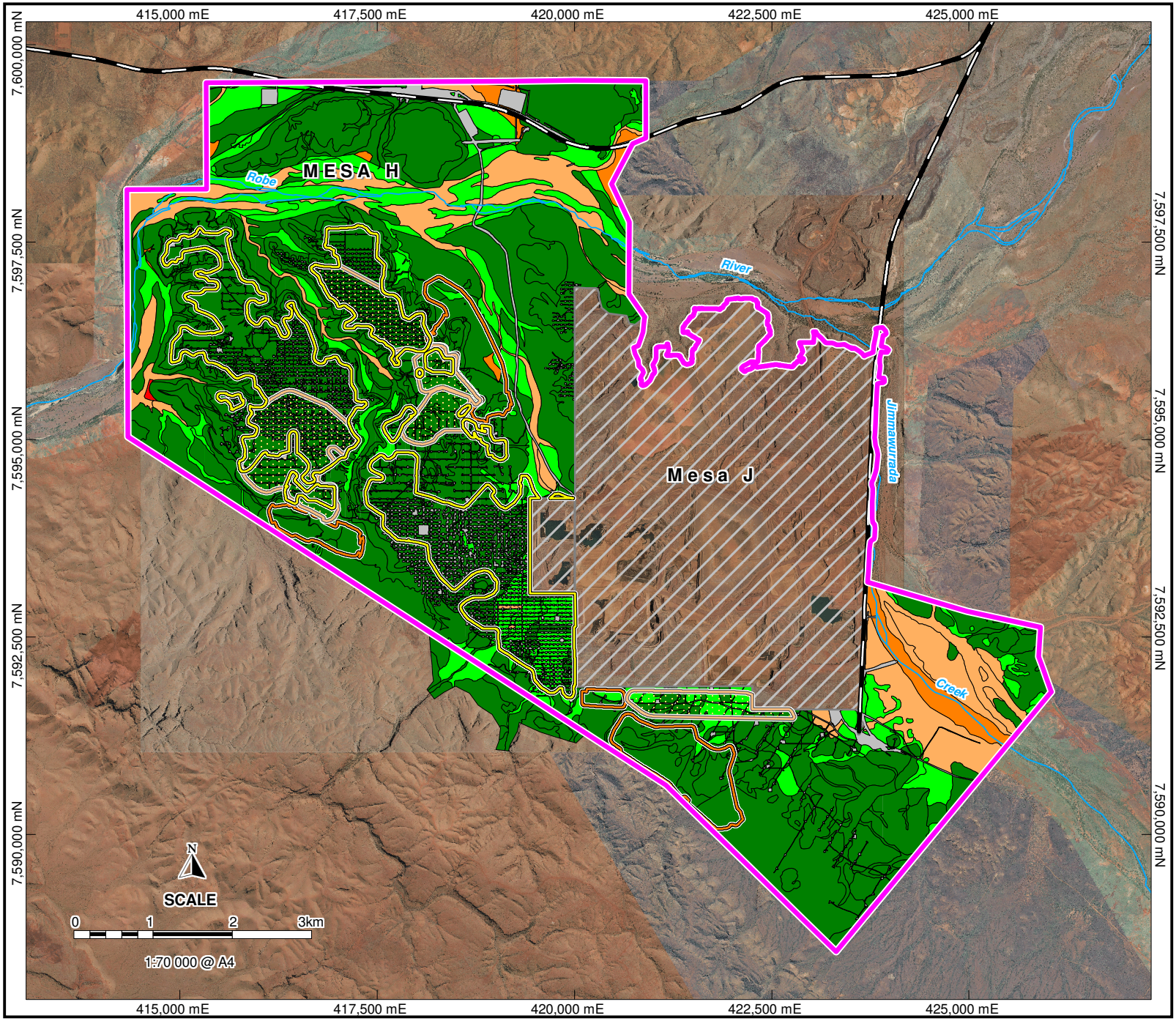


LEGEND

- 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

Rio Tinto

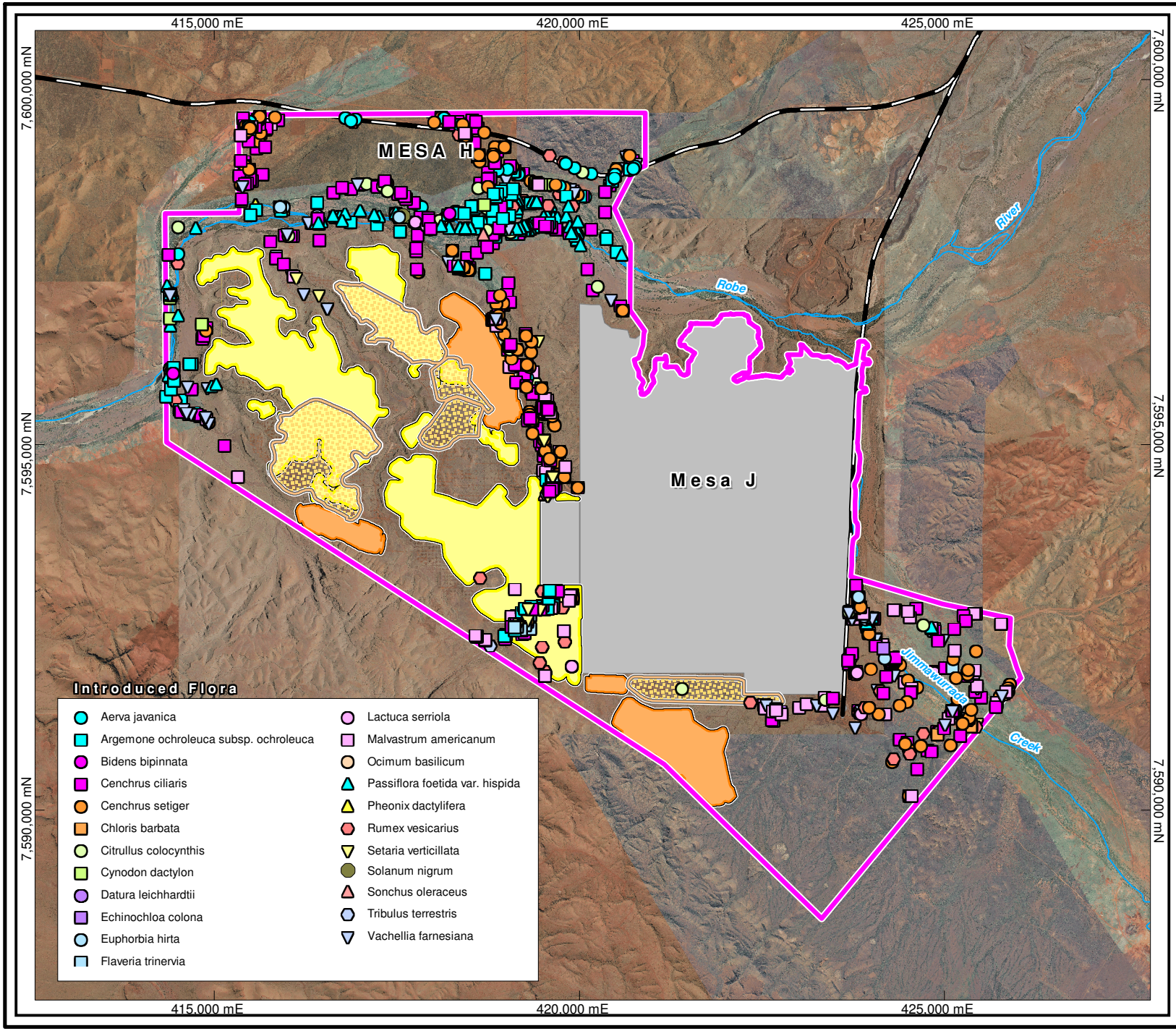
Iron Ore (WA)

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

Rio Tinto

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
    - Robe River: Ground Water Dependant Vegetation (dominated by the Obligate Phreatophyte – *Melaleuca argentea*) along the river and surrounding the semi-permanent and permanent pools
    - 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).

