Development and the adjacent CWSP will create an overlap of the groundwater drawdown cones of depression and result in a cumulative drawdown ranging from 1 – 9 m extending beneath a 12 km section of Jimmawurrada Creek and extend the timeframe for the predicted groundwater recovery once water abstraction ceases. This may result in localised changes to the canopy cover of riparian vegetation in the Jimmawurrada Creek area predominantly over a 6.5 km stretch ('Zone 3') where drawdowns of up to 9 m (14 mbgl) may occur from the cumulative drawdown effects. This impact may be exacerbated taking into consideration an extended dry period combined with seasonal water table lows. Assessment of these impacts are described in Section 9.6.

9.6 Assessment of Impacts

9.6.1 Direct disturbance to sites and places of heritage significance

The location and layout of the mine and associated infrastructure have been designed to avoid or minimise impacts to the identified Aboriginal heritage values. The Proponent is committed to avoiding sites wherever possible and will continue to work in close consultation with the Robe River Kuruma People.

The most significant heritage values in the Proposed Change Area as identified by the Robe River Kuruma People are:

- all watercourses, including the Robe River and Jimmawurrada Creek;
- semi-permanent and permanent pools of the Robe River including Nyithura / Gnieroora (KM-RR16 – Also known as Yeera Bluff pool), Paturarr (DPLH 6396), Parkunya (DPLH 6433), Watpari (DPLH 6432), Martangkuna (DPLH 6395), Talarra (DPLH 6394), Martu Nyunangka (DPLH 6429), Pulari Nunangka (DPLH 6430), Inkoyu (DPLH 6435), Tula Tamarral (DPLH 6436), Tarrarr (DPLH 6437), Partolyu (DPLH 6438), Yarramudda (DPLH 6439), Weedayi (DPLH 6389), Nyirinmaru (DPLH 6434), and Martu Kawarrtja (DPLH 6428 – also known as Duck pool, which is known to dry out from time to time);
- visual amenity of the mesas including use as navigational landmarks;
- Jirtiwi Thalu;
- gender restricted quarry site MJ04-09;
- Deepdale Burial; and
- law grounds.

Infrastructure locations have been designed to limit physical disturbance to the Robe River and avoid direct disturbance to the semi-permanent and permanent pools of the Robe River. The current mine design includes the widening and installation of culverts along an existing access road which crosses the Robe River and will limit disturbance to the Robe River to pre-disturbed areas (<2 ha). Installation of hydrogeological monitoring bores near the Robe River and Jimmawurrada Creek may also be required for monitoring purposes and will be located and managed in consultation with the Robe River Kuruma People.

The mesa escarpments are a feature of the visual landscape and have cultural significance, including use as navigational landmarks. The Proposed Change has been designed to retain the mesa escarpments, except where cuts are required to facilitate haul road access back to the Mesa J Iron Ore Development. The delineation of a MEZ will ensure retention of the mesa escarpments (facades), which will ensure the enduring presence of the mesa landforms within the Robe Valley landscape, thus enabling the mesa landforms to continue to function as navigational landmarks for the Robe River Kuruma People. The proposed escarpment cuts are within the central (internal) gully and southern side of the mesa H landform, thus will not impact the visual amenity of the mesas from the Robe River.

The proposed MEZ will protect the rockshelters from direct disturbance. In consultation with the Robe River Kuruma People, the Proponent has decided to submit applications under Section 18 of the AH Act for the rockshelters on the escarpments where there is any potential for indirect impacts due to vibration as a result of mining activities (particularly blasting). This is a conservative approach as the proposed MEZ has been designed to protect all recorded rockshelters, and blasts will be trimmed as the pit margins approach the MEZ to minimise the risk of damage to the escarpment.

It is anticipated that the Proposed Change will directly impact some artefact scatters on the top of the mesa and on the plains in the Proposed Change Area. Section 18 applications under the AH Act will be submitted for these sites.

A total of 18 sites will be directly impacted as a result of the Proposed Change and will require Section 18 consent under the AH Act, consisting of:

- 17 artefact scatters (including one with an associated scarred tree); and
- one quarry (not gender restricted).

Upon request from the Robe River Kuruma People during consultation on site, the project footprint has been modified and buffered to avoid direct impact to two very significant sites in proximity to the Project: Jirtiwi Thalu and a gender restricted quarry site MJ04-09 in order to preserve the ethnographic and archaeological features and values. The Jirtiwi Thalu site (including a buffer) has been incorporated into the MEZ footprint to ensure protection from both direct and indirect disturbance. Blast management will be implemented in order to preserve the escarpments and heritage features agreed to be protected which may be vulnerable to vibration (e.g. Jirtiwi Thalu) within the potential zone of influence.

All heritage sites immediately adjacent to the proposed mine / infrastructure footprints and not subject to section 18 approvals will be appropriately fenced / signposted or barricaded to ensure inadvertent impacts, both direct and indirect, do not occur. In alignment with the Proponent's Cultural Heritage Management System and Approvals coordination system, all sites will be excised and buffered, according to the relevant activity types, from relevant permits.

The Proponent plans to work with the Kuruma Marthudunera Aboriginal Corporation to ensure that all personnel working in the Development Envelope have participated in some form of Cultural Awareness Training. In addition, and as part of Health, Safety and Environment induction requirements, all personnel will be made aware of their responsibilities to the avoidance and protection of cultural heritage during all ground disturbance activities associated with construction and operation.

9.6.2 Indirect disturbance to sites and places of cultural significance

The Proponent proposes to obtain precautionary Section 18 clearances for all rockshelters at Mesa H within 350 m of blasting. However, there will be ongoing consultation and collaboration with the Robe River Kuruma People throughout the process, due to the large number of sites and large workload involved in excavations associated with statutory requirements.

The Proponent respects and values the heritage and culture of its host communities, and the project footprint has been modified to protect two very significant sites in the project area from direct impact:

- The highly significant ethnographic site, Jirtiwi Thalu (a thalu, or increase site) is located within the resource footprint. Consultation about the cultural values of this site with the Robe River Kuruma People, and the group's views regarding its potential impact by the Mesa H project occurred several times in 2016, with the Robe River Kuruma People expressing a strong desire for the site to remain "on country" and not be impacted. Consequently, this site will be protected by the MEZ and will not be directly or indirectly impacted, with a blast management framework to be implemented in order to protect the site from potential vibrational impact as a result of mine pit blasting. Further work will be undertaken to refine the pit design and blasting management required to protect this site.

- The significant gender restricted quarry site MJ04-09 is located in close proximity to the pit and has been protected from possible impact via modification to the pit wall location and modification to the proposed drainage channel infrastructure design.

Groundwater abstraction is required to enable BWT mining of the ~20% of ore occurring below the water table. The hydrogeological modelling has conservatively assumed some degree of connectivity between the CID aquifer and the Robe River Alluvium. Based on this, the modelling indicates a short term maximum of less than 1 m drawdown to the Robe River to the northwest of Mesa H around Yeera Bluff and <0.5 m drawdown in the Robe River along the northern margin of Mesa H (refer to Section 5.6). The potential impacts of mine dewatering from the Revised Proposal on the pools along the Robe River are predicted to be localised, temporary in duration and relatively small, and fall within the natural fluctuations observed in the water levels of the Robe River (2 – 3 m). Permanent and semi-permanent pools with more than 1 m depth are not expected to be significantly impacted (e.g. Yeera Bluff), however shallower semi-permanent or seasonal pools, immediately to the north of Mesa H (e.g. Duck Pool), could potentially seasonally dry out more quickly during extended periods of low rainfall or during extended periods of drought. This may result in a minor reduction in canopy cover of riparian vegetation across the outer Robe River floodplain, and an associated reduction in local understorey vegetation and fauna density in association with changes to pool size (including availability of bush tucker). Proposed water management mitigation strategies including re-directing BWT mine abstracted water directly back to permanent pools or avoidance of drawdown below a water level of 120 m RL in the proposed pit closest to Yeera Bluff (should monitoring indicate pools levels dropping as a result of mine dewatering), will ensure that the pools are not significantly impacted.

The Proposed Change will also require groundwater abstraction for operational water supply from the Southern Cutback Borefield, which, in combination with the upstream CWSP, and abstraction from the Mesa J Iron Ore Development will result in the lowering of the groundwater table. The cumulative effects of the groundwater drawdown from increased abstraction from the Southern Cutback Borefield, taking into consideration mine pit dewatering (Mesa J and H) and including the CWSP were integrated into the hydrological modelling for the Proposed Change. This enabled an improved understanding of the overall catchment water balance and the cumulative groundwater drawdown. The groundwater was modelled with a lowering of the water table along a 6.5 km stretch of Jimmawurrada Creek (Figure 5-23), which is modelled to be exposed to drawdown up to 9 m. This impact may be exacerbated taking into consideration an extended dry period combined with seasonal water table lows (Section 5.5.2.2). Proposed mitigation comprising the use of a thickener plant for wet processing has enabled the cumulative drawdown to be reduced by approximately 30% from original model predictions. Potential impacts of the reduced groundwater drawdown are likely to include reduction in the canopy cover of *Eucalyptus camaldulensis* subsp. *refulgens* and possible individual tree death, and minor changes to the abundance of understorey vegetation within a 6.5 km section of the creekline.

Surplus water will be discharged to Jimmawurrada Creek and / or West Creek, both tributaries of the Robe River. It is estimated that flow resulting from surplus water discharge will not extend further than 8 km downstream of the discharge points under natural no-flow conditions, and no further than Yeera Bluff. The availability and chemistry of surface water is expected to be similar to the current Mesa J Iron Ore Development, with the periodic increased water availability potentially resulting in unseasonal attraction of native fauna to the tributaries, including waterbirds, reptiles, amphibians and mammals. This may result in sustaining the availability of fauna for hunting along the 8 km section of the creeklines affected but is not expected to significantly impact any specific heritage sites. Discharge, as is the case for the Mesa J Iron Ore Development, will be periodic during the life of the Revised Proposal, and used mainly for post wet season water management. The continuation of the current altered hydrological regime (i.e. ongoing water availability during discharge) may continue to result in temporary changes to riparian vegetation along Jimmawurrada Creek and West Creek. Vegetation adaptation to the altered hydrological regime includes new growth and changes in structure and cover (refer to Section 6 for further details). Once discharge ceases, the ecosystem is expected to gradually revert to one adapted to ephemeral conditions.

Ongoing consultation with the Robe River Kuruma People will be conducted in relation to water management.

9.7 Closure

The Mesa J Hub Closure Plan (Rio Tinto 2018a) is an integrated closure plan encompassing the existing Mesa J and Mesa K operations, together with the inclusion of the Proposed Change, in order to optimise closure outcomes. The plan is an update to and supersedes previous closure plans for the existing Mesa J and K Operations. The Closure Plan includes the mine developments and associated infrastructure contained within the Development Envelope (Mesa J and H) and within Mesa K's Development Envelope. A summary of the approach to closure in the Revised Proposal and how it relates to the social surroundings factor is provided below.

Upon mine closure, the Revised Proposal will be rehabilitated to create a safe, stable and non-polluting landscape revegetated with native species, to maximise environmental and cultural heritage outcomes and to ensure the site does not adversely impact on the current surrounding land use. Further heritage assessments and consultation will be undertaken with the Robe River Kuruma People prior to closure to ascertain potential heritage impacts of closure implementation, and to inform the development of alternative strategies if required. Assessments will also be completed post-closure to confirm that implementation has been undertaken in an appropriate manner.

All reasonable and practicable measures to prevent harm to heritage sites will be undertaken, including during works associated with rehabilitation and closure. Where disturbance is unavoidable, artefacts and cultural material will be disturbed and removed under Section 18 consent of the AH Act. Closure works will consider post closure access requirements to heritage sites, and the return of archaeological materials (as appropriate) salvaged during mine construction and / or operations.

The estimated time for total groundwater table recovery following the cessation of mining is estimated at approximately 50 - 60 years, however, the majority of the drawdown along the Robe River and Jimmawurrada Creek is expected to recover after the first or second significant rainfall event (5 - 10 years). While not anticipated to impact any specific heritage sites, these changes may potentially result in a temporary reduction in the availability of bush tucker (both flora and fauna) and bush medicine along parts of the Robe River and Jimmawurrada Creek during the period of groundwater recovery.

The final closure landform has been considered, with visual amenity aspects incorporated in the development of the mine plan to ensure the visual impact is minimised (refer to Section 11.1.8.1). A strategy to increase backfill has resulted in a reduced number of ex-pit landforms being included in the Revised Proposal. Waste dumps will remain at the same height or lower than the surrounding topography and the view of any waste landforms from the Robe River and the Yarramarda Law Ground will be limited. However, these landforms will remain visible at closure due to their location on a flat plain. The Mesa escarpments will remain intact except for the cuts required to allow for haulage access back to the Mesa J processing facilities.

9.8 Mitigation

Mitigation actions to address the potential impacts and predicted outcomes are presented in Table 9-3.

The Mesa J Hub EMP (Appendix 6) addresses the key environmental factors which were determined by the EPA as being relevant to the appropriate management of dewatering, surface water discharge, conservation significant vegetation communities and fauna species associated with the Mesa J Hub. The EMP identifies:

- mitigation strategies proposed to minimise impacts to significant environmental values;
- the environmental criteria that the Proponent will use to monitor performance of the mitigation strategies to ensure environmental objectives are met;
- trigger criteria, threshold criteria, trigger level actions and threshold contingency actions aligned with the overall management approach; and
- the management strategies that will be implemented in response to monitoring results.

No significant residual impacts are predicted to areas of high environmental value relating to social surroundings therefore no offset is proposed for this factor.

Table 9-3: Mitigation Measures and Predicted Outcomes for Social Surroundings

Potential impacts	Mitigation to address potential impacts	Predicted outcome
EPA objective: To protect social surroundings from significant harm.		
Direct Impacts Direct disturbance via clearing and mine excavation has the potential to impact Aboriginal heritage and cultural values. The most significant sites include: • Robe River, including semi-permanent and permanent pools • Visual amenity of the mesas including use as navigational landmarks • Jirtiwi Thalu • Gender restricted quarry site MJ04-09.	The Revised Proposal falls within the Robe River Kuruma Native Title Determination (WCD2018/003). The Robe River Kuruma People have a Claim Wide Participation Agreement and Indigenous Land Use Agreement with the Proponent. These agreements commit the Proponent and the Robe River Kuruma People to work together to manage and maintain areas in which the Proponent operates. The agreements establish clear processes for heritage and include reporting and communication requirements. **Avoid**: The Proposed Change has been designed to avoid direct impacts to the most significant sites, including direct disturbance to the Robe River (except for upgrading of an existing road crossing, and potential need for monitoring bores) and its associated semi-permanent and permanent pools. The Proposed Change has been designed with a MEZ around the perimeter of the mesa in order to ensure preservation of the most prominent feature; the mesa escarpments, effectively retaining the mesa façade (with the exception of minor access cuts to less prominent sections of the mesa where distinct escarpments are absent). The MEZ enables avoidance of all direct disturbance to recorded sites within the escarpment and supports protection of the integrity of the rockshelters. **Minimise:** Where impacts to heritage sites cannot be avoided, applications will be made under Section 18 of the AH Act in consultation with the Robe River Kuruma People. Further assessment of sites and salvaging of artefacts is expected to occur; artefact salvage will ensure the retention of artefact values ex-situ. The Proponent has established an internal system for managing all ground disturbing activities to ensure compliance with heritage commitments and regulatory requirements. The access cuts for the haul roads have been designed to limit impact to the highest value habitat, areas of heritage significance and the most prominent sections of the escarpment. Escarpment cuts are located away from the Robe River, and will be largely hidden due to their location in the central (internal) gully, and south of the mesa landform. The widths required for the haul road	The Proposed Change has been designed to retain the Mesa H escarpments (where they exist), except where cuts are required to provide access through the mesa landform, back to Mesa J Iron Ore Development. The retention of the mesa escarpments as part of the MEZ will ensure that the visual amenity of the landscape is retained and also ensures protection of identified rockshelter sites from direct impacts. The Project footprint has been further modified and buffered to avoid direct and indirect impacts to two very significant sites: Jirtiwi Thalu and a gender restricted quarry site MJ04-09 in order to preserve their ethnographic and archaeological features and values. Heritage sites will be avoided wherever possible. However, some sites are likely to be disturbed by the Proposed Change. The Proponent will seek approval under Section 18 of the AH Act where direct disturbance to sites cannot be avoided or where there is any potential for impacts due to vibration. This is a conservative approach as the proposed MEZ has been designed to include (preserve) all recorded rockshelters and in-pit blasts will be trimmed as blasting of pits walls approach the MEZ. Approximately seven Section 18 applications are anticipated, consisting of: 74 rockshelters, 17 artefact scatters and one non-gender restricted quarry. The Proponent will continue to work in close consultation with the Robe River Kuruma People and will avoid sites where possible. Where avoidance is not possible, the Proponent will seek approval under Section 18 of the AH Act.

Potential impacts	Mitigation to address potential impacts	Predicted outcome
	access cuts into the mesa escarpments have been minimised as far as possible to allow safe access. Waste dumps have been located away from prominent visual vantage points, including the Robe River and Yarramarda Law Ground, and will remain at heights which are the same level or lower than the surrounding mesas to limit visual impact. The Proponent is committed to consulting with the Robe River Kuruma People regarding the Revised Proposal through LIC meetings and heritage survey processes. The Proponent has developed a Mine Closure Plan consistent with DMP and EPA Guidelines to ensure social surrounds are rehabilitated (returning cultural material back to country) post-closure (Appendix 7). **Rehabilitate:** Visual impacts will be further minimised through construction of the waste dumps to be aesthetically compatible with the surrounding landscape and through rehabilitation of the waste dumps. Mine pits will be backfilled to above pre-mining water table levels to prevent the formation of pit lakes.	

Potential impacts	Mitigation to address potential impacts	Predicted outcome
Indirect Impacts Indirect impacts from the Proposed Change include dewatering, surplus water discharge, and blast vibration. Dewatering may potentially impact sections of the Jimmawurrada creek system and pools within the Robe River, including features and sites of high cultural significance.	The following key management strategies will be implemented to manage indirect impacts: **Avoid:** Based on monitoring of water levels within the semi-permanent and permanent pools of the Robe River during active mine dewatering, should pool water levels decline beyond that predicted in this impact assessment (i.e. up to 1 m beyond natural seasonal fluctuations) as a direct result of dewatering, the Proponent will cease dewatering below 120 m RL in the adjacent Pit 7. **Minimise:** The proposed Blast Management Framework (including management of vibration and retention of escarpments (where they exist) via a MEZ, with an adequate width >30 m to ensure geotechnical stability will minimise any potential impacts to the social value of the mesa escarpments, including the sites of heritage significance, comprising rockshelters present on the mesa escarpment and Jirtiwi Thalu located within the MEZ. Groundwater abstraction will be minimised to that required to access the BWT resource and to meet site water requirements. The use of a thickener is proposed to be used specifically to optimise water recovery and reduce the overall Revised Proposal's water demand from the Southern Cutback Borefield by approximately 30% and thus reduce drawdown impacts to Jimmawurrada Creek. Monitoring of riparian vegetation and groundwater levels will continue to be undertaken along the Robe River and Jimmawurrada Creek in the vicinity of the Revised Proposal. If significant changes to vegetation health are detected as a result of the Revised Proposal, then appropriate mitigation measures will be undertaken, which may include: • optimisation of the location of discharge points in Jimmawurrada Creek to provide periodic supplementary water in areas predicted to be affected by groundwater drawdown • targeted supplementary water (derived from Mesa H mine pit dewatering) directly to permanent pool to reduce the potential for impacts to the pool water levels. Where impacts to heritage sites cannot be avoided, applications will be made under Section 18 of the AH Act in consultation with the Robe River Kuruma People.	The Proponent is committed to avoiding heritage sites wherever possible. However, some sites are likely to be disturbed by the Proposed Change. The Proponent will seek approval under Section 18 of the AH Act where there is any potential for impacts due to vibration. The Revised Proposal will result in the lowering of the groundwater table due to abstraction to enable BWT mining, which may result in a section of Jimmawurrada Creek exhibiting riparian vegetation canopy decline, stress and possible death of some individuals; and some pools of the Robe River showing lower water levels. However, with proposed mitigation (Section 5.9), it is unlikely that the Revised Proposal will significantly impact on the continued presence of pools, riparian vegetation and the heritage values associated with the Robe River. Consultation will continue with the Robe River Kuruma People regarding the alteration of Jimmawurrada Creek and the Robe River hydrological system. Given the Proposed Change has been designed to avoid impacts to the most significant heritage sites in the Proposed Change Area, disturbance to other sites will be minimised and the Proponent is committed to continuing to consult with the Robe River Kuruma People regarding the Revised Proposal through LIC meetings and heritage survey processes, the proponent considers that the Proposed Change can be managed to meet the EPA's objective for this factor.

9.9 Predicted Outcomes

The key Social Surroundings values identified in the Proposed Change Area that are considered relevant to the Proposed Change include:

- all watercourses, including the Robe River and Jimmawurrada Creek;
- semi-permanent and permanent pools of the Robe River including Nyithura / Gnieroora (KM-RR16 – Also known as Yeera Bluff pool), Martu Kawarrtja (DPLH 6428 – Also known as Duck pool), Paturarr (DPLH 6396), Parkunya (DPLH 6433), Watpari (DPLH 6432), Martangkuna (DPLH 6395), Talarra (DPLH 6394), Martu Nyunangka (DPLH 6429), Pulari Nunangka (DPLH 6430), Inkoyu (DPLH 6435), Tula Tamarral (DPLH 6436), Tarrarr (DPLH 6437), Partolyu (DPLH 6438), Yarramudda (DPLH 6439), Weedayi (DPLH 6389) and Nyirinmaru (DPLH 6434);
- visual amenity of the mesas including use as navigational landmarks;
- Jirtiwi Thalu;
- gender restricted quarry site MJ04-09;
- law grounds; and
- Deepdale Burial.

After the mitigation hierarchy has been applied (Table 9-3), including avoidance of direct impacts to Jirtiwi Thalu, the Gender restricted quarry site MJ04-09, rockshelter sites, pools of the Robe River, the majority of the Robe River and the majority of the mesa escarpments; in addition to minimising indirect hydrological impacts to the watercourses and associated pools, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Social Surroundings.

10. AIR QUALITY

This section describes and assesses the potential impacts of the Proposed Change on air quality, mitigation and the predicted outcome for this other environmental factor. The assessment is provided in Section 10.5 and focusses specifically on greenhouse gas emissions as the potential impacts of dust are considered, where relevant, in Sections 6 to 8 and 11.1.

10.1 EPA Objective

The EPA applies the following objective from the *Statement of Environmental Principles, Factors and Objectives* (2018c) in its assessment of proposals that may affect air quality:

- To maintain air quality and minimise emissions so that environmental values are protected.

10.2 Policy and Guidance

10.2.1 EPA Policy and Guidance

The following EPA guidelines and guidance have been considered in the assessment of air quality with respect the above EPA objective:

- EPA (2018c) Statement of Environmental Principles, Factors and Objectives; and
- EPA (2016n) Environmental Factor Guideline: Air quality.

10.2.2 Other Policy and Guidance

The following policies relevant to the protection of air quality have also been considered:

- Clean Energy Act 2011; and
- National Greenhouse and Energy Reporting Act 2007 (NGER Act).

10.3 Environmental Scoping Document

Table 10-1 summarises where the requirements of the ESD are addressed in this section.

Table 10-1: Requirements of the ESD for Air Quality

Task number	Requirement of ESD	Section number
60	Characterise the greenhouse gas emission key sources from the Proposal and estimation of expected Scope 1 (direct) and Scope 2 (energy indirect) greenhouse gas emissions.	Section 10.4
61	Analysis of greenhouse gas intensity (i.e. quantity of CO2-e generated per tonne of product produced).	Section 10.4
62	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Section 10.5

10.4 Assessment of Impacts

The existing Mesa J Iron Ore Development is seen as a relatively low emitter of greenhouse gas with Scope 1 emissions of approximately 46,630 tonnes CO_2 equivalent per year and Scope 2 emissions of approximately 10,815 tonnes CO_2 equivalent per year.

The following aspects of the Proposed Change may result in the production of greenhouse gas emissions and impacts to air quality:

- diesel combustion by haul trucks;
- clearing of native vegetation;
- use of explosives during blasting; and
- power consumption for ore processing.

This Proposed Change will contribute, on average, additional Scope 1 emissions of approximately 51,468 tonnes CO_2 equivalent per year and additional Scope 2 emissions of approximately 5,806 tonnes CO_2 equivalent per year. The key energy demands for this Proposed Change, contributing the most significant proportion of Scope 1 greenhouse gas emissions, are emissions due to combustion of diesel due to greater haulage distances from Mesa H back to the Mesa J Production Hub and emissions due to generation of electricity. The key trade-off being utilisation of existing Mesa J infrastructure including processing facilities and limiting haulage routes / disturbance through the MEZ which translate to greater haulage distances.

The results of an analysis of greenhouse gas intensity for the Revised Proposal indicate the average quantity of CO_2 equivalent generated per tonne of product produced for the Revised Proposal is estimated as follows:

- Scope 1: 5,892 tonnes CO_2 equivalent / tonne.
- Scope 2: 998 tonnes CO_2 equivalent / tonne.

The total cumulative Scope 1 greenhouse gas emissions resulting from the Revised Proposal (the existing Mesa J Iron Ore Development plus the Proposed Change), of up to approximately 120,896 (average 98,098) tonnes CO_2 equivalent per year are not considered a significant contribution to the WA State, or Australian greenhouse gas emissions.

Management of greenhouse gas emissions will continue to be in accordance with relevant legislation and national and state strategies relating to greenhouse gas emissions.

10.5 Mitigation

Mitigation strategies to address the above potential impacts and predicted outcomes are presented in Table 10-2.

Table 10-2: Air Quality: Assessment of Potential Impact, Mitigation and Outcome

<table>
<tr><th>Potential impacts</th><th>Mitigation to address potential impacts</th><th>Predicted outcome</th></tr>
<tr><td colspan="3">EPA Objective: To maintain air quality and minimise emissions so that environmental values are protected.</td></tr>
<tr><td>Greenhouse gas emissions:
The following aspects of the Proposed Change may result in the production of greenhouse gas emissions and impacts to air quality:
• Diesel combustion by haul trucks
• Clearing of native vegetation
• Use of explosives during blasting
• Power consumption for ore processing.
The Proposed Change will contribute additional greenhouse gases as a result of diesel consumption and generation of electricity.
This Proposed Change will contribute, on average:
• additional Scope 1 emissions of approximately 51,468 tonnes CO_2 equivalent per year
• additional Scope 2 emissions of approximately 5,806 tonnes CO_2 equivalent per year.</td><td>Management of greenhouse gas emissions will continue to be, in accordance with relevant legislation and national and state strategies relating to greenhouse gas emissions.
The Proponent has well established procedures for the reporting of greenhouse gas emissions at its Pilbara operations. In accordance with the NGER Act the Proponent reports annually on:
• energy production
• energy consumption
• emissions
• updates on energy management projects.
The Proponent is committed to an ongoing program of reporting and review to identify opportunities to further reduce energy consumption and reduce greenhouse gas emissions.</td><td>The Proposed Change is expected to contribute additional greenhouse gases (primarily carbon dioxide (CO_2) generated by diesel consumption and generation of electricity). However, the Revised Proposal is a relatively small emitter of greenhouse gases for an Iron Ore mining operation.
The potential for impacts to air quality can be appropriately managed via existing legislation. Greenhouse gas emissions have been, and will continue to be, managed under the Clean Energy Act 2011 (Cwth) and reported under the NGER Act (Cwth).
Therefore, The Proponent considers that the Proposed Change can be managed to meet the EPA's objective for this factor.</td></tr>
</table>

11. OTHER ENVIRONMENTAL FACTORS

The ESD identified Landforms as an ‘other environmental factor’ relevant to the Revised Proposal that should be addressed in the ERD. This other factor has been addressed in detail to ensure that all relevant information is provided to address the requirement of the recently updated EPA Landforms factor guidance which includes mesas as a key issue for impact assessment.

11.1 Landforms

This section describes the landform characteristics of the Proposed Change Area and provides an assessment of the potential impacts of the Proposed Change to landform values, proposed mitigation measures and the predicted outcome for this key environmental factor.

11.1.1 EPA objectives

The EPA applies the following objectives from the Statement of Environmental Principles, Factors and Objectives (2018c) in its assessment of proposals that may affect Landforms:

- To maintain the variety and integrity of significant physical landforms so that environmental values are protected.

11.1.2 Policy and Guidance

The following policy and guidance documents have been considered in the assessment of Landforms:

11.1.2.1 EPA Policy and Guidance

- EPA (2018e) Environmental Factor Guideline: Landforms;
- EPA (2018c) Statement of Environmental Principles, Factors and Objectives;
- DMP and EPA (2015) Guidelines for Preparing Mine Closure Plans;
- EPA (2018b) Instructions on how to prepare an Environmental Review Document; and
- EPA (2016c) Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans.

11.1.2.2 Other Policy and Guidance

- Government of Western Australia (2011) WA Environmental Offsets Policy;
- Government of Western Australia (2014) WA Environmental Offsets Guidelines; and
- Western Australian Planning Commission (2007) Visual Landscape Planning in Western Australia.

11.1.3 Environmental Scoping Document

Table 11-1 summarises where the requirements of the ESD are addressed in this section.

Table 11-1: Requirements of the ESD for Landforms

Task number	Requirement of ESD	Section number
63	Provide a description of the geology and morphology of the landforms within the Robe River valley.	Section 11.1.4.3
64	Spatially define the significant mesa habitat (including rocky ridge, gorge and breakaway habitat) along the Robe River, and the location of the operating and proposed mining operations.	Section 11.1.4.7
65	Describe the cumulative impacts on the landforms from historic and reasonably foreseeable future developments.	Section 11.1.6.5

11.1.4 Receiving environment

The Development Envelope is located in the Robe Valley. It is associated with the Robe Land System which is characterised by dissected plateaux and long lines of low mesas. The Proposed Change encompasses Mesa H, one of 34 named CID mesa landforms and numerous minor mesa formations which occur predominantly along the length of the Robe River, spanning over 100 km (~80 km strike length) within the broader Robe Valley.

Mesas are the key landform that will be impacted by the Proposed Change. Exposed Robe Pisolite (or CID) mesas have formed in ancestral drainage channels of the Robe River. As a result of on-going regional uplift and erosion of the surrounding formations, the Robe Pisolite which once formed along valley / drainage floors now forms an inverted topography occurring as mesa-form outcrops ranging from 30 to 50 m above the present surrounding landscape. Mesa H is an example of a Robe Pisolite mesa.

Some mesas in the Robe Valley have undergone mineral exploration and/or mining development. Most of the mesas that have undergone mining development have at least part of the mesa escarpment remaining, including features that are of ecological importance. Mesa H is a physically intact mesa landform that has been subject to exploration activities over a number of years. Mesa J to the east is being mined but has maintained an escarpment (Figure 2-1). The EPA's assessment of Mesa J (EPA 1991) acknowledged that on the mesa scarp are areas of high conservation value, providing habitats that support a range of flora and fauna. A condition of MS 208 is that mining is excluded from those areas of the Mesa J escarpment facing the Robe River.

The mesa formations in the Robe Valley provide important ecological habitats, primarily the gullies and breakaway habitats associated with the mesa escarpments. Sections of the escarpments of Mesa H (and Mesa J) host features such as caves, rock crevices, overhangs, fissures and boulders that provide a range of habitat for fauna, including conservation significant fauna.

The structural formations of the mesas, and shaded areas of ridgelines, support short-range endemic invertebrates by providing mesic qualities and a cooler, more humid microclimate than is present in the surrounding landscape. The CID comprising the mesa formations also provides habitat suitable for troglofauna, and stygofauna habitat where the CID extends below the water table.

Mesas also have significant Aboriginal heritage and cultural values, particularly associated with the mesa escarpments and can include artefact scatters, rockshelters, scarred trees and quarries. The mesa landforms are also features of the landscape with cultural significance, including serving as navigational landmarks.

Landforms in the Robe Valley also have social value. Yeera Bluff (Figure 11-3) is a prominent feature of the landscape, which was formed by the outcropping Brockman Iron Formation adjacent to the northwest section of Mesa H. It is separated from Mesa H by the Robe River and a permanent pool and is used for swimming and camping by the Robe River Kuruma People and local Pannawonica and Pilbara residents.

11.1.4.1 Landform studies

Landform studies and assessments have been undertaken for the Proposed Change and within the broader Robe Valley, including:

- landscape geological mapping and geomorphological characterisation;
- cultural heritage surveys;
- visual amenity assessments; and
- mesa escarpment characterisation, including geotechnical and biophysical.

These studies have enabled the values of the landforms to be defined and enabled the assessment of potential impacts to these landforms from implementation of the Proposed Change. Table 11-2 summarises the key studies and assessments relevant to the Proposed Change and the most recent survey reports are attached in Appendix 12.

Table 11-2: Summary of Supporting Landform Studies

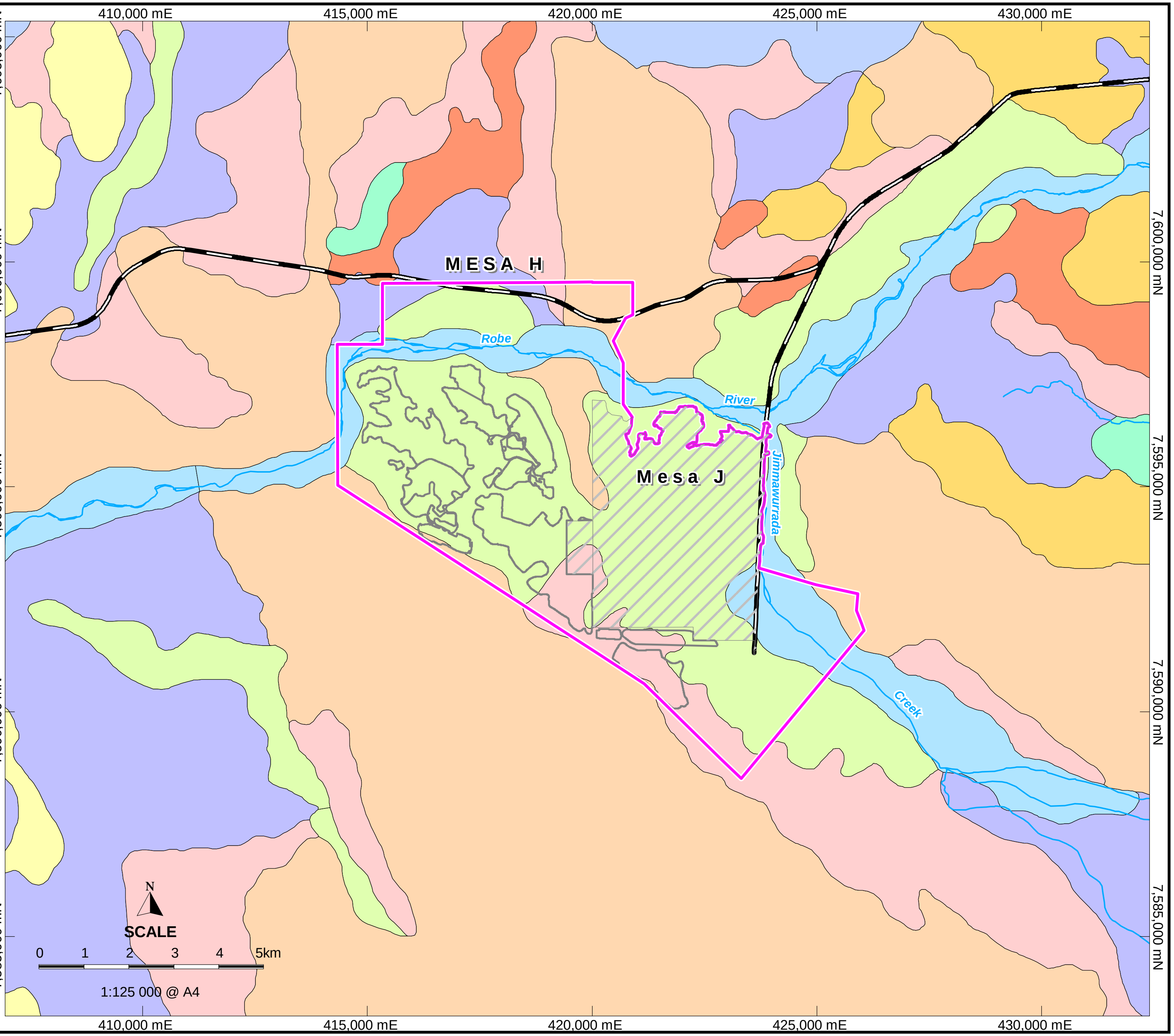
Report	Summary	Survey Date
Mesa H Visual Impact Assessment. Rio Tinto (2017c)	A VIA was completed to assess the changes to visual amenity expected to result from the Proposed Change. The VIA was conducted in three phases; desktop assessment (analysis), field assessment (photo locations) and visual impact (photo montage analysis). The results show present, operational and closure photo montages to illustrate the indicative visual impact of the proposed operations.	June 2016 and April 2018
Robe Valley Deposits Façade Stand-off Distance Memo. Rio Tinto (2017d)	A review was undertaken to establish the appropriate stand-off distance (the distance between the crest of the pit and that of the mesa's natural slope) to be used as a guideline for current and future mining operations on Mesas in the Robe Valley. Various information was reviewed including relevant geotechnical reports relating to the Mesa façade stability, pit slope performance of as-built slopes and the estimated façade stability during closure.	November 2017
Mesa H Façade Assessment. Astron (2017c)	A desktop escarpment assessment was undertaken to categorise, map and rank the ecological value of the mesa escarpments at Mesa H.	October 2017
Mesa A Geotechnical Assessment, Project No. 5978. Snowden (2007)	A geotechnical stability assessment was undertaken for the mesa landforms of the Robe Valley, specifically escarpment stability, utilising observations and field assessments throughout the Robe Valley. This assessment was undertaken for Mesa A, however included a literature review and data analysis of mesa landform geotechnical characteristics, geological structure and hydrogeology, in addition to a field investigation of existing mined areas including Mesa J, K and M.	May 2007
Mesa A – Warramboo Robe River Landscape and Geodiversity Assessment Study. John Cleary Planning (2005)	This assessment reviews the potential impacts of the Mesa A / Warramboo Proposal on the landscape and geodiversity values of the Robe Valley, however the assessment contexts and describes the landscape and geodiversity values of the broader Robe Valley including Mesa H.	June 2005

11.1.4.2 Land Systems

The Proposed Change Area encompasses the land systems listed in Table 11-3 and shown on Figure 11-1 (van Vreeswyk *et al* 2004). Mesa H and Mesa J, and mesas in the broader Robe Valley are mostly associated with the Robe land system.

Table 11-3: Land Systems of the Proposed Change Area

Land System	Geology	Geomorphology	% of Proposed Change Area
Robe	Tertiary pisolitic limonite and laterite (Robe Pisolite).	Erosional surfaces; formed by partial dissection of old Tertiary surfaces, dissected plateaux and long lines of low mesas along present and past river valleys, indented near vertical breakaway faces and steep slopes with limonite outcrop and pisolitic gravelly mantles, restricted gravelly lower slopes and closely to moderately spaced narrow tributary drainage floors. Relief up to 50 m.	57
River	Quaternary alluvium.	Flood plains and river terraces subject to fairly regular overbank flooding from major channels and watercourses, sandy banks and poorly defined levees and cobble plains. Banks, levees and slightly higher upper terraces receive less regular flooding than lower terraces and flood plains.	17
Newman	Lower Proterozoic jaspilite, chert, siltstone, shale, dolomite and minor acid volcanics.	Erosional surfaces; plateaux and mountains - extensive high plateaux, mountains and strike ridges with vertical escarpments and steep scree slopes and more gently inclined lower slopes; moderately spaced dendritic and rectangular tributary drainage patterns of narrow valleys and gorges with narrow drainage floors and channels. Relief up to 450 m.	12
Boolgeeda	Quaternary colluvium.	Predominantly depositional surfaces; very gently inclined stony slopes and plains below hill systems becoming almost level further downslope; closely spaced, dendritic and sub-parallel drainage lines. Relief up to about 20 m.	11
Urandy	Quaternary Alluvium and Colluvium.	Depositional surfaces; level stony plains and plains and fans of sandy alluvium with widely spaced sub-parallel distributary creeklines and channels; subject to sheet flow and overbank flooding. Relief less than 10 m.	3
Mc Kay	Lower Proterozoic shale, chert, mudstone, sandstone and dolomite.	Erosional surfaces; hill tracts, ridges, plateaux remnants and breakaways with steep upper slopes and more gently inclined lower footslopes, restricted stony plains and interfluves; moderately spaced tributary drainage patterns incised in narrow valleys in upper parts becoming broader and more widely spaced downstream. Relief up to 100 m.	<1



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse
- Conceptual Mine Layout

Land System

- Boolgeeda Land System
- Capricorn Land System
- McKay Land System
- Nanutarra Land System
- Newman Land System
- River Land System
- Robe Land System
- Rocklea Land System
- Sherlock Land System
- Urandy Land System

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Figure 11-1: Land Systems

Drawn: M.Swebbs
Date: September, 2018
Plan No: PDE0152230v6
Proj: MGA 94 Zone 50

11.1.4.3 Geology and morphology

The Development Envelope is located within the western Pilbara region and the western extent of the rugged and strongly dissected Hamersley Ranges which includes prominent highpoints, ridges and cliffs (John Cleary Planning 2005).

Three geological formations in the Robe Valley area develop landforms featuring the characteristic deep-red rocky faces and associated gorges and gullies which typify the Robe Valley. In relation to the Proposed Change Area, these are:

- the Robe Pisolite, which forms Mesa H and Mesa J within the Development Envelope, other mesas both to the east and west of the project area on the Robe River, and many other active and former drainages in the region;
- the Marra Mamba Iron Formation which forms the western escarpment of Mesa J, and the northern escarpments of Jimmawurrada Creek; and
- the Brockman Iron Formation which forms the tall faces of Yeera Bluff to the west of Mesa J and is extensive throughout the Hamersley Ranges.

The Proposed Change Area forms part of the ancient Robe River paleo-channel and occurs near the downstream confluence of the Robe River and Jimmawurrada Creek. Mesa H is one of a group of pisolitic goethite-hematite deposits of Tertiary age (known as Robe Pisolite or a more generically known as a CID) which have formed in ancestral drainage channels of the Robe River.

The Robe Pisolite overlies transitional Archaean / Proterozoic rocks of the Mount Bruce Supergroup. In the Proposed Change Area, the Mount Bruce Supergroup comprises a lower Fortescue Group sequence, overlain by sedimentary rocks of the lower Hamersley Group (Figure 11-2). In the vicinity of the Proposed Change, basaltic flows of the Maddina Volcanics are overlain by rocks of the Jeerinah Formation (Upper Fortescue Group). These are in turn overlain by the lowest units of the Hamersley Group; the Marra Mamba Iron Formation and the Wittenoom Dolomite, these last two units form the basement beneath Mesa J and H.

As a result of on-going regional uplift and erosion of the surrounding formations, the Robe Pisolite which once formed along valley / drainage floors now forms an inverted topography occurring as mesa-form outcrops ranging from 30 to 50 m above the present surrounding landscape, or as gently dipping talus / terraced slopes, often blanketed by Quaternary and Recent alluvium.

The river systems are deeply incised into the uplands and are braided in the lower reaches where they eventually cut into the Coastal Plain around Warramboo (Australian Government 2006). The rivers comprise dry shingle and sand-filled channels along which permanent or nearly permanent water holes are located. These rivers are ephemeral and flow after heavy rain, and subsurface groundwater flow occurs along the larger channels which continues throughout most of the year.

The course of the ancestral palaeodrainages and current river courses are controlled by bedrock faults and fractures, or by the presence of more easily eroded rock units. Yeera Bluff is an example of where the Robe River's orientation, forming an unusual 90^{o} bend and associated permanent pool formation appears to be as a result of structural features in basement rocks.

Yeera Bluff (Figure 11-3) is a prominent feature of the landscape, which is formed by the outcropping Brockman Iron Formation adjacent to the northwest section of Mesa H. It is separated from Mesa H by the Robe River and a permanent pool.

The Robe Pisolite itself consists of oolitic, pisolitic, and massive goethite, hematite, and maghemite in a matrix of goethite and minor silica together with detrital material, fragments of fossil wood, and seams of clay. The Pisolite formations are porous and contain various sized void spaces, cavities, solution channels and fractures.