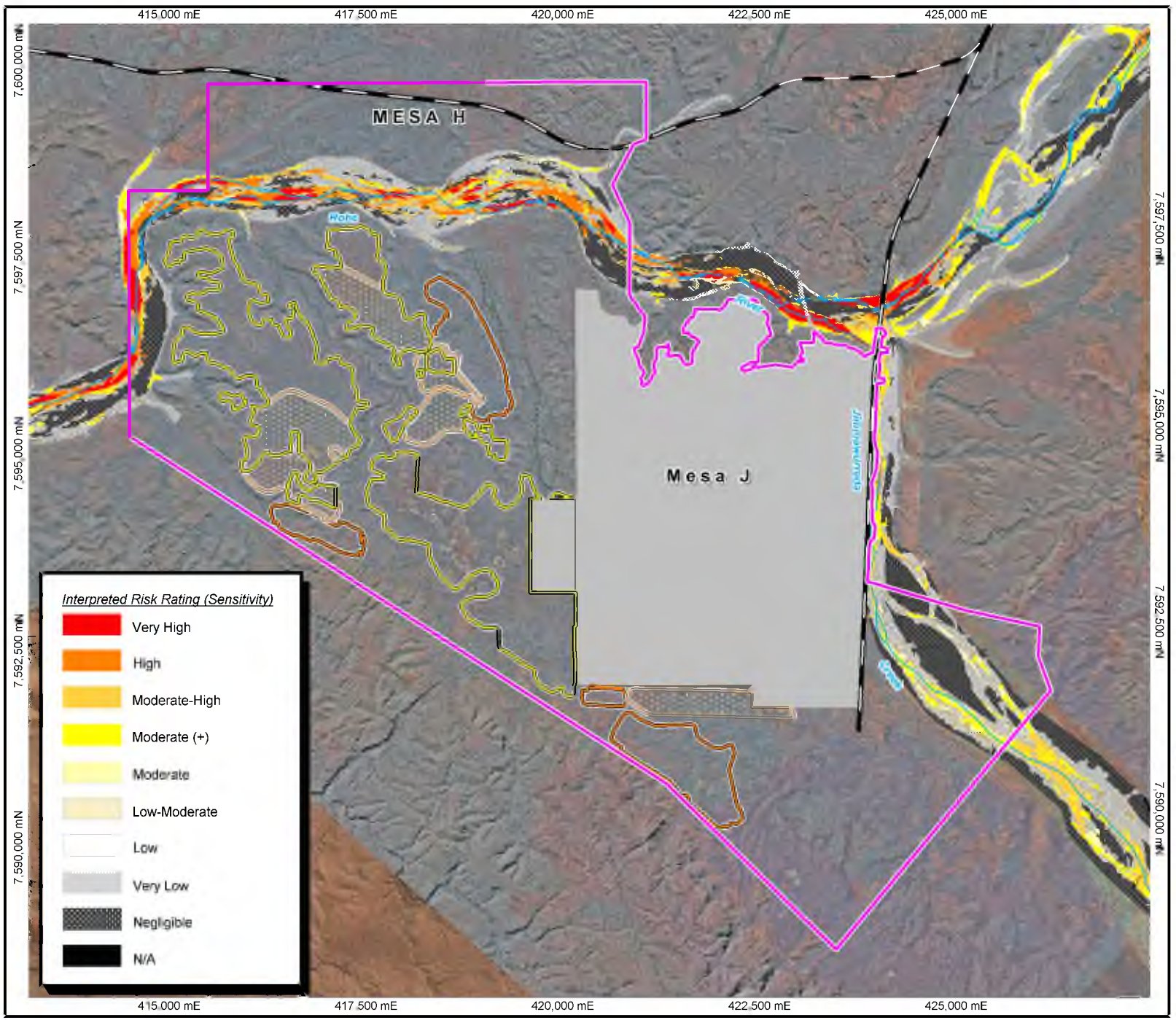
Within the Robe River, an additional 232 ha of OPV may experience some canopy decline during the period of dewatering for Mesa H, however the magnitude of drawdown is

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.



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse
- Conceptual Mine Pit
- Conceptual Waste Dump
- Conceptual Topsoil / Subsoil Stockpile