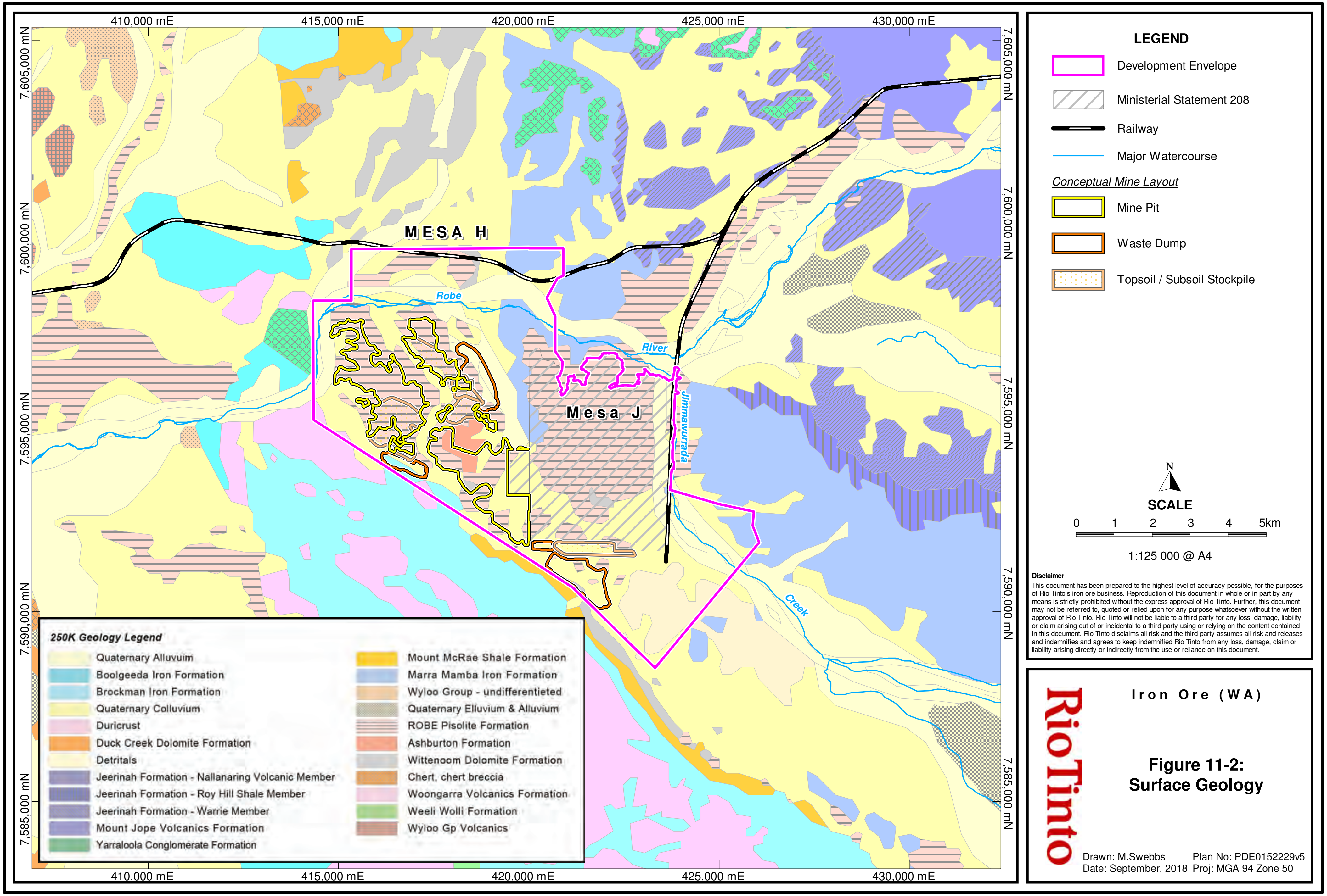

Figure 11-2: Surface Geology

Geospatial Information and Mapping

Figure 11-3: Yeera Bluff in Relation to the Mesa H Landform

11.1.4.4 Rarity

The Robe Land System represents 0.7% of all the land systems delineated within the Pilbara Bioregion (van Vreeswyk *et al*. 2004 in Astron 2017c). Mesa H represents a small portion, approximately 0.3% of the broader Robe River Land System.

Mesa formations are relatively common in the western Pilbara (Figure 11-4) and are associated with a number of geology types including CID. More than 600 individual occurrences of CID have been mapped across the western Pilbara. It is estimated between 250 and 300 of these are exposed Robe Pisolite mesas (John Cleary Planning 2005), such as Mesa J and H.

Thirty-four named mesas and numerous un-named minor mesa formations occur in the Robe Valley (including those in the Proposed Change Area) (Figure 11-5). The mesa formations are most prominent adjacent to the Robe River, but CID is also present at Warramboo, Jimmawurrada, Bungaroo, and near Red Hill homestead.

11.1.4.5 Variety

Within the Proposed Change Area, Mesa H represents ~39% of the total area, comprising a mesa dissected by flowlines and a distinct central valley through the mesa. The Mesa H landform forms moderately prominent escarpments on its northern and western margins where it is adjacent to the Robe River with less distinct and rounded margins along other sides, and slopes adjoining Mesa J on its south-eastern side (Figure 11-6).

Mesa H was described by John Cleary Planning (2005) as:

- A discrete mesa, although tends to blend into the adjacent Mesa J landform in the south-east.
- Moderate-sized escarpment on the river/west side and has a second tier in places.
- Shallow valleys and rounded tops on the south side.
- Long valley flowline through the centre.
- Highly eroded with small mesas in the south-east.
- Eroded with rounded forms in the east.
- Stronger mesa formation in the north-east.

Within the Development Envelope, the Mesa J landform, was described as a relatively large mesa, approximately 2,090 ha in area, with undulating plains on the mesa top, and slopes below the mesa breakaway, including a variety of flowlines. The current Mesa J landform has maintained an escarpment adjacent to the Robe River.

Mesa H is similar to (but less well defined than) other CID mesa's in the Robe Valley and in the broader western Pilbara region.

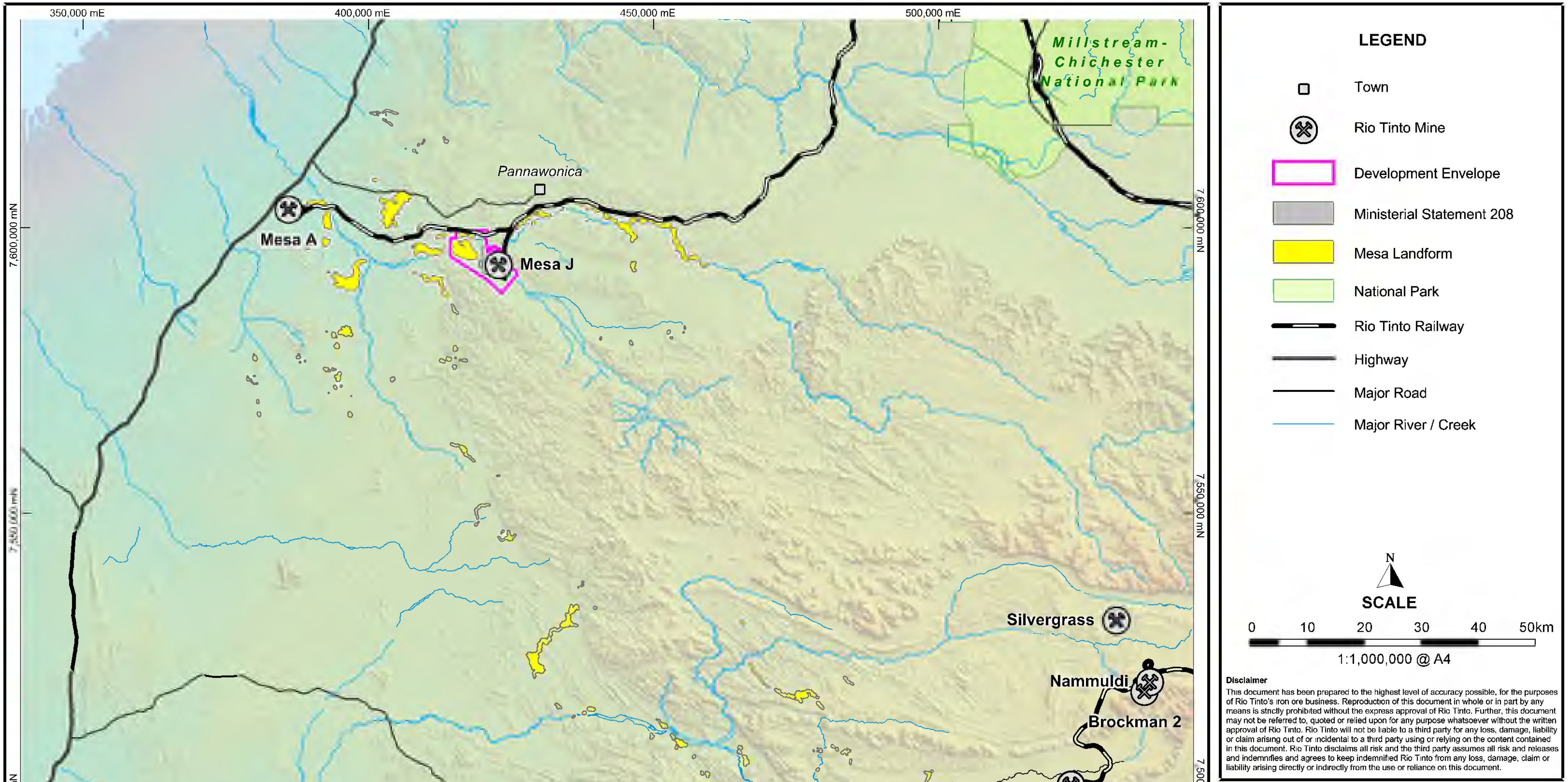

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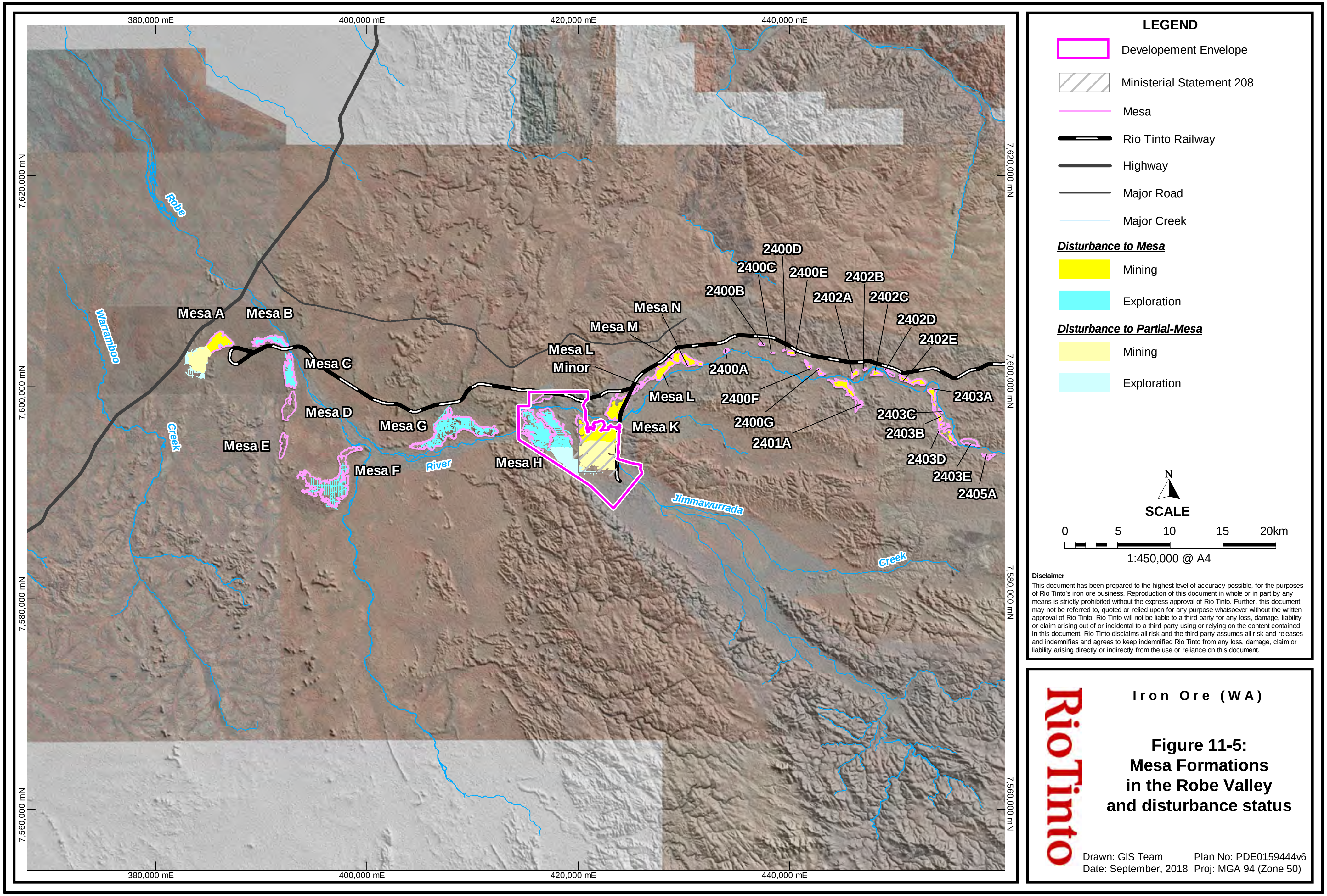
Figure 11-4: Mesa Formations in the Western Pilbara

Drawn: GIS Team
Date: September, 2018
Plan No:PDE0159442v4
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping



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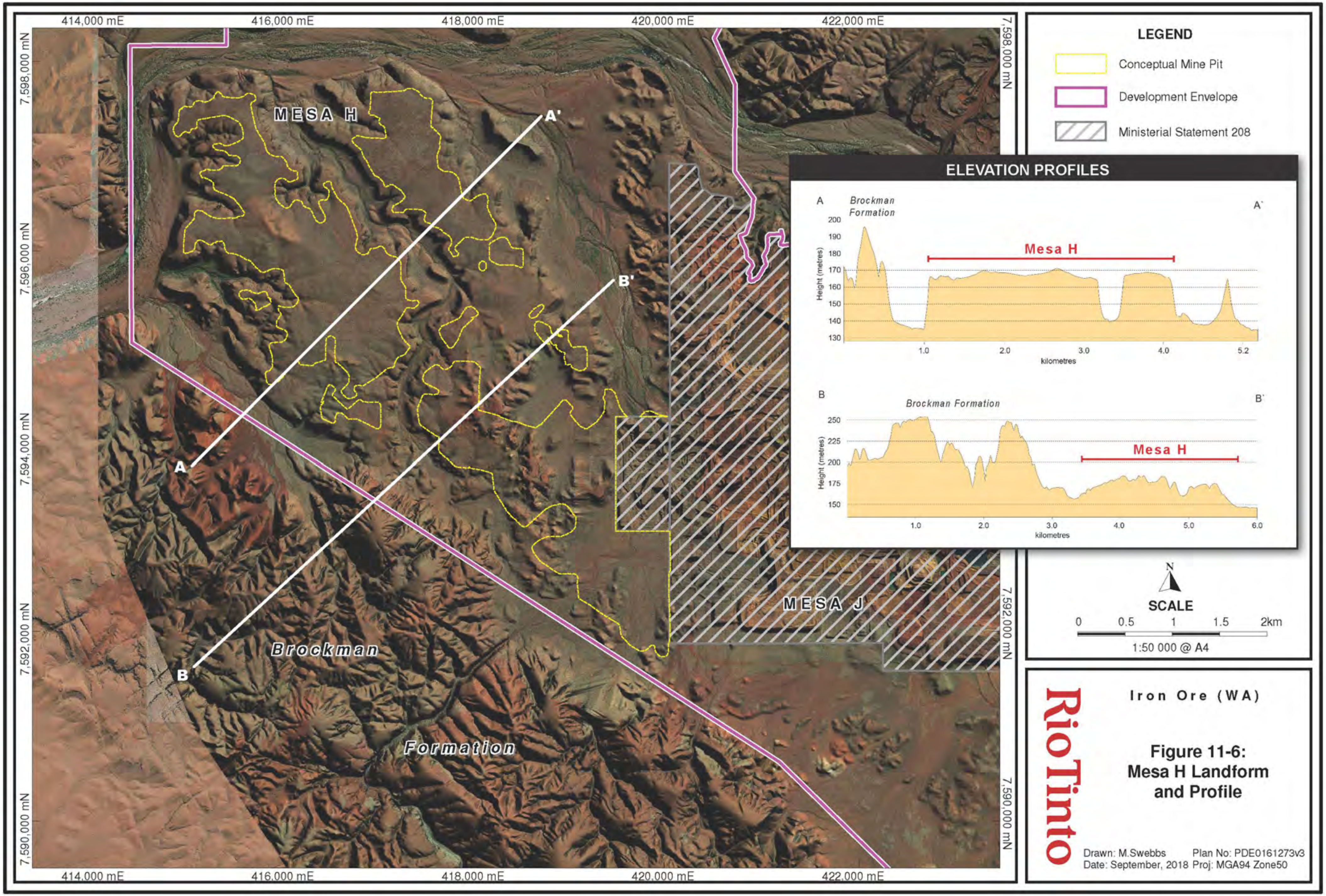

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Iron Ore (WA)

Figure 11-6: Mesa H Landform and Profile

Drawn: M.Swebbs
Date: September, 2018
Plan No: PDE0161273v3
Proj: MGA94 Zone50

11.1.4.6 Integrity

Mesa H is currently a physically intact mesa landform which has been subject to exploration activities including clearing of native vegetation to facilitate exploration drilling over numerous years. As described in Section 11.1.4.5 the Mesa H landform does not display delineated escarpments around its entire circumference and instead forms a moderate-sized escarpment on the river / west side with a second tier in places, and transitions into the adjacent Mesa J landform to the south-east. Mesa H is dissected by numerous valley flowlines, including a main central flowline.

11.1.4.7 Ecological importance

The mesa formations in the Robe Valley provide important ecological habitats, primarily the gullies and breakaway habitats associated with the mesa escarpments, with sections of the escarpments of Mesa H (and Mesa J) hosting features such as caves, rock crevices, overhangs, fissures and boulders that provide a range of habitat for fauna, including conservation significant fauna.

The structural formations of the mesas, and shaded areas of ridgelines, support short-range endemic invertebrates by providing mesic qualities and a cooler, more humid microclimate than elsewhere in the surrounding landscape (EPA 2009 as cited in MWH 2015). The mesa escarpments also provide a refuge from feral cats, fire and livestock and provide areas for breeding (Hill and Ward 2010 and DoE 2013 as cited in Astron 2017c). During rainfall events, the central and minor gullies of Mesa H facilitates surface water runoff to the Robe River.

The caves and deeply incised gullies within the mesa escarpments are considered to provide important habitat for Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and Pilbara Olive Python, which are listed as threatened species under the EPBC Act (see Section 8). The mesa plateaus are considered to be of limited ecological and habitat value to threatened species. The CID comprising the mesa formations also provides habitat suitable for troglofauna, and stygofauna habitat where the CID extends below the water table. Stygofauna and troglofauna have been recorded at Mesa H (see Section 7).

Following Astron's baseline field surveys, a desktop assessment was undertaken in 2017 (Astron 2017c) to categorise and rank the ecological value of the mesa escarpments at Mesa H, to help inform the Proposed Change design and prioritise areas of highest ecological value to ensure these areas were avoided. Each category was scored for a number of ecological factors (conservation significant flora and vegetation, fauna habitats, vertebrate fauna and invertebrate fauna), with priority rating scales of high, moderate and low determined using the mean and standard deviation of all mesa assessment sites. The assessment considered 48 assessment sites. Twenty per cent (91.2 ha) of the total area of mesa façades within the survey area were rated as high priority, 56% (250.2 ha) as moderate priority and 24% (105.4 ha) as low priority (Figure 11-7). The sites rated as high priority were found along the western façade near the Robe River and a small section along the northern façade that passes close to the Robe River (Figure 11-7).

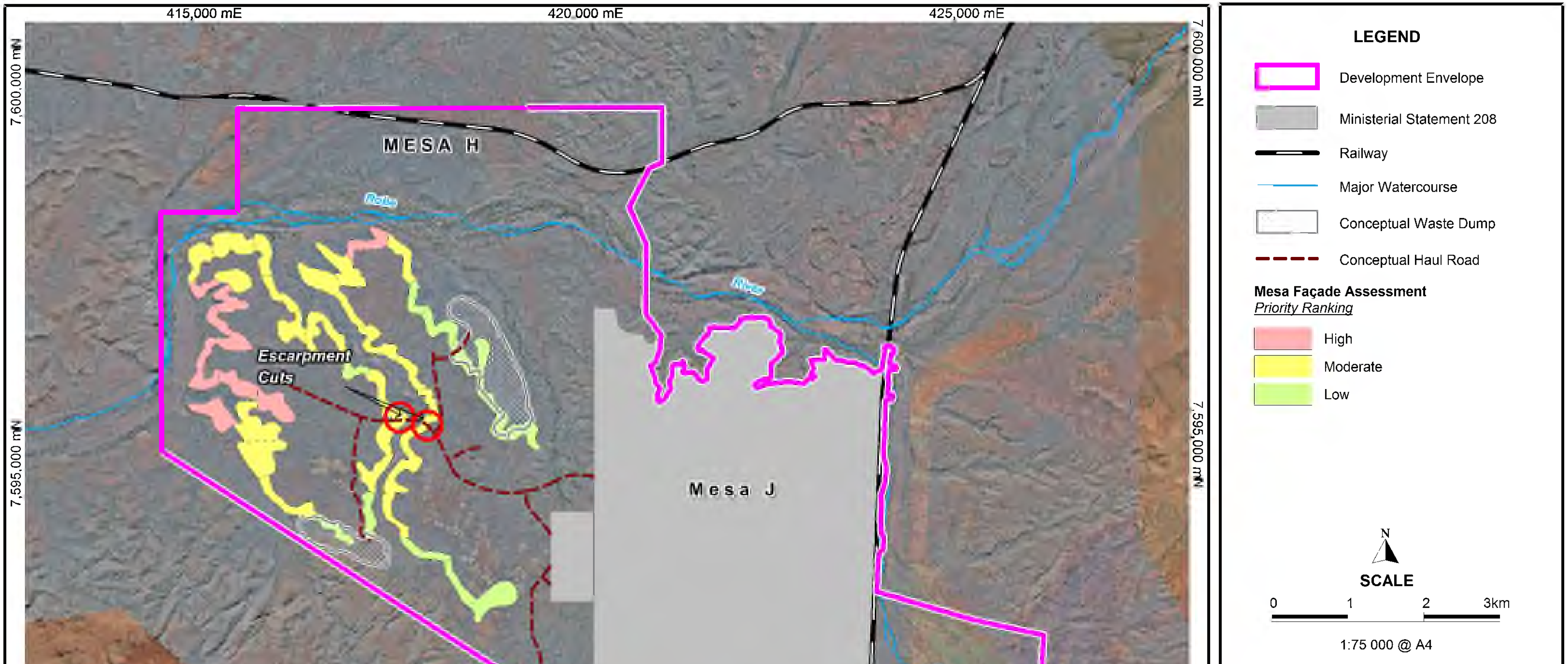

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Figure 11-7: Mesa H Landform Escarpment Ecological assessment and ranking

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Date: Jan, 2019

Plan No: PDE0161830v5
Proj: MGA94 Zone50

11.1.4.8 Scientific importance

Mesa H provides evidence of past ecological processes, as do the other Robe Pisolite mesas in the Robe Valley. Scientific interest has been limited to studies associated with the Revised Proposal.

11.1.4.9 Social importance

Amenity Value

The North West Coastal Highway is the main travel route though the western Pilbara region and is a heavy-use, sealed road supporting a mix of local, industrial and tourist traffic. The main access route in the vicinity of the Revised Proposal is the Pannawonica Access Road, which is a sealed link road extending from the North West Coastal Highway to the town of Pannawonica and carries traffic largely related to the mine operations in the area. Other roads nearby comprise gravel pastoral access roads, many of which are also used for mining exploration activities.

Panoramic, views toward Mesa H are available from the Pannawonica Access Road, due to the open nature of the landforms and sparse vegetation in the area. Views become confined close to, and between, mesa formations, in gullies and near the riparian vegetation. There are views of the mesas from the North West Coastal Highway, and from the Pannawonica Access Road which enhance the landscape amenity and contribute to the tourism experience and may raise interest from travellers (John Cleary Planning 2005).

Heritage Value

Numerous cultural heritage surveys have been undertaken for the Revised Proposal, including for the existing Mesa J Iron Ore Development. These surveys have identified significant Aboriginal cultural heritage values, particularly associated with the mesa escarpments and include artefact scatters, rockshelters, scarred trees and quarries. Sites associated with the mesa landforms that were identified by the Robe River Kuruma People as being of the highest significance include a mythological site (Jirtiwi Thalu) and a gender restricted quarry site MJ04-09. Immediately adjacent to the mesa landforms, the Robe River, its pools, Jimmawurrada creek, a burial (Deepdale Burial) and a Law Ground (Yarramarda Law Ground) were also identified as having the highest significance.

The mesa landforms themselves are also features of the landscape with cultural significance, including use as navigational landmarks. Further detail on heritage values is provided in Section 9.

11.1.5 Potential impacts

A number of potential impacts are identified in the ESD. The potential direct, indirect and cumulative impacts identified for the Proposed Change on the basis of surveys and assessments relating to landforms completed to date, are described in Section 11.1.6 and listed below:

- loss of variety due to removal or degradation of the mesa landforms;
- loss of the integrity of the mesa landforms due to disturbance;
- loss or degradation of the ecological values of the mesa landforms; and
- loss or degradation of the social values of the mesa landforms through loss of indigenous heritage and amenity values.

Similar to the existing operations at Mesa J and other Mesa operations within the Robe Valley, Mesa H will be mined as an open-cut pit operation, and will retain the Mesa façades (escarpments) (Figure 11-8), which are the main distinctive features of the landscape. Mining activities will require removal of topsoil, overburden and ore from within the mesa formation and will require establishment of minor escarpment cuts to allow access to the proposed mine pits and waste dumps, and for heavy haulage of ore back to the Mesa J

Iron Ore Development for processing. The Proposed Change will involve mining the Mesa H CID, equivalent to <50 % of the Mesa H CID volume.

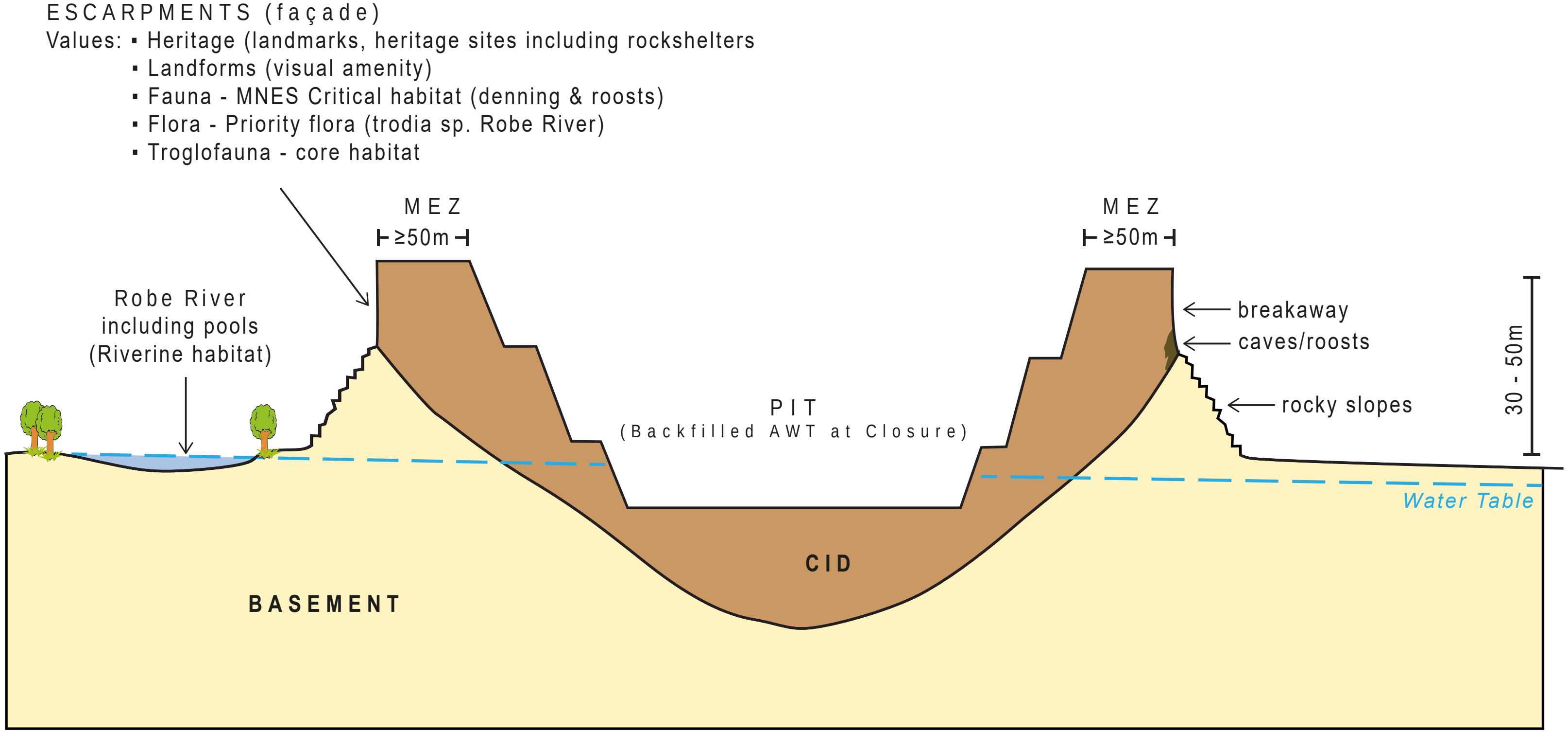
The Proposed Change will impact <30% of the mesa escarpment by surface area, comprised of the following (Figure 11-7):

- 25 ha of high priority habitat;
- 76 ha of moderate priority habitat; and
- 56 ha of low priority habitat.

Mining activities will be confined to the internal sections of the mesa landform. Whilst most of the mineral waste will be backfilled in pit where practical, some external waste dumps will be required to facilitate access to pits during early stages of individual pit development.

Two escarpment cuts will be required at Mesa H to facilitate two haul roads through the interior central gully area linking the east and west pits back to the Mesa J processing facilities. Escarpment cuts (up to 110 m width) will also be required through the mesa to facilitate haul road access from the active mine pits back to Mesa J processing facilities or to mineral waste dumps. The proposed access cuts will result in disturbance to less than 2% of the escarpments at Mesa H.

Figure 11-8: Mesa Landform Mining Schematic



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11.1.6 Assessment of impacts

11.1.6.1 Rarity

Mesa formations are relatively common in the western Pilbara region. It is estimated between 250 and 300 exposed Robe Pisolite mesas occur in the western Pilbara region with 34 named mesas and numerous un-named minor mesa formations and breakaways occurring in the Robe Valley (including those in the Proposed Change Area).

While there will be impacts to Mesa H, the Robe Pisolite landform is relatively common and is not rare at the national, regional or local level. In addition, the areas of landform which host the significant ecological and heritage values; the mesa escarpments, will be retained (Section 11.1.8).

11.1.6.2 Scientific importance

As discussed in Section 11.1.4.8, scientific interest in Mesa H has been limited to studies associated with the Proposed Change. Mesa H is not of recognised scientific interest as a reference site or an example of where important natural processes are operating.

11.1.6.3 Direct impacts

Loss of variety due to removal or degradation of the mesa landforms

The Proposed Change will involve direct impacts from the removal of the internal part of the Mesa H landform.

The mesas represent a distinct type of landform, with the most prominent and unique feature of each mesa being the escarpments. Mesa H is not considered as distinct as other mesas in the Robe Valley (John Cleary Planning 2005), particularly due to the lack of well delineated escarpments around its entire periphery, comprising a moderate-sized escarpment on the Robe river/west side, and gradually transitioning into the adjacent Mesa J landform to the south-east.

Mining has been undertaken historically on 14 mesas in the Robe Valley and is currently underway on two mesas (Mesas A and J) with historic and remnant mining at Mesa K (Figure 11-5). In addition to the Proposed Change at Mesa H, a proposal to undertake mining at Mesas B and C has been referred to the EPA under Section 38 of the EP Act and is currently under assessment. Between Mesa A in the west of the Robe Valley and Mesa 2405A in the far eastern end of the Robe Valley, there are an additional 14 named mesas that have not been previously mined and are not currently part of a proposal for mining.

Most of the mesas that have undergone mining development have at least part of the mesa escarpment remaining, including features that are of ecological importance. Considering only the ‘named’ mesas in the Robe Valley between Mesa A and Mesa 2405A, it is estimated that on average approximately 83% of the mesa escarpments across the Robe Valley are intact, either on mesas that have not been mined or as retained escarpments (Bat Call 2017a).

Mining activities for the Proposed Change will be largely confined to the internal sections of the mesa landform involving topsoil and overburden removal, mineral waste management and open-cut excavation of ore. Whilst most of the mineral waste will be backfilled in pit where practical, some external waste dumps will be required to facilitate access to pits during early stages of individual pit development. Due to the proximity of the Proposed Change to the Robe River on the western and northern sides, limited options for the location of ex-pits dumps are available that do not impact on the Robe River; sites of high heritage or ecological value; or impact the visual amenity of the landscape, which in itself would impact the perceived variety of the landforms. Hence part of the footprint of the external dumps will be located across the less prominent sections of the mesa periphery, as shown in Figure 11-7, particularly where the mesa margin forms a rolling slope, and will therefore minimise or avoid impact to the distinctive features of the mesa landform.

Escarpment cuts (up to 110 m width) will also be required through the mesa to facilitate haul road access from the active mine pits back to Mesa J processing facilities. The access cuts have been specifically located to avoid areas assessed as having high ecological significance based on Astron's (2017c) façade assessment, including avoidance on known ghost bat roosts and sites of high heritage significance. The proposed access cuts will result in disturbance to less than 2% of the escarpment of the mesa. The retention of the mesa escarpments (where they exist) will preserve the prominence and scale of the mesa landforms in the landscape.

Considering the Revised Proposal and reasonably foreseeable proposals (Mesas B and C), 14 named mesas and also numerous un-named minor mesas will remain fully intact representing Robe Pisolite mesas. Also, more than 83% the most prominent feature of the mesa landform: the mesa escarpments will be retained. Given the wider representation of this type of landform both within the Robe Valley and in the wider west Pilbara, it is considered that the Revised Proposal is unlikely to result in the loss of landform variety at the local or regional scale.

Loss of integrity of the mesa landform due to disturbance

The integrity of a landform can be considered both in terms of whether the landform is largely intact and whether the landform has structural integrity.

The interior of the Mesa H landform will be permanently altered due to the development of open-cut mine pits involving the removal of the existing elevated mesa surface and its modification to 'basins'. The base of the excavation will have a depth of up to 60 m lower than the existing mesa-top surface; however, the most valuable feature of the mesa landform – the escarpments will be retained. This mining approach is consistent with the approach currently taken at Mesa J, K and A.

Two escarpment cuts will be required at Mesa H to facilitate two haul roads through the interior central gully area linking the east and west pits back to the Mesa J processing facilities (Figure 2-3). The location of the access cuts has been designed to avoid the most valuable feature of the landform – the prominent escarpments, particularly near the Robe River and in areas of high visibility (see Section 2.2.2).

Geotechnical assessments of the mesa formations across the Robe Valley have been undertaken to understand the natural mesa landform erodibility and to determine the sensitivity of the landforms to damage from mining activities, including retained escarpments.

A literature review by Snowden (2007) looked at natural erosion rates in similar mesa landforms in arid environments and found that natural retreat rates of mesa cliffs in analogous geological and environmental conditions are very low. A subsequent field inspection and desktop study of the mesas of the Robe Valley concluded that the mesa escarpments appear to be stable landforms with very little natural erosion occurring over the last 15 to 20 years. This resilience to erosion is reflected in the nature of which the mesa landforms in the Robe Valley were originally formed, whereby the current 'inverted' topography has formed based on higher erosion rates of the surrounding geological formations, exposing the more resilient CID of the river channel as a topographic high (mesas). The principal mechanism of erosion relates to undercutting of softer clay layers or clay rich basement pisolite forming shallow caves below more competent pisolite; however, this cycle of cave formation is an extremely slow process.

The geotechnical sensitivity of the site was assessed in conjunction with the assessed environmental significance to determine the tolerable blast vibration range required to protect the integrity of the structure.

A geotechnical assessment (Snowden 2007) which reviewed the current stability of the mesas within the Robe Valley observed that at Mesa J, K and M:

- The use of conventional blasting techniques, without specific blast limit management for final pit faces (e.g. trim shots), resulted in crests typically only sustaining 1 – 2 m of backbreak.
- Most faces showed little if any natural erosion over 15 to 20 years. Small, localised sections of softer material erode at slightly higher rates.
- No significant batter scale failures were observed at any of the mines.

Snowden (2007) concluded that within mined mesas, the erosion rates of pit slopes do not appear to be any greater than the rate for natural slopes.

Based on these findings, the mesa landforms associated with the Proposed Change are considered to be robust, with low sensitivity to damage from development activities.

Further studies of the minimum escarpment width required to ensure the structural integrity of retained mesa escarpments in the Robe Valley was undertaken by Rio Tinto (Rio Tinto 2017d). The study considered geological, blasting, geotechnical and wall monitoring data from current Robe Valley mesa mining operations and determined that an escarpment width of 30 m would be adequate to maintain the long-term stability and integrity of mesa escarpments in the Robe Valley. This conclusion is supported by observations from the existing mining operations, including Mesa A, J and K, and the study undertaken by Snowden (2007), which observed a remnant mesa bluff with a maximum width of 63 m and minimum width of 3 m directly adjacent to a pit mined over 20 years ago, which showed no damage from blasting and lacked evidence of notable erosion effects over the last 20 – 30 years. The Mesas A, J and K historical mining operations in the Robe Valley demonstrate that mesa escarpments are stable, and the structural integrity can be maintained by ensuring retention of an adequate width of escarpment. As the Proposed Change has been designed with escarpment widths that are a minimum of 50 m and often greater, the integrity of the remaining landform is not expected to be compromised.

Given the mesa escarpments (where they exist on Mesa H), which represent the highest value feature of the mesa landform will remain largely intact, and the structural integrity of the landform will be maintained through retention of an escarpment width which is geotechnical stable to withstand blasting from mining operations and natural erosion. Also, as discussed in Section 11.1.6.2, 14 named mesas and numerous un-named minor mesas will remain fully intact. Therefore, it is considered that the Proposed Change will not significantly impact the integrity of the mesa landforms in the Robe Valley.

11.1.6.4 Indirect impacts

Loss or degradation of the ecological values of the mesa landforms

The escarpments of the mesa landform, particularly the breakaway and gully habitats located within sections of the escarpments contain the high value habitat for a number of flora and fauna species, including troglofauna, conservation listed species such as the Ghost Bat, Northern quoll, Pilbara Olive Python, and Priority flora such as *Triodia Sp. Robe River*. The façade ecological assessment by Astron (2017c) determined the mesa façades rated as high priority comprised 20% (91.2 ha) of the total area of mesa escarpment and were located along the western side of the mesa near the Robe River and a small section along the northern side which passes close to the Robe River (Figure 11-7). The proposed retention of a MEZ is designed to protect and maintain these sections of the escarpment.

Habitats contained within the Development Envelope, associated with the mesa landforms are not considered restricted at the local, sub-regional or regional scale and no restricted or uncommon geological units or land systems occur within the survey area (Astron 2017e). As the high value flora and terrestrial fauna habitat will be retained and at least 50% of habitat volume of troglofaunal habitat of Mesa H, it is considered that Mesa H will maintain existing ecological and physical processes.

Loss or degradation of the social values of the mesa landforms

<u>Amenity value</u>

The main physical alteration to the mesa landform will be development of open-cut mine pits which will result in the creation of voids in the centre of the mesa landform. Mining will occur below the mesa surface and behind the retained periphery and escarpment faces. Retention of the escarpments (where they exist on Mesa H), will conceal visibility of the mine pits from key vantage points, whilst maintaining the mesa-landforms as a façade, thus minimising the impact to visual amenity. The main alteration to the landscape in terms of visual amenity will be the construction of mineral waste dumps.

As described in Section 2.2.2, part of the proposed ex-pit waste dumps will be required to be located on the less prominent margins of the mesa landform. The location of the dumps has specifically been located to avoid impact on a number of values, including the visual amenity of the landscape and prominent escarpments, and will therefore minimise or avoid impact to the distinctive features of the mesa landform.

A VIA (Rio Tinto 2017c; Appendix 12) was undertaken for Mesa H using a field assessment, desktop 'Viewshed' analysis, with the resultant visual impact presented as photo montages – pre, during and post mining (Figure 11-9). Sites for the VIA were selected based on locations with the greatest potential for visual impact, sites of interest or heritage significance (e.g. views from Law grounds or the Robe River). Some sites were nominated or requested by representatives of the Robe River Kuruma People. The assessment (Rio Tinto 2017c) showed that the proposed mine pits will not be visible behind the retained mesa escarpments.

Ex-pit mineral waste dumps will be partially visible from along a small portion of the Pannawonica Access Road, the site access road and from local elevated sites in the adjacent landscape (including from the Yarramarda Law Ground). The proposed ex-pit waste dumps will remain in line with or lower than the surrounding mesas. The Viewshed modelling shows these waste dumps will mostly be obscured by the surrounding topography or by existing vegetation (including from the Yarramarda Law Ground. The visible sections of the dumps generally occur as low-lying disturbance or tie into the mesa landform (Rio Tinto 2017c).

Given that the mesa escarpments will be retained, and waste dump heights will remain aligned with or lower than the surrounding mesas, it is considered that the Mesa H landforms will continue to support amenity values.

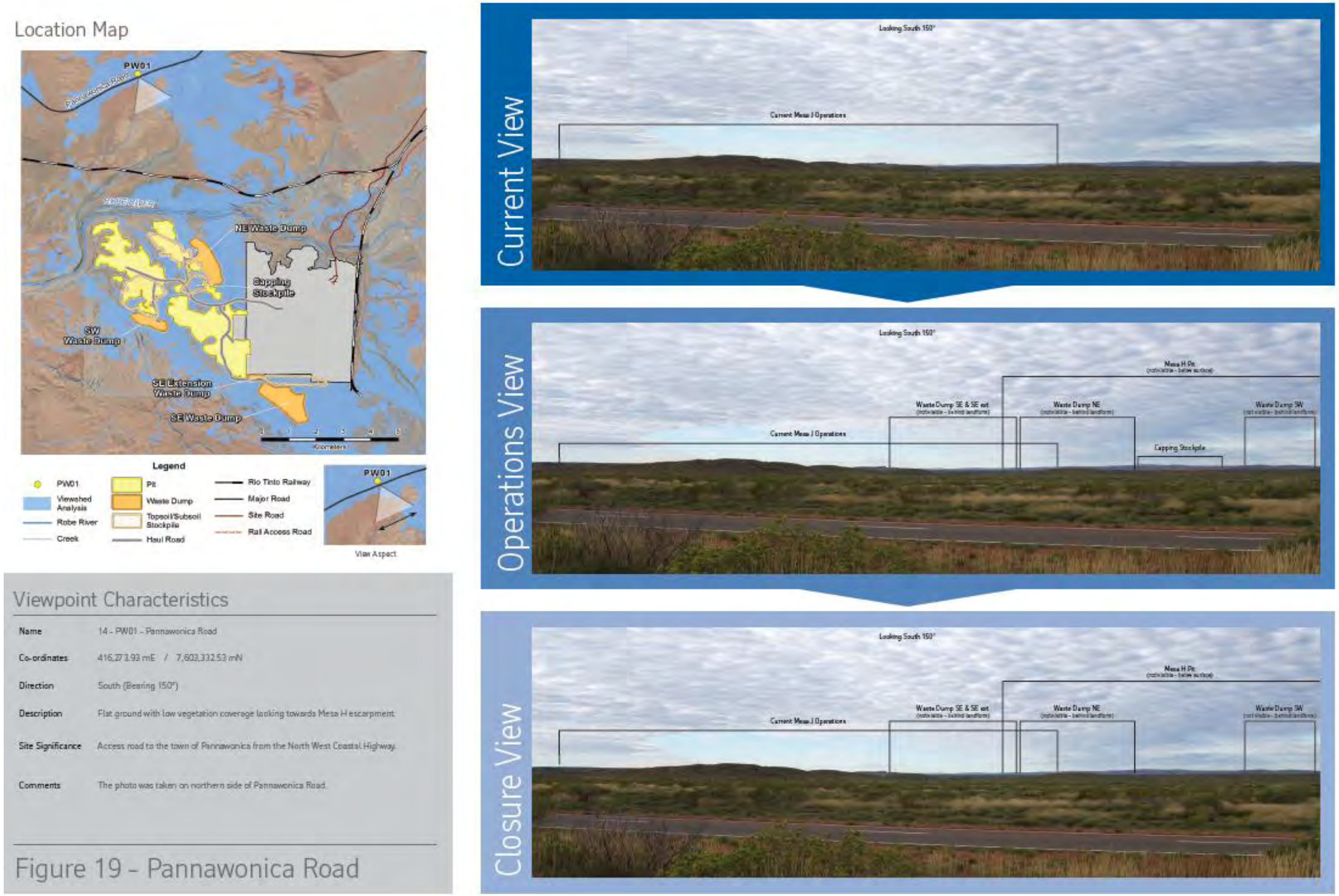


Figure 11-9: Example of Viewshed Analysis Assessment

Heritage value

The Proposed Change has been designed to retain the Mesa H escarpments (where they exist), except where cuts are required to provide haul road access through the mesa landform. The retention of the mesa escarpments as part of the MEZ will ensure that the mesa landforms will still be visibly present and can still be used as navigational landmarks by the Robe River Kuruma People. The proposed escarpment cuts have been designed to minimise impact to visual amenity and heritage values by being located away from the Robe River and away from key heritage site vantage points – the locations of the escarpment cuts are located in areas of lower topographical relief (less prominent parts of the mesa landform) on the southern side of, and within the internal gully of Mesa H. Consequently, it is not expected that these cuts will impact the visual amenity of the mesas as viewed from the Robe River or Law Grounds.

The location and layout of the mine and associated infrastructure has been designed to minimise impacts to Aboriginal heritage sites. The establishment of a MEZ will protect all recorded rockshelter sites from direct disturbance, and there will be no impacts to two very significant sites in proximity to the Project: Jirtiwi Thalu and a gender restricted quarry site MJ04-09.

Given retention of the mesa escarpments, avoidance of direct disturbance to all rockshelter sites, and avoidance to Jirtiwi Thalu and a gender restricted quarry site MJ04-09, it is considered that the Mesa H landform will continue to support significant cultural and heritage values.

11.1.6.5 Cumulative impacts

The most prominent and unique feature of each mesa is the escarpment.

Historical mining undertaken in the Robe Valley in the 1970s did not consistently retain the mesa escarpments. The proportion of escarpment remaining on each of the 14 historically mined mesas varies between 0% and over 90% but is generally less than 50% (Bat Call 2017a). The current mining at Mesas A, J and K has retained the prominent mesa escarpments (where they exist), other than disturbance required for essential infrastructure. The proposed operations at Mesas B, C and H will also include retention of the mesa escarpments, except where escarpment access cuts are required. Considering only the 'named' mesas in the Robe Valley between Mesa A and Mesa 2405A, it is estimated that on average, across the Robe Valley approximately 83% of the mesa escarpments are currently intact, either on mesas that have not been mined or as retained escarpments (Bat Call 2017a).

Snowden's (2007) review of natural and mined mesa escarpments concluded that mining activities have no discernible impact on the natural erosion rates of mesa escarpments and the probability of a catastrophic failure of the remnant mesa escarpments in the Robe Valley is extremely low. The existing operations at Mesas A and J and historical operations in the Robe Valley demonstrate that mesa escarpments are stable, and any risk of collapse can be adequately managed.

The retention of mesa escarpments ensures the most prominent and unique feature of each landform is retained. Given the Proposed Change will retain the prominent escarpments (where they exist), except for escarpment access cuts, the Proposed Change will not significantly alter the cumulative disturbance to the prominent mesa escarpments, in the Robe Valley and their associated integral values (including heritage and ecological).

11.1.7 Closure

The Mesa J Hub Closure Plan (Rio Tinto 2018a) is an integrated closure plan encompassing the existing Mesa J and Mesa K operations, together with the inclusion of the Proposed Change, in order to optimise closure outcomes. The Closure Plan is an update to, and supersedes previous closure plans for the existing Mesa J and K Operations. The Closure Plan includes the mine developments and associated infrastructure contained within the Development Envelope (Mesa J and H) and within Mesa K's Development Envelope.

A summary of the approach to closure for the Revised Proposal and how it relates to the landform factor is provided in Section 11.1.8.1.

11.1.8 Mitigation

Mitigation strategies to address the potential impacts and predicted outcomes are presented in Table 11-4.

The Mesa J Hub EMP (Appendix 6) addresses the key environmental factors which were determined by the EPA as being relevant to the appropriate management of dewatering, surface water discharge, conservation significant vegetation communities and fauna species associated with the Mesa J Hub. The EMP identifies:

- mitigation strategies proposed to minimise impacts to significant environmental values;
- the environmental criteria that the Proponent will use to monitor performance of the mitigation strategies to ensure environmental objectives are met;
- trigger criteria, threshold criteria, trigger level actions and threshold contingency actions aligned with the overall management approach; and
- the management actions that will be implemented in response to monitoring results.

No significant residual impacts are predicted to areas of high environmental value relating to landforms, therefore no offset is proposed for this factor.

11.1.8.1 Summary

Avoid

The Proposed Change has been designed with a MEZ around the perimeter of the mesa to preserve the most prominent landform feature; the mesa escarpments, effectively retaining the mesa façade (with the exception of minor access cuts to less prominent sections of the mesa where distinct escarpments are absent). The retention of the mesa escarpments (where they exist) will preserve the prominence and scale of the mesa landforms in the landscape.

The width of the MEZ proposed for retention will be significantly greater than 30 m (approximately 50 m or more) in width at the surface, which is greater than the predicted width to ensure that the retained escarpment is geotechnically stable and to ensure cave features within the escarpment (façade) are maintained. The MEZ has also been designed to avoid impacts to high value flora and terrestrial fauna habitat.

The access cuts have been specifically located to avoid areas assessed as having high ecological significance based on Astron (2017c) façade assessment, including avoidance on known ghost bat roosts and sites of high heritage significance.

Upon request from the Robe River Kuruma People during consultation, the project footprint has been modified and buffered to avoid direct impact to two very significant sites in proximity to the Proposed Change: 'Jirtiwi Thalu' and a gender restricted quarry site MJ04-09 in order to preserve the ethnographic and archaeological features and values. These sites have also been incorporated into the MEZ.

Mesa J has been in operation since the early 1990s and currently maintains an intact escarpment along its northern margin adjacent to the Robe River which supports visual amenity, heritage and ecological functions. The existing operations at Mesas A and J, K and historical remnant mining operations in the Robe Valley demonstrate that mesa escarpments are stable, and the structural integrity can be maintained by retaining an adequate width of escarpment.

Minimise

The proposed escarpment access cuts have been designed to avoid prominent escarpments, particularly near the Robe River. The proposed access cuts will result in disturbance to less than 2% of the escarpments of the mesa and are located in areas classified as 'moderate' priority (Astron 2017c) (refer Figure 11-7), to avoid areas of high ecological and heritage significance. The widths required for the haul road access cuts into the mesa escarpments have been minimised as far as possible to allow safe access. The cuts are also located in the interior central gully so will not be visible from identified key vantage points.

The escarpment cuts are located away from habitats in the proximity of the Robe River and are designed to avoid direct impact to Ghost Bats roosts, including two diurnal / potential maternal roost caves, and all recorded nocturnal roosts. The escarpment cuts required for haul roads are located >50 m from the nearest nocturnal roost and >500 m from the nearest diurnal / potential maternity roost to minimise construction impacts from development of the cuts and from noise, dust and vibration associated with the haul road. The mine design also incorporates a 40 m setback distance between the back of each diurnal / potential maternal roost cave and the proposed mine pit and >50 m from the entry to nocturnal roosts to minimise the impact of blasting and associated vibration on the structure and quality of roosts.

Due to the proximity of the Proposed Change to the Robe River on the western and eastern sides, there are limited options for siting ex-pits dumps that do not impact on the Robe River or sites of high heritage or ecological value; or impact the visual amenity of the landscape, which in itself would impact the perceived variety of the landforms. Hence part of the footprint of the proposed external dumps will be located across the less prominent sections of the mesa periphery, as shown in Figure 11-7, particularly where the mesa margin forms a rolling slope, and will therefore minimise or avoid impact to the distinctive features of the mesa landform.

Waste dumps will be the same height or lower than the surrounding mesas to limit visual impact when viewed from the Robe River, major public roads (Pannawonica Access Road), or highly significant heritage sites. Waste dumps will be designed in accordance with the internal standards described in the Iron Ore (WA) Landform Design Guidelines.

The proposed Blast Management Framework (including management of vibration and potential for flyrock) and retention of escarpments (where they exist) via a MEZ, with an adequate width >30 m to ensure geotechnical stability will minimise any potential impacts to the ecological and heritage value of the mesa escarpments.

The establishment of a MEZ will protect all rockshelter sites from direct disturbance, however, in consultation with the Robe River Kuruma People, a Section 18 consent under the AH Act for rockshelters will be submitted where there is any potential for indirect impacts due to vibration. This is a conservative, precautionary approach as the proposed MEZ has been designed to protect all rockshelter sites currently recorded, and the width of the MEZ is considered to be geotechnically stable.

The Proposed Change has been designed to retain significant volumes of troglofauna habitat within the mesa landform, consistent with approach for the existing operations at Mesa A. The proposed MEZ will enable intact troglofauna habitat to be retained, with retention of at least 50% of the pre-mining habitat volume.

Vegetation analogous to the P3 PEC '*Triodia sp. Robe River assemblages of mesas of the West Pilbara*' is also present in the mesa facades together with the Priority flora *Triodia sp. Robe River*. The retention of the escarpments will reduce direct impacts to this vegetation assemblage and these Priority flora.

Rehabilitate

Mineral waste generated by mining will be placed in a small number of external dumps as well as progressively backfilled into pit voids as they become available. The current closure strategy for the Revised Proposal is for all BWT pits to be backfilled to appropriate levels to prevent the formation of pit lakes[11] and AWT pits will be backfilled opportunistically with mineral waste.

Mineral waste dumps located on mine sites that are operated by Rio Tinto are designed and rehabilitated in accordance with internal Landform Design Guidelines, which sets out guidance on achieving dumps that are safe, stable, non-polluting, aesthetically compatible with the surrounding landscape, vegetated, and compatible with agreed post-mining land use. The site is expected to encounter some highly erodible materials which will be used for pit backfill or, where placed in external waste dumps, have been designed to incorporate a capping layer of competent material on the external surface, to enable Landform design criteria to be met. A competent waste stockpile area has been included in the mine plan, separate to the waste dumps in order to specifically set aside competent material to achieve this. Waste dumps in the project area are generally limited to 40 m height, to ensure long-term stability and to reduce visual impact.

The mesa landforms have landscape, visual, heritage and ecological value. The mesa escarpments (where they exist) will be retained as part of the MEZ and therefore need to be stable in the long-term, post-closure. Geotechnical assessment of escarpments in the Robe Valley concluded that an escarpment width of 30 m is adequate to maintain the long-term stability and integrity of the mesa escarpments (Rio Tinto 2017d). The Proposed Change has been designed such that retained escarpment widths will be approximately 50 m, which exceeds the minimum requirements of the geotechnical criteria.

All disturbed surfaces will be rehabilitated including pit floors to maximise the ecological value. The ex-pit waste dumps will be rehabilitated to be compatible with the surrounding landscape and will be revegetated.

The proposed final land use assumes that the site will be rehabilitated to create a safe, stable and non-polluting landscape revegetated with native species, to maximise environmental and cultural heritage outcomes and ensure the site does not adversely impact on the current surrounding land use. Due to the nature of the mining activity undertaken, the final landform will include large voids and waste dumps. It is recognized that surrounding areas are likely to remain subject to pastoral, cultural heritage and local tourist activities, as well as retaining important ecological functions, hence the Mesa J Hub closure final land use will be determined prior to closure during final planning phases and in consultation with key stakeholders.

[11] With the exception of Pit 15 at Mesa J, currently used as a water storage area, and subject to appropriate quality modelling

Table 11-4: Mitigation Measures and Predicted Outcomes for Landforms

Potential impacts	Management to address potential impacts	Predicted outcome
EPA Objective: To maintain the variety and integrity of distinctive landforms so that environmental values are protected.		
Direct: Loss of Variety The development of open cut pits at Mesa H has the potential to result in the loss or degradation of landform variety due to the physical removal of part of the landform.	The following key management measures will continue to be implemented to manage potential impacts to the variety of the landforms as a result of mining: **Avoid**: The Proposed Change has been designed with a MEZ around the perimeter of the mesa in order to ensure preservation of the most prominent feature; the mesa escarpments, effectively retaining the mesa façade (with the exception of minor access cuts to less prominent sections of the mesa where distinct escarpments are absent). **Minimise**: The access cuts for the haul roads have been designed to limit impact to the highest value habitat, areas of heritage significance and the most prominent sections of the escarpment. The widths required for the haul road access cuts into the mesa escarpments have been minimised as far as possible to allow safe access.	The Mesa H landform is not considered to have any particular physical attributes which are distinctive from other mesas occurring in the Robe Valley. The retention of the escarpments (or façades) will, to a large extent, preserve the prominence and scale of the mesas within the landscape, and therefore the Revised Proposal will retain variety of representation of Robe Pisolite mesas in the Robe Valley. The Proponent considers that the potential impacts can be managed, and the residual impact is not considered to be significant and therefore does not warrant the application of offsets.
Direct: Loss of integrity The development of pits, waste dumps and stockpiles will result in temporary and permanent changes to the local mesa landform integrity.	The following key management measures will continue to be implemented to manage potential impacts to the integrity of the landforms as a result of mining: Avoid: A MEZ has been designed to preserve the mesa escarpments, except for minor access cuts to less prominent sections of the mesa periphery. The width of the MEZ proposed for retention will be greater than 30 m (approximately 50 m) in width at the surface to ensure that the retained escarpment is geotechnically stable and to ensure cave features within the escarpment (façade) are maintained. **Minimise**: Backfilling of pits during operations is proposed, to limit the volume of waste being stored in external waste dumps. Where limited space results in the requirement for waste dumps to be placed on the margins of the Mesa across sections of the MEZ, these dumps have been located in areas which avoid the highest value ecological and social (heritage and visual amenity) features and away from the Robe River. Waste dumps will be designed in accordance with the internal standards described in the Iron Ore (WA) Landform Design Guidelines.	Although the Proposed Change will affect the integrity of Mesa H by removal of the interior of the landform, the highest value aspect of the landform, the escarpments, will be retained (excluding minor access cuts). The Proposed Change has been designed to minimise the size of the escarpment cuts such that the disturbance represents less than 2% of the perimeter of the mesa escarpment, thereby maintaining the integrity of the mesa escarpments. Two ex-pit waste dumps will be located on the periphery of the mesa landform in less well-defined escarpment areas, avoiding the highest value sections of the mesa landform. The existing operations at Mesas A and J, K and historical mining operations in the Robe Valley demonstrate that mesa escarpments are stable, and the structural integrity can be maintained by ensuring retention of an adequate width of escarpment. As the Proposed Change has been designed with escarpment widths that are greater than 30 m at the crest of the mesa landform, the integrity of the remaining landform is not expected to be compromised.

Potential impacts	Management to address potential impacts	Predicted outcome
	Rehabilitate: The Proponent proposes that mining be subject to a new MS (Appendix 3). The contemporary conditions of the new MS shall require the Proponent to implement a Closure Plan in accordance with the DMP / EPA *Guidelines for Preparing Mine Closure Plans.* The Closure Plan (Appendix 7) includes a Closure Objective to ensure that the final landform is stable and considers ecological and hydrological issues. **Other legislation:** DMP / EPA Guidelines for Preparing Mine Closure Plans.	The mesa escarpments which represent the most valuable feature of the mesa landform will remain largely intact, and the structural integrity of the landform will be maintained through retention of a geotechnically stable escarpment width. Mineral waste has been scheduled to be backfilled in-pit as far as practical. Where ex-pit waste dumps are required, their location has been designed to avoid the highest ecological and social values of the mesa landform, therefore it is considered that the Proposed Change will not significantly impact the integrity of the mesa landform. The Proponent considers that the potential impacts can be managed, and the residual impact is not considered to be significant and therefore does not warrant the application of offsets.
Indirect: <u>Loss or degradation of the ecological value</u> Mining has the potential to result in the loss or degradation of the ecological values of the mesa landform.	The following key management strategies will be implemented to manage impacts to the ecological value of the landforms: **Avoid**: The key ecological values identified associated with the mesa landforms occur primarily on the mesa escarpments. The Proposed Change has been designed to retain the mesa escarpments excluding minor access cuts. The locations and designs of the escarpment cuts were selected to avoid disturbance to the sections of the escarpments with the highest ecological value. The Proposed Change has been designed to avoid all of the recorded Ghost Bat roosts including diurnal/potential maternal roosts and nocturnal Ghost Bat roosts. **Minimise**: The CID within the mesa formations provides troglofauna habitat. The Proposed Change has been designed to retain at least 50% by volume of pre-mining troglofauna habitat. The proposed Blast Management Framework (including management of vibration and potential for flyrock) and retention of escarpments (where they exist) via a MEZ, with an adequate width >30 m to ensure geotechnical stability will minimise any potential impacts to the ecological value of the mesa escarpments, including the Ghost Bat roosts present on the mesa escarpment.	The mesa escarpments and subterranean habitat within the mesas are of ecological importance. The Proposed Change has been designed to retain the mesa escarpments (where they exist) excluding minor access cuts. The design and locations of the escarpment cuts have been selected to avoid disturbance to the escarpment sections with the highest ecological value. The Proposed Change will minimise the size of the escarpment cuts such that the proposed cuts represent disturbance to less than 2% of the perimeter of the mesa escarpment. Connected troglofauna habitat (except at the escarpment cuts) representing at least 50% of the mesa pre-mining habitat volume will be retained. Given the retention of mesa escarpments, avoidance of the escarpment sections with the highest ecological value, retention of at least 50% of the pre-mining troglofauna habitat volume on the mesa and implementation of blast management, it is considered that the Proposed Change is unlikely to significantly impact the ecological values of the mesa landforms. The Proponent considers that the potential impacts can be managed, and the residual impact is not considered to be significant and therefore does not warrant the application of offsets.

Potential impacts	Management to address potential impacts	Predicted outcome
	Rehabilitate: All disturbed surfaces will be rehabilitated including pit floors to maximise the ecological value.	
Indirect: Loss or degradation of the social value Mining has the potential to result in loss or degradation of the social values of the mesa landforms through loss of indigenous heritage and amenity values. The potential requirement to install abandonment bunds on some areas of the MEZ may also reduce the social value of the Landform.	The following key management strategies will be implemented to manage impacts to the social value of the landforms: **Avoid**: Retention of the mesa escarpments (where they exist) will avoid impact to significant heritage sites located in the escarpments as well as reduce impacts to visual amenity of the landscape. Direct disturbance to recorded rockshelters, Jirtiwi Thalu, and a gender restricted quarry site MJ04-09 will be avoided. **Minimise**: The location and layout of the mine and associated infrastructure has been designed to minimise impacts to Aboriginal heritage sites. The proposed Blast Management Framework (including management of vibration and retention of escarpments (where they exist) via a MEZ, with an adequate width >30 m to ensure geotechnical stability will minimise any potential impacts to the social value of the mesa escarpments, including the sites of heritage significance including caves, rockshelters present on the mesa escarpment and Jirtiwi Thalu located within the MEZ. Where impacts to heritage sites cannot be avoided, applications will be made under Section 18 of the AH Act in consultation with the Robe River Kuruma People. Escarpment cuts are located away from the Robe River, and will be largely hidden due to their location within the central (internal) gully, and south of the mesa landform. Waste dumps have been located away from prominent visual vantage points, including the Robe River, and will remain at heights which are the same level or lower than the surrounding mesas to limit visual impact.	Given the proposed retention of the mesa escarpments, avoidance of direct disturbance to all recorded rockshelter sites, the inclusion of Jirtiwi Thalu and the gender restricted quarry MJ04-09 in the MEZ, the management of sites under the AH Act that may be disturbed, the proposed blast management framework and the proposed management of mineral waste, it is considered that the Proposed Change is unlikely to significantly impact the social heritage and amenity values associated with the mesa landforms. The Proponent considers that the potential impacts can be managed, and the residual impact is not considered to be significant and therefore does not warrant the application of offsets.

Potential impacts	Management to address potential impacts	Predicted outcome
	Rehabilitate: Visual impacts will be further minimised through construction of the waste dumps to be aesthetically compatible with the surrounding landscape and through rehabilitation of the waste dumps. It is proposed to use the natural escarpments as abandonment bunds to prevent inadvertent access rather than additional disturbance on the retained escarpments (MEZ).	

11.1.9 Predicted outcomes

The key Landforms values identified in the Proposed Change Area that are considered relevant to the Proposed Change are:

- Landform variety;
- Landform integrity;
- Ecological importance; and
- Social importance:
  - Heritage values; and
  - Amenity values.

After the mitigation hierarchy has been applied (Table 11-4), the Revised Proposal (together with the existing Mesa J Iron Ore Development and other foreseeable proposals) would result in the following outcomes in relation to Landforms:

- At least 14 named mesas and numerous un-named minor mesas representative of Robe Pisolite mesas will remain intact in the Robe Valley.
- The mesa escarpments (or facades) of Mesa H will remain largely intact through the MEZ.
- Mesa H landform will remain visible in the landscape.
- The highest ecological, social and heritage values will be maintained through the establishment of the MEZ.
- The structural integrity of the escarpments associated with Mesa H will be maintained.
- The significant heritage sites of Jirtiwi Thalu and a gender restricted quarry MJ04-09 will be protected.
- All 74 recorded rockshelters associated with Mesa H will be protected.
- More than 50% by volume of troglofaunal habitat within Mesa H will be retained.
- The integrity of the mesa escarpments will be maintained by limiting escarpment cuts to less than 2% of the perimeter of the Mesa H escarpment.
- Ex-pit waste dumps will remain in line with or lower than the surrounding mesas.

The Mesa H landform is not considered to have any particular physical attributes which are distinctive from the many remaining intact mesas in the Robe Valley. The retention of the escarpments (or façades) of Mesa H will, to a large extent, preserve the prominence and scale of the mesas within the landscape, and the ecological, social and heritage values it supports. Therefore, the Proposed Change will not significantly impact the variety and integrity of Robe Pisolite mesas in the Robe Valley.

The Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Landforms because the Proponent would:

- maintain the Mesa H escarpment through the MEZ; and
- implement the updated Mesa J Hub EMP, Mesa J Cultural Heritage Management Plan and the Mesa J Hub Closure Plan.

The Proponent's view is that there would be no significant residual impacts from the Proposed Change on Landforms.

12. MATTERS OF NATIONAL AND ENVIRONMENTAL SIGNIFICANCE

12.1 Controlled Action Provisions

The Proposed Change was referred to the Minister for Environment and Energy in August 2017 to determine whether approval is required under the EPBC Act in relation to potential impacts to six species listed as threatened under the EPBC Act. On 14 October 2017, the Minister determined that the Proposed Change is a Controlled Action (EPBC 2017/8017) under Section 75 of the EPBC Act and thus requires assessment and a decision about whether approval should be granted under the EPBC Act. The controlling provision is 'Listed threatened species and communities' (Section 18 and 18A of the EPBC Act). These species are identified in Table 12-1 below.

Table 12-1: Matters of National Environmental Significance Likely to be Impacted by the Proposed Change

Common name	Species name	Conservation status
Mammals		
Northern Quoll	*Dasyurus hallucatus*	Endangered
Ghost Bat	*Macroderma gigas*	Vulnerable
Pilbara Leaf-nosed Bat	*Rhinonicteris aurantia*	Vulnerable
Reptiles		
Pilbara Olive Python	*Liasis olivaceus barroni*	Vulnerable
Fish		
Blind Cave Eel	*Ophisternon candidum*	Vulnerable

12.2 Policy and Guidance

The relevant policy and guidance for MNES includes:

- Significant Impact Guidelines: 1.1 – Matters of National Environmental Significance (DoE 2013);
- National Recovery Plan for the Northern Quoll *Dasyurus hallucatus* (Hill and Ward 2010);
- EPBC Act referral guidelines for the endangered Northern Quoll *Dasyurus hallucatus* (DoE 2016);
- Conservation Advice *Macroderma gigas* (Ghost Bat) (TSSC 2016a);
- Conservation Advice *Rhinonicteris aurantia* (Pilbara form) (Pilbara Leaf-nosed Bat) (TSSC 2016b);
- Approved Conservation Advice for *Liasis olivaceus barroni* (Olive Python - Pilbara subspecies) (DEWHA 2008b);
- Approved Conservation Advice for *Rostratula australis* (Australian Painted Snipe) (DSEWPaC 2013);
- Approved Conservation Advice for *Ophisternon candidum* (Blind Cave Eel) (DEWHA 2008a);
- Threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads (DSEWPaC 2011c);
- Commonwealth Listing Advice on ten species of Bats (TSSC 2001);
- Threat abatement plan for predation by the European red fox (DEWHA 2008); and
- Threat abatement plan for predation by feral cats (Department of the Environment [DoE] 2015).

12.2.1 Environmental Scoping Document

This section addresses ESD Required Work items 29, 31, 33, 34 and 35 specifically in relation to MNES.

12.3 Existing Environmental Values

12.3.1 MNES that may be impacted by the Proposed Change

The five MNES identified in Table 12-1 have been recorded within and outside of the Proposed Change Area. The Blind Cave Eel has also been recorded outside of the Proposed Change Area, within the modelled extent of groundwater drawdown for the Revised Proposal, in Jimmawurrada Creek.

The Australian Painted Snipe is also a MNES (Endangered) and although not recorded in the Proposed Change Area, is considered moderately likely to occur. Information about this species, it's distribution and potential impacts from the Proposed Change is provided in Sections 8.4.5.10 and 8.6.10. Given the species' wide distribution and availability of habitat outside of the Development Envelope, the proposed disturbance is considered unlikely to impact any itinerant visitors to the area or the conservation status of the species. Therefore, the Australian Painted Snipe is not considered further in this assessment.

A summary of surveys conducted to date and a detailed description of survey findings for each of the MNES species recorded in the Proposed Change Area is provided in Section 8.4. A summary of findings is provided below.

Habitats suitable for MNES species are discussed in Section 12.3.2 and shown in Figure 12-1 and MNES records within the Development Envelope are shown in Figure 12-2.

12.3.2 Habitat suitability for MNES

Seven habitat types were recorded in the Proposed Change Area (Astron 2017e) including:

- Riverine;
- Drainage Line;
- Gorge;
- Breakaway;
- Rocky Hills;
- Low Hills and Slopes; and
- Loamy / Stony Plains.

These are described in Section 8.4.2.1 and depicted in Figure 8-3.

The above habitat types have been grouped into five broad habitat types according to landforms and their importance to, and use by, the MNES species present in the Proposed Change Area as described below.

Utilising the available habitat mapping (for the Proposed Change and Mesa A Hub Revised Proposal), landforms and aerial photography, these habitat types were extrapolated and mapped for the remainder of the Robe Valley; encompassing a total area of 81,637 ha. These amalgamated habitat types are described below and shown in Figure 12-1 and have been used to support a cumulative assessment of impacts in the Robe Valley:

- **Breakaways and Gullies** – incorporates Breakaway and Gorge habitats;
- **River** – incorporates Riverine and Drainage Line habitats;
- **Mesa Plateau** - Low Hills and Slopes;
- **Hills** – incorporates Rocky Hills; and
- **Plains** – Loamy / Stony Plains.

12.3.2.1 Breakaways and gullies

The rocky terrain of the Breakaways and Gullies habitat provides a diverse variety of micro-niches and sheltering opportunities in close proximity to the robe River, in an otherwise flat landscape. In relation to MNES, the Breakaways and Gullies habitat provides:

- Denning, shelter and foraging habitat for the Northern Quoll;
- temporary potential nocturnal roosting habitat and foraging habitat for the Pilbara Leaf-nosed Bat;
- diurnal, potential maternity and nocturnal roosting and foraging habitat for the Ghost Bat; and
- breeding, shelter and foraging habitat for the Pilbara Olive Python, particularly the area in close proximity to the semi-permanent and ephemeral pools in the Robe River.

The mesa escarpments are part of the Breakaways and Gullies habitat. In their assessment of the Mesa H escarpments, Astron (2017c) divided the escarpments into 48 sections of approximately 500 m in length (446.8 ha) and assessed the ecological value of each section on a scale ranging from Low to High, in terms of their priority for retention. The escarpment sections were rated based on their habitat value for, and known occurrences of, flora and vegetation, vertebrate fauna and invertebrate fauna. The desktop assessment utilised the field data and literature already gathered and compiled during Level 2 flora, vegetation and fauna surveys completed by Astron and aligns with the EPA's guideline for landforms.

Ten of the 48 assessment sites were rated as high priority for retention (21%), 25 were rated as moderate priority (52%) and 13 were rated as low priority (27%) (Astron 2017e). The ten sites rated as high were found along the western façade near the Robe River and a small section along the northern façade that passes close to the Robe River. The western façade along the Robe River is characterised by structurally diverse habitats with high moisture retention, providing refuge and shelter sites for MNES species such as the Ghost Bat, Northern Quoll and Pilbara Olive Python.

12.3.2.2 River

River habitat is considered to be of high importance to fauna, particularly the portion mapped as Riverine by Astron (2017e) providing a range of ecological values to a wide suite of species. This habitat type provides a range of micro-niches for fauna species to exploit, such as for shelter and foraging. A number of semi-permanent and permanent pools occur in the survey area (Astron 2016a) and provide drinking opportunities for a range of species along with attracting prey for predators. In relation to MNES, the River habitat provides:

- foraging and dispersal habitat for the Northern Quoll;
- foraging and dispersal habitat for the Pilbara Leaf-nosed Bat and Ghost Bat;
- shelter, foraging and dispersal habitat for the Pilbara Olive Python; and
- foraging and dispersal habitat in the riverine alluvials for the Blind Cave Eel.

12.3.2.3 Mesa Plateau

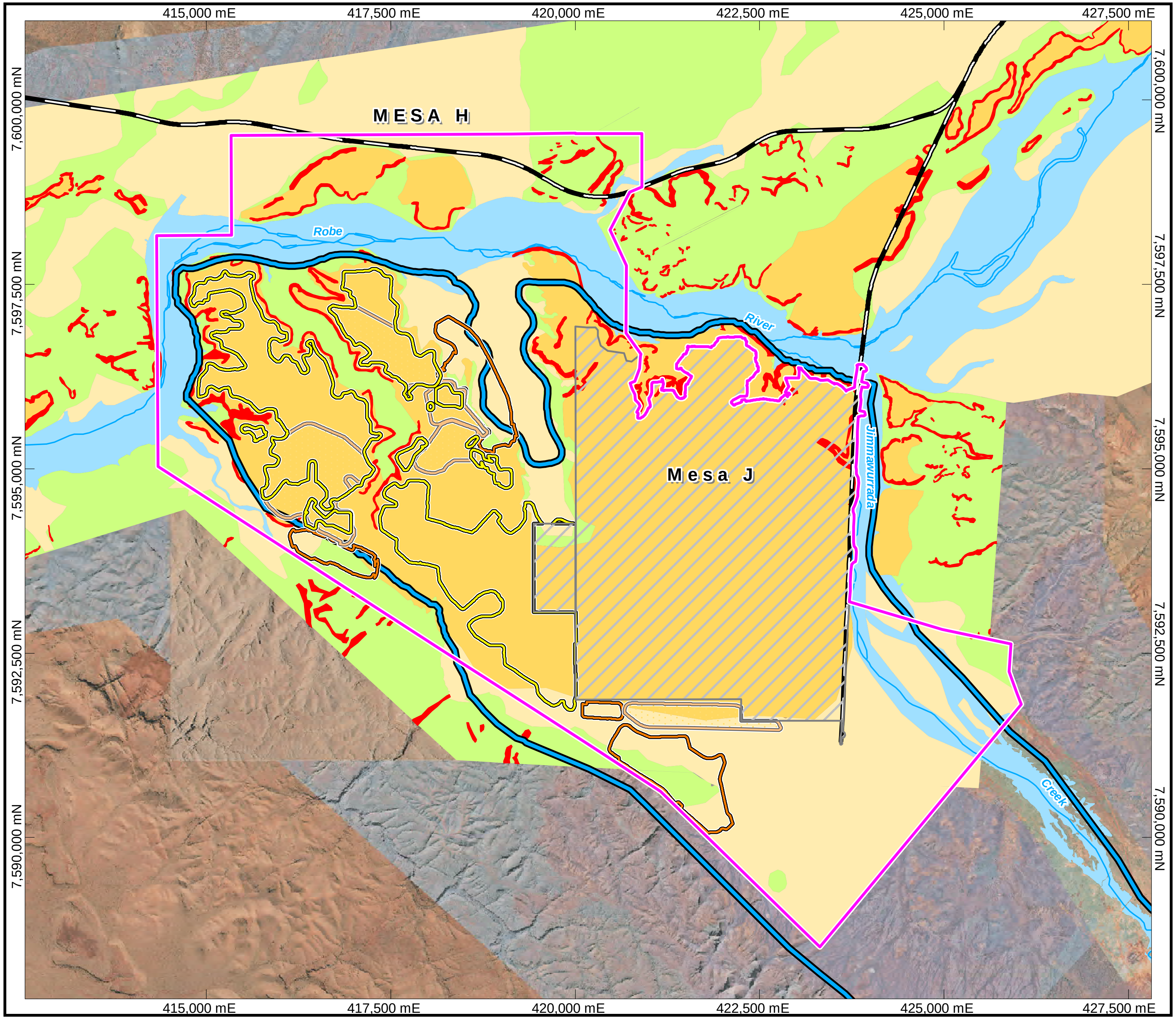
The elevated flat top hills of the Mesa Plateau habitat generally have low vegetation complexity which results in low diversity of microhabitats, such as leaf litter for refuge and shelter. In relation to MNES, the Mesa Plateau habitat provides some foraging and dispersal habitat, for the Northern Quoll, Pilbara Leaf-nosed Bat and Ghost Bat.

12.3.2.4 Hills

The Hills habitat type is widespread and common throughout the Pilbara region. This habitat generally has low vegetation complexity and therefore low diversity of microhabitats. In relation to MNES, the Hills habitat provides some foraging and dispersal habitat for the Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and Pilbara Olive Python but is considered to be of limited value to MNES (Astron 2017e).

12.3.2.5 Plains

The Plains habitat type is widespread and common throughout the Pilbara region. In relation to MNES, the Plains habitat provides limited foraging and dispersal habitat for the Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and the Pilbara Olive Python as it does not provide significant refugia or shelter (Astron 2017e).



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse
- Groundwater Drawdown Extent

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile

MNES Habitat

- Breakaways and gullies
- Hills
- Mesa Plateau
- Plain
- River

N

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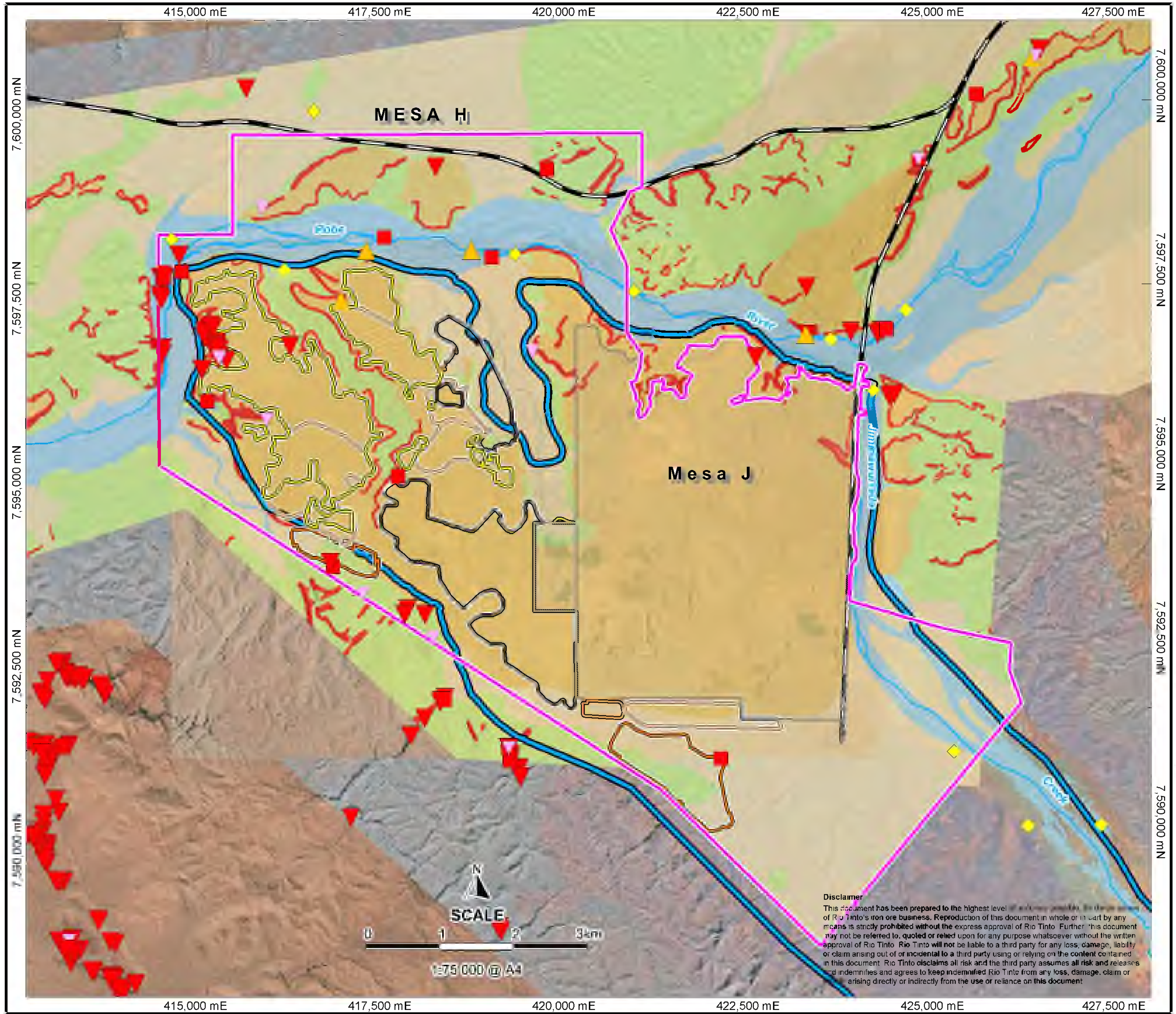
Iron Ore (WA)

Figure 12-1: MNES habitat in the Study Area

Drawn: M.Swebbs
Date: Jan, 2019

Plan No:PDE0159441v5
Proj:MGA94 Zone50

Geospatial Information and Mapping



LEGEND

Development Envelope

Ministerial Statement 208

Railway

Major Watercourse

Groundwater Drawdown Extent

Conceptual Mine Layout

Mine Pit

Waste Dump

Topsoil / Subsoil Stockpile

MNES Habitat

Breakaways and gullies

Hills

Mesa Plateau

Plain

River

Conservation Listed Fauna

Ghost Bat *(Macroderma gigas S3)*

Northern Quoll *(Dasyurus hallucatus S2)*

Pilbara leaf-nosed bat *(Rhinonicteris aurantia S3)*

Pilbara Olive Python *(Liasis olivaceus subsp. barroni S3)*

Blind Cave Eel

Rio Tinto

Iron Ore (WA)

Figure 12-2: MNES records (including historical records) within the Development Envelope

Drawn: M.Swebbs
Date: Feb, 2019

Plan No:PDE0165463v2
Proj:MGA94 Zone50

Geospatial Information and Mapping

12.3.3 Northern Quoll (*Dasyurus hallucatus*)

The Northern Quoll was originally found across northern Australia from the North-West Cape of WA to south-east Queensland; however, its abundance has significantly declined in recent years. The primary cause of the recent decline in this species across northern Australia has been death from predation attempts on the toxic introduced Cane Toad (*Rhinella marina*), resulting in the collapse of some Northern Quoll populations in Queensland and the Northern Territory (Tingley et al. 2013 cited in DBCA 2018). Cane toads have not yet reached the Pilbara, but are projected to naturally colonise the Pilbara mainland (and potentially its offshore islands) between 2026–2064 (Kearney et al. 2008 and Tingley et al. 2013 cited in DBCA 2018).

The Northern Quoll is now restricted to five regional populations across Queensland, the Northern Territory and the Kimberley and Pilbara in Western Australia on both the mainland and offshore islands (DotEE 2017a). The Pilbara population of Northern Quoll is separated from the Kimberley population by approximately 500 km of arid Great Sandy Desert and is genetically distinct (DBCA 2018). Both the mainland Pilbara and Kimberley populations of Northern Quolls retain high levels of genetic diversity and show no evidence of recent or long-term population bottleneck. This indicates that despite habitat fragmentation and population decline, the Pilbara population has not yet suffered a loss in genetic diversity (DBCA 2018).

Primary areas of Northern Quoll occupation in the Pilbara include the western edge of the Hamersley Ranges, in the granite outcrops of the Abydos Plain, and in the more rugged areas of the Chichester Ranges (Molloy et al. 2017). Molloy et al. (2017) also identified a high potential for Northern Quoll to occur within the eastern Pilbara where very few records currently exist due to low survey effort.

Northern Quoll are strongly associated with rocky habitats which are used for shelter and denning purposes with surrounding vegetated habitats used for foraging and dispersal (DotEE 2017a). Recent studies have confirmed that Pilbara Northern Quolls are broadly carnivorous but are largely opportunistic in their diet and were recorded to consume vertebrates (mammals, birds, reptiles, frogs), as well as arthropods, molluscs, fruit, and carrion (DBCA 2018).

Rocky habitats adjoining drainage lines have a heightened level of importance given the close proximity of denning habitat to foraging and dispersal areas, therefore Rocky habitats and River habitats and the connection between them is considered important for the species. A large area of habitat for this species is protected within the Millstream-Chichester National Park and the Karijini National Park located approximately 110 km north-east and 215 km south-east of the Development Envelope respectively.

There are 4,153 records of Northern Quoll from the Pilbara (DBCA 2018). The majority of these are recent records; only 315 records date back further than 2009. Northern Quoll are common in the Robe Valley, with 906 records known from this region outside the Development Envelope (Figure 12-3). Northern Quoll has also been recorded in historical mining areas in this region, particularly where mesa escarpments are largely intact. Astron (2016e) recorded the Northern Quoll numerous times during a survey in the East Deepdale and Middle Robe region approximately 60 km east of the Development Envelope. The majority of these records were from the Breakaway habitat type (45 records), with some records from the Riverine (13), Stony Hills and Slopes (two) and Mesa (seven) fauna habitats. The results indicate the species' reliance upon rocky terrain habitat for shelter and denning. Similarity measures of species assemblages amongst sites showed the Breakaway fauna habitat type to be statistically different and unique to other fauna habitat types for mammal species including the Northern Quoll. This is likely due to the number of micro-niches that provide shelter and denning opportunities in this habitat type. The Breakaway habitat was, therefore, considered highly suitable for the Northern Quoll while the Mesa, Riverine and Drainage habitats that act as ecological linkage corridors and may provide refuge and foraging opportunities were considered to be areas of moderate suitability (Astron 2016e). Overall the results of the survey indicate Northern Quoll are utilising intact escarpments around previously impacted sites and that a resident Northern Quoll population is present in the East Deepdale/Middle Robe region within the Breakaway habitat type (Astron 2016e).

The Northern Quoll population recorded in the Proposed Change Area is classifiable as a ‘population important for the long-term survival’ of the species as defined by DoE (2016) as it is characterised by numerous camera triggers of multiple individuals across multiple cameras and or traps on the site (DoE 2016) occurring in refuge-rich habitat. The species was recorded 32 times in the Proposed Change Area by Astron in 2016, including six captures (four confirmed separate individuals), 24 remote camera location recordings and four scats, tracks and/or trace records (Astron 2017e). The majority of records were found in Breakaways and Gullies and River habitat types which are equivalent to the Breakaway habitat and Riverine and Gorge habitats defined in Section 12.3.2. Each of these MNES habitats are considered the most important habitat types for this species.

Rio Tinto have a total of 50 records of Northern Quoll from all surveys undertaken within the Development Envelope (Figure 12-4):

- 23 records from Breakaways and Gullies habitat;
- 16 records from the Mesa Plateau or Hills habitat (approximately half of these records were within 10 m of the Breakaways and Gullies habitats); and
- 11 from River habitat.

A total of 82% of the records of Northern Quoll from within the Development Envelope were from Breakaways and Gullies, in Hills and Mesa Plateau habitat within 10 m of Breakaways and Gullies and River habitat. Of the 71 sampling sites located within Breakaways and Gullies habitat type (including those sites in Hills and Mesa Plateau habitat within 10 m of Breakaways and Gullies), Northern Quoll was recorded at 42% of the sites. Similarly, of the 26 sites within River habitat, 42% of sites also recorded Northern Quoll. Lower percentages were observed in the other habitats; 19% positive records and 11% positive records in Hills and Mesa Plateau habitat (beyond the 10 m zone close to the Breakaways and Gullies).