N

SCALE

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Rio Tinto

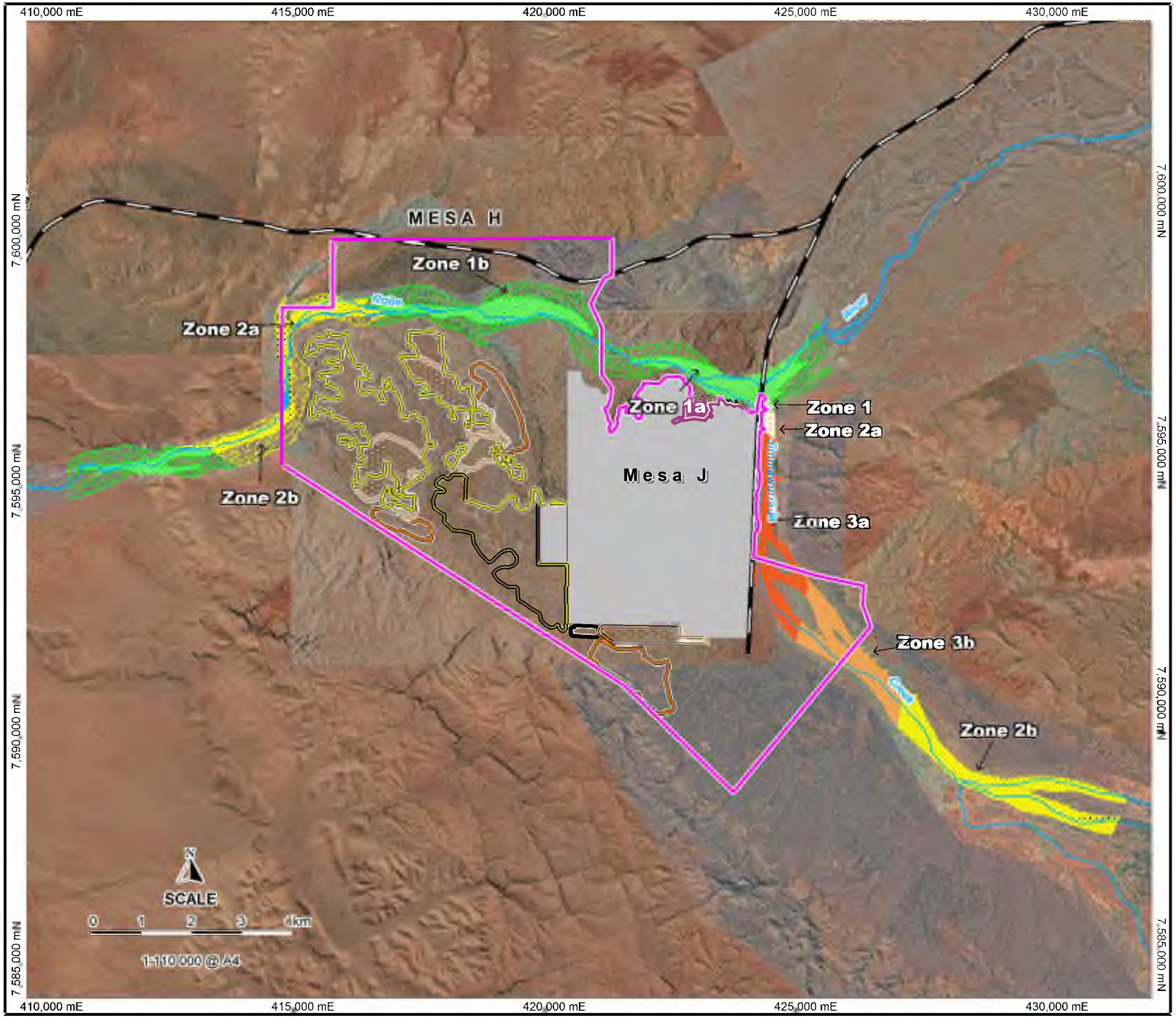
Iron Ore (WA)

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

Drawn: M.Swebbs
Date: Dec, 2018

Plan No:PDE0155751v4
Proj:MGA94 Zone50

Geospatial Information and Mapping



LEGEND

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

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile

Groundwater Drawdown Zones

Robe River

- RR Zone 1a - <0.5m
- RR Zone 1b - <0.5m
- RR Zone 2a - <1m
- RR Zone 2b - <1m

Jimmawurrada Creek

- Jim Zone 1 - 1-4m
- Jim Zone 2a - 4-8
- Jim Zone 2b - 4-8m
- Jim Zone 3a - 8-9m
- Jim Zone 3b - 3-8m

Rio Tinto

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.	

Inherent impact	Mitigation	Residual impacts	Assessment of significance[3]	Offset required?
	• Erosion from landforms does not threaten surrounding significant natural ecosystems.			
Indirect Impacts				
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	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	**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.	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.	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?
	• 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:
    - approximately 2 ha of sub-regionally significant riparian vegetation along the Robe River; and
    - 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