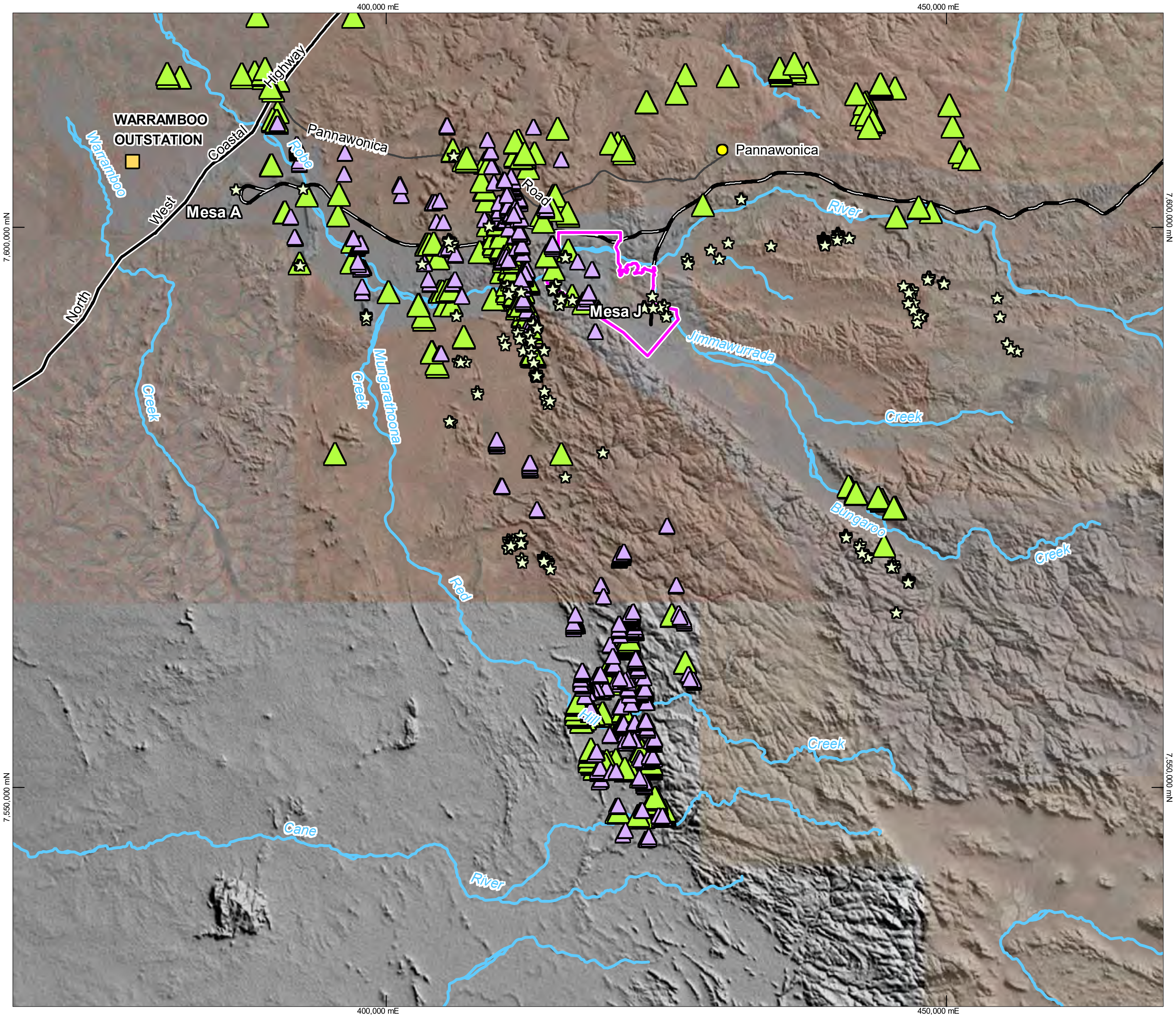
The Northern Quoll records and percentages of positive records indicate that, consistent with the regional information described above, the local occurrence of Northern Quolls in the Development Envelope is strongly associated with rocky habitat.

All habitat that provides shelter for breeding, refuge from fire / or predation and potential poisoning from the Cane Toad, (*Rhinella marina*) is considered to be ‘habitat critical to the survival’ of the species and usually occurs in the form of (DoE 2016):

- Rocky habitats such as ranges, escarpments, mesas, , gorges, breakaways, boulder fields, major drainage lines or treed creek lines
- Structurally diverse woodland or forest areas containing large diameter trees, termite mounds or hollow logs
- Offshore islands where the Northern Quoll is known to exist.

Habitat defined as critical to the survival of the Northern Quoll (DoE 2016) includes all habitat within the modelled distribution of the species which provides shelter/breeding and/or dispersal and foraging habitat associated with or connecting populations important for the long-term survival of the species. This definition is highly inclusive and could be considered to include all foraging/dispersal habitat in the vicinity of multiple records of Northern Quoll. The local population of Northern Quoll has a strong association with the Breakaways and Gullies habitat and portions of the River habitat. Based on the evidence from the Robe Valley data (Astron 2016e) and locations of records in the Development Envelope, the core habitat locally is considered to comprise the Breakaways and Gullies habitat (including areas within 10 m of this habitat) and portions of the River habitat (specifically the Riverine portion as defined as a terrestrial fauna habitat type in Section 8.4.3). This is consistent with the conclusion of Astron (2017e) that the Breakaways and

Gullies habitat in particular contains rocky environments of high relief that are particularly important for Northern Quolls in the Pilbara as they provide denning sites for breeding and shelter and diverse microhabitats for foraging. Other foraging and dispersal habitat within the Development Envelope is considered widespread and low value and not considered critical to the survival of the species. Estimates of the home range of Northern Quoll vary and are likely to be affected by factors such as habitat and seasonality. Home ranges are expected to be smaller in well connected rocky habitats (such as the area near Mesas H and J) than in areas where rocky habitats are isolated in the landscape and home ranges of males are expected to be greater in the breeding season than in the non-breeding period. A 2015 study in an area 143 km north-west of Newman in the Pilbara, estimated Northern Quoll home ranges to be 58 ha for males and 13.4 ha for females (Henderson 2015). DotEE's Species Profile and Threats Database profile for Northern Quoll describes the estimated home range of the species as greater than 100 ha for males and 35 ha for females based on a radio tracking and live trapping study undertaken in lowland savannah of Kakadu National Park (Oakwood 2002). Threats to the Northern Quoll include ingestion of the Cane Toad and its lethal toxin, removal, degradation and fragmentation of habitat (including impacts from pastoral activities), inappropriate fire regimes, predation following fire, weeds and feral predators (DoE 2016; DotEE 2017a).



LEGEND

- Development Envelope
- Rio Tinto Northern Quoll records
- TSOP Northern Quoll record
- DBCA Northern Quoll records
- Rio Tinto Railway
- Highway
- Major road
- Major Watercourse

Data sourced from: Department of Biodiversity, Conservation and Attractions (2018) Threatened and Priority Fauna. Database Search for Rio Tinto tenements accessed on the 6/11/18. Prepared by the Species and Communities Program for Rio Tinto for the purposeof understanding fauna habitat utilisation and facilitating management outcomes.

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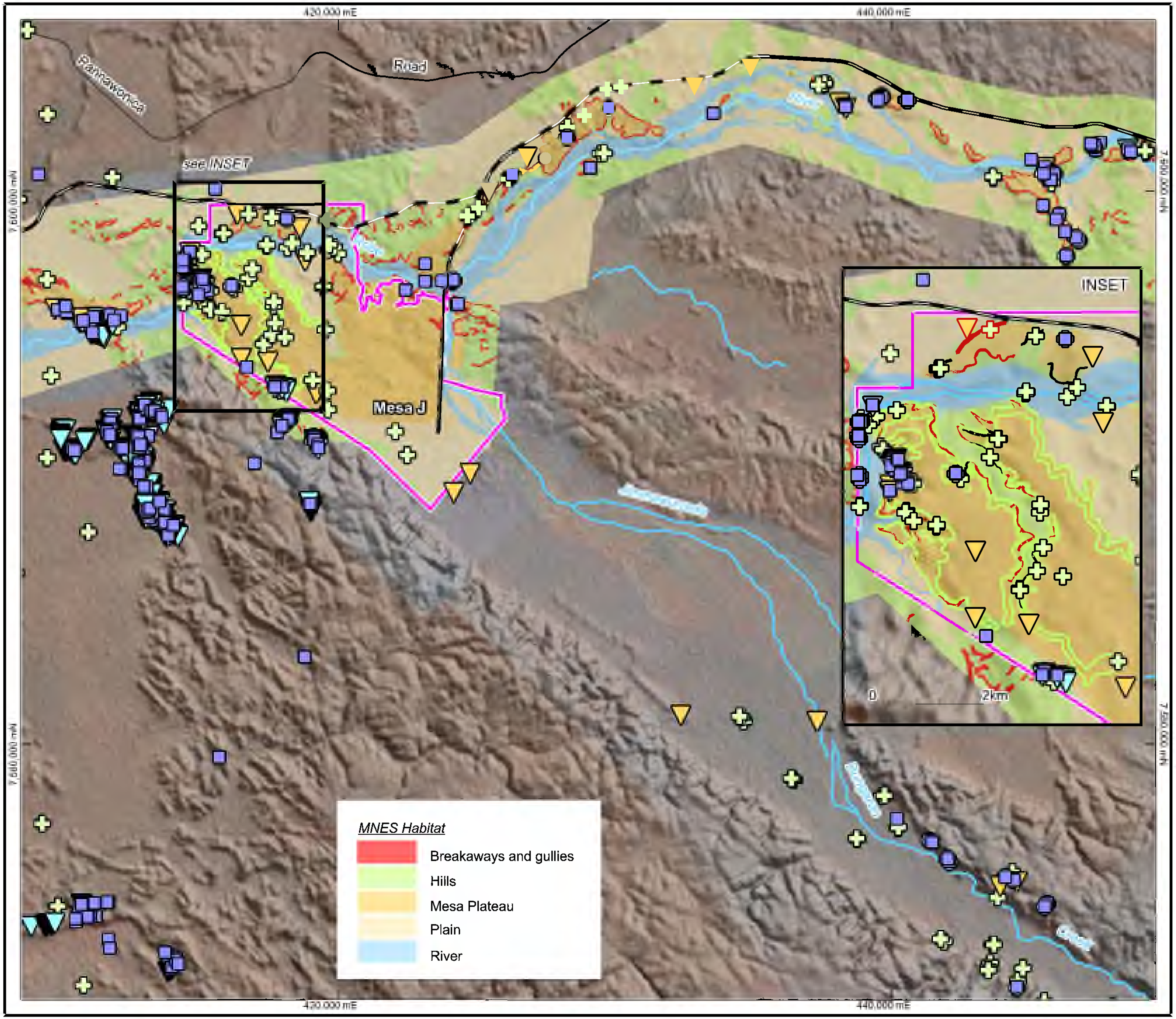
Iron Ore (WA)

Figure 12-3: Northern Quoll records in the Robe Valley

Drawn: T.M.
Date: Jauary, 2019

Plan No: PDE0165069v1
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Mining Exclusion Zone
- Northern Quoll record

Northern Quoll Sampling

- Cage trap
- Elliott trap
- Northern Quoll trapping site
- Motion Camera
- Rio Tinto Railway
- Major Watercourse
- Major Road

Data sourced from: Department of Biodiversity, Conservation and Attractions (2018) Threatened and Priority Fauna. Database Search for Rio Tinto tenements accessed on the 6/11/18. Prepared by the Species and Communities Program for Rio Tinto for the purposeof understanding fauna habitat utilisation and facilitating management outcomes.

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RioTinto

Iron Ore (WA)

Figure 12-4: Northern Quoll sampling locations and records in or near the Development Envelope

Drawn: T.M.
Date:Feb, 2019

Plan No: PDE0165068v3
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping

12.3.4 Ghost Bat (*Macroderma gigas*)

The Ghost Bat roosts during the day in caves, rock crevices and disused mines. Roost sites used permanently are generally deep natural caves or disused mines with a relatively stable temperature of 23-28° C and humidity above 50%. Individuals require a range of cave sites and move between roosts seasonally or according to weather conditions. Populations are widely dispersed when not breeding and concentrate in relatively few roost sites when breeding. Caves with multiple entrances appear to be required for breeding sites (TSSC 2016a).

The Ghost Bat utilises three types of roost regularly:

- Nocturnal roosts (or feeding sites) are used only at night, either habitually or for transitory visits. They are typically shallow, poorly insulated caves and shelters that are well lit during the day (Bat Call 2017b). The Ghost Bat hunts at night and uses nocturnal caves to consume prey it has captured in the surrounding area.
- Diurnal roosts (or day roosts) are caves and mine adits that are deeper and more complex than nocturnal roosts. They typically have one or more large chambers at or beyond the twilight area with additional fissures or chambers at the rear in the fully dark regions. They have a minimum roof height in the chambers of 2 – 3 m providing protection from attack by terrestrial predators. They are often at mid-levels or lower in the strata making them well insulated. The stable temperature and elevated humidity of these caves relative to the ambient conditions create physiologically benign conditions (McKenzie and Bullen 2009).
- Maternity roosts are diurnal roosts that usually include an interior chamber that rises toward the rear trapping warmer, more humid air at the top.

Ghost Bats forage over a wide range of habitats typically up to 2 km from their diurnal roost site and individuals generally return to the same foraging areas each night. Foraging Ghost Bats use echolocation during flight to detect prey and use passive sit-and-wait hunting techniques using eyesight to scan for prey from roosts up to 3 m above the ground, such as rocky overhangs and tree branches (TSSC 2016a).

To persist in an area, the Ghost Bat requires a group of caves / shelters that provide diurnal and nocturnal sites and a gully or gorge system that opens onto a plain or riparian line that provides good foraging opportunities. The persistence of the species in the Pilbara is believed to depend on the availability of diurnal roosts that have stable temperature and humidity (TSSC 2016a).

Studies undertaken by Biologic (2016) indicate that groups of Ghost Bats move about within a local area and that multiple groups may use a cave. Biologic (2016) note that there generally isn't a continuous presence of Ghost Bats in any one cave and that it is rare to encounter a maternity group despite visiting the most suitable recorded caves in an area across a number of breeding seasons. Field observations in the vicinity of the proposed Mining Area C Development, approximately 100 km north-west of Newman in the Pilbara region, suggest that maternity groups may use different maternity roosts across different seasons (Biologic 2016). In particular, a maternity group was recorded in 2015 in a small cave that had previously shown little evidence of Ghost Bat occupancy. Hormone analysis showed scats from numerous caves across the area contained progesterone levels consistent with pregnancy thus indicating that the concept of a centralised maternity roost may not be applicable in the Pilbara region. Further information on Ghost Bat activity in the Pilbara and their use of caves in historical mining areas in the Robe Valley is provided in Section 8.6.3.3.

Ghost Bat individuals generally return to the same foraging areas each night. The Ghost Bat can have a relatively small nightly foraging range (up to 2 km from the roost) (Tidemann *et al.* 1985; Pettigrew *et al*. 1986) but has the flight capability to range widely (Bullen and McKenzie 2002), perhaps tens of kilometres in a night. This is evident from genetic markers, which suggest that males are particularly likely to disperse long distances throughout the landscape (Worthington Wilmer *et al*. 1994).

Ghost Bats hunt their prey in two primary ways (Bat Call 2017b). They hunt birds and bats "air-to-air" at cave entrances and elsewhere by swooping from above or from a perch. They also hunt ground level prey in their target food size range by dropping onto the prey from a perch, either tree branch or rock outcrop. Their diet includes small mammals including other bats, birds, reptiles, frogs and large insects. The proportion of food items in the diet varies with availability and reported foraging areas vary from a few to 10 km from the roost cave (Bat Call 2017b). One Ghost Bat carcass was found recently entangled in a barbed wire fence in the Fortescue Marsh over 12 km from the nearest cave forming rocky strata suitable for roosting (Stephen Van Leeuwen pers. comm.). The approved conservation advice for the Ghost Bat (TSSC 2016a) identifies the key threat to the species as the destruction of, or disturbance to known roosts and nearby areas. There are currently no defined criteria for habitat critical for the survival of the species, or identified important populations; however, the population in the Pilbara is genetically distinct from other geographically isolated populations, and contains up to 29% of the current estimated number of Ghost Bat individuals. Current population trends indicate that the WA population is likely to decline by over 30% in the future, with local extinctions predicted in the central and eastern Hamersley Range (TSSC 2016a). The approved conservation advice (TSSC 2016a) for the Ghost Bat identifies the primary conservation actions as:

- protection of roost sites from mining, human disturbance and collapse; and
- replace the top strands of barbed wire in fences near roost sites with single-strand wire.

The Ghost Bat has a patchy distribution in the Pilbara with a regional Pilbara population estimated at 1,500 to 2,000 individuals (Bat Call 2017b). The Ghost Bat is common and widespread in small numbers within the Robe Valley; 104 records are known from this region, across various mesas (Figure 12-5). The number of Ghost Bat records from the desktop assessment and field survey suggest that the Ghost Bat is common and widespread in small numbers within the vicinity of Mesa H as well as the Robe Valley more broadly. The contextual survey undertaken by Astron (2017d) estimated that there are approximately 350 individuals that occur in the Hamersley sub region, although relatively few breeding records exist. Observations to date in the Robe Valley indicate that the Robe Valley Ghost Bats are moving through the landscape opportunistically and possibly seasonally and are taking advantage of all of the foraging and roosting opportunities provided by the valley of the river, its tributaries and the various caves available (B. Bullen,Bat Call WA, pers. Comm. 2019).

The most significant habitats in the Proposed Change Area for the species are the Breakaways and Gullies habitat, including the mesa escarpments, and the River habitat (Figure 12-6). These areas provide potential roost and foraging habitat.

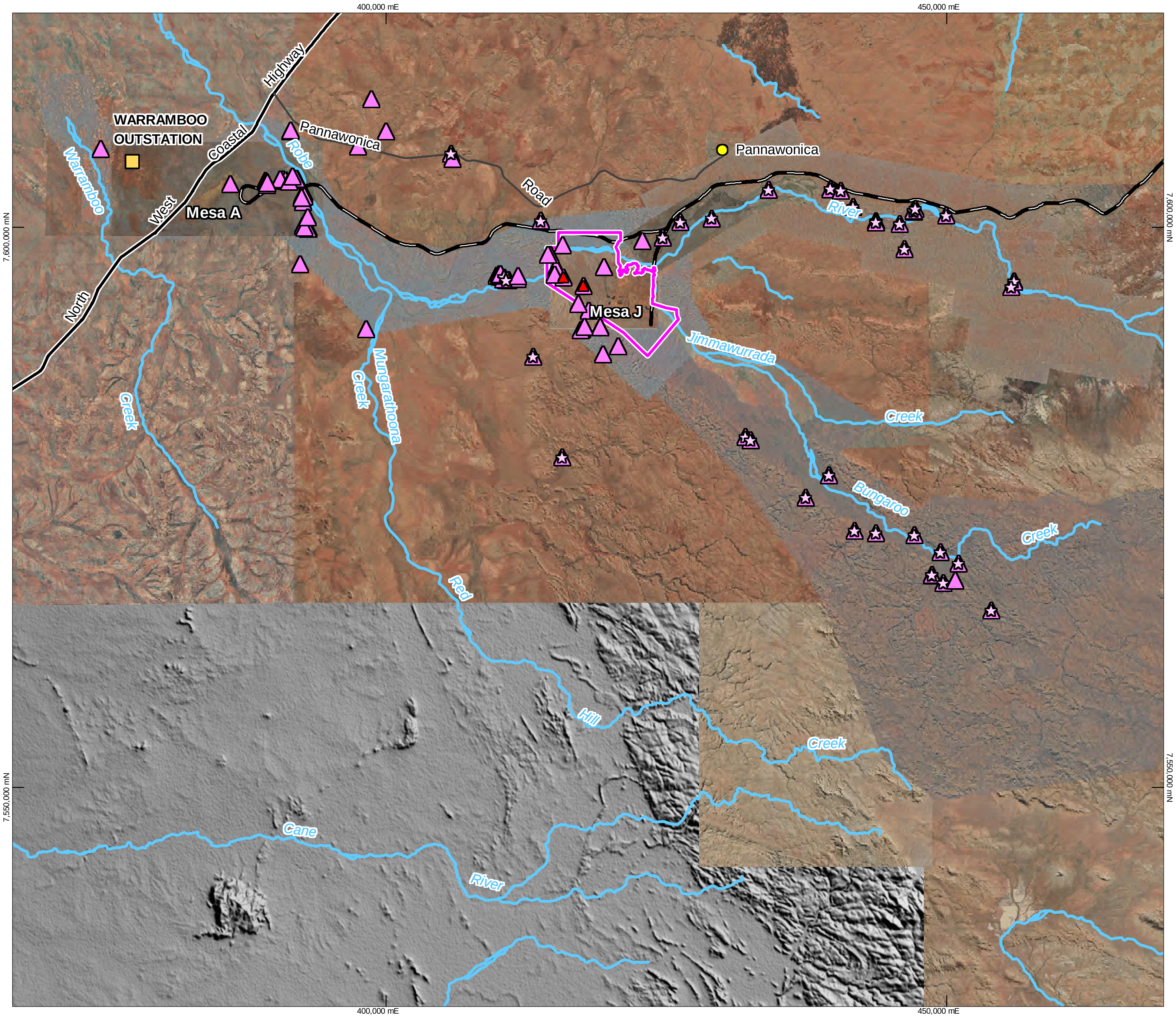
A total of 13 records, 2 diurnal roosts / possible maternal roosts and, nine nocturnal feeding roosts have been identified in the Proposed Change Area (Figure 12-6). Twelve of the records were from the Astron (2014) survey, comprising four acoustic recordings and eight scat/visual sighting/remains locations. The additional one record was from the most recent survey (Astron 2017e) comprising scats. Four acoustic recordings of the Ghost Bat were also detected during the Astron (2017e) survey at one location outside of the Proposed Change Area approximately 900 m to the south-west (Figure 12-6).

The 13 records of Ghost Bat from within the Proposed Change Area are also the total known from the broader Development Envelope (Figure 12-6):

- four records from Breakaways and Gullies habitat;
- eight records from the Mesa Plateau or Hills habitats; and
- one from River habitat.

The Ghost Bat records from habitats other than Breakaways and Gullies (Hills, Mesa Plateau and River) ranged between approximately four to 580 m from Breakaways and Gullies habitat. This supports the known behaviour that Ghost Bats forage over a wide range of habitats up to 2 km from their diurnal roost site. There are an additional 28 null records from the Development Envelope (from placement of acoustic recorders and also targeted searches) which are fairly evenly distributed across the landscape; 12 within Breakaways and Gullies and 16 across the remaining habitat types.

A contextual study undertaken by Astron (2017d) confirmed that the most significant habitat for Ghost Bats in the Mesa H survey area occur in the small sections of Breakaways and Gullies habitat (approximately 4.1 ha mapped as high quality habitat) located along the western side of Mesa H. The connection of this habitat to the Robe River is also considered significant.



LEGEND

- Development Envelope
- Rio Tinto Ghost Bat records
- Ghost Bat Roost (Diurnal/ potential maternal)
- DBCA Ghost Bat records
- Rio Tinto Railway
- Highway
- Major Road
- Major Watercourse

Data sourced from: Department of Biodiversity, Conservation and Attractions (2018) Threatened and Priority Fauna. Database Search for Rio Tinto tenements accessed on the 6/11/18. Prepared by the Species and Communities Program for Rio Tinto for the purposeof understanding fauna habitat utilisation and facilitating management outcomes.

N

SCALE

5 0 5 10 15km

1:500 000 @ A4

RioTinto

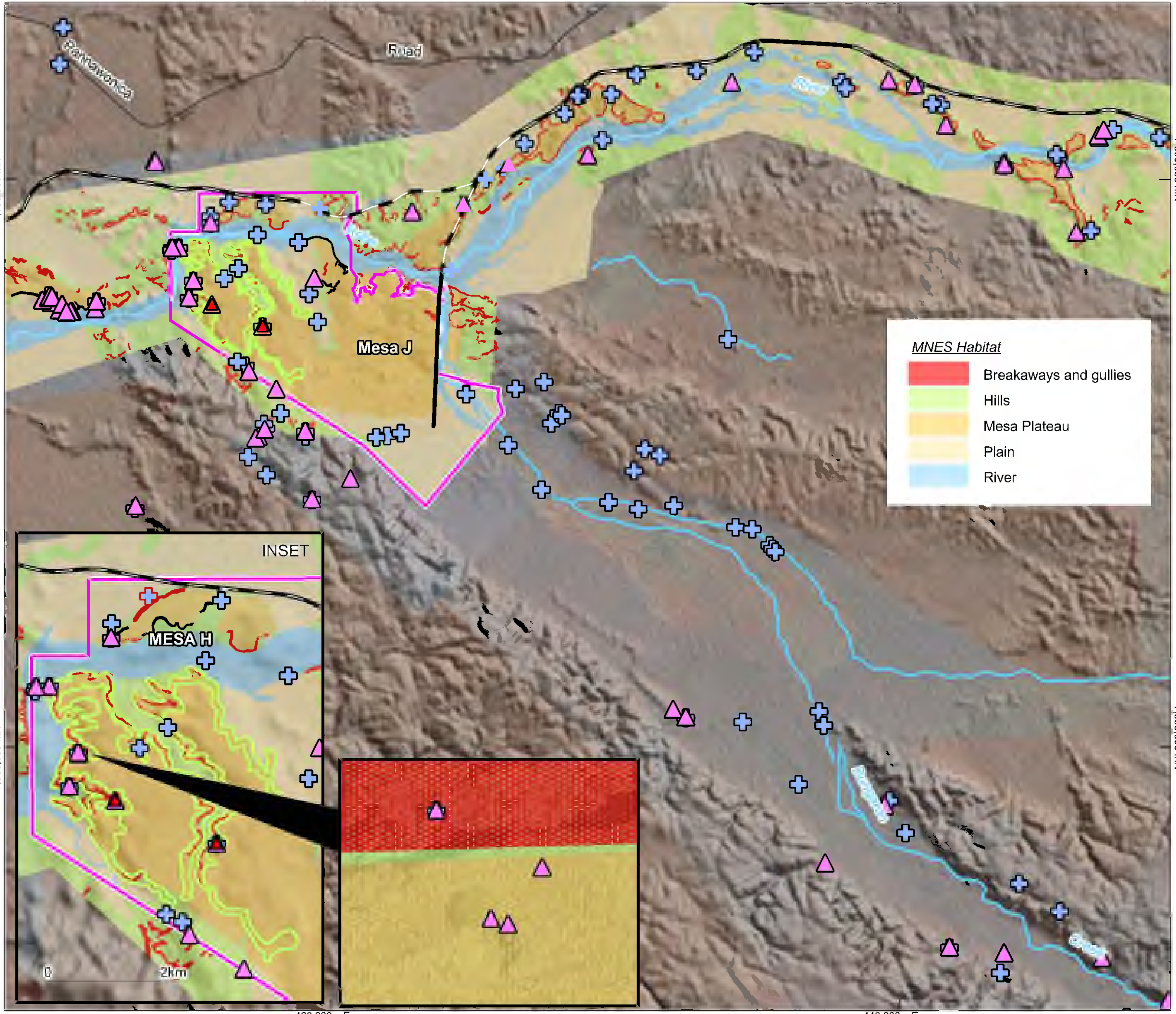
Iron Ore (WA)

Figure 12-5: Ghost Bat records in the Robe Valley

Drawn: T.M.
Date: January, 2019

Plan No: PDE0165179v1
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping



Rio Tinto

Iron Ore (WA)

Figure 12-6: Ghost Bat sampling locations and records in or near the Development Envelope

Drawn: T.M.
Date: January, 2019

Plan No: PDE0165182v2
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping

12.3.5 Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia)*

The Pilbara Leaf-nosed Bat population that occurs in the Pilbara and upper Gascoyne is considered to be one interbreeding biological population of genetic divergence which is of national significance (TSSC 2016a). The Pilbara Leaf-nosed Bat has been recorded 119 times across the Robe Valley (Figure 12-7) and occurs in colonies concentrated around significant roosting sites, often associated with disused mining infrastructure. Most of the known natural roosting sites coincide with areas of current or future interest for mining development; hence mining activities are an identified threat to Pilbara populations of the species (DotEE 2017b).

The Pilbara Leaf-nosed Bat is restricted to deep roosting caves and mine adits (manmade horizontal shafts) with stable, warm and humid microclimates. The species is thought to prefer such environments because it has a limited ability to thermo-regulate and retain water (DotEE 2017b). The Pilbara Leaf-nosed Bat is known to have a typical dry season foraging range up to 20 km from its primary roost caves (Bat Call 2016) but may forage at greater distances if suitable water sources are available. The availability and use of transitory diurnal roosts is dependent upon wet season conditions when the humidity of temporary roosts is elevated making them suitable for use. The species is likely to return to its primary roosting location in dry periods as demonstrated by perennial occupation of certain roost sites (DotEE 2017b).

The Pilbara Leaf-nosed Bat is most often observed in flight over waterholes, up to 3 m above the land surface, but sometimes within centimetres of the ground. In the Pilbara, the species has been observed in *Triodia* hummock grasslands covering low rolling hills and shallow gullies; within scattered *Eucalyptus camaldulensis* along the creeks; over small watercourses amongst granite boulder terrain; over pools and low shrubs in ironstone gorges; and above low shrubs and around pools in gravelly watercourses with a *Melaleuca* overstorey (DotEE 2017b). As with all cave-roosting bats, the Pilbara Leaf-nosed Bat has separate diurnal and nocturnal habitats including roosting sites and foraging sites. Roosting sites may occur in rocky breakaways, scarps and gorges as these areas have the greatest potential to support relatively warm humid microclimates.

The type and quality of potential foraging habitat surrounding known or suspected roost sites can also be critical to the survival of the Pilbara Leaf-nosed Bat. The Conservation Advice for the species (TSSC 2016b) lists the types of habitat that are used for foraging and their relative priority but also indicates that assessment of significance of habitat removal would include assessment of "the relative proportion of identified foraging habitats to be removed (e.g. within a surrounding 10 km radius from the roost)". The conservation advice states that actions are:

- highly likely to have a significant impact on Pilbara Leaf-nosed bats if an action causes the loss of confirmed or even potential roost sites; and
- may have a significant impact on Pilbara Leaf-nosed bats if an action disrupts breeding or removes a significant proportion of foraging habitat within proximity (e.g. 10 km radius from the roost).

There is currently no recovery plan for this species. A full summary of policy/guidance relevant to the Pilbara Leaf-nosed Bat is provided in Section 8.6.4.1.

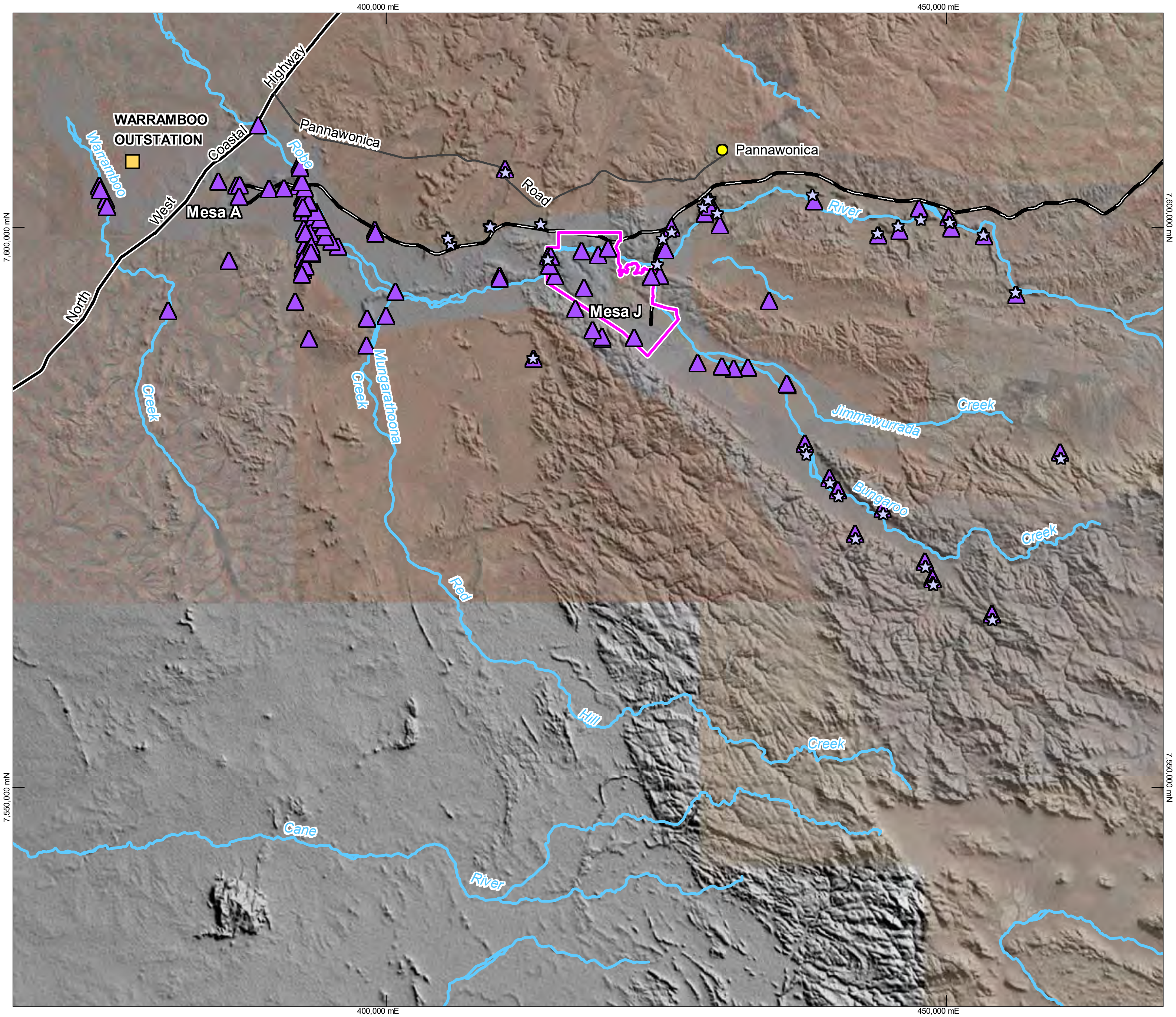
The Pilbara Leaf-nosed Bat has been recorded 11 times in the Proposed Change Area. The species was recorded at five of the 11 bat SM2 detector locations in the Proposed Change Area by Astron (2017e). The species was recorded a further six times in the Proposed Change Area during the earlier Level 1 survey of Mesa H (Astron 2014). During the most recent survey (Astron 2017e), seven locations yielded low activity levels, while one location (BAT 14) recorded high activity levels with 257 calls (Astron 2017e). BAT 14 was located at the entrance to a large gorge system, of which most occurs in the south of the survey area and outside of the Proposed Change Area. Four bat detectors were subsequently placed along the gorge system for a period of five days in June 2016, following completion of the main survey and results indicate that individuals likely originate from a known roost site approximately 10 km south of the survey area (Astron 2017e).

Ongoing surveying for the species within the broader Robe Valley by Rio Tinto from 2015 to 2017 in the vicinity of the Development Envelope identified multiple calls in the vicinity of the Robe River, along the southern boundary of the Proposed Change Area and within a gully. The surveys did not identify any roosts at Mesa A, B, C, D, E or F (Rio Tinto 2017e). It is likely that the species utilises habitats around the mesas and the Robe River for foraging, as part of a larger home range.

The 11 records of Pilbara Leaf-nosed Bat from within the Proposed Change area are also the total that have been recorded in the broader Development Envelope and comprise (Figure 12-8):

- three from Breakaways and Gullies habitat;
- five from River habitat;
- two from Hills habitat; and
- one from Plains habitat.

There are an additional 19 null records in the Development Envelope from placement of acoustic recorders which are largely from Plains, River and Mesa Plateau habitats with five null records from Breakaways and Gullies. The Pilbara Leaf-nosed Bat records and null records from the Development Envelope indicate that, consistent with the regional information described the species likely utilises habitats in the Proposed Change Area for foraging as part of a larger home range.



LEGEND

Development Envelope

Rio Tinto Pilbara Leaf-nosed Bat records

DBCA Pilbara Leaf-nosed Bat records

Rio Tinto Railway

Highway

Major road

Major Watercourse

Data sourced from: Department of Biodiversity, Conservation and Attractions (2018) Threatened and Priority Fauna. Database Search for Rio Tinto tenements accessed on the 6/11/18. Prepared by the Species and Communities Program for Rio Tinto for the purposeof understanding fauna habitat utilisation and facilitating management outcomes.

N

SCALE

5 0 5 10 15km

1:500 000 @ A4

Rio Tinto

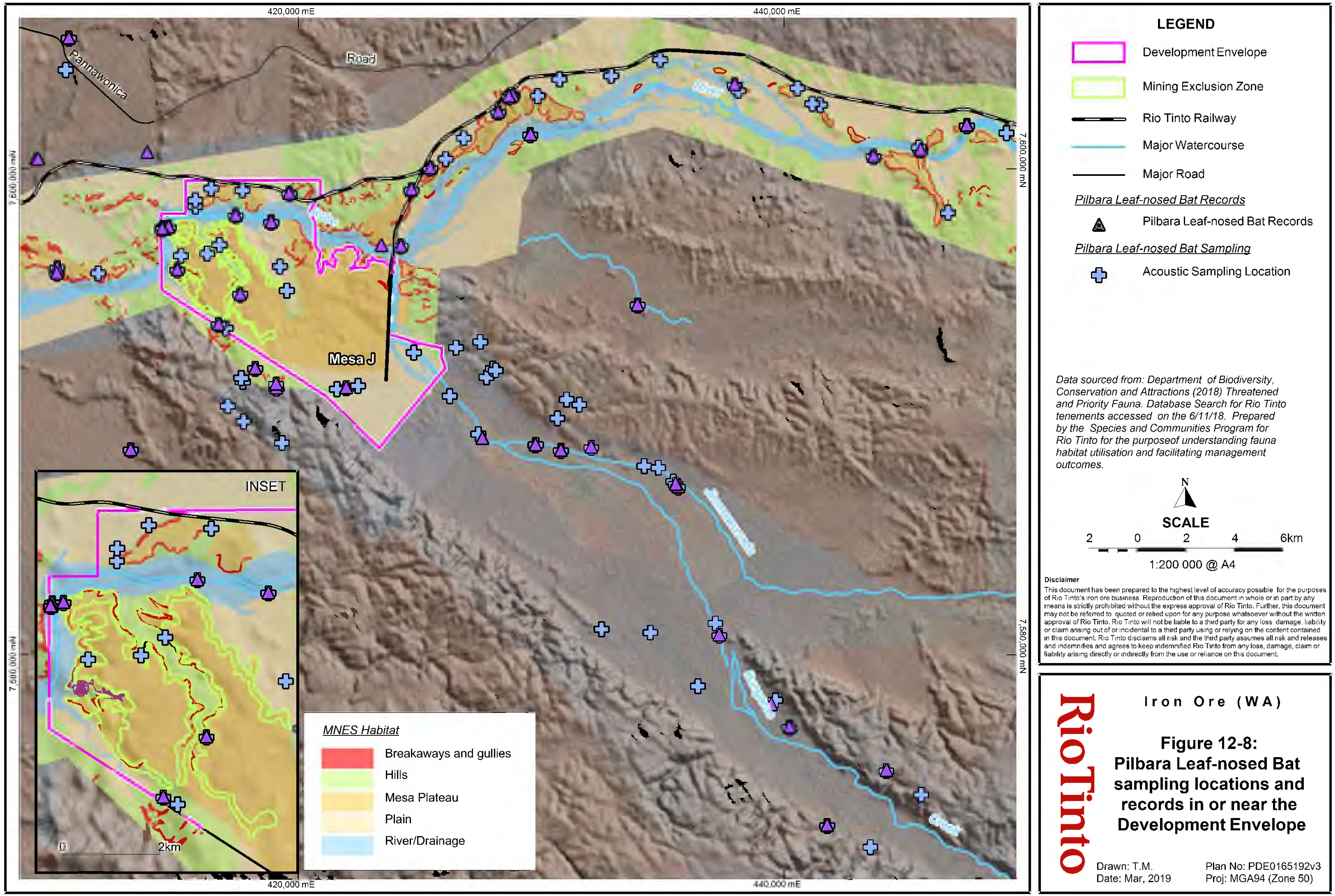
Iron Ore (WA)

Figure 12-7: Pilbara Leaf-nosed Bat records in the Robe Valley

Drawn: T.M.
Date: January, 2019

Plan No: PDE0165191v1
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping



RioTinto

Iron Ore (WA)

Figure 12-8: Pilbara Leaf-nosed Bat sampling locations and records in or near the Development Envelope

Drawn: T.M.
Date: Mar, 2019

Plan No: PDE0165192v3
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping

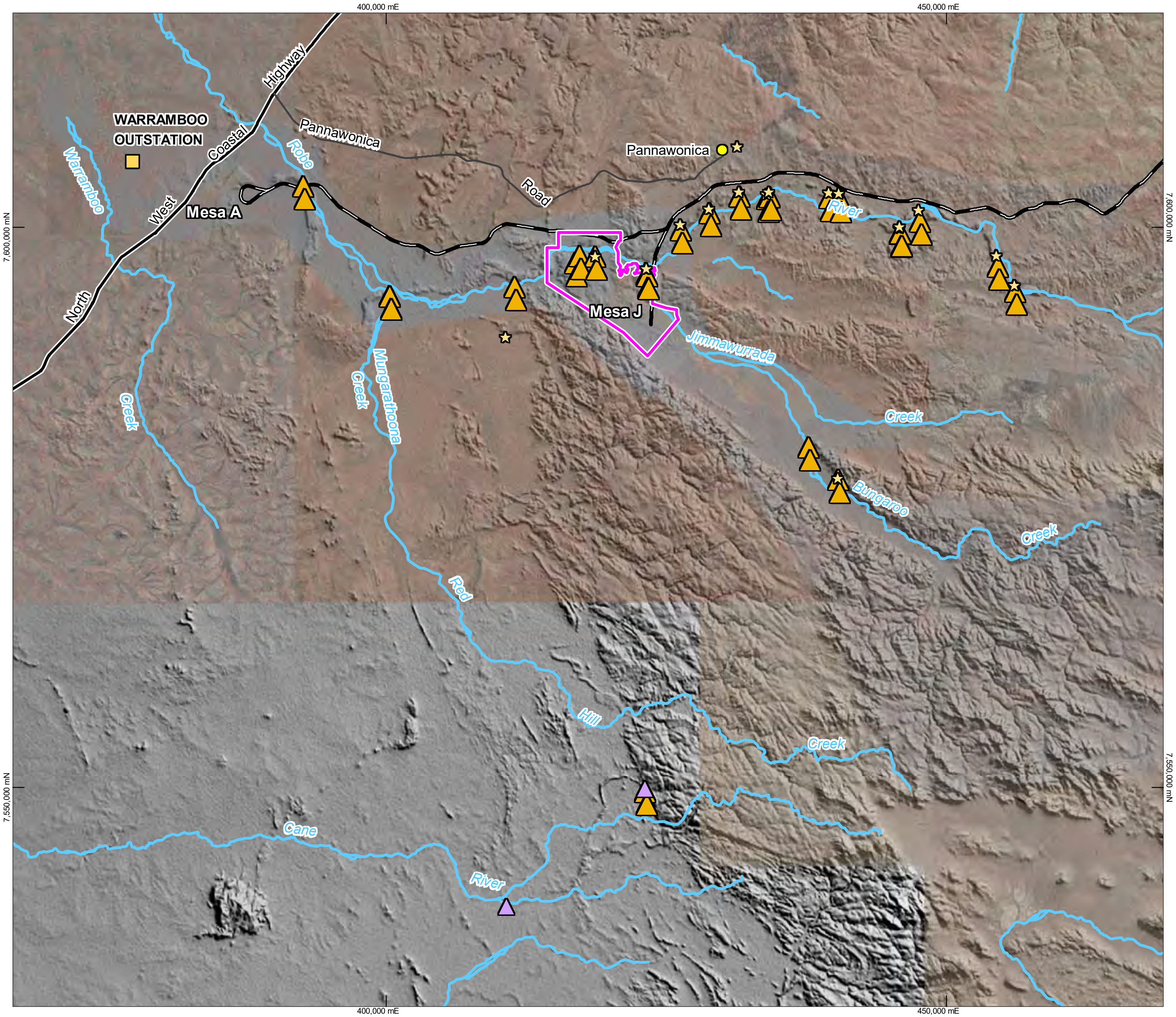
12.3.6 Pilbara Olive Python (*Liasis olivaceus barroni*)

The Pilbara Olive Python is restricted to ranges within the Pilbara region including the Hamersley Range and islands of the Dampier Archipelago. It is widespread in the region and occurs as scattered populations. It is known to occur at more than 60 locations across the Pilbara (G. Humphreys, Biota Environmental Sciences, pers. comm. 2012), 21 of which are currently recognised in the Commonwealth Conservation Advice (DEWHA 2008b) including populations at Pannawonica, Millstream, Tom Price and the Burrup Peninsula. The species has been recorded 23 times across the Robe Valley outside the Development Envelope (Figure 12-9).

The Pilbara Olive Python is predominantly found in rocky areas within the Pilbara, showing a preference for gorges with streams and permanent pools. Individuals spend the cooler winter months hiding in caves and rock crevices away from water sources, and the warmer summer months moving around widely, usually in close proximity to water and rock outcrops. The species uses waterholes to hunt and ambushes prey on animal trails or by striking from a submerged position in water holes (DEWHA 2008b; MWH 2015; DotEE 2017c). Individuals occupy distinct home ranges and males can travel distances of up to 4 km during the breeding season (June to August) to locate females.

A large area of habitat for this species is protected within the Millstream-Chichester National Park and the Karijini National Park located approximately 110 km north-east and 215 km south-east of the Development Envelope respectively.

A single juvenile Pilbara Olive Python was recorded in River habitat within the Proposed Change Area and scats were recorded on two further occasions in Hills and Mesa Plateau MNES habitat types. Breakaways and Gullies habitat and River habitat likely provide breeding and foraging habitat, particularly areas close to semi-permanent and permanent pools in the Robe River.



LEGEND

- Development Envelope
- Rio Tinto Pilbara Olive Python records
- TSOP Pilbara Olive Python records
- DBCA Pilbara Olive Python records
- Rio Tinto Railway
- Highway
- Major road
- Major Watercourse

Data sourced from: Department of Biodiversity, Conservation and Attractions (2018) Threatened and Priority Fauna. Database Search for Rio Tinto tenements accessed on the 6/11/18. Prepared by the Species and Communities Program for Rio Tinto for the purposeof understanding fauna habitat utilisation and facilitating management outcomes.

N

SCALE

5 0 5 10 15km

1:500 000 @ A4

Rio Tinto

Iron Ore (WA)

Figure 12-9: Pilbara Olive Python records in the Robe Valley

Drawn: T.M.
Date: January, 2018

Plan No: PDE0165193v1
Proj: MGA94 (Zone 50)

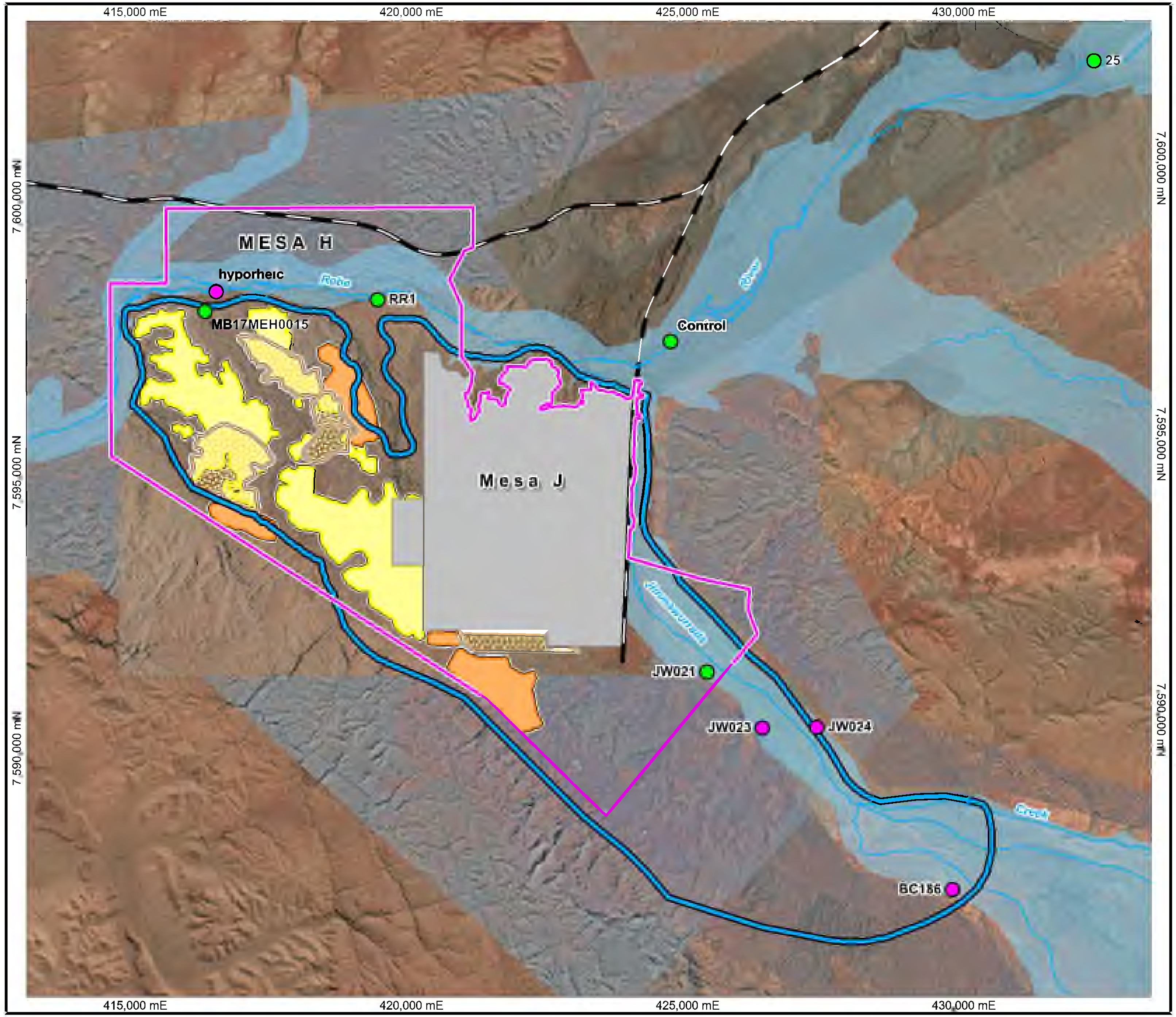
Geospatial Information and Mapping

12.3.7 Blind Cave Eel (*Ophisternon candidum*)

The Blind Cave Eel is one of only two vertebrate animals known from Australia that are restricted to subterranean waters. It is known from the Cape Range peninsula and Barrow Island, approximately 225 km west of the Revised Proposal and Jimmawurrada - Bungaroo Creek. It inhabits subterranean caves, fissures and wells with stratified waters ranging from freshwater at the surface to seawater salinities at depth and is known to traverse this range of salinity (DEWHA 2008a). The waters which they inhabit lack surface connection to the sea.

The Blind Cave Eel has recently been recorded four times in the Proposed Change Area (Biota 2019a); and a further five confirmed physical records have been recorded within 1 - 5 km east of the Proposed Change Area, within the cumulative groundwater drawdown footprint of the Revised Proposal, in Jimmawurrada / Bungaroo Creek (Biota 2019b). Three genomes sequenced from previous records from the Jimmawurrada / Bungaroo Creek have confirmed that the species is the same as the species recorded at Cape Range. Moore et al. (2018) also states that genetic and morphological data support a single species of subterranean Ophisternon in Western Australia. However, a degree of divergence has been observed in their genetic sequence, likely as a consequence of lack of contemporary subterranean habitat connection, therefore precluding the exchange of individuals and genetic material between the populations (WAM pers comm, Moore et al. 2018). Additional eDNA studies are currently in progress to determine the habitat range for the eel given inherent sampling difficulties in the subterranean environment (Refer to Section 7.5). Using separate eDNA methodologies from two different laboratories a further four positive recordings of Blind Cave Eel have been confirmed in additional locations outside the Proposed Change Area; in the upper Robe River and in the Robe River north of Mesa J, supporting the likelihood of habitat connectivity and features between the creek / river systems. More recently, a confirmed record was collected from the hyporheic zone in the alluvial gravels of the Robe River (WRM 2019 in prep), indicating a broader habitat range in the creek systems than previously understood, and supporting the hypothesis by Moore et al 2018 of their inland origins within the Jimmawurrada – Bungaroo – Robe River systems is likely to have occurred via hyporheic and parafluvial pathways along the Robe River, which was originally connected to the coastal aquifers from which they originated. Further work is in progress to understand the broader habitat range.

The conservation advice for the Blind Cave Eel lists the key threats to the species as sedimentation from mining and construction, canal development, water abstraction, point source pollution from sewage, landfill, dumping and mining; and diffuse pollution from urban development (DEWHA 2008a).



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse
- Blind Cave Eel Record (eDNA)
- Blind Cave Eel Record
- Potential Blind Cave Eel Habitat

Data Source: Regional 1:250K geology GSWA - DMIRS and RTIO Mesa J Mapping 1:5000 (Nov 2003)

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile

Groundwater Drawdown

- Drawdown Extent

N

SCALE

0 1 2 3 4 5km

1:100 000 @ A4

RioTinto

Iron Ore (WA)

Figure 12-10: Blind Cave Eel records in or near the Development Envelope

Drawn: M.Swebbs
Date: Feb, 2019

Plan No: PDE0165461v2
Proj: MGA 94 (Zone 50)

12.4 Potential Impacts on MNES

The following provides a summary of aspects of the Proposed Change which may result in direct and indirect impacts to MNES. Further assessment of potential impacts is provided in Sections 12.5 and 12.6.

12.4.1 Direct impacts

12.4.1.1 Loss of habitat due to clearing

Clearing will remove up to 2,200 ha of fauna habitat, disturbing foraging habitat and potentially breeding habitat for some of the MNES species recorded in the area. Alternatives were considered for various aspects of the Proposed Change to minimise the potential environmental impacts including avoiding as far as practicable important habitat for MNES. Discussion of justification of the Proposed Change and the alternatives considered is provided in Section 2.3.

The estimates given below (and tabulated in Sections 8.5 and 8.6) of the potential extent of disturbance in each habitat type represent upper limits for key habitat types.

Breakaways and Gullies

The Proposed Change has been designed to limit disturbance to Breakaways and Gullies habitat, resulting in clearing of approximately 3.5 ha. This represents up to approximately 4% of the mapped Breakaways and Gullies habitat within the Proposed Change Area.

The mesa façade assessment undertaken by Astron (2017c) identified ten out of 48 sites as high priority for retention. These sites were found along the western façade near the Robe River and a small section along the northern façade that passes close to the Robe River. The western façade along the Robe River is characterised by structurally diverse habitats with high moisture retention, providing refuge and shelter sites for MNES species such as the Ghost Bat, Northern Quoll and Pilbara Olive Python. All disturbance to these high priority sections of the mesa escarpment has been avoided.

Mesa Plateau

The majority of disturbance will be on the mesa plateau from development of the mine pits. The Proposed Change has been designed to limit disturbance to the Mesa Plateau habitat as far as possible and will clear approximately 57% of the mapped extent of this habitat type in the Proposed Change Area.

River

The Proposed Change has been designed to limit disturbance to the River habitat, to less than 4% of the mapped extent of River habitat (less than 24 ha) in the Proposed Change Area. The majority of this clearing is within the Drainage Lines habitat type (22 ha) rather than the higher value Riverine habitat (<2 ha).

Hills

The Hills habitat type is widespread locally and regionally and is not considered significant habitat for MNES. The Proposed Change will clear approximately 1% of the mapped extent of this habitat type in the Proposed Change Area.

Plains

The Plains habitat type is widespread locally and regionally and is not considered significant habitat for MNES. The Proposed Change will clear approximately 64% of the mapped extent of this habitat type in the Proposed Change Area.

12.4.1.2 Degradation of foraging and dispersal habitat due to groundwater abstraction

A reduction in groundwater levels may temporarily reduce aquatic habitat for the Blind Cave Eel until significant rainfall events top up the alluvial aquifers or until groundwater levels recover.

12.4.1.3 Direct loss of individuals due to fauna strike

The Northern Quoll, Pilbara Olive Python, Pilbara Leaf-nosed Bat and Ghost Bat may be affected by vehicle strike, as a result of construction and operation of the mine which may result in injury or mortality of individuals.

12.4.1.4 Cumulative clearing across the Robe Valley

The fauna habitats of the entire Robe Valley have been mapped to enable an assessment of the cumulative habitat loss from existing and reasonably foreseeable projects in the region (Figure 8-13). This assessment is directly relevant to MNES and is presented in Section 8.5.3.

The habitat types that are most significant to conservation significant fauna (i.e. Breakaway and Gullies habitat and River habitat) have more than 90% of their pre-European extent remaining within the Robe Valley (Section 8.5.3).

12.4.2 Indirect impacts

12.4.2.1 Degradation of foraging and dispersal habitat due to groundwater abstraction

Groundwater abstraction for pit dewatering will result in localised drawdown in the Mesa H CID aquifer that has some connectivity to the Robe River alluvial aquifer. The potential for reduction in water levels in the Robe River alluvial aquifer and associated permanent and semi-permanent pools may be up to 1 m, which may result in shallow (<0.8 m) seasonal and semi-permanent pools drying out more quickly during prolonged periods of drought. This is not anticipated to change the permanent or semi-permanent nature of any of the pools or change riparian vegetation which provides fauna habitat, as the water will still be accessible to root systems. The permanent pool (Gnieroora at Yeera Bluff) in the section of the Robe River adjacent to Mesa H is approximately 3-4 m deep. This pool will continue to be permanent but may have lower levels during dry periods. The key impact on fauna habitat will be a small reduction in the length of time semi-permanent pools exist after rainfall. Shallower pools such as Duck Pool may dry out more quickly during extended dry periods than would currently be the case. The temporary habitat values that these semi-permanent pools provide include drinking water, associated foraging habitat (both vegetation and prey availability) and shelter. As the size of the pools contract and understorey wetland vegetation cover reduces during dry periods, these habitat values will be reduced more quickly due to groundwater abstraction.

The majority of water in the Robe River alluvial aquifer derives from streamflow recharge and throughflow from upstream within the alluvial aquifer. Therefore, the potential for discernible drawdown impact is limited to dry conditions. Monitoring in the Robe River alluvial aquifer has shown natural water level fluctuations of up to 3 m. The EWRs for the Robe River (DoW 2012) were developed using an approach that allows for the highly variable water conditions experienced in the Pilbara. The EWRs for drought conditions in the Robe River are to maintain phreatophytic vegetation and permanent pools as refuges for fauna. These EWRs are expected to be met during implementation of the Proposed Change.

Groundwater abstraction in the Southern Cutback Borefield for water supply will remain within existing licence limits for the Mesa J Iron Ore Development. Mesa H will utilise some water from this Borefield for wet processing when dewatering is not sufficient. The cumulative impacts of the existing Mesa J Iron Ore Development dewatering, Mesa H water supply and the adjacent CWSP abstraction will extend the depth and extent of groundwater drawdown below Jimmawurrada Creek and the timeframe to groundwater recovery. This abstraction may result in some changes to riparian vegetation including a reduced canopy cover and changes to understorey vegetation biomass along a 12 km extent of the ephemeral Jimmawurrada Creek. Substantial drawdowns are expected within a 6.5 km stretch where drawdowns of up to 9 m (14 mbgl) may occur from the cumulative effects of Mesa H, Mesa J and the Coastal Water Supply. However, if natural recharge in Jimmawurrada Creek is reduced by 50% due to an extended dry period (H3 numerical model 'Uncertainty Run 2' (Rio Tinto 2019a)), the water table levels could be lowered by almost 3 m in addition to the historical seasonal fluctuations; this would translate to localised changes in water table depths of up to 14 m from pre-mining conditions, or ~18 mbgl by 2030. No permanent or semi-permanent pools occur along Jimmawurrada Creek and hence changes to the surface water regime are predicted to be limited to potential decreased persistence of ephemeral pools following large rainfall events.

The footprint of the periodic surplus water discharge will overlap with areas subject to groundwater drawdown including along the Robe River and sections of Jimmawurrada Creek and thus may partially mitigate the potential impact from groundwater drawdown in these areas.

12.4.2.2 Alteration of foraging and dispersal habitat due to discharge of surplus water

Discharge of surplus groundwater into tributaries of the ephemeral Robe River; Jimmawurrada Creek and / or West Creek will be periodic and predominantly required during the wet season to manage water volumes which exceed on-site storage capacity. The abstracted groundwater quality is fresh and the resultant discharge will likely result in formation of temporary pools, rather than continuous flow, across the discharge extent of up to 8 km from the discharge outlets, similar to the current footprint for the existing Mesa J Iron Ore Development. This may continue to increase the temporal and seasonal availability of surface water, leading to an increase in the utilisation of the area by fauna, potentially including the Blind Cave Eel for the duration of discharge. However, discharge will not be continuous during operations and habitat values are unlikely to be significantly altered beyond their current levels.

12.4.2.3 Loss or degradation of habitat due to noise and vibration

The Northern Quoll, Pilbara Olive Python, Pilbara Leaf-nosed Bat and Ghost Bat utilise caves and shelters on the mesa escarpments for denning and shelter or roosting. Vibrations associated with blasting have the potential to result in loss of, or damage to, the caves and shelters in the mesa escarpment utilised by the MNES species. The mesa landforms and caves are considered stable and robust and the retained mesa facades and caves are not expected to collapse as a result of the Proposed Change.

Noise and vibration emissions from clearing, construction and blasting have the potential to cause the Northern Quoll and Ghost Bat to temporarily vacate shelters and diurnal/maternal roosts for the duration of the impact.

12.4.2.4 Degradation of habitat due to dust and light emissions

The Proposed Change is located adjacent to an active mining area and will likely result in increased airborne dust emissions from vegetation clearing, construction activities and mine operation. Dust may impact the health of vegetation which provides foraging habitat for MNES and could potentially impact the quality of Ghost Bat roosts.

Increased night time light emissions in and around the Proposed Change Area may alter nocturnal foraging behaviour. Light emissions are likely to result in increased availability of prey species (insects) near the Proposed Change Area for the Pilbara Leaf-nosed Bat and Ghost Bat. Light emissions are unlikely to have a significant impact on the nocturnal behaviour of the Northern Quoll and Pilbara Olive Python.

12.4.2.5 Vehicle movement

The Northern Quoll, Pilbara Olive Python, Pilbara Leaf-nosed Bat and Ghost Bat may be affected by vehicle strike, as a result of construction and operation of the mine which may result in injury or mortality of individuals.

12.5 Assessment of Impacts to Threatened Species

12.5.1 Summary of significance of impacts to MNES

The predicted residual impacts on MNES have been assessed in terms of their significance in accordance with the Significant Impact Guidelines 1.1, relevant conservation advice and referral guidelines. Where sufficient scientific information exists, the detailed understanding of local species occurrence and habitat use in the Robe Valley has been used to support a local definition of core habitat that is critical to the survival of local populations. It is noted that the referral guidelines provide broad definitions of critical habitat at the national level, however this should not preclude using the extensive Pilbara and Robe Valley datasets on MNES species (except Blind Cave Eel) to inform a more detailed understanding and assessment of the significance of habitats and impacts. A summary of the assessment of significance of the residual impacts on each MNES in provided in Table 12-2 to Table 12-6 and a full assessment specifically against the significant impact criteria for each MNES is presented in Section 12.5.2.

The predicted significant residual impacts on MNES are the direct loss of habitat for the Northern Quoll and the Blind Cave Eel.

Table 12-2: Assessment of Significance of Residual Impact on Northern Quoll

Aspect	Summary
Nature of the attribute being impacted	
Level of statutory protection	Endangered
Regional distribution	Distinct Pilbara population. More than 4,153 records within the Pilbara (DBCA 2018) with high levels of genetic diversity.
Local distribution	The majority (80%) of records in the Proposed Change Area were found in Breakaways and Gullies (or within 10 m) and River habitat types.
Habitat values within impact area	Northern Quolls are strongly associated with rocky habitats for denning and foraging and river habitats are important for foraging and dispersal. All other habitats provide some potential for foraging and dispersal.
Quality or importance of the attributes being impacted with regard to the Northern Quoll ongoing viability	The foraging and dispersal values of the Plains, Mesa Plateau and lower order Drainage lines (a portion of MNES River habitat) are considered low. Northern Quoll (particularly breeding age males) may utilise all of these habitats but these values are common and widespread. Rocky habitats and River habitats and the connection between them is considered important for the species. The mesa facades and the gullies linking to the Robe River within the Proposed Change Area are considered high quality habitat for Northern Quoll and important to the survival of the local population.
Resilience of the Northern Quoll to impacts	Northern Quoll are highly mobile and have been demonstrated to be able to persist adjacent to (or even within) active mining areas.
What is the nature of the residual impact?	

Aspect	Summary
Type of impact	Loss of habitat through clearing and land disturbance.
Extent of impact	3.5 ha of Breakaways and Gullies, 3.8 ha of habitat within 10 m of Breakaways and Gullies habitat and <2 ha of River habitats. Other habitat types in the Proposed Change Area are common and widespread and the local loss of these habitats is considered of low importance with regard to the Northern Quoll's ongoing viability.
Duration	For the life of mine.
Permanent or temporary nature of the residual impacts	The impact is conservatively treated as permanent although rehabilitation at closure will re-establish some habitat value.
Significance of residual impact	Due to the widespread availability of foraging and dispersal habitat, the residual impact of the loss of these habitats is not considered significant to the viability of the species. Breakaways and Gullies and River (specifically the Riverine terrestrial fauna habitat component) habitats are considered of high importance to Northern Quoll and the Proposed Change has been designed to largely avoid these habitats. However, the loss of even small areas of these important habitats is considered significant and is therefore proposed to be offset.

Table 12-3: Assessment of Significance of Residual Impact on Ghost Bats

Aspect	Summary
Nature of the attribute being impacted	
Level of statutory protection	Vulnerable
Regional distribution	Distinct Pilbara population. Current estimates for the total population in the Pilbara range from 1,300 to 2,000 individuals, with approximately 1,500 in the Chichester sub-region and approximately 350 in the Hamersley sub-region (TSSC 2016a).
Local distribution	The Ghost Bat is common and widespread in small numbers within the Robe Valley. The 13 records within the Proposed Change Area were fairly evenly spread among Breakaways and Gullies, Hills and Mesa Plateau habitats with one record in the River habitat.
Habitat values within impact area	There are two diurnal roosts / possible maternal roosts and nine nocturnal roosts within the survey area around Mesa H. Foraging habitat includes plains and riparian areas that are connected to the rocky cave-forming habitats. The broader Plains and Hills habitats provide widespread and common potential foraging habitat.
Quality or importance of the attributes being impacted with regard to the Ghost Bat ongoing viability	The most significant habitat for Ghost Bats in the Mesa H area occur in the small sections of Breakaways and Gullies habitat located along the western side of Mesa H (Astron 2017d) and the connection of this habitat to the Robe River.

Aspect	Summary
Resilience of the Ghost Bat to impacts	To persist in an area, the Ghost Bat requires a group of caves / shelters that provide diurnal and nocturnal sites and a gully or gorge system that opens onto a plain or riparian line that provides good foraging opportunities. The persistence of the species in the Pilbara is believed to depend on the availability of diurnal roosts that have stable temperature and humidity (TSSC 2016b). Ghost Bats have been found to continue roosting in retained habitat adjacent to active mining operations, and return to roosts post mining operations (Batcall 2017a). Observations to date in the Robe Valley indicate that the Robe Valley Ghost Bats are moving through the landscape opportunistically and possibly seasonally and are taking advantage of all of the foraging and roosting opportunities provided by the valley of the river, its tributaries and the various caves available (B. Bullen,Bat Call WA, pers. Comm. 2019).
What is the nature of the residual impact?	
Type of impact	Loss of habitat through clearing and land disturbance.
Extent of impact	All caves (diurnal and nocturnal) will be retained. The connection of the cave habitat in the mesa façade (MEZ) will maintain direct access to the Robe River and connected foraging habitat. There will be a local loss of the potential foraging habitat on the Plains and Hills habitat but as this habitat is widespread and common, the proposed local loss of this habitat is considered of low importance with regard to the Ghost Bat's ongoing viability.
Duration	For the life of mine.
Permanent or temporary nature of the residual impacts	The impact to potential foraging habitat is conservatively treated as permanent although rehabilitation at closure will re-establish some foraging habitat value.
Significance of residual impact	All direct impacts to Ghost Bat caves will be avoided and indirect impacts will be effectively managed. Maintaining the integrity of the roost caves will ensure the caves will remain suitable as roosting habitat. Although Ghost Bats may temporarily vacate the roost caves, it is expected that they will return post mining; a behavioural pattern that is reflective of the species' temporary occupancy of caves within the greater Robe Valley due to other seasonality and resource availability factors. Due to the widespread availability of foraging and dispersal habitat, and the retention of the connection between roosting, dispersal and foraging habitats in the landscape, the residual impact of foraging habitat loss is not considered to be significant.

Table 12-4: Assessment of Significance of Residual Impact on Pilbara Leaf-nosed Bats

Aspect	Summary
Nature of the attribute being impacted	
Level of statutory protection	Vulnerable
Regional distribution	There is a distinct Pilbara and upper Gascoyne population of this species. The size of the population is unknown, however colonies range in size from few individuals to several hundred. One colony discovered in the western Pilbara has been found and two independent assessments have suggested numbers in the several thousand but this is still to be confirmed (TSSC 2016b).
Local distribution	There are a total of 11 records of Pilbara Leaf-nosed Bat from within the Development Envelope . The majority were from the River and Breakaways and Gullies habitat types.
Habitat values within impact area	There have been no diurnal roosts (either confirmed or potential) recorded within the Development Envelope. The nearest diurnal roost is >10 km to the south-east. Surveys have confirmed the presence of Pilbara Leaf-nosed Bat in the Development Envelope so the area has foraging and dispersal habitat value. As the nearest roost is 10 km to the south-east of the Proposed Change Area, the potential foraging habitat within the Proposed Change Area, although utilised by the bats, is not considered important to the preservation of the population. The foraging habitat within Jimmawurrada Creek in the south-eastern corner of the Proposed Change Area as well as outside the Proposed Change area, are within the 10 km radius of the nearest known roost and would likely support foraging habitat.
Quality or importance of the attributes being impacted with regard to the Pilbara Leaf-nosed Bat ongoing viability	The Conservation advice for this species lists the loss of suitable roosts as highly likely to lead to a long term decrease in the size of the PLNB population. The Conservation advice lists the types of habitat that are used for foraging and their relative priority but also indicates that assessment of significance of habitat removal would include assessment of "the relative proportion of identified foraging habitats to be removed (e.g. within a surrounding 10 km radius from the roost)". Therefore, although potential foraging habitat occurs within the Development Envelope, and a proportion will be cleared it is not likely to be important to the preservation of the population. Similarly, groundwater drawdown is expected to indirectly impact a section of Jimmawurrada Creek, and therefore affect Pilbara Leaf-nosed Bat foraging habitat. Although the drawdown is expected to result in a reduction of riparian canopy, the impacts will be temporary and localised within the south-eastern corner of the Proposed Change Area and outside the Development Envelope and the viability of the riparian zone will be maintained. There are also alternate adjacent suitable foraging locations / opportunities in other habitat types and in areas beyond the Development Envelope close to the known roost site.

Aspect	Summary
Resilience of the Pilbara Leaf-nosed Bat to impacts	The persistence of the species in the Pilbara depends on the availability and protection of diurnal roosts that have stable temperature and humidity' (TSSC 2016b). There are currently four Pilbara Leaf-nosed Bat permanent roost caves in reasonably close proximity to active large scale open cut mining operations. These are BHP Cattle Gorge mine at 500 m, Atlas Iron Mt Webber mine at ~ 1 km, Ratty Spring at ~ 1.3 km and Paraburdoo East roost at ~ 2 km from active open cuts. Ongoing monitoring has confirmed that all four caves have remained viable diurnal roosts for the species and remain maternity roost candidates (B. Bullen,Bat Call WA, pers. Comm. 2019). Pilbara Leaf-nosed Bats regularly forage up to 20 km from their diurnal roost and so the preservation of foraging habitat nearby is not a limiting factor to their presence (B. Bullen,Bat Call WA, pers. Comm. 2019). However, virtually all diurnal roosts have a permanent water source with easy flying distance of the roost, typically within 5 km e.g. Ratty Spring pools, and Bellary Creek pools near Paraburdoo (B. Bullen,Bat Call WA, pers. Comm. 2019) . It is currently thought that the preservation of these pools is of equal importance to the stability of the Pilbara Leaf-nosed Bat roost, particularly in the late dry season.
What is the nature of the residual impact?	
Type of impact	Loss of habitat through clearing and land disturbance.
Extent of impact	There are no roosts (known or potential) within the Development Envelope so there will be no loss of roost habitat. There will be a small (<2 ha) loss in foraging habitat in the River habitat but as this habitat is more than 10 km from the nearest roost site, this habitat is considered of low importance with regard to the Pilbara Leaf-nosed Bat ongoing viability. A portion of the foraging habitat on Jimmawurrada Creek ('Zone 3') is likely to be subject to temporary groundwater drawdown of up to 9 m which is likely to result in temporary impacts including canopy decline and increased tree mortality.
Duration	For the life of mine in the Development Envelope. Temporary impact to Jimmawurrada Creek during the period of groundwater abstraction.
Permanent or temporary nature of the residual impacts	The impact associated with clearing is conservatively treated as permanent although rehabilitation at closure will re-establish some foraging habitat value. Indirect impacts as a result of groundwater drawdown are considered to be negligible to the Robe River and temporary to a section of Jimmawurrada Creek riparian vegetation during the period of peak abstraction.
Significance of residual impact	The conservation advice for Pilbara Leaf-nosed Bats provides advice that actions are: • highly likely to have a significant impact on Pilbara Leaf-nosed bats if an action causes the loss of confirmed or even potential roost sites. There are no roosts within the Proposed Change Area.

Aspect	Summary
	• may have a significant impact on Pilbara Leaf-nosed bats if an action disrupts breeding or removes a significant proportion of foraging habitat within proximity (e.g. 10 km radius from the roost). The nearest roost is >10 km south-east of the Proposed Change Area and therefore the proposed clearing will not remove any foraging habitat within proximity of the nearest roost. The predicted indirect impacts to the riparian vegetation of Jimmawurrada Creek in the south-eastern corner of the Proposed Change Area and outside of the Development Envelope fall within 10 km of the nearest roost, however these impacts are expected to result in temporary and localised reductions in riparian canopy but maintain functioning foraging habitat for Pilbara Leaf-nosed Bats. Therefore, the Proposed Change is not expected to have a significant residual impact on Pilbara Leaf-nosed Bats.

Table 12-5: Assessment of Significance of Residual Impact on Pilbara Olive Python

Aspect	Summary
Nature of the attribute being impacted	
Level of statutory protection	Vulnerable
Regional distribution	Known to be widespread in the region and occurs as scattered populations at more than 60 locations across the Pilbara (G. Humphreys, Biota Environmental Sciences, pers. comm. 2012), 21 of which are currently recognised in the Commonwealth Conservation Advice (DEWHA 2008b) including populations at Pannawonica, Millstream, Tom Price and the Burrup Peninsula.
Local distribution	The species has been recorded 23 times across the Robe Valley outside the Development Envelope, and three times within the Proposed Change Area; one in River habitat and scats were recorded on two occasions in Breakaways and Gullies habitat.
Habitat values within impact area	Breakaways and Gullies habitat provides breeding, shelter and foraging habitat particularly areas close to semi-permanent and permanent pools in the Robe River. River habitat likely provides shelter, foraging and dispersal habitat.
Quality or importance of the attributes being impacted with regard to the Pilbara Olive Python ongoing viability	The approved conservation advice for the Pilbara Olive Python describes preferred habitat for the Pilbara Olive Python as including deep gorges and water holes (DEWHA 2008b). In the Proposed Change Area these habitats are represented by Breakaways and Gullies and River habitat. Mesa Plateau habitat types provide some foraging and dispersal habitat for the species, and Hills and Plains provide some or limited habitat value and are widespread and common throughout the Pilbara region.
Resilience of the Pilbara Olive Python to impacts	The conservation advice for the Pilbara Olive Python lists the key threats to the species as predation by foxes and cats, predation of food sources by feral animals and removal of habitat. Although they are slow moving and susceptible to vehicle strike, the species has been observed persisting in

Aspect	Summary
	developed areas of the Pilbara sheltering in overburden heaps, railway embankments and caves of an iron ore mine in Pannawonica and utilising man-made water sources, such as sewerage treatment ponds and recreational lakes in Tom Price (DEWHA 2008b).
What is the nature of the residual impact?	
Type of impact	Loss of habitat through clearing and land disturbance.
Extent of impact	3.5 ha of Breakaways and Gullies and < 2 ha of River habitats. Other habitat types are common and widespread and the local loss of these habitats is considered of low importance with regard to the Pilbara Olive Python's ongoing viability.
Duration	For the life of mine.
Permanent or temporary nature of the residual impacts	The impact is conservatively treated as permanent although rehabilitation at closure will re-establish some habitat value.
Significance of residual impact	There will be limited impact to habitats which may be classified as preferred habitat for Pilbara Olive Python, namely the Breakaway and Gullies habitat and the River habitat. The residual impact of foraging habitat loss is not considered to be significant given the widespread occurrence and availability of this habitat for the species locally and regionally.

Table 12-6: Assessment of Significance of Residual Impact on Blind Cave Eel

Aspect	Summary
Nature of the attribute being impacted	
Level of statutory protection	Vulnerable
Regional distribution	The Blind Cave Eel is known to occur on the Cape Range peninsula and Barrow Island in the north-west of Western Australia where it inhabits the caves and underground waters (DEWHA 2008a). More recently it has been found in the inland Pilbara near Bungaroo. The species is restricted to subterranean waters.
Local distribution	A total of nine records have been returned from nine locations within Bungaroo Creek, Jimmawurrada Creek and the Robe River alluvial aquifers, comprising both physical records and eDNA records. Records occur within and outside the modelled impact area.
Habitat values within impact area	Based on sampling records and physical geological / hydrogeological properties, the major creekline alluvial aquifers, including the hyporheic zones are understood to provide the primary habitat for the Blind Cave Eel in the Robe Valley. These major alluvial aquifers are extensive and interconnected within the Robe Valley, extending up to ~250 km from the upper Robe River ~150km from the upper Bungaroo to the Pilbara Coast.

Aspect	Summary
Quality or importance of the attributes being impacted with regard to the Blind Cave Eel ongoing viability	The conservation advice for the Blind Cave Eel lists the key threats to the species as sedimentation from mining and construction, canal development, water abstraction, point source pollution from sewage, landfill, dumping and mining; and diffuse pollution from urban development (DEWHA 2008a). The Proposed Change avoids removal of the alluvial habitat substrate to allow maintenance of habitat connectivity however will temporarily reduce habitat via cumulative groundwater drawdown.
Resilience of the Blind Cave Eel to impacts	The habitat of the Blind Cave Eel in the vicinity of the Development Envelope is currently subject to groundwater drawdown as a result of the Mesa J and Coastal Water Supply Projects, which have been in operation since 1992 and 2012 respectively. Ongoing annual stygofauna monitoring has recently recorded positive records of the Blind Cave Eel – 89% of which have been recorded post 2012 when both Projects were operating and abstracting groundwater concurrently and during an extended dry period with low rainfall. This preliminary information indicates an ongoing viable population, particularly as many of the records comprised juveniles, despite cumulative effects of the two operations.
What is the nature of the residual impact?	
Type of impact	Reduction in habitat through groundwater abstraction and associated groundwater drawdown.
Extent of impact	Predicted maximum of 9 m drawdown (cumulative) across a 6.5 km stretch of Jimmawurrada Creek (14 mbgl). >50% of potential habitat retained. <1 m drawdown in the Robe River (within natural groundwater fluctuations).
Duration	During the Life of Mine. Peak cumulative drawdown estimated at 2030.
Permanent or temporary nature of the residual impacts	Temporary reduction in groundwater levels in the alluvial aquifers in which large rainfall events or cyclonic activity can completely re-set the water table levels to baseline levels.
Significance of residual impact	The impacts to Blind Cave Eel are considered to comprise an increased risk of temporary habitat reduction due to cumulative groundwater drawdown during operations. Given the current limited status of knowledge of this species, there is uncertainty regarding the area of risk, the degree of habitat modification and the range and sensitivity of the species. Therefore, this risk is proposed to be offset to enhance further research into the understanding of the occurrence and range of this species.

12.5.2 Assessment against significant impact criteria for MNES

Table 12-7 through to Table 12-11 provide an assessment of potential impacts to MNES against the significant impact criteria for each recorded MNES.

Table 12-7: Assessment Against the Significant Impact Criteria for Northern Quoll

Significant impact criteria	Assessment of impacts to Northern Quolls
Potential to cause a long-term decrease in the size of a population	The National Recovery Plan for the Northern Quoll (Hill and Ward 2010) identifies Cane Toads as the most significant threat to Northern Quoll. While the Pilbara was once thought likely to provide a refuge for the Northern Quoll from the Cane Toad, recent modelling suggests that Cane Toads will invade the region (Cramer *et al*. 2016). Destruction of habitat from mining is also identified as a threat. The National Recovery Plan describes habitat critical to the survival of Northern Quoll as habitat where Northern Quolls are least exposed to threats or least likely to be in the future, and this includes rocky areas and offshore islands. Prevention of fragmentation of potential refuge habitats yet to be colonised by Cane Toads in WA, and halting population declines in areas yet to be colonised by Cane Toads, are identified as high priorities. The definition of habitat critical to the survival of the Northern Quoll provided in both the National Recovery Plan and by the DoE (2016), is a very broad definition of the habitat type preferred by the Northern Quoll. Recent studies in the Proposed Change Area have identified the Breakaways and Gullies habitat as supporting the greater majority of local conservation significant populations (80% of records in the Proposed Change Area were found in Breakaways and Gullies (or within 10 m) and River habitat types)) and are thus considered to be of greatest value to the continuing conservation of the Northern Quoll within the Development Envelope. **Clearing** Potential impacts to Northern Quoll denning, foraging and dispersal habitats from clearing are unlikely to lead to a long-term decrease in the size of the Northern Quoll population. The Proposed Change has been designed to avoid the highest value Northern Quoll habitat: the disturbance will impact only a small proportion of the available potential denning habitat (Breakaways and Gullies habitat) and foraging and dispersal habitat (River habitat). A MEZ will be established around the mesa escarpment which sterilises ore to protect fauna and the highest habitat values supported by the mesa escarpment (Astron 2017c). Specifically, the Proposed Change will result in direct disturbance to 3.5 ha of Breakaways and Gullies, which provides suitable denning habitat for Northern Quoll, which represents less than 0.4% of the current extent of undisturbed Breakaway and Gullies habitat (924.6 ha) in the Robe Valley, and up to 24 ha of River habitat (the majority of which is the less significant Drainage Line habitat defined for the Terrestrial Fauna factor) which provides foraging and dispersal habitat. This impact represents 0.3% of the current mapped extent of River habitat in the Robe Valley. The escarpment cuts were designed to avoid the sections of the escarpments with the highest ecological value, including the highest value Northern Quoll habitat (Figure 12-11). The majority of disturbance for the Proposed Change will occur in the Low Hills and Slopes, and Loamy / Stony Plain habitats due to development of the mine pits within the mesas. Cumulatively, this Proposed Change will increase the existing mining footprint within the Robe Valley, resulting in the total cumulative clearing (including historical clearing, the Revised Proposal and reasonably foreseeably projects) of Breakaway and Gullies habitat reaching 9.6% and cumulative clearing of River habitat reaching 1%. After the mitigation hierarchy has been applied, including avoidance of direct impacts to key habitat and key habitat features, the Proponent considers that the direct impact to core habitat for the Northern Quoll; 3.5 ha of Breakaways and Gullies habitat, 3.8 ha of habitat within 10 m of Breakaways and Gullies habitat and 1.3 ha of River habitat (specifically the Riverine portion of this habitat as defined in Section 8.4.3), is considered to be a significant residual impact for the Northern Quoll and requires offsetting (Section 13). Given the proposed mitigation and offset, the Proponent considers that the Proposed Change can be managed effectively and are not expected to lead to a long-term decrease in the size of the local or regional Northern Quoll population. **Groundwater abstraction**

Significant impact criteria	Assessment of impacts to Northern Quolls
	Potential impacts to Northern Quoll foraging and dispersal habitat from groundwater abstraction are unlikely to lead to a long-term decrease in the size of the Northern Quoll population. Groundwater abstraction for pit dewatering will result in localised groundwater drawdown in the Mesa H CID aquifer that has some connectivity to the Robe River alluvial aquifer. There is some uncertainty regarding the level of hydraulic connection between the alluvial aquifer and the CID aquifer and therefore the modelling and this impact assessment has been based on a worst-case scenario assuming that there is a level of hydraulic connection and that the basement underlying the alluvial aquifer has some degree of permeability. Under this scenario, the modelling indicates the potential for a reduction in water levels in the Robe River alluvial aquifer and the Robe River semi-permanent and permanent pools may be up to a maximum of 1 m. This drawdown could result in shallow (<0.8 m) seasonal and semi-permanent pools drying out more quickly during prolonged periods of drought. The permanent pool at Yeera Bluff in the section of the Robe River adjacent to Mesa H is approximately 3-4 m deep. This pool will continue to be permanent but may have lower levels during dry periods. The key impact on fauna habitat will be a small reduction in the length of time semi-permanent pools exist after rainfall. The temporary habitat values that these semi-permanent pools provide include drinking water, associated foraging habitat (both vegetation and prey availability) and shelter. As the size of the pools contract and understorey wetland vegetation cover reduces during dry periods, these habitat values will be reduced more quickly due to groundwater abstraction. The majority of the water in the alluvial aquifer (~90%) comes from streamflow recharge and throughflow from upstream within the alluvial aquifer. Therefore, the potential for any drawdown is limited to dry conditions. Monitoring in the Robe River alluvial aquifer has shown natural water level variation of up to 3 m. The EWRs for the Robe River (DoW 2012) were developed using an approach that allows for the highly variable water conditions experienced in the Pilbara. The EWRs for drought conditions in the Robe River are to maintain phreatophytic vegetation and permanent pools as refuges for fauna. These EWRs and their significance for Northern Quolls in maintenance of foraging habitat are expected to be met during implementation of the Revised Proposal. Groundwater abstraction in the Southern Cutback Borefield for water supply will remain within existing licence limits for the Mesa J Iron Ore Development. Mesa H will utilise some water from this Borefield for wet processing when dewatering is not sufficient. The cumulative impacts of the existing Mesa J Iron Ore Development dewatering, Mesa H water supply and the adjacent CWSP abstraction will extend the depth and extent of groundwater drawdown below Jimmawurrada Creek and the timeframe to groundwater recovery within a 12 km section of the creek. Substantial drawdowns are expected within a 6.5 km stretch where drawdowns of up to 9 m (14 mbgl) may occur from the cumulative effects of Mesa H, Mesa J and the Coastal Water Supply. However, if natural recharge in Jimmawurrada Creek is reduced by 50% due to an extended dry period (H3 numerical model 'Uncertainty Run 2' (Rio Tinto 2019a)), the water table levels could be lowered by almost 3 m in addition to the historical seasonal fluctuations; this would translate to localised changes in water table depths of up to 14 m from pre-mining conditions, or ~18 mbgl by 2030. No permanent or semi-permanent pools occur along Jimmawurrada Creek so changes in the surface water regime will be limited to potential decreased persistence of ephemeral pools following rainfall. Any potential changes to pools in the Robe River or vegetation along Jimmawurrada Creek are not expected to significantly impact Northern Quoll habitat. **Discharge of surplus water** Discharge of surplus groundwater into tributaries of the ephemeral Robe River; Jimmawurrada Creek and/or West Creek will be periodic and predominantly required during the wet season to manage water volumes which exceed on-site storage capacity. The abstracted groundwater quality is fresh and the resultant discharge will likely result in formation of temporary pools, rather than continuous flow, across the discharge extent of up to 8 km from the discharge outlets, similar to the current footprint for the existing Mesa J Iron Ore Development. It may result in a temporary increase in utilisation of the area by Northern Quoll for foraging and dispersal, for the duration of discharge. Given the temporary nature of the discharge to

Significant impact criteria	Assessment of impacts to Northern Quolls
	a system that is adapted to highly variable flow conditions, it is unlikely to be any long-term impact on the Northern Quoll foraging and dispersal behaviour. Following cessation of discharge, Jimmawurrada Creek and the Robe River will return to the natural ephemeral flow regime. **Noise and vibration** Noise and vibration from mining operations are unlikely to lead to a long-term decrease in the size of the Northern Quoll population. The mesa escarpments provide denning habitat for the Northern Quoll. Vibrations associated with blasting have the potential to cause instability to caves and shelters of within the mesa escarpment. The delineation of a MEZ will serve to provide a buffer zone between the mine pit and the mesa escarpment which provides suitable denning habitat; and will reduce noise and vibration impacts on available shelters. Blast management measures will be implemented to ensure the structural integrity of the mesa escarpment is not compromised by the proposed mining operation. These are described further in Section 8.9. Noise from blasting and general mining operations has the potential to disturb Northern Quoll while denning. The buffer zone provided by the MEZ and the aspect of the denning habitat (facing away from the mining area) will reduce potential impacts from noise. Monitoring at Process Minerals Poondano West indicates the ongoing presence of a population of Northern Quoll despite mining activity. Northern Quoll numbers fluctuated over time and were lowest in 2012 during mining, potentially due to temporary displacement of some individuals, however a population remained present and continues after site remediation. Numbers increased to their highest level in 2014 after mining ceased; however, declined in 2015 across all sites (including control sites). Given that mining activity ceased and there is no correlation between capture numbers and distance from the impact sites, the declines are considered unlikely to be due to previous mining disturbance (Astron 2015f). A correlation between numbers and the distance from human settlement is apparent (Astron 2015f). Northern Quoll also continue to be observed in close proximity to current mining operations at Mesa A. **Dust and light** Dust and light emissions are unlikely to lead to a long-term decrease in the size of the Northern Quoll population. There is a general perception that dust deposition on plants causes negative impacts to plants. However, the Pilbara is a naturally dusty environment. A study examining the impacts of dust on plant health in semi-arid environments found no evidence to support that negative impacts result from dust deposition up to 77 g/m^2/month (Matsuki *et al* 2016). Dust deposition monitoring conducted in 2016 approximately 340 m from the current Mesa A mine pit and approximately 100 m from the plant showed a maximum dust deposition rate of 9.4 g/m^2/month. Based on dust monitoring to date and the study by Matsuki *et al* (2016), any decline in vegetation health and hence Northern Quoll foraging habitat due to dust deposition is likely to be limited to the area immediately adjacent to the proposed mining operation. Given that impacts to vegetation from dust emissions will occur in only a small proportion of the available Northern Quoll foraging habitat and that Northern Quoll continue to be observed in close proximity to current mining operations at Mesa A, dust emissions are considered unlikely to lead to a long-term decrease in the size of the Northern Quoll population. Lighting in the mining area will be directed into the pit, away from potential Northern Quoll denning habitat present in the mesa escarpments. Light emissions at the existing Mesa A / Warramboo operations (and the existing adjacent Mesa J Iron Ore Development) do not appear to adversely impact Northern Quoll. Light emissions from other areas in the operation may alter Northern Quoll foraging behaviour but given that the area impacted will be small compared with the available Northern Quoll foraging habitat, this is not expected to significantly impact the local population. **Vehicle movements** Vehicle movements for the Proposed Change are unlikely to result in a long-term decrease in the Norther Quoll population. There have been no recorded incidents of vehicle collision with Northern Quoll.