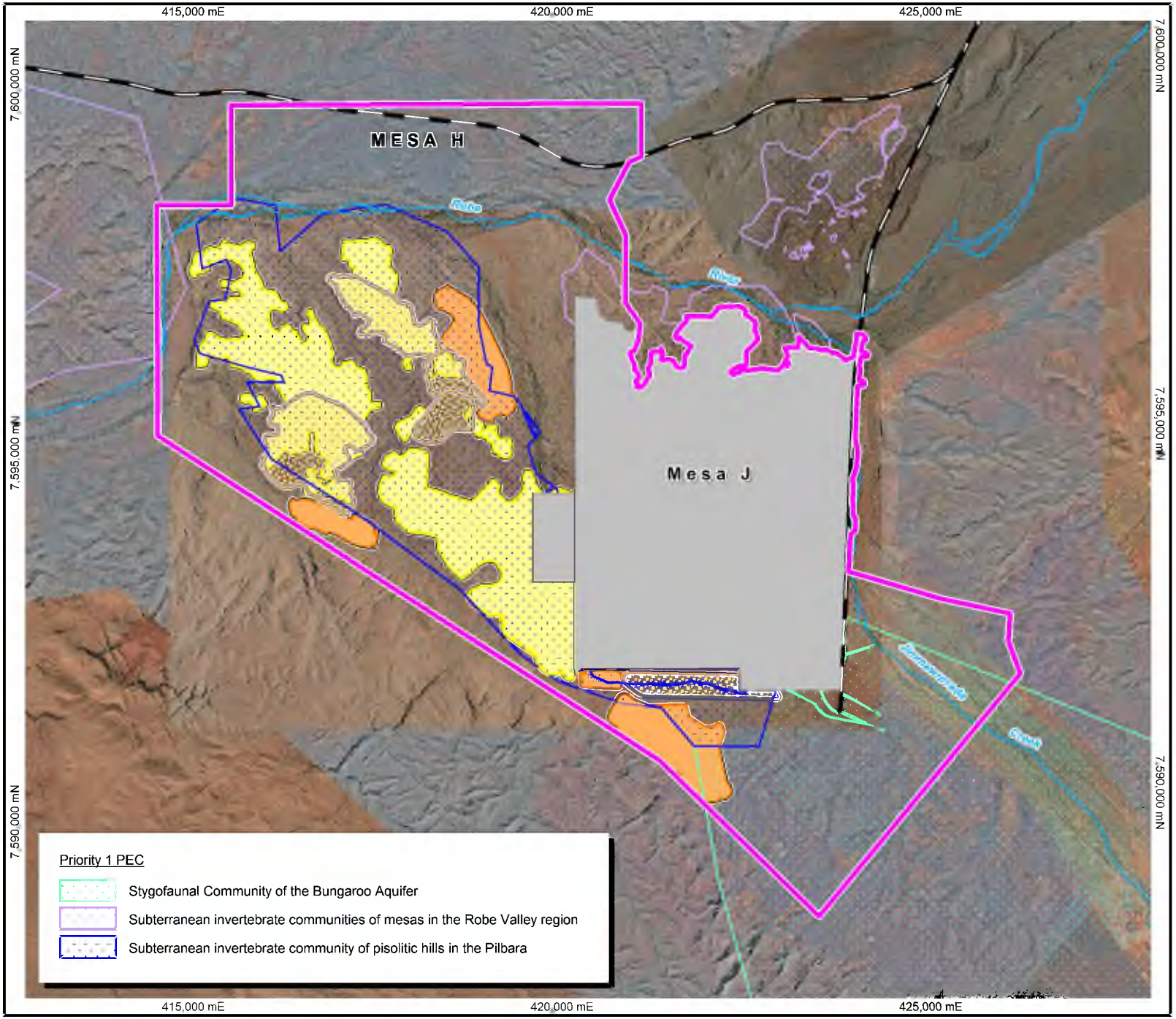
Subterranean fauna surveys within the Robe Valley have documented the occurrence of both troglobitic and stygobitic fauna communities.

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.



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

Rio Tinto

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:

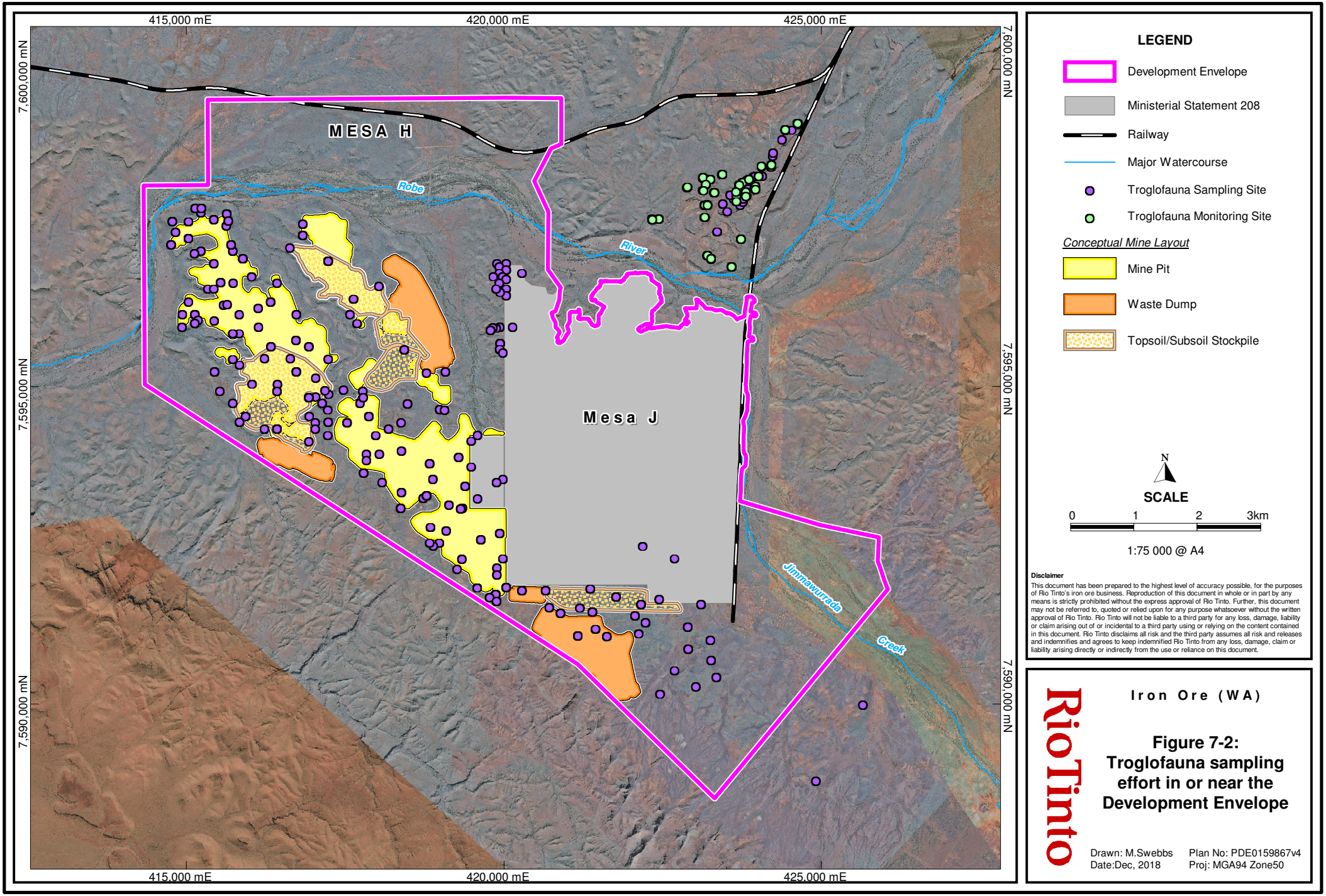
- previous relevant studies conducted within 40 km of the Development Envelope;
- TECs and PECs listed by the DBCA that are of relevance to subterranean fauna and within 40 km of the development envelope;
- assessment of the geology of the Proposed Change Area in a local context; and
- database searches 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.

[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



Rio Tinto

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).

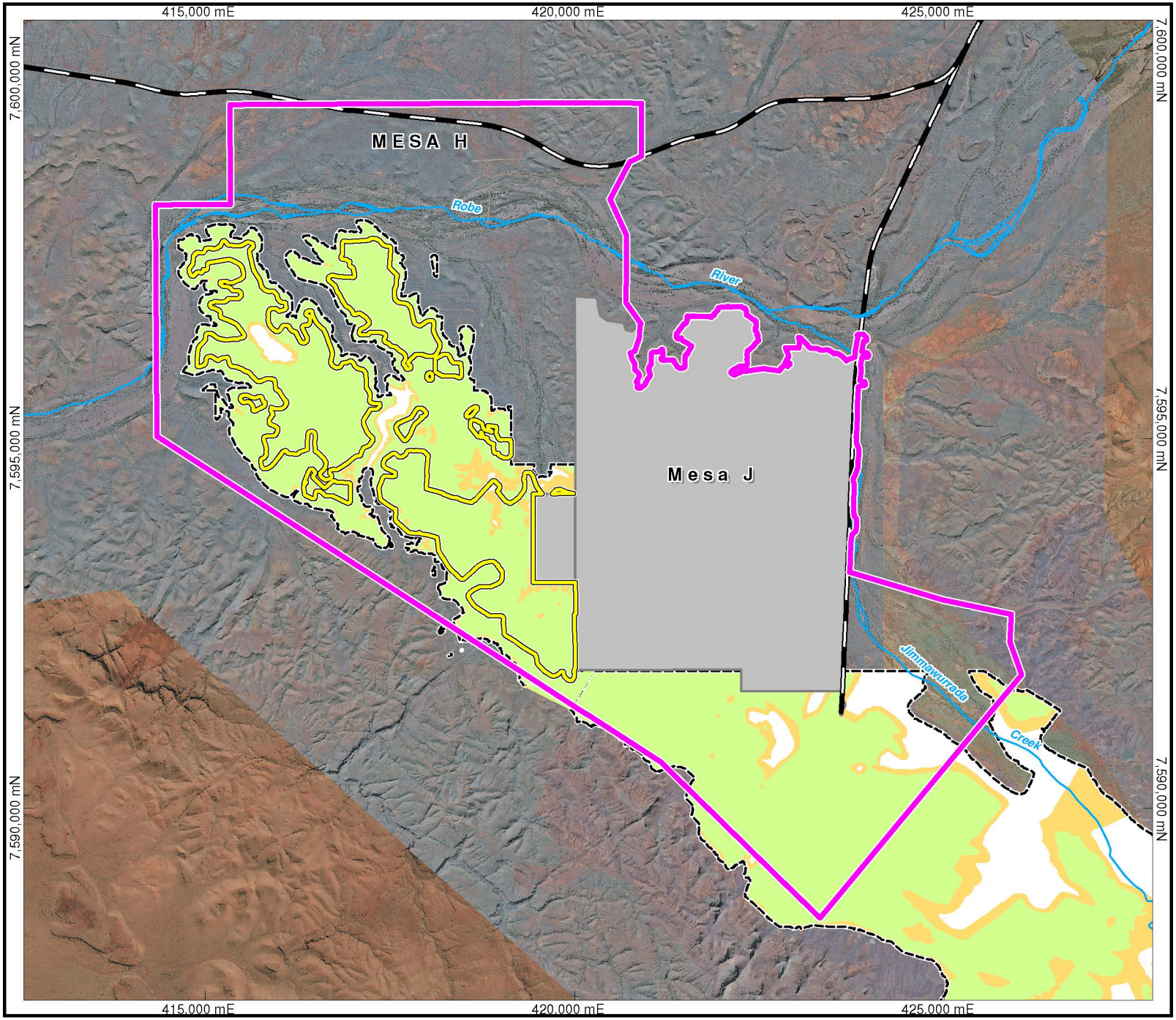
The modelled troglofauna habitat prospectivity was evaluated for the Proposed Change Area as determined from regional surface geology and site specific data including mapping of thickness of prospective geological units, stratigraphic logging, images and information from drill holes; 3D Habitat prospectivity 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.