Significant impact criteria	Assessment of impacts to Northern Quolls
Potential to reduce the area of occupancy of the species	**Clearing** It is unlikely the proposed clearing will reduce the area of occupancy of the Northern Quoll. As described previously, the Proposed Change has been designed to avoid the highest value Northern Quoll habitat and that the disturbance will impact only a small proportion of the available denning habitat (Breakaways and Gullies habitat) and valuable foraging and dispersal habitat along major watercourses (Riverine habitat). The direct impact to core habitat for the Northern Quoll; 3.5 ha of Breakaways and Gullies habitat, 3.8 ha of habitat within 10 m of Breakaways and Gullies habitat and 1.3 ha of Riverine habitat, is considered to be a significant residual impact for the Northern Quoll and therefore is proposed to be offset. **Groundwater abstraction** Groundwater abstraction for pit dewatering will result in localised drawdown in the Mesa H CID aquifer that has some connectivity to the Robe River alluvial aquifer. The potential for reduction in water levels in the Robe River alluvial aquifer may decrease the extent of semi-permanent pools and reduce their persistence during times of drought. As the size of the pools contract and understorey wetland vegetation cover reduces during dry periods, these habitat values will be reduced more quickly due to groundwater abstraction. This is not expected to reduce the area of occupancy of the local population of Northern Quolls. In the event that surface water levels in pools of the Robe River reduce more than the predicted range as a result of mine dewatering for the Revised Proposal, these will be mitigated with an adaptive management approach that may include discharge of surplus abstracted groundwater from Mesa H dewatering directly into permanent pools; or avoidance of BWT mining below the 120 m RL in the pit closest to the Robe River in order to avoid or mitigate the impact. Groundwater abstraction in the Southern Cutback Borefield for water supply will remain within existing licence limits for the Mesa J Iron Ore Development and is unlikely to significant increase impacts under Jimmawurrada Creek. The cumulative impacts of the existing Mesa J Iron Ore Development dewatering, Mesa H water supply and the adjacent CWSP abstraction will extend the depth and extent of groundwater drawdown below Jimmawurrada Creek and the timeframe to groundwater recovery within a 6.5 km section of the creek. No permanent or semi-permanent pools occur along Jimmawurrada Creek so changes in the surface water regime will be limited to potential decreased persistence of ephemeral pools following rainfall. **Discharge of surplus water** The proposed discharge will be periodic and is unlikely to reduce the area of occupancy. The discharge may result in a temporary increase in utilisation of Jimmawurrada Creek, and sections of the Robe River for the duration of discharge. **Noise and vibration** Noise and vibration from mining operations are unlikely to reduce the area of occupancy of the Northern Quoll. As described previously, significant impacts to Northern Quoll individuals while denning and to denning habitat are not expected given the ongoing presence of Northern Quoll near active mining operations, the buffer zone provided by the MEZ and the proposed blast management measures to be implemented. **Dust and light** Dust and light emissions are unlikely to reduce the area of occupancy of the Northern Quoll. Based on dust monitoring to date and the study by Matsuki *et al.* (2016) described previously, any decline in Northern Quoll foraging habitat due to dust deposition is likely to be limited to the area immediately adjacent to the proposed mining operation. Similarly, light emissions may alter Northern Quoll foraging behaviour in some isolated areas of the operation which would form a small proportion of the broader Northern Quoll habitat available.

Significant impact criteria	Assessment of impacts to Northern Quolls
Potential for fragmentation of an existing population into two or more populations	**Clearing** It is unlikely the proposed disturbance will fragment an existing Northern Quoll population. The species is highly mobile and a small proportion of habitat available to the species will be affected by the Proposed Change. The Proposed Change will clear up to 2 ha of preferred foraging and dispersal habitat which is less than 1% of the mapped extent in the Proposed Change Area. The majority of disturbance will be on the mesa plateau from development of the mine pits. With the exception of two escarpment cuts for essential haul roads, an area of mesa plateau immediately adjacent to the denning and shelter habitat provided by the mesa escarpments will be retained around each mesa as part of the MEZ. The Proposed Change has been designed to limit disturbance to the River habitat adjacent to Mesa H to less than 4% of the River habitat in the Proposed Change Area (with most of this clearing within Drainage Line habitat rather than the Riverine habitat type associated with the Robe River). Foraging habitat immediately adjacent to denning habitat will thus be retained. The Proposed Change will maintain habitat connectivity, particularly along the Robe River and will utilise existing Mesa J linear infrastructure where available. Northern Quoll are known to move over installed linear infrastructure such as roads and rail and therefore the haul road access cuts through the mesa escarpment are not expected to fragment the Northern Quoll populations that utilise this habitat. **Groundwater abstraction** As described previously, groundwater abstraction for pit dewatering may temporarily reduce the water levels in the Robe River alluvial aquifer and permanent or semi-permanent pools. The key impact will be a small reduction in the length of water residency in semi-permanent pools after rainfall. Abstraction will not change the permanent or semi-permanent nature of pools and will not fragment groundwater dependent habitat for the species. Abstraction for water supply from the existing Southern Cutback Borefield will extend the time for groundwater recovery and may impact riparian vegetation along a small section of Jimmawurrada Creek; however, these impacts are not expected to fragment Northern Quoll habitat. **Discharge of surplus water** The proposed discharge is unlikely to fragment an existing Northern Quoll population. Discharge is predicted to result in temporary pools, rather than continuous flow, across the discharge extent and may increase utilisation of the area for foraging, for the duration of discharge.

Significant impact criteria	Assessment of impacts to Northern Quolls
Potential to adversely affect habitat critical to the survival of a species	**Clearing** While the Proposed Change will disturb habitat classifiable as habitat critical to the survival of the Northern Quoll, the proposed loss of habitat is not considered significant due to the avoidance of the highest value denning habitat and the extensive availability of foraging habitat both within and outside of the Proposed Change Area. The proposed habitat loss is not expected to affect the survival of the species locally or regionally. Northern Quoll utilise a wide range of rocky and vegetated habitats for foraging, and habitat within 2 km of denning habitat is considered foraging and dispersal habitat (DoE 2016). Habitat critical to the survival of the Northern Quoll comprises habitat within the modelled distribution of the species that provides shelter for breeding, refuge from fire / or predation (DoE 2016). This habitat usually occurs in the form of rocky habitat which in the Pilbara includes ranges, escarpments, mesas, gorges and breakaways (DoE 2016). The core habitat locally is considered to comprise the Breakaways and Gullies habitat, the area within 10 m of this habitat and portions of the River habitat (specifically the Riverine portion). Of the approximately 925 ha of Breakaways and Gullies, and 7,994 ha of River habitat retained in the Robe Valley, the Proposed Change will directly impact up to approximately 3.5 ha and 24 ha, respectively. This represents approximately 0.3% of the Breakaway and Gullies habitat available and 0.3% of the River habitat in the Robe Valley. The Proposed Change has been designed to avoid disturbance to the highest value denning habitat. The outputs from the Astron (2017c) escarpment assessment were used to ensure the locations of the proposed escarpment cuts avoid disturbance to the highest value Breakaways and Gullies habitat (Figure 12-11). However, after the mitigation hierarchy has been applied, including avoidance of direct impacts to key habitat and key habitat features, the Proponent considers the direct impact to core habitat for the Northern Quoll; 3.5 ha of Breakaways and Gullies habitat, 3.8 ha of habitat within 10 m of Breakaways and Gullies habitat and 1.3 ha of River habitat (specifically the Riverine portion), is considered to be a significant residual impact for the Northern Quoll and therefore is proposed to be offset. Groundwater abstraction, surplus water discharge and noise, vibration, dust and light emissions are unlikely to adversely affect habitat critical to the survival of the Northern Quoll.
Potential to disrupt the breeding cycle of a population	**Clearing** Given the Proposed Change has been designed to avoid the highest value Northern Quoll habitat, particularly along the Robe River, and given that the disturbance will impact only a small proportion of the available denning habitat which is proposed to be offset, it is unlikely the Proposed Change will disrupt the breeding cycle of a Northern Quoll population. **Groundwater abstraction and surplus water discharge** Proposed groundwater abstraction and surplus water discharge are unlikely to disrupt the breeding cycle of a population. Groundwater abstraction and surplus water discharge may temporarily alter the quality of Northern Quoll foraging and dispersal habitat; however, the area that may be impacted represents only a small proportion of available foraging and dispersal habitat in the Robe Valley. **Noise and vibration** Noise and vibration from mining operations are unlikely to disrupt the breeding cycle of a Northern Quoll population. As described previously, significant impacts to Northern Quoll individuals while denning and to denning habitat are not expected given the ongoing presence of Northern Quoll near active mining operations, the buffer zone provided by the proposed MEZ and the proposed blast management measures to be implemented.

Significant impact criteria	Assessment of impacts to Northern Quolls
Potential to modify, destroy, remove isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?	It is unlikely the Proposed Change will lead to a decline of the Northern Quoll species. Although critical habitat for the species will be impacted, the impacts will be minimal relative to the regional habitat available. Regardless, the direct impact to core habitat for the species is considered to be a significant residual impact and is proposed to be offset. The proposed direct impact of habitat loss, a portion of which will be offset, is not expected to affect the survival of the species locally or regionally. Similarly, the potential indirect impacts from the Proposed Change are unlikely to significantly affect Northern Quoll habitat or individuals to the extent that the species could decline.
Potential for the establishment of invasive species that are harmful to an endangered species	The Cane Toad is the invasive species which poses the greatest threat to Northern Quoll however is not currently established in the Pilbara. Cane Toads absorb water through their skin from dew or any moist material and need constant access to moisture to survive. A number of semi-permanent and permanent pools are present within the Proposed Change Area and at a number of locations both upstream and downstream of the Proposed Change along the Robe River. It is therefore considered that there is currently sufficient water continuously available in the Robe River to enable establishment of the Cane Toad in the Robe Valley should it spread to the Pilbara. The Proponent will implement quarantine and hygiene controls to prevent the inadvertent introduction of Cane Toads. The Proposed Change is not considered to further increase the risk of the Cane Toad becoming established in the area. The feral cat also poses an existing threat to the species. Monitoring of Northern Quoll in the vicinity of the Proposed Change Area as part of Rio Tinto's Threatened Species Offset Plan demonstrated that Northern Quolls suffer high levels of mortality due to predation by feral cats (Morris *et al* 2014, cited in Palmer *et al* 2017). However, the Proposed Change is not expected to increase the potential presence of feral cats in the Development Envelope as the Proponent will continue to implement feral fauna control in areas in which it operates.
Potential for the introduction of disease that may cause the species to decline	The Proposed Change will not introduce disease that may cause the species to decline.
Potential interference with the recovery of the species	Given the proposed disturbance will impact only a small proportion of the available Northern Quoll habitat and that the Proposed Change has been designed to avoid the highest value denning habitat which is proposed to be offset, the Proposed Change is unlikely to interfere with the recovery of the Northern Quoll. Land management actions are being undertaken as part of the Threatened Species Offset Plan (TSOP) on parts of Yarraloola Pastoral Station. Yarraloola Pastoral Station underlies and surrounds the Development Envelope. The TSOP recognises that mineral resources in the offset area will be developed and accounts for this through selection of a land management area that is much larger than the area of habitat impacted. The Proposed Change will, therefore, not interfere with the land management actions under the TSOP.

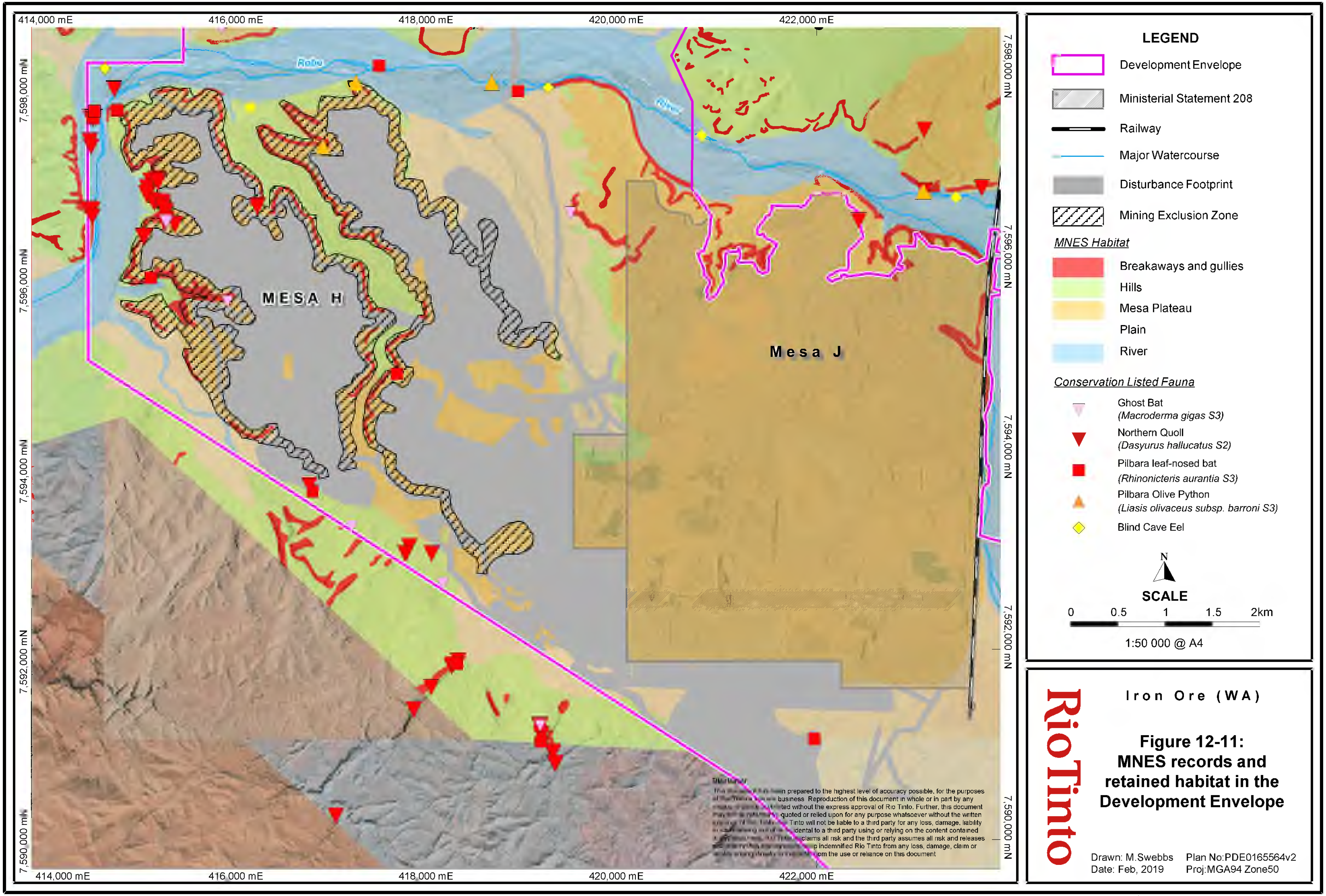


Figure 12-11: MNES records and retained habitat in the Development Envelope

Table 12-8: Assessment Against the Significant Impact Criteria for the Ghost Bat

Significant impact criteria	Assessment of impacts to Ghost Bat
Potential to lead to a long-term decrease in the size of an important population of a species	The approved conservation advice for Ghost Bat identifies the key threat to the species as the destruction of, or disturbance to known roosts and nearby areas. There are currently no defined criteria for habitat critical for the survival of the species or identified important populations. The most significant habitats in the Proposed Change Area for the species are the Breakaways and Gullies habitat, including the mesa escarpments, and the River habitat; these areas represent potential roosting and foraging habitat. **Clearing** It is unlikely the proposed clearing will lead to a long-term decrease in the size of an important Ghost Bat population. The Proposed Change has been designed to avoid the highest value habitat including the two recorded diurnal/potential maternal roosts, all nine nocturnal roosts and will establish a MEZ around these roost sites. Astron (2017d) identified 4.1 ha of high quality habitat for Ghost Bats along the western side of Mesa H. Disturbance to this habitat will be avoided by the Proposed Change. The Proposed Change will limit disturbance to the mesa escarpments (Figure 12-11), particularly high value habitat, resulting in an impact up to 3.5 ha of potential roost habitat including Breakaways and Gullies habitats which represents less than approximately 0.5% of the available Breakaway and Gullies habitat in the Robe Valley and up to 24 ha of River habitat which supports Ghost Bat foraging and dispersal, and which represents approximately 0.3% of the current mapped extent of River habitat (7994 ha) in the Robe Valley. The approved conservation advice for Ghost Bat identifies the key threat to the species as the destruction of, or disturbance to known roosts and nearby areas. The approved conservation advice (TSSC 2016a) for Ghost Bat identifies the primary conservation actions as: • Protection of roost sites from mining, human disturbance and collapse • Replace the top strands of barbed wire in fences near roost sites with single-strand wire. Current estimates for the total population in the Pilbara range from 1,300 to 2,000 individuals, with approximately 1,500 in the Chichester sub-region and approximately 350 in the Hamersley sub-region (TSSC 2016a). Cumulatively, the Proposed Change will increase the existing mining footprint in the Robe Valley resulting in the total cumulative clearing (including historical clearing, the Revised Proposal and reasonably foreseeably projects) of Breakaway and Gullies habitat reaching 9.6% and cumulative clearing of River habitat reaching 1%. The cumulative impacts on foraging and roosting habitat in the Robe Valley is not expected to lead to a long-term decrease in the size of the local or regional Ghost Bat population. Further afield, BHP proposes to impact 17 known Ghost Bat caves at the proposed Area C Southern Flank Proposal (approximately 300 km south-east of the Revised Proposal) including five high value caves. The Area C Southern Flank Proposal also includes the loss of 9,307 ha of foraging habitat. This proposal is predicted to result in a reduction in that local population and will increase the cumulative impacts to the species in the Pilbara region. The proposed avoidance of roost complexes associated with the recorded diurnal / potential maternal roost sites and all of the recorded nocturnal roost sites is consistent with the approved conservation advice (TSSC 2016a), therefore the Proposed Change is unlikely to contribute to impacts to Ghost Bat at a regional scale. **Groundwater abstraction** Groundwater abstraction is unlikely to result in a long-term decrease in the size of an important population.

Significant impact criteria	Assessment of impacts to Ghost Bat
	Groundwater abstraction for pit dewatering will result in localised drawdown in the Mesa H CID aquifer that has some connectivity to the Robe River alluvial aquifer. The potential for reduction in water levels in the Robe River alluvial aquifer by up to 1 m may decrease the extent of semi-permanent pools and reduce their persistence during times of drought. As the size of the pools contract and understorey wetland vegetation cover reduces during dry periods, these habitat values will be reduced more quickly due to groundwater abstraction. The impacts will be seasonal and within the range of natural variation levels already experienced. On this basis, the impacts may reduce but are unlikely to significantly impact the abundance of prey for Ghost Bats. In the event that surface water levels in pools of the Robe River reduce more than the predicted range as a result of mine dewatering for the Revised Proposal, these will be mitigated with an adaptive management approach that may include discharge of surplus abstracted groundwater from Mesa H dewatering directly into permanent pools; or avoidance of BWT mining below the 120 m RL in the pit closest to the Robe River in order to avoid or mitigate the impact. Groundwater abstraction in the Southern Cutback Borefield for water supply will remain within existing licence limits for the Mesa J Iron Ore Development and is unlikely to significant increase impacts under Jimmawurrada Creek. The cumulative impacts of abstraction may result in reduced canopy cover within a 6.5 km section of the creek. No permanent or semi-permanent pools occur along Jimmawurrada Creek so changes in the surface water regime will be limited to potential decreased persistence of ephemeral pools following rainfall. These changes are unlikely to significantly affect foraging habitat for Ghost Bats. **Dust and light** Dust is unlikely to significantly affect the quality of foraging habitat or cause a decline in the size of the Ghost Bat population, given that dust emissions will occur in only a small proportion of the available foraging habitat. Lighting for the Proposed Change is unlikely to affect the quality of foraging habitat or cause a decline in the size of the Ghost Bat population. Lighting will be directed into the pit. Light may alter nocturnal foraging behaviour; however, the area impacted will be small compared with the available extent of foraging habitat. **Noise and vibration** Noise and vibration from mining operations are unlikely to lead to a long-term decrease in the size of the Ghost Bat population. The mesa escarpments provide roosting habitat for Ghost Bat. Vibration impacts associated with blasting have the potential to result in damage to or collapse of shelters or caves within the mesa escarpment. A geotechnical assessment of the caves that form the diurnal/potential maternal Ghost Bat roost complexes determined that the geotechnical sensitivity of these roosts to structural instability is low (Rio Tinto 2017g). In addition, the MEZ will provide a buffer zone of at least 40 m between the mine pit and the diurnal/potential maternal roost caves and a Blast Management Framework to control PPV will be implemented to ensure the structural integrity of potential diurnal/maternal Ghost Bat roost caves is not compromised. The Blast Management Framework will be implemented to ensure blast vibration levels at the identified diurnal/potential maternal Ghost Bat roosts remain below the trigger level PPV set in the EMP (see EMP in Appendix 6). Measures that may be used to achieve the required blast control are discussed in Section 8.6.3.2. Additional information regarding the characteristics of the rock between the proposed disturbance and the diurnal/maternal roost caves, the geotechnical stability of the rock and the Proponent's Blast management control is also provided in Section 8.6.3.2. Noise from blasting and general mining operations has the potential to disturb Ghost Bats while roosting. The buffer zone provided by the MEZ and the aspect of roosts (away from the mining area) will reduce potential noise impacts. Maintaining the integrity of the roost caves will ensure the caves will remain suitable as roosting habitat. Although Ghost Bats may temporarily vacate the

Significant impact criteria	Assessment of impacts to Ghost Bat
	roost caves, it is expected that they will return post mining; a behavioural pattern that is reflective of the species' temporary occupancy of caves within the greater Robe Valley due to other seasonality and resource availability factors. Ghost Bat monitoring at the West Angelas mine site has been undertaken since 2012 (Biologic 2015). Monitoring in one cave located 70 m from the mine pit has shown evidence of Ghost Bat activity in every year until 2014, with a lack of activity in that year, and a subsequent return of activity recorded in the 2015 survey. Another cave located 90 m from the mine pit showed sporadic use over the monitoring period. The field observations thus indicate that Ghost Bats naturally move between a number of caves and that maternity groups may also use different roosts across different seasons. Monitoring for MNES at Mineral Resources' Poondano Iron Ore Project, approximately 20 km south-east of Port Hedland in July 2015 found an ongoing presence of a Ghost Bat population following mining activity, demonstrating that integral habitat values were preserved (Astron 2015f). The Proponent requires personnel to comply with strict guidelines regarding cave entry for safety reasons as well as protection of heritage and environmental values. The Proponent will continue to apply these guidelines. Disturbance to Ghost Bats resulting from human visitation to caves is, therefore, unlikely to result in any changes to the Ghost Bat population in the Proposed Change Area. Given the low geotechnical sensitivity to roost structural instability; the ongoing presence of Ghost Bats at the Poondano site and presence in previously mined areas in Middle Robe (Bat Call 2017b); the proposed blast and human visitation management measures; noise and vibration from the Proposed Change are unlikely to lead to a long-term decrease in the size of the Ghost Bat population. **Physical presence of infrastructure** Fencing and other infrastructure are unlikely to lead to a long-term decrease is the size of the Ghost Bat population. Ghost Bats have the potential to collide with barbed wire fencing. The proponent has recorded a single incident of collision where a Ghost Bat was entangled in a cattle fence. The Proponent will install non-barbed wire fencing, except where legislated. Where barbed wire fencing is required for legislative compliance, reflectors will be attached to make fencing more visible and to reduce the risk of Ghost Bat injury or mortality due to entanglement with fencing. This approach has been applied elsewhere in the Pilbara and appears to be effective. **Vehicle movements** Vehicle movements for the Proposed Change are unlikely to result in a long-term decrease in the Ghost Bat population. Ghost Bats are known to be able to fly low, resulting in potential for collisions with vehicles. However, vehicle movements at night (when Ghost Bats are most active) are greatly reduced compared with daytime vehicle movements and are generally limited to in-pit operations. There have been no recorded incidents of vehicle collision with Ghost Bats.
Potential to reduce the area of occupancy of an important population	**Clearing** The Proposed Change is unlikely to reduce the area of occupancy of the species. The Proposed Change will retain the most important habitat for Ghost Bat including the two recorded diurnal/potential maternal roosts and all nocturnal roosts. The proposed mesa escarpment cut and associated haul road were moved early in the design process to avoid impact to both the diurnal roost and two nearby nocturnal roosts; with the proposed haul road location now approximately 500 m to the north of the diurnal roost. Therefore, the species is likely to continue to occupy habitat within the Proposed Change Area.

Significant impact criteria	Assessment of impacts to Ghost Bat
	Noise and vibration Noise and vibration emissions are unlikely to reduce the area of occupancy of an important population. Noise impacts may cause individuals to flee roosts during mining operation due to blasting; however, this potential has been minimised through implementation of the MEZ. Numerous other roosts are available throughout the Robe Valley if temporary relocation occurs. This impact is considered unlikely based on historical evidence including the continued presence of Ghost Bats at the Poondano mine site; the presence of scats from a shelter and under a breakaway at active operations at Mesa A at Mesa J respectively and re-use of roosts in previously mined areas of East Deepdale / Middle Robe of the Robe Valley (Bat Call 2017a). The initial mining undertaken in the Robe Valley did not specifically prioritise retention of the mesa escarpments. The proportion of escarpment remaining on each of the 14 historically mined mesas varies between 0% and over 90% but is generally less than 50% (Bat Call 2017a). Nine of the ten mesas with partial escarpment retention were assessed for Ghost Bat activity. Evidence of Ghost Bat usage was found on six of these mesas demonstrating that retained escarpments continue to offer roosting opportunities for the Ghost Bat (Bat Call 2017a). Evidence of current Ghost Bat presence on historically mined mesas in the Robe Valley indicates that Ghost Bats either continued to use the roosts during mining operations or returned to the area after completion of mining. Ghost Bat roosts are present throughout the Robe Valley. A contextual field survey (Astron 2017d) recorded the following roosts/potential roosts in the Robe Valley (excluding those in the Proposed Change Area): • Three maternal / potential maternal roosts (one confirmed, two potential), including a maternity roost at Mesa F approximately 20 km to the east-south-east of the Proposed Change • Four diurnal / potential diurnal roosts (three confirmed, one potential) • 26 confirmed nocturnal roosts (total only from this study; other nocturnal roosts have been and continue to be recorded in the Robe Valley). Field observations of Ghost Bats and hormone analysis in the east Pilbara suggest that maternity groups may use different maternity roosts across different seasons and the concept of a centralised maternity roost may not be applicable in the Pilbara region (Biologic 2016). Vibrations associated with blasting have the potential to result in damage to or collapse of the caves and shelters in the mesa escarpments which has the potential to reduce the area of occupancy of the Ghost Bat. A geotechnical assessment of the caves that form the potential diurnal / maternal Ghost Bat roosts determined that the geotechnical sensitivity of these roosts to structural instability is low (Rio Tinto 2017g). In addition, the Proponent will implement a Blast Management Framework to limit vibration emissions to potential maternity roosts as described in Section 8.9 and 8.6.3.2. Given impacts from noise and vibration will be reduced by the buffer provided by the MEZ; evidence that Ghost Bats either continue to be present during mining operations or return to roosts after mining; availability of other roosts in the Robe Valley and evidence that Ghost Bats may use different maternity roosts across seasons, it is considered that the Proposed Change is unlikely to result in a long-term reduction in the area of occupancy of the Ghost Bat. **Dust and light** Dust emissions are unlikely to reduce the area of occupancy of Ghost Bat. While dust has the potential to impact the quality of Ghost Bat foraging habitat and can impact eyesight of individuals (TSSC 2016a), natural protection is afforded to Ghost Bat roots from the orientation away from mine operations. The proposed mesa escarpment cut and associated haul road were moved early

Significant impact criteria	Assessment of impacts to Ghost Bat
	in the design process with the proposed location now approximately 500 m to the north of the diurnal roost which will reduce potential dust impacts. Light emissions are unlikely to reduce the area of occupancy of Ghost Bat. Temporary lighting will predominantly be installed in active mine areas facing inwards towards the mine pits. Lighting may influence nocturnal foraging behaviour as lights may attract invertebrates which are a food source, however, light spill is currently present from the adjacent Mesa J Iron Ore Development and additional light spill from the Proposed Change is not expected to have an adverse impact on the occupancy area of the Ghost Bat population. The ongoing presence of Ghost Bats at the Poondano mine site despite mining operations (Astron 2015f) indicate that integral habitat values were preserved (Astron 2015f), enabling persistence at the site.
Potential to fragment an existing important population into two or more populations	**Clearing** It is unlikely the proposed disturbance will fragment the existing Ghost Bat population. As described above, the recorded diurnal/ potential maternal roosts and nocturnal roosts have been avoided and only a small proportion of foraging habitat will be impacted. Clearing and infrastructure for the Proposed Change and other potential impacts will not create physical barriers to the movement of Ghost Bats and will maintain habitat connectivity. It is therefore unlikely to fragment the local Ghost Bat population.
Potential to adversely affect habitat critical to the survival of the species	**Clearing** It is unlikely the Proposed Change will adversely affect habitat critical to the survival of the species, to the extent the species will decline at the local or regional scale. There is currently no definition of 'habitat critical to the survival of the species' for Ghost Bat; however, the approved conservation advice for Ghost Bat (TSSC 2016a) identifies protection of roost sites as the highest priority conservation management action. It is suggested that Ghost Bats require an 'apartment block' of roosting opportunities (Bat Call 2017a), including at least one deep cave with characteristics of a maternity roost, multiple caves/shelters and overhangs in close proximity offering nocturnal and refuge opportunities. In addition, these roost locations often need to be located within a productive set of gullies and gorges locally within a productive foraging area within 5 - 10 km radius and good quality riparian areas nearby (Bat Call 2017a). This range of habitats and values will be retained within the Proposed Change Area. Ghost Bat have been recorded using other caves in the Robe Valley (Biota 2011b; Astron 2017d), demonstrating the species is not restricted to the habitat within the Proposed Change Area. A contextual study of Ghost Bat habitat in areas west of Mesa H through to Mesa A (Astron 2017d), found 26 nocturnal feeding roosts, four diurnal roosts, two potential maternal roosts. Both potential maternal roosts are large complexes on the southward facing gorge systems, outside of the Proposed Change Area. Furthermore, 20 of the 34 mesas on the robe River system have recent Ghost Bat records, 18 of which have not been mined but a number have had skeletal exploratory drilling. Twelve out of the 18 unmined mesas have evidence of Ghost Bat activity (Bat Call 2017a). The Proposed Change will retain the two recorded diurnal / potential roosts and all nocturnal roosts, and will directly impact up to 24 ha of River habitat which provides foraging and dispersal habitat. All other potential impacts are unlikely to affect habitat critical to the survival of the species.

Significant impact criteria	Assessment of impacts to Ghost Bat
Potential to disrupt the breeding cycle of an important population	**Clearing** Given the Proposed Change will retain the two recorded diurnal/potential maternity roosts, the Proposed Change is unlikely to disrupt the breeding cycle of an important population. **Noise and vibration** Noise and vibration related impacts have the potential to cause Ghost Bats to flee roosts during mine operation, which could potentially disrupt the breeding cycle of the local population. In addition to the Poondano example, there is also evidence to suggest that maternity groups may use different maternity roosts across different seasons (Biologic 2016). As there are other roosts present in the vicinity of the Development Envelope (including the maternity roost at Mesa F, approximately 20 km from the Proposed Change Area), it may be possible for Ghost Bats to utilise an alternative roost. The potential to disturb roosting Ghost Bats will be reduced by the buffer zone between the mine pit and the mesa escarpment that will be created by the delineation of the MEZ and by the aspect of the roost habitat (facing away from the mining area). Vibrations associated with blasting have the potential to disrupt the breeding cycle of Ghost Bats through loss of or damage to the caves and shelters in the mesa escarpments. A geotechnical assessment of the caves that form the potential diurnal / maternal Ghost Bat roosts determined that the geotechnical sensitivity of these roosts to structural instability is low (Rio Tinto 2017g). In addition, the Proponent will implement a Blast Management Framework to limit vibration emissions to potential maternity roosts as described in Section 8.9 and 8.6.3.2. All other potential impacts are unlikely to disrupt the breeding cycle of the species.
Potential to modify, destroy, remove isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	It is unlikely the direct or indirect impacts associated with the Proposed Change will lead to a decline of Ghost Bat. The proposed habitat loss is not expected to affect the survival of the species locally or regionally. The most significant habitat features for this species will be avoided and protected through appropriate mitigation measures including the delineation of a MEZ and blast management measures. Therefore, none of the potential impacts are likely to result in a significant impact to the availability or quality of habitat for this species.
Potential to result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat	The Cane Toad is a known threat to the Ghost Bat as Ghost Bats may prey on Cane Toads. Cane Toads are not currently established in the Pilbara, and the Proposed Change is unlikely to increase the opportunity for Cane Toads to become established. Cane Toads absorb water through their skin from dew or any moist material and need constant access to moisture to survive. A number of semi-permanent and permanent pools are present within the Proposed Change Area and at a number of locations both upstream and downstream of the Proposed Change along the Robe River. It is therefore considered that there is currently sufficient water continuously available in the Robe River to enable establishment of the Cane Toad in the Robe Valley should it spread to the Pilbara. The Proponent will implement quarantine and hygiene controls to prevent the inadvertent introduction of Cane Toads. The Proposed Change is not considered to further increase the risk of the Cane Toad becoming established in the area. The feral cat also poses an existing threat to the species. The Proposed Change is not expected to increase the potential presence of feral cats in the Development Envelope as the Proponent will continue to implement feral fauna control in areas in which it operates.

Significant impact criteria	Assessment of impacts to Ghost Bat
Potential to introduce disease that may cause the species to decline	The Proposed Change will not introduce disease that may cause the species to decline.
Potential to interfere with the recovery of the species	Given the Proposed Change will retain the known diurnal/maternal roosts and all nocturnal roosts and implementation of management measures including MEZ and blast management measures to protect the structural integrity of roosts and prevent disturbance, the Proposed Change is considered unlikely to interfere with the recovery of the species.

Table 12-9: Assessment Against the Significant Impact Criteria for the Pilbara Leaf-nosed Bat

Significant impact criteria	Assessment
Potential to lead to a long-term decrease in the size of an important population of a species	The approved conservation advice (TSSC 2016b) for the Pilbara Leaf-nosed Bat defines critical habitat as including permanent and transitory diurnal and breeding roosts, and identifies priority foraging habitat as gorges with pools, gullies, rocky outcrops, major watercourses and grassland and woodland. No roosts will be impacted. **Clearing** No diurnal, breeding or nocturnal roosts for the Pilbara Leaf-nosed Bat have been recorded in the Proposed Change Area. The Proposed Change will impact only a small proportion of foraging habitat and there are no recorded Pilbara Leaf-nosed Bat roosts in the Proposed Change Area. It is unlikely the proposed clearing will lead to a long-term decrease in the size of the Pilbara Leaf-nosed Bat population. The population of this species which occurs in the Pilbara and upper Gascoyne is considered to be one interbreeding biological population of genetic divergence which is of national significance (TSSC 2016b). The individuals recorded at the entrance to a gorge south of the Proposed Change Area are part of this population; and likely originate from a yet to be discovered roost south or east of the Proposed Change Area (Bat Call 2017). Ongoing monitoring by Rio Tinto from 2015 to 2017 has not identified a Pilbara Leaf-nosed Bat roost at Mesa A, B, C, D, E, F or H (Rio Tinto 2017c). The Proposed Change will not lead to a decrease in the size of the population. No roosts will be directly impacted by the Proposed Change. Clearing will directly impact up to 24 ha of foraging and dispersal habitat, including River habitat, which represents approximately 0.3% of the mapped extent of River habitat (7,994 ha) in the Robe Valley. The predicted impacts of this Proposed Change will add to the impacts of the Mesa J Iron Ore Development and the Mesa A Hub Revised Proposal, which will impact foraging habitat only. The presence of Pilbara Leaf-nosed Bat in the Development Envelope confirms the area has foraging and dispersal habitat value. However, as the nearest roost is 10 km to the south-east of the Proposed Change Area, the potential foraging habitat within the Proposed Change Area, although utilised by the bats, is not considered important to the preservation of the population. Cumulatively, it is not expected that the Revised Proposal will lead to a long-term decrease in the size of the Pilbara Leaf-nosed Bat population locally or regionally. **Groundwater abstraction** Potential impacts to Pilbara Leaf-nosed Bat foraging habitat from groundwater abstraction are unlikely to lead to a long-term decrease in the size of the foraging population. Groundwater abstraction may result in minor reduction in surface water levels of permanent and semi-permanent pools of the Robe River. River habitat with pools are priority foraging habitat for this species and they are often found over large watercourses and pools. It is likely that pools attract prey which support foraging of the species. Groundwater abstraction for pit dewatering will result in localised drawdown in the Mesa H CID aquifer that has some connectivity to the Robe River alluvial aquifer. The potential for reduction in water levels in the Robe River alluvial aquifer by up to 1 m may decrease the extent of semi-permanent pools and reduce their persistence during times of drought. As the size of the pools contract and understorey wetland vegetation cover reduces during dry periods, these habitat values will be reduced more quickly due to groundwater abstraction. The impacts will be seasonal and within the range of natural variation levels already experienced. On this basis, the impacts may reduce but are unlikely to significantly impact the abundance of prey. In the event that surface water levels in pools of the Robe River reduce more than the predicted range as a result of

Significant impact criteria	Assessment
	mine dewatering from the Proposed Change, these will be mitigated with an adaptive management approach that may include discharge of surplus abstracted groundwater from Mesa H dewatering directly into permanent pools; or avoidance of BWT mining below the 120 m RL in the pit closest to the Robe River in order to avoid or mitigate the impact. Groundwater abstraction in the Southern Cutback Borefield for water supply will remain within existing licence limits for the Mesa J Iron Ore Development and is unlikely to significantly increase impacts under Jimmawurrada Creek. The cumulative impacts of abstraction may result in reduced canopy cover within a 6.5 km section of the creek. A portion of the foraging habitat on Jimmawurrada Creek ('Zone 3') is likely to be subject to the temporary groundwater drawdown of up to 9 m which is likely to result in temporary impacts including canopy decline and increased tree mortality. Functioning foraging habitat for Pilbara Leaf-nosed Bats is expected to be maintained due to the temporary nature of the impacts. The portions of this zone which lay within the south-eastern corner of the Proposed Change Area and continue outside of the Development Envelope to the south-east fall within 10 km of the nearest roost. The 10 km radius around the known roost covers an area of 31,416 ha, and within this, 'Zone 3' of Jimmawurrada Creek occupies 1.02% (319 ha). Therefore, the temporary impacts expected to this portion of the habitat within 10 km of the known roost will affect a small proportion of the total foraging habitat available within the radius. No permanent or semi-permanent pools occur along Jimmawurrada Creek so changes in the surface water regime will be limited to potential decreased persistence of ephemeral pools following rainfall. These changes are unlikely to significantly affect foraging habitat for Pilbara Leaf-nosed Bats. **Discharge of surplus water** Potential impacts to Pilbara Leaf-nosed Bat foraging and dispersal habitat from proposed discharge of surplus water are unlikely to lead to a long-term decrease in the size of the Pilbara Leaf-nosed Bat population. Similar to the existing Mesa J Iron Ore Development, continued periodic discharge of surplus water for the Proposed Change may lead to an increase in utilisation of the area by Pilbara Leaf-nosed Bat for foraging and dispersal for the duration of discharge. Following cessation of discharge, Jimmawurrada Creek and the Robe River will return to the natural ephemeral flow regime, thus there is unlikely to be any long-term impact on Pilbara Leaf-nosed Bat foraging and dispersal behaviour. **Noise and vibration** Noise and vibration from mining operations are unlikely to lead to a long-term decrease in the size of the Pilbara Leaf-nosed Bat population. The most significant noise and vibration from the proposed mining operation will occur during the day from blasting activities. Given that no Pilbara Leaf-nosed Bat roosts have been recorded in the Proposed Change Area, and that the species forages at night, noise and vibration from the Proposed Change are unlikely to impact the population. In addition, there are currently four Pilbara Leaf-nosed Bat permanent roost caves in reasonably close proximity to active large scale open cut mining operations where monitoring has confirmed the persistence of the species despite operation of the mines; all four caves have remained viable diurnal roosts for the species and remain maternity roost candidates (B. Bullen,Bat Call WA, pers. Comm. 2019). **Dust and light** Dust is unlikely to significantly affect the quality of foraging habitat or cause a decline in the size of the Pilbara Leaf-nosed Bat population, given that dust emissions will occur in only a small proportion of the available foraging habitat. Lighting for the Proposed Change is unlikely to affect the quality of foraging habitat or cause a decline in the size of the Pilbara Leaf-nosed Bats population. Pilbara Leaf-nosed Bats are known to be attracted to light. Lighting will be directed into the pit. Light may alter nocturnal foraging behaviour; however, the area impacted will be small compared with the available extent of foraging habitat. **Physical presence of infrastructure**

Significant impact criteria	Assessment
	Pilbara Leaf-nosed Bats may collide with barbed wire fencing. The Proposed Change will utilise existing infrastructure at the adjacent Mesa J Iron Ore Development where possible. Additional key infrastructure for the Proposed Change will be primarily installed in the Plains habitat which provides only limited foraging and dispersal habitat for the Pilbara Leaf-nosed Bat. No new major infrastructure will be installed in the Robe River (with the exception of an access road widening and potentially monitoring bores), which provides key foraging habitat for the Pilbara Leaf-nosed Bat. The Proponent will install non-barbed wire fencing, except where legislated. Where barbed wire fencing is required for legislative compliance, reflectors will be attached to make fencing more visible and to reduce the risk of fauna injury or mortality due to entanglement with fencing. This approach has been applied elsewhere in the Pilbara and appears to be effective. **Vehicle movements** Vehicle movements for the Proposed Change are unlikely to result in a long-term decrease in the Pilbara Leaf-nosed Bat population. Pilbara Leaf-nosed Bats are known to be attracted to light and fly low, resulting in the potential for vehicle collisions. However, vehicle movements at night (when Pilbara Leaf-nosed Bats are most active foraging) are greatly reduced compared with daytime vehicle movements and are generally limited to in-pit operations. There have been no recorded incidents of vehicle collisions with Pilbara Leaf-nosed Bats.
Potential to reduce the area of occupancy of an important population	The area of occupancy of the Pilbara Leaf-nosed Bat is limited by the availability of suitable diurnal roosts (TSSC 2016b). No diurnal roosts have been recorded in the Proposed Change Area and individuals recorded in the Proposed Change Area are considered likely to originate from a roost remote from the Development Envelope. **Clearing** It is unlikely the proposed clearing will reduce the area of occupancy of the Pilbara Leaf-nosed Bat. The Proposed Change has been designed to avoid the highest value habitat and the disturbance will only impact a small proportion of the available foraging habitat for the species. In addition, as the nearest roost is 10 km to the south-east of the Proposed Change Area, the potential foraging habitat within the Proposed Change Area, although utilised by the bats, is not considered important to the preservation of the population. **Groundwater abstraction** Potential impacts to Pilbara Leaf-nosed Bat foraging and dispersal habitat from groundwater abstraction are unlikely to reduce the area of occupancy of the species. As described above, impacts to pools and reduced canopy cover may affect foraging habitat along Jimmawurrada Creek outside the Development Envelope temporarily. **Discharge of surplus water** Potential impacts to Pilbara Leaf-nosed Bat foraging and dispersal habitat from discharge of surplus water are unlikely to reduce the area of occupancy of the Pilbara Leaf-nosed Bat. A small proportion of the mapped foraging and dispersal habitat will be periodically impacted as it currently is from the existing Mesa J Iron Ore Development. The increased availability of water in Jimmawurrada Creek and the Robe River during the period of discharge has the potential to extend the foraging range of the Pilbara Leaf-nosed Bat. Jimmawurrada Creek and the Robe River will return to an ephemeral system following cessation of discharge. **Noise and vibration** Noise and vibration impacts from mining operations are unlikely to reduce the area of occupancy of the Pilbara Leaf-nosed Bat. No Pilbara Leaf-nosed Bat roosts have been recorded in the Proposed Change Area. Given noise and vibration will predominantly occur during the day, it is unlikely to impact nocturnal foraging behaviour. **Dust and light**

Significant impact criteria	Assessment
	Dust and light emission are unlikely to reduce the area of occupancy of the species. No Pilbara Leaf-nosed Bat roosts have been recorded in the Proposed Change Area. Based on dust monitoring to date for the existing Mesa J Iron Ore Development, any decline in the quality of foraging habitat is likely to be limited to the area immediately adjacent to the proposed mining operation. Light emissions may alter nocturnal foraging in some areas, similar to light emissions already present in the Mesa J Iron Ore Development area. The light spill would affect a small proportion of the Pilbara Leaf-nosed Bat foraging habitat; however, this is not expected to reduce the area of occupancy.
Potential to fragment an existing important population into two or more populations	**Clearing** The proposed disturbance is unlikely to fragment a population, given that no roosts have been recorded in the Proposed Change Area. The Proposed Change will not create physical barriers to movement and therefore will not fragment the existing population in the vicinity of the Development Envelope. All other potential impacts are unlikely to fragment the Pilbara Leaf-nosed Bat population.
Potential to adversely affect habitat critical to the survival of the species	**Clearing** While the Proposed Change is unlikely to impact on habitat critical to the survival of the species, given that no diurnal roosts have been identified in the Proposed Change Area, and only a small portion of available foraging habitat will be impacted, it is unlikely that the Proposed Change will significantly impact the survival of the species. All other potential impacts are unlikely to disrupt the breeding cycle of the Pilbara Leaf-nosed Bat population.
Potential to disrupt the breeding cycle of an important population	**Clearing** No Pilbara Leaf-nosed Bat diurnal or breeding roosts have been recorded in the Proposed Change Area. In addition, ongoing monitoring of Pilbara Leaf-nosed Bat across mesas in the Robe Valley confirmed that the source roost is not located at Mesa A, B, C, D, E F or H (Rio Tinto 2017c). It is likely the species utilises suitable habitat in the Proposed Change Area for foraging only, and it is >10 km from the nearest known roost so is not considered important to the preservation of the population. The Proposed Change will therefore not impact the breeding cycle of an important population.
Potential to modify, destroy, remove isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?	It is unlikely the Proposed Change will lead to decline of the Pilbara Leaf-nosed Bat. No roosts will be affected and only a small proportion of foraging habitat >10 km from the nearest known roost will be impacted. None of the potential direct or indirect impacts are likely to result in a significant impact to the availability or quality of the foraging habitat for this species. The proposed habitat loss is therefore not expected to affect the survival of the species locally or regionally.
Potential for the establishment of invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat	The TSSC (2016b) notes that the Pilbara Leaf-nosed Bat has been exposed to the degradation and modification of natural habitats caused by introduced species such as invasive weeds, domestic herbivores and other larger feral ungulates since the arrival of Europeans, however these invasive species are unlikely to have a significant effect overall. The Proposed Change will not introduce invasive species that are harmful to the Pilbara Leaf-nosed Bat.
Potential to introduce disease that may cause the species to decline	There are no known diseases threatening the Pilbara Leaf-nosed Bat (TSSC 2016). The Proposed Change will not introduce disease that may cause the species to decline.

Significant impact criteria	Assessment
Potential to interfere with the recovery of the species	The primary objective for preventing the decline of the Pilbara Leaf-nosed Bat is to protect known and suspected diurnal roost sites and to avoid activities within close proximity to these roosts that could cause roost abandonment and fatalities of individuals (TSSC 2016b). Given that the Proposed Change will not impact any known or suspected Pilbara Leaf-nosed Bat roosts and that proposed disturbance will impact only a small proportion of available foraging habitat >10 km from the nearest known roost site, the Proposed Change is unlikely to interfere with the recovery of the Pilbara Leaf-nosed Bat.

Table 12-10: Assessment Against the Significant of Impact Criteria for the Pilbara Olive Python

Significant impact criteria	Assessment of impacts to Pilbara Olive Python
Potential to lead to a long-term decrease in the size of an important population of a species	There are currently no defined criteria for habitat critical for the survival of the Pilbara Olive Python, or identified important populations. The approved conservation advice for the Pilbara Olive Python describes preferred habitat for the Pilbara Olive Python as including deep gorges and water holes (DEWHA 2008b), however notes that estimating population size for the Pilbara Olive Python is difficult due to the cryptic nature of the species, lack of reliable trapping methods or census techniques and the narrow range of reliable surveys (DEWHA 2008b). The most significant habitat in the Proposed Change Area for the species are the Breakaways and Gullies habitat, particularly the area in close proximity to the Robe River. **Clearing** It is unlikely the proposed clearing will lead to a long-term decrease in the size of the Pilbara Olive Python population. The Proposed Change has been designed to avoid the highest value denning habitat, contained in the mesa escarpments. Specifically, the Proposed Change will directly impact less than 4% of suitable denning habitat (Breakaways and Gullies habitat) and approximately 3% of suitable hunting, foraging and dispersal habitat (River habitat) in the Proposed Change Area. A MEZ will be established around the periphery of the mesa to protect fauna and habitat values supported by the mesa escarpment (Figure 12-11). The Proposed Change will utilise existing infrastructure at the Mesa J Iron Ore Development where possible. Additional key infrastructure for the Proposed Change will be primarily installed in the Plains habitat which provides only limited foraging and dispersal habitat for the Pilbara Olive Python. Cumulatively, this Proposed Change will add to footprint of the existing Mesa J Iron Ore Development together with the Mesa A Hub Revised Proposal and will result in the direct impact to 24 ha of foraging habitat comprising River habitat, and limited loss of potential denning habitat. On this basis, it is expected that the Revised Proposal will not contribute significant additional impacts to the Pilbara Olive Python which may cause a long-term decrease in the size of the population. **Groundwater abstraction** Groundwater abstraction is unlikely to lead to a long-term decrease in the size of the Pilbara Olive Python population. Groundwater abstraction for pit dewatering will result in localised groundwater drawdown in the Mesa H CID aquifer that has some connectivity to the Robe River alluvial aquifer. There is some uncertainty regarding the level of hydraulic connection between the alluvial aquifer and the CID aquifer and therefore the modelling and this impact assessment has been based on a worst-case scenario assuming that there is a level of hydraulic connection and that the basement underlying the alluvial aquifer has some degree of permeability. Under this scenario, the modelling indicates the potential for a reduction in water levels in the Robe River alluvial aquifer and the Robe River semi-permanent and permanent pools may be up to a maximum of 1 m. This is not anticipated to change the permanent or semi-permanent nature of any of the pools or change riparian vegetation which provides fauna habitat, as the water will still be accessible to root systems. Monitoring in the Robe River alluvial aquifer has shown natural water level variation of up to 3 m. This drawdown could result in shallow (<0.8 m) seasonal and semi-permanent pools drying out more quickly during prolonged periods of drought. The permanent pool at Yeera Bluff in the section of the Robe River adjacent to Mesa H is approximately 3-4 m deep. This pool will continue to be permanent but may have lower levels during dry periods. The key impact on Pilbara Olive Python habitat will be a small reduction in the length of time semi-permanent pools exist after rainfall and a potential reduction in riparian vegetation canopy cover during drought conditions. The temporary habitat values that these semi-permanent pools provide include drinking water, associated foraging habitat (both vegetation and prey

Significant impact criteria	Assessment of impacts to Pilbara Olive Python
	availability) and shelter. As the size of the pools contract and understorey wetland vegetation cover reduces during dry periods, these habitat values will be reduced more quickly due to groundwater abstraction, however will be fully replenished during large rainfall events. The majority of the water in the alluvial aquifer (~90%) comes from streamflow recharge and throughflow from upstream within the alluvial aquifer. Therefore, the potential for any drawdown is limited to dry conditions. Monitoring in the Robe River alluvial aquifer has shown natural water level variation of up to 3 m. The EWRs for the Robe River (DoW 2012) were developed using an approach that allows for the highly variable water conditions experienced in the Pilbara. The EWRs for drought conditions in the Robe River are to maintain phreatophytic vegetation and permanent pools as refuges for fauna. These EWRs and their significance for Pilbara Olive Python in maintenance of foraging habitat are expected to be met during implementation of the Proposed Change. In the event that surface water levels in pools of the Robe River reduce more than the predicted range as a result of mine dewatering from the Proposed Change, these will be mitigated with an adaptive management approach that may include discharge of surplus abstracted groundwater from Mesa H dewatering directly into permanent pools; or avoidance of BWT mining below 120 m RL in the pit closest to the Robe River in order to avoid or mitigate the impact. Groundwater abstraction in the Southern Cutback Borefield for water supply will remain within existing licence limits for the Mesa J Iron Ore Development. Mesa H will utilise some water from this Borefield for wet processing when dewatering is not sufficient. The cumulative impacts of the existing Mesa J Iron Ore Development dewatering, Mesa H water supply and the adjacent CWSP abstraction will extend the depth and extent of groundwater drawdown below Jimmawurrada Creek and the timeframe to groundwater recovery within a 12 km section of the creek. Substantial drawdowns are expected within the 6.5 km stretch where drawdowns of up to 9 m (14 mbgl) may occur from the cumulative effects of Mesa H, Mesa J and the Coastal Water Supply. This impact may be exacerbated taking into consideration an extended dry period combined with seasonal water table lows. No permanent or semi-permanent pools occur along Jimmawurrada Creek so changes in the surface water regime will be limited to potential decreased persistence of ephemeral pools following rainfall. Any potential changes to pools in the Robe River or vegetation along Jimmawurrada Creek are not expected to significantly impact Pilbara Olive Python habitat. **Discharge of surplus water** Discharge of surplus groundwater into tributaries of the ephemeral Robe River; Jimmawurrada Creek and / or West Creek will be periodic and predominantly required during the wet season to manage water volumes which exceed on-site storage capacity. The abstracted groundwater quality is fresh and the resultant discharge will likely result in formation of temporary pools, rather than continuous flow, across the discharge extent of up to 8 km from the discharge outlets, similar to the current footprint for the existing Mesa J Iron Ore Development. It may result in a temporary increase in utilisation of the area by Pilbara Olive Python for foraging and dispersal, for the duration of discharge. Given the temporary nature of the discharge to a system that is adapted to highly variable flow conditions, it is unlikely to be any long-term impact on the Pilbara Olive Python foraging and dispersal behaviour. Following cessation of discharge, Jimmawurrada Creek and the Robe River will return to the natural ephemeral flow regime. **Vehicle movements** The species may be impacted by vehicle strike, causing injury or mortality to individuals. The Pilbara Olive Python is almost entirely nocturnal; vehicle movements at night are greatly reduced than during the day and are generally limited to in-pit operations. Whilst individuals may be impacted, vehicle movements for the Proposed Change are unlikely to result in a long-term decrease in the Pilbara Olive Python population.

Significant impact criteria	Assessment of impacts to Pilbara Olive Python
Potential to reduce the area of occupancy of an important population	**Clearing** It is unlikely the proposed disturbance will reduce the area of occupancy of the Pilbara Olive Python. The Proposed Change will retain the majority of the mesa escarpments and gullies, including the Breakaway habitat, except where minor cuts are required to allow access to the mesas. Cuts will be positioned in low value habitat and are unlikely to impact denning habitat. **Groundwater abstraction** It is unlikely that groundwater abstraction will reduce the area of occupancy of a population. Groundwater abstraction to enable BWT mining may result in minor reduction in surface water levels in permanent and semi-permanent pools of the Robe River. The reduction is predicted to be within the normal range of seasonal variation. As described above, impacts to pools and reduced canopy cover may affect foraging habitat during extended dry periods. **Discharge of surplus water** It is unlikely that discharge of surplus water will reduce the area of occupancy of a population. As described above, discharge may temporarily increase the residency time of surface waters which is not expected to adversely impact the species. **Noise and Vibration** It is unlikely that noise and vibration emissions will reduce the area of occupancy of the Pilbara Olive Python. While the species relies on ground vibrations to detect prey and avoid predators, noise and vibration emission from blasting will be intermittent, lasting for between two and ten seconds at a time. The brief and sporadic nature of blasts is unlikely to reduce the area of occupancy.
Potential to fragment an existing important population into two or more populations	**Clearing** The Proposed Change has been designed to limit clearing to shelter and breeding habitat for the Pilbara Olive Python and it is unlikely the limited clearing of potential denning and hunting habitat will fragment an existing important population of the species. The installation of mine infrastructure has been reduced to utilise existing infrastructure of the Mesa J Iron Ore Development were possible and is unlikely to create physical barriers to movement. All other potential impacts are unlikely to fragment the Pilbara Olive Python population.
Potential to adversely affect habitat critical to the survival of the species	There are currently no defined criteria for habitat critical for the survival of the Pilbara Olive Python. The approved conservation advice for the Pilbara Olive Python describes preferred habitat for the Pilbara Olive Python as including deep gorges and water holes. **Clearing** The Proposed Change has been designed to avoid the highest value denning habitat, contained in the mesa escarpments. Specifically, the Proposed Change will directly impact less than 4% of suitable denning habitat (Breakaways and Gullies habitat) and approximately 3% of suitable hunting, foraging and dispersal habitat (River habitat) in the Proposed Change Area. A MEZ will be established around the periphery of the mesa to protect fauna and habitat values supported by the mesa escarpment (Figure 12-11). The Proposed Change will utilise existing infrastructure at the Mesa J Iron Ore Development where possible. Additional key infrastructure for the Proposed Change will be primarily installed in the Plains habitat which provides only limited foraging and dispersal habitat for the Pilbara Olive Python. **Groundwater drawdown**

Significant impact criteria	Assessment of impacts to Pilbara Olive Python
	Groundwater abstraction for pit dewatering will result in localised groundwater drawdown in the Mesa H CID aquifer that has some connectivity to the Robe River alluvial aquifer. Modelling indicates the potential for a reduction in water levels in the Robe River alluvial aquifer and the Robe River semi-permanent and permanent pools may be up to a maximum of 1 m. Monitoring in the Robe River alluvial aquifer has shown natural water level variation of up to 3 m. This drawdown could result in shallow (<0.8 m) seasonal and semi-permanent pools drying out more quickly during prolonged periods of drought. The permanent pool at Yeera Bluff in the section of the Robe River adjacent to Mesa H is approximately 3-4 m deep. This pool will continue to be permanent but may have lower levels during dry periods. The key impact on Pilbara Olive Python habitat will be a small reduction in the length of time semi-permanent pools exist after rainfall and a potential reduction in riparian vegetation canopy cover during drought conditions. All other potential impacts are unlikely to adversely affect habitat critical to survival of the species.
Potential to disrupt the breeding cycle of an important population	**Clearing** Given the Proposed Change has been designed to avoid the highest value habitat in the mesa escarpments and that disturbance will impact only a small proportion of the available denning habitat, it is unlikely the Proposed Change will disrupt the breeding cycle of a Pilbara Olive Python population. All other potential impacts are unlikely to disrupt the breeding cycle of the species.
Potential to modify, destroy, remove isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	It is unlikely the Proposed Change will lead to decline of the Pilbara Olive Python. None of the potential direct or indirect impacts are likely to result in a significant impact to the availability or quality of the habitat for this species. The proposed habitat loss is not expected to affect the survival of the species locally or regionally and no other threatening processes for this species are expected to be exacerbated by the Proposed Change (e.g. feral predation and fire events). Groundwater drawdown may reduce the water levels of permanent and semi-permanent pools by up to 1 m, which will reduce the persistence of semi-permanent pools during drought conditions. This potential drawdown is within the natural variability of the groundwater levels. On this basis, the Proposed Change is unlikely to affect the availability of habitat to the extent that the species is likely to decline.
Potential to result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat	The Cane Toad poses a threat to the Pilbara Olive Python as the Pilbara Olive Python may prey on Cane Toad. Cane Toads are not currently established in the Pilbara, and the Proposed Change is unlikely to increase the opportunity for Cane Toads to become established. Cane Toads need constant access to moisture to survive. A number of semi-permanent and permanent pools are present within the Proposed Change Area and at a number of locations both upstream and downstream of the Proposed Change along the Robe River. It is therefore considered that there is currently sufficient water continuously available in the Robe River to enable establishment of the Cane Toad in the Robe Valley should it spread to the Pilbara. The Proponent will implement quarantine and hygiene controls to prevent the inadvertent introduction of Cane Toads. The Proposed Change is not considered to further increase the risk of the Cane Toad becoming established in the area. The feral cat is also a threat to the species, due to direct predation (particularly of juveniles), as well as predation of prey items such as the Northern Quoll (DEWHA 2008b). The Proponent will continue to implement feral fauna control in areas where it operates.
Potential to introduce disease that may cause the species to decline	The Proposed Change is unlikely to introduce disease that may cause the species to decline.

Significant impact criteria	Assessment of impacts to Pilbara Olive Python
Potential to interfere with the recovery of the species	Given the proposed disturbance will impact only a small proportion of the available Pilbara Olive Python habitat, and the Proposed Change has been designed to avoid the highest value denning habitat, the Proposed Change is unlikely to interfere with the recovery of the Pilbara Olive Python.

Table 12-11: Assessment of Significance of Impacts to Blind Cave Eel

<table>
<tr><th>Significant impact criteria</th><th>Assessment of impacts to Blind Cave Eel</th></tr>
<tr><td>Potential to lead to a long-term decrease in the size of an important population of a species</td><td>Groundwater abstraction
It is unlikely the Proposed Change will lead to a long-term decrease in the size of the Blind Cave Eel population.
The alluvial aquifers overlying the CID formation in Jimmawurrada Creek contain known habitat for the Blind Cave Eel. Jimmawurrada Creek forms an upstream tributary which intersects the Robe River to the east of the Proposed Change Area and is the downstream extent of Bungaroo Creek. These creek systems are interconnected and provide a potential dispersal route for the Blind Cave Eel.
The Proposed Change will retain the alluvial aquifer habitat and flow paths of the creeks; however, may result in a localised reduction in habitat due to the lowering of the groundwater table from cumulative abstraction of groundwater for water supply and mine pit dewatering. The hydrogeological modelling indicates the potential for some reduction in water levels in the Robe River alluvial aquifer and semi-permanent and permanent pools, with a peak groundwater drawdown of <1 m in the Robe River, and peak drawdown of <10 m within Jimmawurrada Creek. Recovery of the groundwater table will occur over time once water abstraction ceases, and intermittently recovers during large rainfall events.
Groundwater abstraction for water supply from the existing Southern Cutback Borefield combined with drawdown from the Mesa J Iron Ore Development and drawdown from the upstream Coastal Water Supply Project will increase groundwater drawdown below a 12 km section of Jimmawurrada Creek, which would encompass known Blind Cave Eel records (including outside the Proposed Change Area) and extend the timeframe for the predicted groundwater recovery once water abstraction ceases. Only 6.5 km of this section has drawdown of greater than 3 m; therefore, the majority of the aquifer and associated habitat will remain intact in this section of the creek. These impacts are expected to be temporary and wet season flows are expected to continue to provide seasonal recharge and connectivity of the alluvial habitat through these creek systems. Groundwater drawdown will also be ameliorated by surplus water discharge, which will occur within the groundwater drawdown area of the Southern Cutback Borefield.
Any temporary changes to groundwater levels in the alluvial aquifer of Jimmawurrada Creek and the Robe River near Mesa H are unlikely to significantly impact habitat for the Blind Cave Eel and are likely to represent only a small proportion of the habitat available in the broader Robe Valley.
Given the creek flow lines and alluvial substrate will remain largely physically undisturbed, and the interconnected nature of Bungaroo Creek, Jimmawurrada Creek and the Robe River systems, the availability of core habitat remains extensive in the broader Robe Valley. Management and mitigation options for groundwater drawdown, such as optimised discharge locations and targeted supplementary water supply directly to permanent pools in the Robe River would be considered should monitoring indicate drawdown from dewatering activities (as compared to natural climatic variances).
Cumulatively, the Revised Proposal will contribute to the changes to the hydrological regime, through additional dewatering to enable BWT mining. No increase in abstraction rate from the Southern Cutback Borefield is expected. It is not expected that the Proposed Change will lead to a long-term decrease in the size of a population of Blind Cave Eel.
Despite the temporary nature of the impacts expected to the Blind Cave Eel and the availability of habitat within and outside of the Proposed Change Area, given the current limited status of knowledge of this species, there is uncertainty regarding the area of risk, the degree of habitat modification associated with the temporary impacts and the range and sensitivity of the species. Therefore, this risk is proposed to be offset to enhance further research into the understanding of the occurrence and range of this species (Section 13.3).</td></tr>
</table>

Significant impact criteria	Assessment of impacts to Blind Cave Eel
Potential to reduce the area of occupancy of an important population	**Groundwater abstraction** The Proposed Change is unlikely to reduce the area of occupancy of an important population of the Blind Cave Eel. The Proposed Change will retain core subterranean habitat through retention of the alluvial aquifers and seasonal connectivity of these aquifers. Given that potential disturbance to habitat via groundwater drawdown will be temporary and represents only a small proportion of habitat available in the broader Robe Valley. Despite this, the risk to the species is proposed to be offset to enhance further research into the understanding of its occurrence and range (Section 13.3).
Potential to fragment an existing important population into two or more populations	**Groundwater abstraction** The Proposed Change is unlikely to fragment an existing important population into two or more populations. The Proposed Change will not create physical barriers to the movement of Blind Cave Eel and will maintain habitat connectivity.
Potential to adversely affect habitat critical to the survival of the species	**Groundwater abstraction** The Proposed Change is unlikely to adversely affect habitat critical to the survival of the species. The Proposed Change will retain core subterranean habitat through retention of the alluvial aquifers and connectivity of these aquifers. Potential disturbance to habitat via groundwater drawdown will be temporary and represents only a small proportion of habitat available in the broader Robe Valley.
Potential to disrupt the breeding cycle of an important population	**Groundwater abstraction** The Proposed Change is unlikely to disrupt the breeding cycle of an important population. The Proposed Change will retain breeding habitat through retention of the subterranean alluvial aquifer habitat.
Potential to modify, destroy, remove isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Groundwater abstraction** The Proposed Change is unlikely to affect habitat to the extent that the species is likely to decline. The Proposed Change will retain core subterranean habitat through retention of the alluvial aquifers and connectivity of these aquifers. Impacts to groundwater levels are modelled to be minor along the Robe River and localised to a 12 km section of Jimmawurrada Creek. Substantial drawdowns are expected within a 6.5 km stretch where drawdowns of up to 9 m (14 mbgl) may occur from the cumulative effects of Mesa H, Mesa J and the Coastal Water Supply. The habitat will continue to be seasonally connected following rainfall events. Any disturbance to habitat would be temporary and would represent only a small proportion of the habitat available in the broader Robe Valley.
Potential to result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat	The Proposed Change is unlikely to introduce invasive species that are harmful to the Blind Cave Eel. The Proposed Change will manage surface and groundwater from the same connected catchments and aquifers. The Blind Cave Eel habitat is subterranean, and the environment subject to significant natural flooding events which would support broad catchment connectivity.
Potential to introduce disease that may cause the species to decline	The Proposed Change will not introduce disease that may cause the species to decline.
Interfere with the recovery of the species?	Given the proposed disturbance will retain core habitat for the species, and only minor, temporary reduction of habitat may occur as a result of groundwater abstraction, the Proposed Change is considered unlikely to interfere with the recovery of the species.

12.6 Assessment of Impacts to Migratory Species

A total of six species listed as migratory under the EPBC Act have been recorded or are considered likely to occur in the Proposed Change Area, based on an assessment of habitat requirements. The species are all birds and include the Fork-tailed Swift, Common Sandpiper, Sharp-tailed Sandpiper, Wood Sandpiper, Common Greenshank and Oriental Pratincole. None of these species have been recorded in the Proposed Change Area but are considered moderately likely to occur. Information about these species, their distribution and potential impacts from the Proposed Change is provided in Sections 8.4.5 and 8.6.

An summary assessment of the significance of impacts to all of these species is provided in Table 12-12 below.

Table 12-12: Assessment of Significance of Impacts to Migratory Species

Significant impact criteria	Assessment of impacts to migratory species
Potential to substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	The River habitat potentially used by migratory species extend well beyond the Development Envelope; only a small proportion of available habitat is located within the Proposed Change Area and all of the migratory species identified as likely to occur in the Proposed Change Area, have wide distributions across Australia and their occurrence in the Development Envelope is expected to be transitory only.
Potential to result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species.	Feral cats and foxes may pose a threat to the migratory species; however, the Proposed Change is unlikely to increase the abundance of feral fauna in the Development Envelope. In addition, the Proponent will continue to undertake feral fauna control in areas it controls.
Potential to seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	No migratory species were recorded in the Proposed Change Area and the species identified are considered moderately likely to occur as transitory visitors. The Proposed Change Area is not known to support an ecologically significant proportion of the population of any migratory species.

12.7 Predicted Outcome

There are five MNES that are likely to be impacted by the Proposed Change:

- Northern Quoll;
- Ghost Bat;
- Pilbara Leaf-nosed Bat;
- Pilbara Olive Python; and
- Blind Cave Eel.

The most important habitats in the Proposed Change Area for MNES are:

- Breakaways and Gullies habitat which includes denning and foraging habitat for the Northern Quoll and Pilbara Olive Python and roosting habitat for the Ghost Bat and Pilbara Leaf-nosed Bat; and
- River habitats which includes denning/shelter habitat and a dispersal route for Northern Quoll and Pilbara Olive Python and foraging habitat for the Pilbara Leaf-nosed Bat and Ghost Bat.

The key predicted outcomes for MNES are:

- 3.5 ha loss of Breakaways and Gullies habitat.
- 23.2 ha loss of River habitat (with <2 ha within the higher value Riverine habitat type and the rest within Drainage Line habitats).
- Avoidance of disturbance to the highest value denning habitat for Northern Quoll. No significant disturbance to foraging habitat given the extensive availability of foraging habitat both within and outside the Proposed Change Area.
- Direct impact to core habitat for the Northern Quoll; 3.5 ha of Breakaways and Gullies habitat, 3.8 ha of habitat within 10 m of Breakaways and Gullies habitat and 1.3 ha of Riverine habitat.
- No direct disturbance to the two recorded diurnal / maternal and all nocturnal Ghost Bat roosts within the Proposed Change Area. The Blast Management Framework will be implemented to ensure blast vibration levels at the identified diurnal/potential maternal Ghost Bat roosts remain below the trigger level PPV set in the EMP (see EMP in Appendix 6). Measures that may be used to achieve the required blast control are discussed in Section 8.6.3.2.
- No direct disturbance to Pilbara Leaf-nosed Bat roost habitat. The Proposed Change will have only limited direct impact on foraging habitat that is >10 km from the nearest known roost site. A portion of the foraging habitat along Jimmawurrada Creek is within 10 km of the known roost and will be subject to temporary impacts to riparian vegetation. Given the availability of foraging habitat in the vicinity and also within 10 km of the known roost, this is unlikely to have a significant impact.
- Limited impact to habitats which may be classified as preferred habitat for Pilbara Olive Python, namely the Breakaway and Gullies habitat and the River habitat. The proposed disturbance is therefore considered unlikely to have a significant impact.
- No direct impact to any known records of Blind Cave Eel. Existing records indicate that it occurs in subterranean caves and in creekline alluvials, including the hyporheic zone. Indirect impacts from groundwater drawdown may temporarily reduce the availability of this habitat, particularly across a 12 km section of the alluvial aquifer habitat in Jimmawurrada Creek. However, habitat connectivity and availability will be retained across the impact area and the mapped habitat will remain extensive in the Robe Valley. Despite this, the risk to the species is proposed to be offset to enhance further research into the understanding of its occurrence and range (Section 13.3).

As described in this section, whilst small portions of habitat that may be classified as critical, priority or preferred habitat for some of the MNES will be impacted, these impacts are not of a scale or level of significance where a decline in any of these species would occur as a result. The proposed mitigation strategies will reduce the predicted impacts to MNES and ensure the highest value habitat for each species is protected as far as practicable from direct and indirect impacts. The Proposed Change is therefore not inconsistent with any relevant policy, guidance, Recovery Plan or Threat Abatement Plan for the Northern Quoll, Ghost Bat, Pilbara Leaf-nosed Bat, Pilbara Olive Python or Blind Cave Eel. The direct impact to 3.5 ha of Breakaways and Gullies habitat, 3.8 ha of habitat within 10 m of Breakaways and Gullies habitat and 1.3 ha of Riverine habitat for the Northern Quoll and the risk to the Blind Cave Eel from groundwater drawdown along a portion of Jimmawurrada Creek are considered to be significant residual impacts and are proposed to be offset (Section 13).

13. OFFSETS

13.1 WA Environmental Offsets Policy and Guidance

The WA Environmental Offsets Policy (Government of Western Australia 2011) and WA Environmental Offsets Guideline (Government of Western Australia 2014b) provide guidance to proponents on the approach needed to determine offset requirements for proposals. The Environmental Offsets Guideline (2014) states that:

‘In general, significant residual impacts include those that affect rare and endangered plants and animals (such as declared rare flora and threatened species that are protected by statute), areas within the formal conservation reserve system, important environmental systems and species that are protected under international agreements (such as Ramsar listed wetlands) and areas that are already defined as being critically impacted in a cumulative context. Impacts may also be significant if, for example, they could cause plants or animals to become rare or endangered, or they affect vegetation which provides important ecological functions’.

The rate, scale and nature of current and future development, combined with the impacts of other land uses and threatening processes, have raised the EPA’s concerns about cumulative environmental impacts in the Pilbara region (EPA 2017b). In particular, the EPA is concerned about the clearing of native vegetation combined with pastoralism, feral animals, weeds and climate change in the Pilbara, and the lack of reliable information on the extent and condition of native vegetation at a regional scale (EPA 2017b). The Pilbara is mostly Crown land and, as such, traditional land acquisition offsets are not possible in the region. In addition, tenure constraints including pastoral leases and mineral tenements make it difficult to implement on-ground conservation actions to deliver long-term protection of biodiversity (EPA 2014).

Subsequently the EPA has determined that a proactive approach to compensating for the clearing of native vegetation in the Pilbara is required and have established a strategic regional conservation initiative for the consolidation and management of offset funds for the Pilbara; the Pilbara Environmental Offsets Fund (the Fund). The Fund is currently being established by the WA Government in response to recommendations from the EPA for a strategic, coordinated approach to the application of environmental offsets to achieve broad-scale biodiversity conservation outcomes.

The Fund pools environmental offsets for resource and infrastructure projects approved under the EP Act which are conditioned in accordance with the WA Environmental Offsets Policy (Government of Western Australia 2011) and associated guidelines (Government of Western Australia 2014b). Offsets contributed to the Fund will be used to implement conservation projects that counterbalance any significant residual impacts of those developments at a landscape level in the Pilbara.

The EPA notes that in establishing and implementing the Fund, the WA Government has committed to ensuring that the offsets implemented via the Fund will:

- be relevant and proportionate to the values being impacted (Principle 3);
- use sound knowledge and ensure the offset counterbalances the significant residual impact and delivers long term environmental benefits (Principle 4); and
- be adaptive and be evaluated to ensure that it achieves the outcomes required (Principle 5) (EPA 2017b).

The EPA has been of the view that proposed offsets for similar projects to the Proposed Change with similar significant residual impacts (e.g. BHP’s recent Mining Area C – Southern Flank Project) requiring a contribution to the Fund, will counterbalance those significant residual impacts (EPA 2017b). Projects funded will address the priorities outlined in the Pilbara Conservation Strategy (Government of Western Australia 2017) including Karijini National Park restoration, management of Fortescue Marsh and also management of fire, feral animals and weeds in the Pilbara region. The projects implemented through the Fund will be approved by the Minister for Environment and project development will address matters including partnerships, scheduling, procurement, funding arrangements, performance measures and reporting requirements, which will be prepared in consultation with stakeholders (Government of Western Australia 2017).

Contributions to the Fund to offset the clearing of native vegetation considered in Good to Excellent condition has been used as the standard offset approach by the EPA and proponents in the Pilbara since 2012. Where there are other environmental values with elevated significance, a higher offset is applied to account for this greater value.

Environmental aspects of this Proposed Change were assessed for potential significant residual impacts. The results of the assessment are presented in the following section.

13.2 EPBC Environmental Offsets Policy

The EPBC Act Environmental Offsets Policy (DSEWPaC 2012b) outlines the Australian Government's approach to the use of environmental offsets under the EPBC Act. Offsets are measures that compensate for the residual adverse impacts of an action on the environment. They provide environmental benefits to counterbalance the impacts that remain after the application of avoidance and mitigation measures. These remaining impacts are 'residual impacts.' For assessments under the EPBC Act, offsets are only required if the residual impacts of a project are significant.

Contributions to the Pilbara Offset Fund have been used to offset the significant residual impacts to MNES. The use of the Fund for MNES offsets demonstrates that contributions to the Fund have been considered appropriate in terms of the EPBC Act Environmental Offset Policy. The current standard approach to MNES offsets in the Pilbara is the application of conditions to EPBC Act approvals that required either a contribution to the Fund at the rate of $3,000 per hectare of critical habitat cleared (i.e. four times the rate of offset required for vegetation in good to excellent condition), $1,500 per hectare of suitable/foraging habitat, or an alternative but equivalent resourcing of an offset project that will provide direct benefits to the MNES in the Pilbara. The proponent understands that discussions between the State and Commonwealth are progressing to ensure that contributions to the Fund provide the required outcomes for MNES and that this type of offset condition will continue to be used.

13.2.1 Northern Quoll

The regional records of Northern Quoll show that the species is strongly associated with rocky habitats. This is supported by the local records in and around the Development Envelope which indicate that the Northern Quoll is strongly associated with the Breakaways and Gullies habitat, Riverine habitat and the directly adjacent habitat (likely for foraging and dispersal) (12.3.3). Within the Development Envelope, 82% of records are within River habitat, Breakaways and Gullies habitat or within 10 m of Breakaways and Gullies habitat. Based on the local records and evidence from the Robe Valley data (Astron 2016e) and locations of records in the Development Envelope, the critical habitat locally is considered to comprise the Breakaways and Gullies habitat and portions of the River habitat.

The Proposed Change will result in disturbance to 3.5 ha of Breakaways and Gullies habitat and a further 3.8 ha of adjacent habitat within 10 m of Breakaways and Gullies habitat. The Proposed Change will also result in disturbance to 1.3 ha of Riverine habitat, which is the component of the broader River MNES habitat unit that is associated with the Robe River (Section 12.3.2). The Drainage Line habitat which is also included within MNES habitat includes the ephemeral creeks and is not considered important to the Northern Quoll.

The Proposed Change has been designed to avoid the highest value Northern Quoll habitat: the disturbance will impact only a small proportion of the available potential denning habitat (Breakaways and Gorge habitat) and foraging and dispersal habitat (Riverine). A MEZ will be established around the mesa escarpment which sterilises ore to protect fauna and the highest habitat values supported by the mesa escarpment. The proposed disturbance represents less than 0.4% of the current extent of undisturbed Breakaway and Gullies habitat in the Robe Valley (924.6 ha).

Indirect impacts on terrestrial fauna habitats including those associated with groundwater drawdown may alter fauna habitats but are still expected to retain habitat values. Therefore, indirect impacts on terrestrial MNES habitats are not considered significant and are not proposed to be offset.

After the application of mitigation measures, the Proposed Change is expected to result in the following outcomes for Northern Quoll:

- Clearing of 3.5 ha of critical Breakaways and Gullies habitat and a further 3.8 ha of adjacent habitat within 10 m of Breakaways and Gullies Habitat.
- Clearing of 1.3 ha of Riverine habitat.
- Retention of more than 95 ha or 95% of the potential denning habitat within the Proposed Change Area and avoidance of disturbance to the highest value potential denning habitat for Northern Quoll within the Breakaways and Gullies habitat unit.
- Retention of more than 141 ha or 99% of the Riverine habitat within the Proposed Change Area which provides important foraging and dispersal habitat.
- No significant disturbance to foraging habitat given the extensive availability of foraging habitat both within and outside the Proposed Change Area.
- Indirect impacts are not expected to cause any significant loss or modification of habitat values for Northern Quolls.
- Potential impacts to Northern Quoll denning, foraging and dispersal habitats from clearing are unlikely to lead to a long-term decrease in the size of the Northern Quoll population.
- The population of Northern Quoll will remain within the Development Envelope.

The direct impact to 3.5 ha of Breakaways and Gullies habitat, 3.8 ha of habitat within 10 m of Breakaways and Gullies habitat and 1.3 ha of Riverine habitat is considered to be a significant residual impact.

The proposed offset for the significant residual impact is the contribution of $3,000 per ha of direct impacts to 8.6 ha of core habitat or an alternative but equivalent resourcing of an offset project that will provide direct benefits to Northern Quoll in the Pilbara.

13.2.2 Blind Cave Eel

The Blind Cave Eel is known to be restricted to subterranean environments within groundwater systems including subterranean caves; fissures; transmissive geological formations and karst and alluvial aquifers in the western Pilbara (DEWHA 2008a). In the Development Envelope and immediate locality, the Blind Cave Eel is known to inhabit the major alluvial aquifers of Bungaroo Creek, Jimmawurrada Creek and the Robe River, including within the shallower hyporheic zone.

Given the current limited status of knowledge of the Blind Cave Eel and its habitat, particularly for the inland Pilbara records, any habitat loss in the vicinity of known records is treated conservatively. Based on information to date, the critical habitat for the Blind Cave Eel in the vicinity of the Proposed Change is understood to be the major creekline alluvial aquifers where both physical and eDNA records have been identified.

At its peak, the cumulative groundwater drawdown as a result of Mesa J, Mesa H and the Coastal Water Supply Project is predicted to result in a cone of depression extending up to 12 km along Jimmawurrada Creek; with the peak drawdown of up to 9 m (14 mbgl) along a 6.5 km section of Jimmawurrada Creek during 2030 (‘Zone 3’).

The alluvial aquifers in the Pilbara are subject to major recharge events associated with large rainfall and cyclonic events, where groundwater levels have been found to fully recover in response to rainfall (Dobbs, R & Davies, PM 2009, Rio Tinto 2019a).

Hence, whilst groundwater drawdown will temporarily reduce suitable saturated habitat for the Blind Cave Eel in Jimmawurrada Creek, the physical substrate comprising the alluvial aquifer geology will remain intact; and as groundwater levels recover post rainfall events and post mining, the habitat values of the affected alluvial aquifer for Blind Cave Eel would be expected to return. Therefore, the residual impact is reversible and temporary, however given the limited records of the species, any habitat impact in the vicinity of these records is treated conservatively. It is noted that even during the peak groundwater drawdown combined with extended dry conditions and seasonal water table lows would not dry out the full depth of saturated alluvial aquifer habitat in Jimmawurrada Creek, with between 10 – 22 m of saturated habitat thickness retained in the centre of the alluvial channel. Therefore, habitat connectivity will be maintained throughout the project life.

The Robe River alluvial aquifer is also considered to form important habitat for the Blind Cave Eel. Mine pit dewatering is not expected to result in a significant change to groundwater levels in the adjacent alluvial aquifer of the Robe River (<1 m). These small potential drawdowns will leave the majority of the habitat intact even during dry conditions. The drawdown is well within the range of natural groundwater table variability experienced in the Robe Valley and would also recover fully following rainfall events. Therefore, the potential habitat loss in the Robe River alluvial aquifer is considered negligible and is not considered a significant residual impact. Groundwater levels in the Robe River alluvial aquifer levels will be monitored to ensure that changes are no greater than predicted. A contingency option of avoiding mining below the 120 mRL in the Mesa H pit closest to the Robe River is proposed if conditions are particularly dry or if monitoring indicates a lowering of the water table as a result of mine pit dewatering.

The Proposed Change has been designed to minimise water requirements by using (and optimising) the existing Southern Cutback water supply borefield to limit the areas and extent affected by groundwater drawdown. The use of a thickener in the wet plant cycle is also proposed, which will significantly reduce overall site water demand by up to 30% and minimise drawdown in the Jimmawurrada Creek alluvial aquifer.

The Proposed Change does not include any direct removal / excavation of the physical substrate of the alluvial aquifers and therefore the potential habitat for Blind Cave Eel will remain intact and available when groundwater levels recover. The Proposed Change has been designed to minimise impacts to the known and potential Blind Cave Eel habitat through minimising groundwater abstraction and basing the assessment on the *cumulative impacts* to groundwater levels as a result of the Proposed Change, the adjacent Mesa J Iron Ore Development and the Coastal Water Supply operations. The proposed water efficiency measures will enable significant connected alluvial aquifer habitat to be maintained from Bungaroo Creek and the Upper Robe River, through to the downstream Robe River, which extends over 250 km to the Pilbara Coast.

More records of Blind Cave Eel are likely to be found as knowledge about this relatively recently identified species increases.

Potential indirect impacts on the Blind Cave Eel habitat such as those associated with water quality could alter the habitat value; however, the Proposed Change is not anticipated to detrimentally impact groundwater quality. Therefore, indirect impacts on Blind Cave Eel habitats are not considered significant and are not proposed to be offset.

After the application of mitigation measures, the Proposed Change is expected to result in the following outcomes for Blind Cave Eel:

- No direct physical removal of habitat substrate.
- Temporary reduction in habitat availability as a result of groundwater drawdown.
- Retention of more than 60% of the potential known Jimmawurrada – Robe River saturated alluvial aquifer habitat, taking into account cumulative impacts from other projects. In addition, assuming an extended dry period combined with seasonal water table lows, ~44% of saturated habitat would still be retained.

- Extensive connected habitat outside the Proposed Change impact area will remain from upstream Bungaroo and the upper Robe River, to potential habitat downstream of the Proposed Change, in the Robe River.
- Indirect impacts are not expected to cause any significant loss or modification of habitat values for the Blind Cave Eel.
- Potential impacts to the Blind Cave Eel habitats from groundwater drawdown are unlikely to lead to a long-term decrease in the Blind Cave Eel population.
- The habitat of the Blind Cave Eel will remain connected between Bungaroo Creek – Jimmawurrada Creek and the Robe River.

The direct, albeit temporary impact to the groundwater levels in Jimmawurrada Creek of up to 9 m (~14 mbgl) over a 6.5 km stretch (up to 18 mbgl during an extended dry period and seasonal water table lows) is considered to be a significant residual impact to Blind Cave Eel habitat. There is uncertainty regarding the area of risk (noting that estimates have been based on reasonable worst case assumptions so impacts are not likely to be greater than expected), the degree of habitat modification and the range and sensitivity of the species. Therefore, this risk is proposed to be offset through providing $1 M of funding for further research into the occurrence and range of this species.

13.3 Assessment of significant residual impacts – EP Act

The evaluation of potential impacts of the Proposed Change on the preliminary key environmental factors is detailed in Sections 5 to 11. This evaluation resulted in the identification of environmental aspects that may result in a significant residual impact.

The Offsets Template as per the WA Environmental Offsets Guidelines (Government of Western Australia 2014b) has been used to further examine the significant residual impacts of the Proposed Change. It has been determined that offsets are required and a summary of those proposed is provided in Table 13-1. Table 13-2 presents a summary of the evaluation of significant residual impacts for each of the key environmental values.

Following application of the mitigation hierarchy, the significant residual impacts that are relevant under WA legislation only have been identified for the Proposed Change as:

- Clearing of up to 1,986 ha of native vegetation in Good to Excellent condition.
- Clearing of up to 2 ha of Riverine riparian vegetation.
- Clearing of 6 ha of vegetation analogous to the Triodia sp. Robe River PEC.
- Clearing of approximately 9.2 ha and 788.1 ha of the Priority 1 PECs, the Subterranean invertebrate community of mesas in the Robe Valley region and the Subterranean invertebrate community of pisolitic hills in the Pilbara, respectively.
- Direct reduction of stygofauna habitat through groundwater drawdown of the Jimmawurrada Creek alluvial aquifer over 'Zone 3' (a 6.5 km stretch of maximum drawdown) with other environmental values: the Priority 1 PEC Stygofauna community of the Bungaroo Aquifer.

The above values co-occur so the areas affected are not additive.

Direct clearing of up to 2,200 ha of native vegetation may also impact MNES fauna habitats; the assessment of residual impacts to MNES habitat and proposed offsets are discussed in Sections 13.3 and 13.5.