LEGEND

- Development Envelope
- Ministerial Statement 208
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Limit of high confidence habitat modelling

Habitat Prospectivity (high confidence)

- Habitat Prospectivity : High
- Habitat Prospectivity : Medium
- Habitat Prospectivity : Low

N

SCALE

0 1 2 3km

1:75 000 @ A4

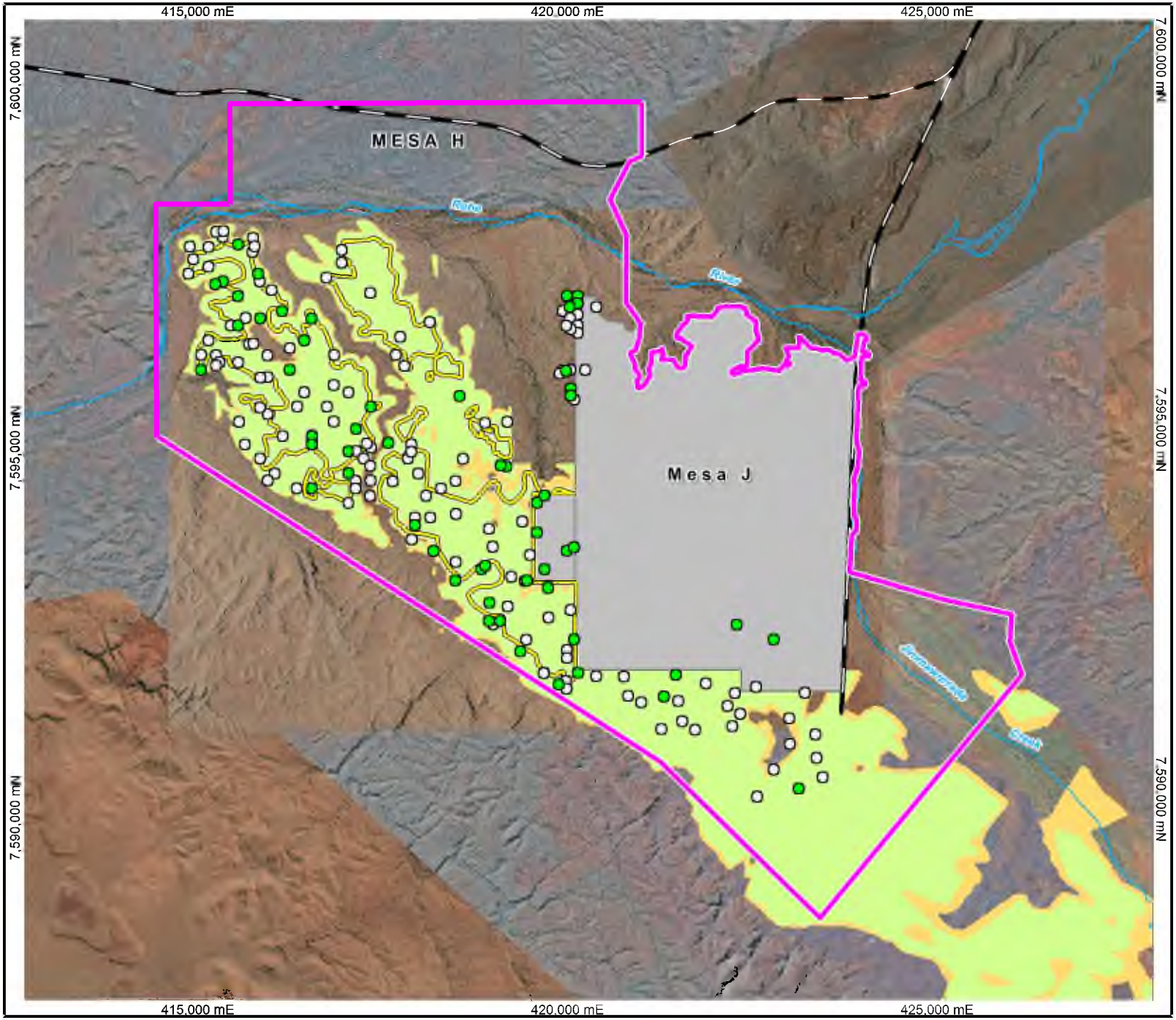
Rio Tinto

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

Rio Tinto