Consideration of the Residual Impact Significance Model in the WA Environmental Offsets Guidelines (Government of Western Australia 2014b) indicates that the above significant residual impacts may require offsets.

13.4 Assessment of significant residual impacts – EPBC Act

The predicted residual impacts on MNES have been assessed in terms of their significance in accordance with the Significant Impact Guidelines 1.1, relevant conservation advice and referral guidelines. It is noted that the referral guidelines provide broad definitions of critical habitat at the national level, however this should not preclude using the extensive Pilbara and Robe Valley datasets on MNES species (except Blind Cave Eel) to inform a more detailed understanding and assessment of the significance of habitats and impacts at a local and regional level. Where sufficient scientific information exists, the detailed understanding of local species occurrence and habitat use in the Robe Valley has been used to support a local definition of core habitat that is critical to the survival of local populations. A summary of the assessment of significance is provided for each MNES in 12.5.1. The predicted significant residual impacts on MNES as a result of the Proposed Change (the Action) are the direct loss of habitat for the Northern Quoll and the Blind Cave Eel.

Following the application of mitigation measures, the Proposed Change is expected to result in the direct loss of core habitat for the Northern Quoll via the direct loss of up to 8.6 ha of core habitat (including all Breakaways and Gullies habitat and areas within 10 m of Breakaways and Gullies habitat and Riverine habitat). It is considered necessary to provide offsets to address this loss.

The Proposed Change is also expected to have a significant (temporal) residual impact on the Blind Cave Eel due to the lowering of the groundwater table in the Jimmawurrada Creek alluvial aquifer where the species is known to occur. The physical substrate comprising the alluvial geology will remain intact, however groundwater abstraction will temporarily lower the groundwater levels and reduce the availability of suitable habitat for the Blind Cave Eel. Therefore, this is considered a direct impact on Blind Cave Eel habitat. Due to the limited records of this species and its known use of the Jimmawurrada Creek and Robe River alluvial aquifers, temporary removal of suitable habitat through groundwater abstraction, although reversible, is considered a significant residual impact and will be offset.

Following the application of mitigation measures, the Proposed Change is not expected to result in significant residual impacts to other MNES and no offsets are required or proposed for these species.

13.5 Proposed Offsets

The Proponent proposes environmental offsets in the form of financial contributions to the Fund at the following specified rates for each significant residual impact. The area of Northern Quoll core habitat to be affected is an upper limit as the mine planning around minimising impact to Gorge and Breakaway habitat has been undertaken in detail. The exact location of infrastructure within the vegetation in good to excellent condition and within the extent of the PEC (which occurs extensively within the Development Envelope) has not yet been determined. Therefore, the areas requiring offset outlined below and throughout this ERD are estimates only. The actual quantum of impact and offsets required will be determined through an Impact Reconciliation Procedure in accordance with EPA instructions as outlined in the Draft Conditions included in Appendix 3. The proposed offset rates for contributions to the Fund and the estimated areas are:

- $3,000 per hectare for Northern Quoll core habitat (8.6 ha). The Proponent understands that the Fund may include habitat improvement so this contribution is also expected to offset impacts too good to excellent native vegetation and riparian vegetation within that 8.6 ha.
- Provision of $1 M of funding for further research into the occurrence and range of the Blind Cave Eel.
- $1,500 per hectare for PECs and riparian vegetation (that is not MNES habitat but may also be native vegetation in good to excellent condition) (approximately 1,315 ha). This offset contribution will address significant residual impacts to the specific PECs and riparian vegetation values and to native vegetation of good to excellent condition.
- Where MNES core habitat and PECs co-occur a total of $3,000 ha will be provided to the Fund.
- $750 per hectare for native vegetation that is in good to excellent condition in the Hamersley subregion (up to 876.4 ha).

The total offset value is $3,655,600 (of which $1,025,800 is directly related to MNES impacts) (Table 13-1).

The contributions to the Fund are inclusive and offsets at the higher rates for MNES also include benefits to the other listed environmental values. It is expected that a condition of approval under the EP Act will be the requirement for the proponent to apply to the CEO seeking a reduction in the funding required for State offsets where MNES offsets also apply. The contributions to the Fund are inclusive and offsets at the higher rates for MNES also include benefits to the other listed environmental values.

The impacts to Blind Cave Eel are an increased risk of temporal habitat reduction during operations due to groundwater drawdown. There is uncertainty regarding the area of risk, the degree of habitat modification and the range and sensitivity of the species. Therefore, this risk is proposed to be offset through funding of research into the occurrence and range of this species.

Table 13-1: Summary of proposed offset

Environmental value	Area of significant impact (ha)	Proposed offset rate	Proposed Offset amount
Northern Quoll core habitat	8.6	$3000 / ha	$25,800
PEC and riparian vegetation	Approximately 1,315 (excludes riparian vegetation that is within the Northern Quoll core habitat)	$1500 / ha	$1,972,500
Good to excellent vegetation in the Hamersley Subregion	Up to 876.4 (excludes vegetation within Northern Quoll core habitat, PEC and riparian vegetation)	$750 / ha	$657,300
Increased risk of Blind Cave Eel habitat reduction	There is uncertainty regarding the area of risk, the degree of habitat modification and the range and sensitivity of the species. Therefore, this risk is proposed to be offset through funding of research into the occurrence and range of this species.		$1M

The significant residual impacts on MNES and the proposed offset are described in Section 13.4 In determining State offsets, the proponent has taken into consideration the six principles of the WA Environmental Offsets Policy which underpin the WA Government's assessment and decision-making processes, in relation to the use of environmental offsets, as outlined below.

1. **Environmental offsets will only be considered after avoidance and mitigation options have been pursued.** As outlined in Section 2.3, avoidance and minimisation of impact has been included as part of the Proposed Change planning process. The proponent considered various options in the development of the Proposed Change and designed the Proposed Change to avoid environmental impacts. The project has been designed to avoid or minimise clearing or disturbance to vegetation, flora or habitats with higher conservation significance by utilising and / or upgrading existing Mesa J Iron Ore Development infrastructure; placement of waste fines disposal in-pit; and use of a thickener for the waste fines also requires minimal additional clearing and minimises water requirements and significantly reduces the impacts of groundwater abstraction. One of the key avoidance strategies is the retention of the majority of the mesa escarpment areas, which is designed to retain troglofauna habitat and avoid several significant environmental values including those associated with conservation significant fauna and cultural heritage. The application of the mitigation hierarchy for the Proposed Change (Section 14.2) has ensured that all practical avoidance and mitigation measures have been considered and pursued where appropriate. Offsets have only been considered for those significant impacts that are not able to be avoided or minimised.
2. **Environmental offsets are not appropriate for all projects**. The identified significant residual impacts are considered appropriate to be offset as they are not considered to be minor (i.e. too minor to require an offset) or likely to be environmentally unacceptable regardless of offsets.
3. **Environmental offsets will be cost-effective, as well as relevant and proportionate to the significance of the environmental value being impacted**. The Proponent considers the proposed offsets are cost-effective and relevant and proportionate to counterbalance the significant residual impacts of the Proposed Change. The offsets for vegetation are considered appropriate in that the significant residual impacts identified are not related to one specific threatened species or community, rather they relate to the cumulative loss of vegetation due to clearing in

the Pilbara and therefore the contribution to the Fund will allow implementation of projects that will benefit Pilbara vegetation and flora values more broadly. The contribution to the Fund for the subterranean fauna PECs is considered appropriate given that subterranean fauna ecosystems are not currently well understood. Contribution to the Fund will enable management or research to be undertaken that will benefit subterranean fauna values more broadly. Actions initiated through the Fund would be in addition to the Proponent's current contribution to subterranean fauna research initiatives.

4. **Environmental offsets will be based on sound environmental information and knowledge.** As previously highlighted, the Pilbara is predominately Crown land and, as such, traditional land acquisition offsets are not possible and on-ground conservation actions are difficult for a single proponent to implement due to tenure constraints including pastoral leases and mineral tenements. Contribution to the Fund is not a traditional offset where, for example a single conservation project would need to consider sound environmental information and knowledge about a particular species or community; however, the conservation and research projects to be implemented at a broad-scale through the Fund are intended to address the cumulative impacts of mining in the Pilbara as identified by the EPA and provide a more detailed understanding of conservation values in the Pilbara region to improve decision-making regarding conservation and management.
5. **Environmental offsets will be applied within a framework of adaptive management.** The proponent understands an adaptive management framework should be applied in relation to environmental offsets to take account of the potential risks. One of the key risks associated with the Fund as an environmental offset for the majority of projects in the Pilbara, is managing the time-lag between establishing offsets and generating the anticipated benefits. This challenge and the adaptive management framework around conservation outcomes are being addressed in the development of the Fund mechanisms including partnerships, scheduling, procurement, funding arrangements, performance measures and reporting requirements, in consultation with stakeholders.
6. **Environmental offsets will be focussed on longer term strategic outcomes.** The EPA recognises that the establishment of the Fund is consistent with this principle in that strategic approaches, such as the use of the Fund, will provide a coordination mechanism to implement offsets across a range of land tenures (Government of Western Australia 2014b). The Fund provides a strategic, coordinated approach to the application of environmental offsets to achieve broad-scale biodiversity conservation outcomes for the Pilbara region. Rio Tinto recognises the commitment of the EPA to this strategic approach and is a participant in the working group for establishment of the Fund.

Table 13-2: WA Environmental Offsets Template Part 1 - Identification of Residual Impacts and Requirements for Offsets

Existing environment/Impact	Mitigation			Significant Residual impact? (Yes/No)
	Avoid and Minimise	Rehabilitation type	Likely Rehabilitation Success	
Flora and Vegetation Clearing of vegetation in Good to Excellent condition Clearing of riparian vegetation.	Disturbance to Priority flora and riparian vegetation will be avoided as far as practicable and clearing will only occur in approved areas. The clearing footprint has been minimised through general project design and through selection of in-pit disposal of waste fines in Mesa J rather than development of an external WFSF.	Disturbed areas will be rehabilitated progressively as mining activities are completed. The conditions of the new MS shall require the Proponent to implement a Closure Plan in accordance with the DMP / EPA Guidelines for Preparing Mine Closure Plans. The Closure Plan (Appendix 7) includes a Closure Objective to ensure that vegetation on rehabilitated land is self-sustaining and compatible with the final land use.	**Can the environmental values be rehabilitated / Evidence?** To date, approximately 148.5 ha of rehabilitation has been completed at the Mesa J Iron Ore Development (however some of this has been reclaimed due to ongoing mining operations) and has generally established well, with a range of native perennial species present and established. **Operator experience in undertaking rehabilitation?** Rio Tinto conducts rehabilitation activities progressively at all its operations in the Pilbara. All rehabilitation is undertaken in accordance with the Rio Tinto Iron Ore Rehabilitation Handbook, which is reviewed and updated periodically to reflect changes in industry standards, reflect new knowledge obtained through research and development, and to adopt learnings from ongoing rehabilitation projects. The Handbook addresses: • soil resource management • rehabilitation techniques • local provenance species seeding practices • records and data management • on-going monitoring. **What is the type of vegetation being rehabilitated?** A total of 38 vegetation units have been mapped in the Proposed Change Area. As a general overview the Revised Proposal is located within the Fortescue Botanical District of the Eremaeum botanical province which is characterised by tree (*Eucalyptus* spp. and *Corymbia* spp.) and shrub (*Acacia* spp., *Hakea* spp., *Grevillea* spp. and *Senna* spp.) steppe	Yes, the clearing of native vegetation in Good to Excellent Condition and clearing of riparian vegetation. **Extent** Up to 1,986 ha of native vegetation in Good to Excellent Condition and 2 ha of riparian vegetation **Quality** Good to Excellent Conservation Significance 1,986 ha of Good to Excellent condition native vegetation and 2 ha of River habitat comprising riparian vegetation. **Land Tenure** N/A **Time Scale** N/A - no temporary clearing Consideration of the Residual Impacts Significance Model indicates that the residual impact is significant because it involves clearing of Good to Excellent condition vegetation and clearing of

Existing environment/Impact	Mitigation			Significant Residual impact? (Yes/No)
	Avoid and Minimise	Rehabilitation type	Likely Rehabilitation Success	
			communities and *Triodia* spp. hummock grasslands (Beard 1990). **Time lag** Progressive rehabilitation will continue to be undertaken throughout the life of the Revised Proposal where feasible, however the majority of the rehabilitation will be undertaken at closure. **Credibility of the rehabilitation proposed (evidence of demonstrated success)** Refer to the Proponent's Mesa J Hub Closure Plan.	riparian vegetation of high local significance.
Subterranean Fauna	The Proposed Change has been designed to minimise disturbance to the subterranean fauna PECs as far as practicable. The mine plan has also been designed to retain at least 50% by volume of connected pre-mining troglofauna habitat. Mesa J was selected as the preferred location for the WFSF rather than the alternative location of in-pit at Mesa H in order to avoid impacts to the troglofauna and stygofauna habitat at Mesa H. The original design of the MEZ has been modified several times during the mine planning stages in order to avoid as many single location and singleton troglofauna as practicable. The need for groundwater abstraction for water supply will be minimised through the use	N/A	N/A	Yes, the clearing of the troglofauna P1 subterranean fauna PECs and direct impact through dewatering to the P1 stygofauna PEC **Extent** Approximately 797.3 ha of the troglofauna PECs and direct, temporal impact as a result of groundwater drawdown across a 12 km stretch (maximum drawdown extent of 9 m over a 6.5 km stretch 'Zone 3', (or up to 18 mbgl based on consideration of an extended dry period and seasonal water table lows) of the Jimmawurrada Creek alluvial aquifer impacting the stygofauna PEC, which includes habitat for the Blind Cave Eel.

Existing environment/Impact	Mitigation			Significant Residual impact? (Yes/No)
	Avoid and Minimise	Rehabilitation type	Likely Rehabilitation Success	
	of water from dewatering as far as practicable and through the use of a thickener in the WFSF that improves recovery of water from the waste stream (reducing abstraction requirements by up to 30%). The use of the existing Southern Cutback Borefield which is already utilised to supply water for Mesa J avoids the need for a new groundwater abstraction area for Mesa H water supply.			There is uncertainty regarding the area of risk for the Blind Cave Eel from the drawdown in the affected section of Jimmawurrada Creek (noting that estimates have been based on reasonable worst case assumptions so impacts are not likely to be greater than expected), the degree of habitat modification and the range and sensitivity of the species. **Quality** Partially disturbed by mineral exploration activities and previous / current cumulative groundwater abstraction but overall quality is Good - Excellent. **Conservation Significance** Habitat supports SRE and conservation listed troglofauna and stygofauna species. **Land Tenure** N/A **Time Scale** Troglofauna: N/A - no temporary disturbance for troglofauna

Existing environment/Impact	Mitigation			Significant Residual impact? (Yes/No)
	Avoid and Minimise	Rehabilitation type	Likely Rehabilitation Success	
				Stygofauna: • For the Life of Mine through to closure for Mesa H based on groundwater recovery; and • Temporal along Jimmawurrada Creek during active groundwater abstraction during the life of the mine or until recharge occurs from significant rainfall / cyclonic events.
Terrestrial Fauna	The Proposed Change has been designed with a MEZ around the perimeter of Mesa H which is designed to avoid impact to the majority of the significant rocky habitats for terrestrial fauna including all significant caves. The majority of River habitat will also be avoided. Indirect impacts to the integrity of the habitat values of the caves will be minimised through sufficient setback distances from mining activities and implementation of a Blast Management Framework. Utilisation of existing Mesa J infrastructure, processing facilities and rail facilities as	Disturbed areas will be rehabilitated progressively as mining activities are completed. The conditions of the new MS shall require the Proponent to implement a Closure Plan in accordance with the DMP / EPA Guidelines for Preparing Mine Closure Plans. The Closure Plan (Appendix 7Appendix 7) includes a Closure Objective to ensure that vegetation on rehabilitated land is self-sustaining and compatible with the final land use. Habitat elements considered as part of the final landform design include: • Vegetation known to provide food or shelter • Retaining and replacing woody debris	See response as per Flora and Vegetation above.	Yes, the direct impact to core habitat for Northern Quoll. **Extent** 3.5 ha of Breakaways and Gullies habitat, 3.8 ha of habitat within 10 m of Breakaways and Gullies habitat and 1.3 ha of Riverine habitat. **Quality / Conservation Significance** The regional records of Northern Quoll show that the species is strongly associated with rocky habitats. This is supported by the local records in and around the Development Envelope which indicate

Existing environment/Impact	Mitigation			Significant Residual impact? (Yes/No)
	Avoid and Minimise	**Rehabilitation type**	**Likely Rehabilitation Success**	
	well as placement of haul roads away from significant habitat will minimise overall impacts to terrestrial fauna habitat.	• Generation and retention of leaf litter using small scale topography • Introducing or leaving rocky features such as oversized waste burden or scree slopes • Returning soil to allow opportunities for burrowing fauna • Managing feral predators and herbivores across both reference and rehabilitated areas • Backfilling of the MEZ in locations to allow fauna habitat continuation.		that the Northern Quoll is strongly associated with the Breakaways and Gullies habitat, Riverine habitat and the habitat directly adjacent to Breakaways and Gullies habitat (likely for foraging and dispersal). **Land Tenure** N/A **Time Scale** N/A - no temporary clearing Consideration of the Residual Impacts Significance Model indicates that the residual impact is significant because it involves clearing of core habitat for Northern Quoll.

Part 3 – Conclusion

14. HOLISTIC IMPACT ASSESSMENT

Sections 5 to 11 provide detailed assessment of the potential environmental impacts and proposed environmental management strategies for each of the environmental factors. This section provides an integrated, holistic assessment of the impacts of the Proposed Change on the whole environment by considering the interactions and connections between the preliminary key environmental factors. Only *significant environmental values* that may be impacted by the Proposed Change are considered in this section.

The preliminary key environmental factors identified as relevant to this Proposed Change (and as identified in the ESD) are: *Flora and Vegetation*; *Subterranean Fauna*; *Terrestrial Fauna*; *Inland Waters* (formerly *Hydrological Processes* and *Inland Waters Environmental Quality*); *Social Surroundings*; and *Air Quality*. In addition, Closure and Offsets are considered relevant to the Proposed Change and are considered in relation to each of the factors. Landforms is considered as an 'other environmental factor' as outlined in the ESD.

14.1 Proposal Activities

The following Proposed Change activities involve interactions between preliminary key environmental factors and have the potential to impact significant environmental values.

14.1.1 Land disturbance

The Proposed Change will require clearing and disturbance of up to 2,200 ha of native vegetation and fauna habitat in the Development Envelope of 6,638 ha. Land disturbance has the potential to impact on vegetation, fauna habitats, social surroundings and landforms.

The highest value aspect of the Mesa H landform, the escarpments, will be retained. The only clearing within these areas will be the access cuts to the mesa plateau which account for <2% of the mesa escarpment. The design and locations of the escarpment cuts have been selected to avoid disturbance to the escarpment sections with the highest ecological and heritage values. This will largely preserve landform values and maintain the visual amenity associated with this landscape.

The key focus for the Proposed Change design was to **avoid the high value** aspects of the following identified environmental values:

- **Landforms and Social Surroundings:** The Proposed Change has been designed to avoid as far as practical, disturbance to the mesa escarpments (facades); all major river drainage lines (Robe River and Jimmawurrada Creek); and all semi-permanent and permanent pools to protect the landform and amenity values of these landscape features, in addition to associated ecological and heritage values.
- ***Triodia* Sp. Robe River:** The Proposed Change has been designed to avoid disturbance as far as practicable to vegetation analogous to the *Triodia Sp.* Robe River PEC (AprTwTsr) (5.7 ha out of the total 14.6 ha mapped within the Proposed Change Area will be cleared).
- **Riparian vegetation**: Creeklines, including the associated pools and riparian vegetation will largely be avoided. Some minor clearing of riparian vegetation will be required to facilitate widening and installation of culverts along an existing access road which crosses the Robe River (2 ha of the total mapped 148 ha) and to facilitate monitoring locations.
- **Conservation Significant Fauna (MNES):** The Proposed Change has been designed to minimise disturbance to the highest value denning and roosting habitat

for conservation significant terrestrial fauna species, particularly Ghost Bat, Pilbara Leaf-nosed Bat (although no Pilbara Leaf-nosed Bat roosts currently known in the Proposed Change Area) and Northern Quoll. MEZs will be established to protect the highest value habitats. The Proposed Change footprint avoids direct disturbance the two recorded diurnal/potential maternal Ghost Bat roosts and all nine nocturnal roosts. The Proposed Change also limits disturbance to high-value fauna habitats (Breakaways and Gullies habitat and River habitat), with 0.5 ha loss of Breakaways and Gullies habitat and 23.2 ha loss of River habitat (of which < 2 ha is within the higher value Riverine habitat type, with the remainder comprising Drainage Line habitats).

- **Subterranean fauna**: Retention of at least 50% by volume of pre-mining troglofauna habitat and retention of connected habitat for stygofauna. There will be no direct disturbance / physical removal of habitat or known records of the Blind Cave Eel.
- **Significant Heritage sites:** The Proposed Change has been designed to avoid disturbance to most key heritage sites as identified by the Robe River Kuruma People including: Jirtiwi Thalu, the Gender restricted quarry site MJ04-09, rock shelter sites (with the exception of one site which will be subject to a Section 18 clearance under the AH Act), pools of the Robe River, the majority of the Robe River and the mesa escarpments; in addition to minimising indirect hydrological impacts to the watercourses and associated pools.

14.1.2 Abstraction of groundwater

Groundwater drawdown as a result of mine pit dewatering will lower the groundwater table in the Mesa H CID Aquifer and basement aquifers which has some connectivity to the Robe River alluvial aquifer and associated pools. The groundwater table is modelled to be lowered by approximately 25 m in the CID aquifer. The modelling indicates a short term maximum drawdown of up to 1 m in the Robe River alluvial aquifer to the north-east of Mesa H around Yeera Bluff and <0.5 m drawdown in the Robe River along the northern margin of Mesa H.

Therefore, the potential for discernible drawdown impact will be limited to dry conditions. The majority of water in the Robe River alluvial aquifer originates from streamflow recharge and throughflow from upstream within the alluvial aquifer. The potential impacts of mining and dewatering from the Proposed Change on the pools along the Robe River are predicted to be localised, temporary in duration and relatively small, and fall within the natural fluctuations observed in the water levels of the Robe River (2 – 3 m). The main effects are likely to be experienced during extended dry periods where groundwater drawdown may exacerbate climatically lowered water levels in the pools.

The permanent pool (Gnieroora at Yeera Bluff) in the section of the Robe River adjacent to Mesa H is approximately 3 – 4 m deep. This pool will continue to be permanently present, however, may potentially experience a greater reduction in size than it ordinarily would during extended dry periods. Shallower semi-permanent or seasonal pools, immediately to the north of Mesa H (e.g. Duck Pool), could potentially dry out more rapidly and for longer periods during extended periods of low rainfall or drought.

Groundwater abstraction from the Southern Cutback Borefield for operational water supply will remain within existing licence limits as currently set for the existing Mesa J Iron Ore Development. Mesa H will utilise a portion of water from this Borefield for wet ore processing, particularly during the period prior to mine pit dewatering, or when surplus dewatering volumes are not sufficient. The cumulative impacts of the existing Mesa J Iron Ore Development dewatering, Mesa J and H water supply and the adjacent CWSP abstraction will extend the depth and extent of groundwater drawdown below Jimmawurrada Creek and the timeframe to groundwater recovery. Groundwater abstraction for water supply from these cumulative effects will lower the groundwater table by 4 to 9 m along a 12 km extent of the ephemeral Jimmawurrada Creek, of which a 6.5 km stretch will be exposed to the peak drawdown of 9 m (translating to ~14 mbgl) from the cumulative drawdown. This impact may be exacerbated taking into consideration an extended dry period combined with seasonal water table lows.

Groundwater levels in the Mesa J and Mesa H mining areas will recover until a balance is reached between groundwater inflows and groundwater outflows. Backfilled pit voids will enable groundwater levels to eventually recover to pre-development levels. Once mining is complete and dewatering ceases, complete aquifer recovery is predicted to take between 50 and 60 years, however, the majority of the drawdown along the Robe River and Jimmawurrada Creek is expected to recover after the first or second significant rainfall event (5 - 10 years).

The footprint of the periodic surplus water discharge will overlap with areas subject to groundwater drawdown including along the Robe River and sections of Jimmawurrada Creek and thus may partially mitigate the potential impact from groundwater drawdown in these areas.

The predicted impacts to key environmental values in relation to groundwater abstraction are:

Stygofauna: The subterranean habitat below Jimmawurrada Creek will be affected by groundwater drawdown which will reduce the saturated aquifer thickness and stygofauna habitat available, however; wet season flows are expected to continue to provide seasonal recharge and connectivity of the alluvial habitat through this creek system. Therefore, any localised impact to subterranean habitat, including for the Blind Cave Eel is likely to occur during the dry season only and is not expected to permanently fragment any Blind Cave Eel habitat or populations, or significantly affect the distribution of the Blind Cave Eel. Notably, based on current hydrogeological information (Rio Tinto 2019b), the primary habitats for stygofauna and the Blind Cave Eel in the vicinity of the Proposed Change are the CID aquifers and surficial formations including the major alluvial aquifers which are well-represented in the region. These geological / hydrogeological formations extend beyond the proposed extent of the drawdown both upstream and downstream of the impact areas and as such, do not represent isolated stygofauna habitat. Therefore, the Proposed Change is considered unlikely to significantly affect the ecological integrity of stygofauna habitat.

However, the direct, albeit temporary impact to the groundwater levels in Jimmawurrada Creek of up to 9 m (~14 mbgl) over a 6.5 km stretch (or up to 18 mbgl based on consideration of an extended dry period and seasonal water table lows) is considered to be a significant residual impact to Blind Cave Eel habitat. There is uncertainty regarding the area of risk (noting that estimates have been based on reasonable worst case assumptions so impacts are not likely to be greater than expected), the degree of habitat modification and the range and sensitivity of the species. Therefore, this risk is proposed to be offset through providing $1 M of funding for further research into the occurrence and range of this species.

Riparian vegetation:

- <u>Jimmawurrada Creek</u>: Hydrological modelling predicts up to 9 m peak groundwater drawdown from the cumulative effect of abstraction for water supply (including the CWSP) and Mesa J Iron Ore Development mine pit dewatering in Jimmawurrada Creek. Drawdown will be the greatest along a 6.5 km section of the creek and is likely to result in impacts to riparian vegetation including canopy decline and potentially some mortality, together with changes in understorey composition and abundance. The remainder of the defined flow channel within the area affected by drawdown (5.5 km) is likely to experience a degree of increased drought stress. The absence of significant groundwater dependent riparian vegetation along Jimmawurrada Creek (e.g. *Melaleuca argentea* dominated communities), however the mitigating influence of discharge through existing licensed outlets will partially mitigate the impact of groundwater drawdown and reduce the area effected by groundwater drawdown impacts.

- Robe River: Groundwater sensitive, significant *Melaleuca argentea* dominated communities along the Robe River and fringing the semi-permanent and permanent pools are predicted to temporarily experience less than 1 m of groundwater drawdown from mine dewatering potentially resulting in some impacts to understorey vegetation, however the mitigating influence of the alluvial aquifer flows, discharge through existing licensed outlets into adjacent tributaries (Jimmawurrada Creek or West Creek) and cyclonic rainfall events mean that aside from some minor canopy decline, impacts to riparian vegetation are unlikely.

MNES habitat: The potential for reduction in water levels in the Robe River alluvial aquifer and associated permanent and semi-permanent pools may be up to 1 m, which may result in shallow (<0.8 m) seasonal and semi-permanent pools drying out more quickly during prolonged periods of drought. This is not anticipated to change the permanent or semi-permanent nature of any of the pools or significantly impact riparian vegetation which provides fauna habitat, as the water table levels will remain accessible to riparian root systems. The key impact on fauna habitat will be a small reduction in the length of time semi-permanent pools exist after rainfall. The temporary habitat values that these semi-permanent pools provide include drinking water, associated foraging habitat (both vegetation and prey availability) and shelter. As the size of the pools contract and understorey wetland vegetation cover reduces during dry periods, these habitat values may be reduced more quickly during periods of groundwater abstraction.

14.1.3 Discharge of surplus water

The Proposed Change will utilise surplus water derived from mine pit dewatering on site for operational purposes, particularly ore processing. Discharge currently periodically occurs from the existing Mesa J Iron Ore Development, predominantly to manage water post wet season when on site storage capacity is exceeded. It is proposed that surplus water generated from dewatering for the Proposed Change is also used on site or potentially to mitigate impact of groundwater drawdown, however, similar to the existing Mesa J Iron Ore Development, when storage capacity on site is exceeded, excess water is proposed to be periodically discharged via existing (and / or optimised) operational discharge outlets at Jimmawurrada Creek and or West Creek, both being tributaries of the Robe River. The proposed continuation of periodic discharge of surplus water into Jimmawurrada Creek and or West Creek (as per the current Mesa J Iron Ore Development) may continue to intermittently alter the hydrological regime up to 8 km downstream of the discharge point(s), from ephemeral systems to those which have localised continuous flow immediately downstream of the discharge point, in the tributaries, transitioning into a series of isolated pools during times of discharge. The ongoing change to the hydrological regime may continue to result in short-term changes to riparian vegetation and fauna utilisation along the affected sections of Jimmawurrada Creek and or West Creek. Following cessation of discharge, riparian vegetation and fauna utilisation of Jimmawurrada Creek, West Creek and the Robe River is expected to return to that adapted to an ephemeral system. Discharge associated with the Revised Proposal is not expected to cause significant additional impacts beyond those that have already been experienced as a result of over 27 years of mining operations (including dewatering and discharge), with discharge potentially mitigating areas of impact associated with groundwater drawdown beneath Jimmawurrada Creek and potential minor-negligible drawdown in the Robe River.

The predicted impacts to key environmental values in relation to discharge of surplus water are:

- **Riparian vegetation:** Ongoing periodic surplus water volume may result in temporary, localised vegetation waterlogging stress and decline in vegetation health along Jimmawurrada creek and or West Creek. The discharge will be temporary and intermittent, particularly required post wet season when surplus water storage capacity is exceeded. Given the temporary nature of the discharge to a system that is already subject to the same discharge regime and is adapted to highly variable flow conditions, it is unlikely that there will be any significant residual impact on riparian vegetation. There may be some increase in the recruitment and cover of *Melaleuca argentea*, and sedges and rushes. Some decline in health of *Eucalyptus victrix* (including dead trees) limited to the low flow channels is also possible. Taking into account the discharge history and current degree of vegetation augmentation; the proposal to continue periodically discharging surplus water into Jimmawurrada creek and or West Creek, (which flow into the Robe River), is anticipated to result in very minimal changes to vegetation beyond that already realised.
- **MNES habitat:** Any potential increased use of Jimmawurrada Creek and / or West Creek, and the Robe River by MNES during periods of discharge is expected to be temporary until the vegetation and water availability reverts back to that of an ephemeral system. However, given the temporary nature of the proposed discharge and that this area represents a small proportion of foraging and dispersal habitat in the Proposed Change Area and the broader Robe Valley for MNES, significant impacts to MNES species from surplus water discharge are considered unlikely.

14.2 Application of the Mitigation Hierarchy

The Proponent has applied the mitigation hierarchy in the *Western Australian Environmental Offsets Guidelines* (Government of Western Australia 2014b) for all proposed activities, including those listed above.

14.2.1 Avoidance

Avoidance is the preferred strategy for managing potentially significant impacts to the environment. This Proposed Change has been designed to avoid potentially significant impacts to the environment; specifically, **avoidance of *direct* disturbance to**:

- mesa escarpments - except for minor access cuts (landscape, terrestrial fauna including MNES, troglofauna, Priority Flora and heritage values);
- water courses and associated pools:
    - Robe River - except for widening of an existing access road and for monitoring locations (riparian vegetation, terrestrial fauna, aquatic fauna and heritage values);
    - Semi-permanent and permanent pools of the Robe River; and
    - Jimmawurrada Creek.
- diurnal / potential maternal, and all nocturnal ghost bat roosts (terrestrial fauna values); and
- most key heritage sites as identified by the Robe River Kuruma People (heritage values).

14.2.2 Minimisation

After avoidance strategies were considered, mitigation measures to minimise the remaining significant impacts were investigated to reduce these to an acceptable level. This Proposed Change has been designed to minimise the remaining potentially significant impacts to the environment; specifically, minimisation of disturbance to:

- mesa escarpments (terrestrial fauna, heritage and landscape values);
- watercourses and associated pools (terrestrial fauna, flora and vegetation, subterranean fauna, hydrological and heritage values);
- subterranean fauna habitat and PECs (subterranean fauna values);
- vegetation analogous to the *Triodia Sp. Robe River* PEC (AprTwTsr); and
- high local significance vegetation and conservation listed flora (flora and vegetation values).

14.2.3 Rehabilitate

Following consideration of avoidance and minimisation measures, rehabilitation measures were considered to further reduce remaining impacts. The closure strategy includes ensuring prioritisation of backfill to prevent the formation of pit lakes.

The Proponent proposes that mining be subject to a new MS (Appendix 3). The conditions of the MS shall require the Proponent to manage the implementation of this Revised Proposal to '*ensure that the Proposal is rehabilitated and decommissioned in an ecologically sustainable manner'*. The conditions of the MS shall also require the Proponent to implement a Closure Plan (Appendix 7) in accordance with the DMP / EPA *Guidelines for Preparing Mine Closure Plans*.

The rehabilitation is anticipated to ensure that the Revised Proposal will not compromise land use options in the area.

14.2.4 Offset

If, after the previous steps of the mitigation hierarchy have been considered, significant residual impacts to the environment are expected, then offsets are proposed. The Proponent proposes the following environmental offsets:

- $3,000 per hectare for Northern Quoll core habitat (8.6 ha). The offset may include habitat improvement so this contribution is also expected to offset impacts to good to excellent native vegetation and riparian vegetation within that 8.6 ha.
- Provision of $1 M of funding for further research into the occurrence and range of the Blind Cave Eel.
- $1,500 per hectare for PECs and riparian vegetation (that is not MNES habitat but may also be native vegetation in good to excellent condition) (approximately 1,315 ha). This offset contribution will address significant residual impacts to the specific PECs and riparian vegetation values and to native vegetation of good to excellent condition.
- Where MNES core habitat and PECs co-occur; a total of $3,000 per hectare will be provided to the Fund.
- $750 per hectare for native vegetation that is in good to excellent condition in the Hamersley subregion (up to 876.4 ha).

The exact location of infrastructure within the vegetation in good to excellent condition and within the extent of the PEC (which occurs extensively within the Development Envelope) has not yet been determined. Therefore, the areas requiring offset outlined below and throughout this ERD are estimates only. The actual quantum of impact and offsets required will be determined through an Impact Reconciliation Procedure in accordance with EPA instructions as outlined in the Draft Conditions included in Appendix 3.

Given proposed avoidance and mitigation strategies, there are no other significant residual impacts expected as a result of the Proposed Change that would require offsets.

14.3 Conclusion

The key environmental values in the western Pilbara have been identified as the river systems, gorges and rocky hills/breakaways. These landscape features provide significant shelter and foraging opportunities for fauna (in particular MNES fauna), include aquatic and cave habitats and have high heritage and amenity values. The iron ore resource is associated with the mesas and it has been identified that the breakaways and cave systems of the mesa escarpments are the most significant features of the mesas both environmentally and socially. Therefore, the protection of these escarpments (through limiting clearing in this area and the creation of a MEZ), while allowing mining of the internal mesa plateau, has been the overarching approach to mine planning for the Proposed Change. This approach is expected to protect the MNES habitat values, heritage and amenity values associated with the escarpments. Where key MNES habitat values cannot be protected, an offset has been proposed specifically for Northern Quoll core habitat.

The Proposed Change avoids almost all direct disturbance of riparian vegetation associated with the Robe River and tributaries. Potential indirect impacts from dewatering and surface water discharge into Jimmawurrada Creek and or West Creek (and the adjoining sections of the Robe River) may occur. The effects of groundwater abstraction and dewatering have been modelled extensively and ongoing monitoring of key environmental values will be undertaken to ensure that no unforeseen impacts occur. The potential for reduction in water levels in the Robe River alluvial aquifer from dewatering is not anticipated to change the permanent or semi-permanent nature of any of the pools or change riparian vegetation which provides fauna habitat. The requirement for surplus water discharge has been minimised as far as possible and will be managed such that surface discharge extends no further than 8 km downstream of the discharge point under natural no-flow conditions. Given discharge currently occurs from the existing Mesa J Iron Ore Development the temporary discharge to a system that is adapted to highly variable flow conditions, is unlikely to have a significant residual impact on riparian vegetation. No irreversible impact on riparian vegetation is anticipated as a result of dewatering or surplus water discharge. The proposed mitigation strategies (outlined in Section 5.9) will ensure that the environmental objective for Inland Waters is met and that the significant river and creek systems in the vicinity of the Proposed Change Area are protected.

The nature of mining a resource or abstracting groundwater from a particular geological stratum means there is an inherent risk that any short-range endemic species of subterranean fauna may be at risk from habitat loss. Therefore, the definition of habitat and habitat connectivity for subterranean fauna as well as survey coverage has been a key consideration in this environmental assessment. Within Mesa H and also with other impact areas the troglofauna and stygofauna habitat present is well connected and extends beyond the proposed impact areas. With regard to stygofauna; although the Proposed Change will result in the localised reduction of habitat and potential loss of individuals across part of Mesa H and a 12 km section of Jimmawurrada CID and alluvial aquifers, it is unlikely to significantly affect stygofauna diversity, given the extent of habitat connectivity and mitigation measures proposed, and seasonal and cyclonic topping up of these aquifers. Considering the proposed mitigation strategies for subterranean fauna, including the continuation of the MEZ approach; reduction of water abstraction by 30 % by the use of a thickener, greater recovery of water from the waste stream, and maintaining physical connected habitat; it will be ensured the proposed mining at Mesa H can be conducted such that the ecological integrity of troglofauna and stygofauna habitat, as well as the diversity and ecological integrity of the troglofauna and stygofauna assemblages present are likely to be retained. However, given the large proportion of habitat being disturbed within the two subterranean fauna PECs, the proponent is proposing to offset direct impacts to these areas as well as proposing an offset for the Blind Cave Eel due to the high level of uncertainty around the risk to this species and it's habitat from drawdown along Jimmawurrada Creek.

The Proponent considers that the Proposed Change is in accordance with the EP Act Environmental Principles (Section 4.1). The proposed rehabilitation is designed to ensure that the Proposed Change will not compromise land use options in the area and therefore is consistent with the environmental principle of intergenerational equity. The Proposed Change can be managed effectively through avoidance, management and mitigation measures to ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.

Based on the proposed avoidance of significant areas, proposed mitigation strategies and the continued implementation of existing management strategies (including offsets for the identified potentially significant residual impacts), the Proponent considers that the EPA objectives can be met for all environmental factors; that the Proposed Change is environmentally acceptable; and can be adequately managed through the draft MS conditions provided in Appendix 3.

14.4 Environmental Management

Rio Tinto has developed and refined environmental management objectives, systems and procedures over decades of operational mining experience in the Pilbara region that are successfully applied at multiple iron ore mine sites.

The key components of the environmental management approach that have been implemented include:

- The Rio Tinto Iron Ore Group HSECQ Policy. The HSECQ Policy is the guiding document for environmental management and provides context and direction for continuous improvement.
- Rio Tinto Iron Ore (WA) operates under an Environmental Management System (EMS), contained within the HSECQ Management System. The HSECQ Management System is a continuous improvement model covering:
    - systematic assessment of environmental risk and legal requirements; systems for training, operational control, communication, emergency response and corrective actions;
    - the development of objectives and targets for improvements; and
    - audits and review.
- Conditions of the relevant MS (Appendix 3).

  The existing Mesa J operates under the existing MS (MS 208, Appendix 5). Subject to approval of this Revised Proposal, the Proponent requests that a new MS is published to supersede the existing Ministerial Statements. A Proponent drafted MS is provided as Appendix 3 for the EPA Services of the DWER's consideration.
- Management strategies of the relevant EMP (Appendix 6).

  The Proponent currently operates under the existing, approved Mesa J Iron Ore Development EMP (dated 2012). An updated Condition EMP is proposed to demonstrate that the environmental outcomes for key environmental factors (inland waters, flora and vegetation and terrestrial fauna) are met. This EMP will be implemented subject to approval by the EPA and will supersede the existing approved EMP.
- Closure strategies of the relevant Closure Plan (Appendix 7). The Rio Tinto closure approach will continue to guide closure planning for this Proposed Change. This approach governs:
    - commencement of planning for closure prior to project implementation;
    - the development of closure plans;
    - stakeholder consultation regarding closure;
    - financial provisioning for closure; and
    - the ongoing review of closure plans, which will become increasingly detailed as the site approaches closure
- Existing licences issued under Part V of the EP Act and the RIWI Act, and any amendments as required:
    - Licence L6820/1993/12, issued under Part V of the EP Act for processing of ore, dewatering (discharge), screening, power generation, sewage facility, landfill and bulk storage of chemicals.
    - Groundwater Licence GWL6820/1993-12, issued under the RIWI Act for abstraction of 30,000 kL from the Southern Cutback Borefield for water supply and mine dewatering purposes.

The Proponent will continue to implement key components of the environmental management approach in accordance with the existing Project's approved practices.

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16. APPENDICES

The following supporting documents are contained on CD_ROM inside the back cover of this ERD. It should be noted the terminology used in some of these appendices will differ from that defined in Section 1.1. This is due to the terminology recently being revised to reflect the nature of the Proposed Change being part of the Revised Proposal. The key terms to note are 'the Proposal area' or 'the Project area' are referred to in this ERD as 'the Proposed Change area', which encompasses the new activities of the Revised Proposal associated with mining at Mesa H (i.e. the subject of this assessment), and the 'Mesa H Development Envelope' is referred to in this ERD as 'the Development Envelope' encompassing the Revised Proposal, including the existing Mesa J Iron Ore Development and Proposed Change.

Appendix 1: Section 38 Referral Form

Appendix 2: Environmental Scoping Document

Appendix 3: Draft Ministerial Statement

Appendix 4: Section 68 EPBC referral Form

Appendix 5: Ministerial Statement 208

Appendix 6: Draft Environmental Management Plans (Mesa J and Mesa H)

Appendix 7: Mesa J Hub Closure Plan

Appendix 8: Key Inland Waters Studies

- Mesa J H3 Hydrogeological Assessment. (Rio Tinto 2019a)
- Peer Review: Mesa H: H3: Hydrogeological Assessment (Independent Groundwater Consultants 2017)
- Mesa H Groundwater Modelling Review (RPS 2018)
- Surplus water discharge extent assessment: Mesa H (Rio Tinto 2017a)
- Mesa H 2017 AMD Risk Assessment Update Summary (Rio Tinto 2017b)

Appendix 9: Key Flora and Vegetation Survey Reports

- Mesa H Level 2 Vegetation and Flora Assessment (Astron 2016a)
- Mesa H Riparian community assessment (Astron 2016b)
- Assessment of Groundwater Dependent Vegetation distribution on the Robe River – Targeted Riparian Vegetation Survey- Stage 1 (Rio Tinto 2018d)
- Addendum to Assessment of Groundwater Dependent Vegetation distribution on the Robe River – Targeted Riparian Vegetation Survey- Stage 1: Groundwater Dependent Vegetation distribution within Jimmawurrada Creek Rio Tinto (2018e)

Appendix 10: Key Subterranean Fauna Survey Reports

- Subterranean Fauna Assessment (Biota 2019a)
- Subterranean Fauna Habitat and Impact Risk Assessment (Biota 2019b)
- eDNA Metabarcoding Preliminary Report: Blind Cave Eel survey in the Pilbara WA and Follow-up report (TrEnD 2018)
- Mesas A and K Targeted Troglofauna Survey, October 2017 (Biota 2017)

Appendix 11: Key Terrestrial Fauna Survey Reports

- Mesa H Level 2 Fauna Assessment 2016 (Astron 2017e)
- Mesa H Project Baseline Aquatic Ecosystem Survey Wet Season Sampling 2016 (WRM 2017)

- Robe Valley Mesa A to Mesa 2405A, impact of mining on Ghost bat presence and activity, April 2017, including assessment of caves on Mesas F and G (Bat Call 2017a)
- Robe Valley Mesa H, Ghost bat roost cave assessment (Bat Call 2017b)
- Mesa H Ghost Bat, Macroderma gigas - Contextual Study (Astron 2017d)
- Mesa H Night Parrot Survey (Astron 2017b)
- Mesa J Project Aquatic Ecosystems Pools Study (Streamtec 2017)
- Recent Examples of Blast Vibration Control (Rio Tinto 2013)
- Geotechnical Assessment – Diurnal Ghost Bat Roosts in Robe Valley (Rio Tinto 2017g)

Appendix 12: Key Landforms Studies

- Mesa H Façade Assessment (Astron 2017c)
- Mesa H Visual Impact Assessment (Rio Tinto 2017c)
- Robe Valley Deposits Façade Stand-off Distance Memo (Rio Tinto 2017d)