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

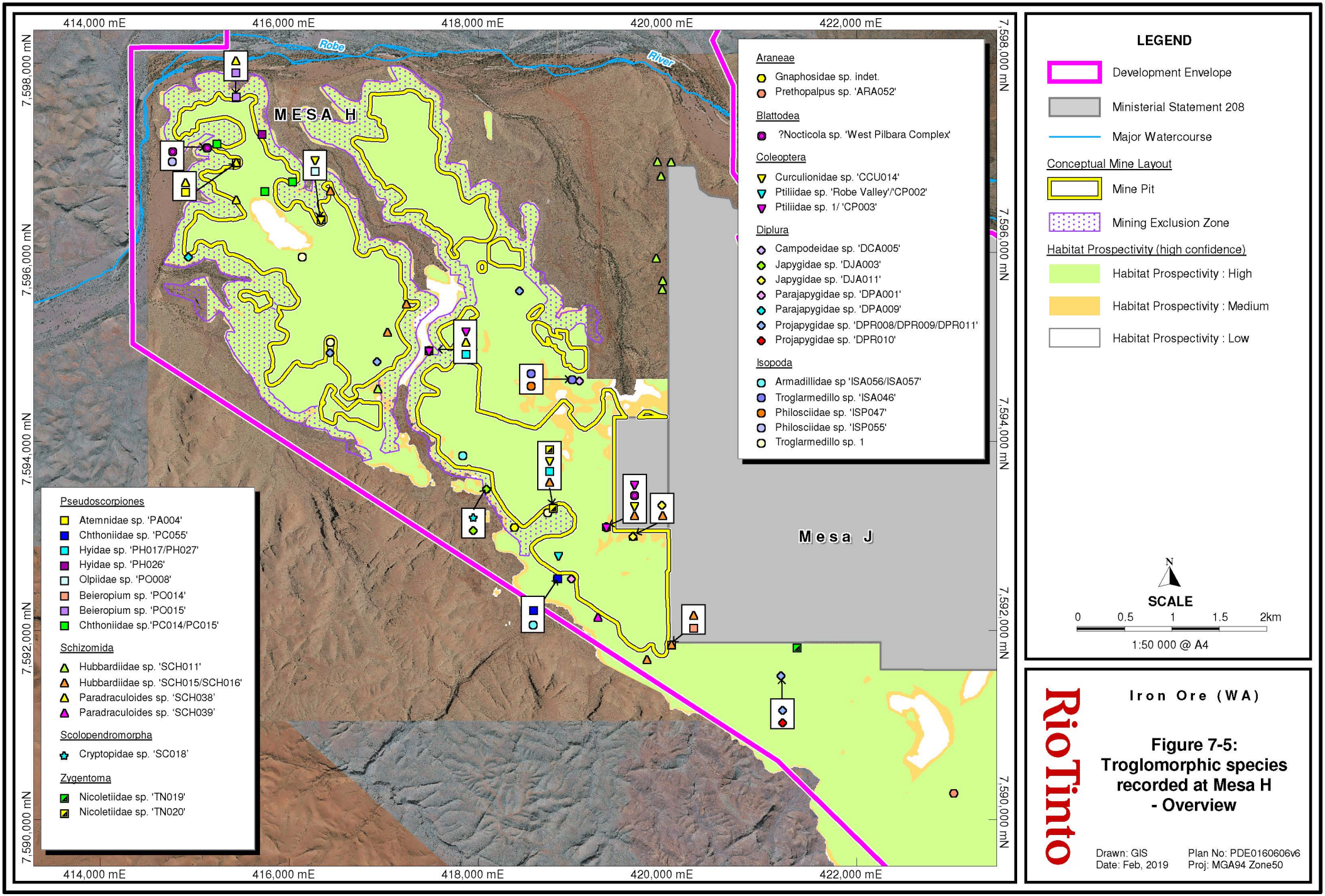
A number of troglofauna specimens could not be identified to species level, including *Diplura* sp. indet., *Pseudoscorpiones* sp. indet., *Isopoda* sp. indet., *Schizomida* sp. indet. and *Gnaphosidae* sp. indet. (Biota 2019a). While it is considered likely that these specimens represent range-restricted 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).

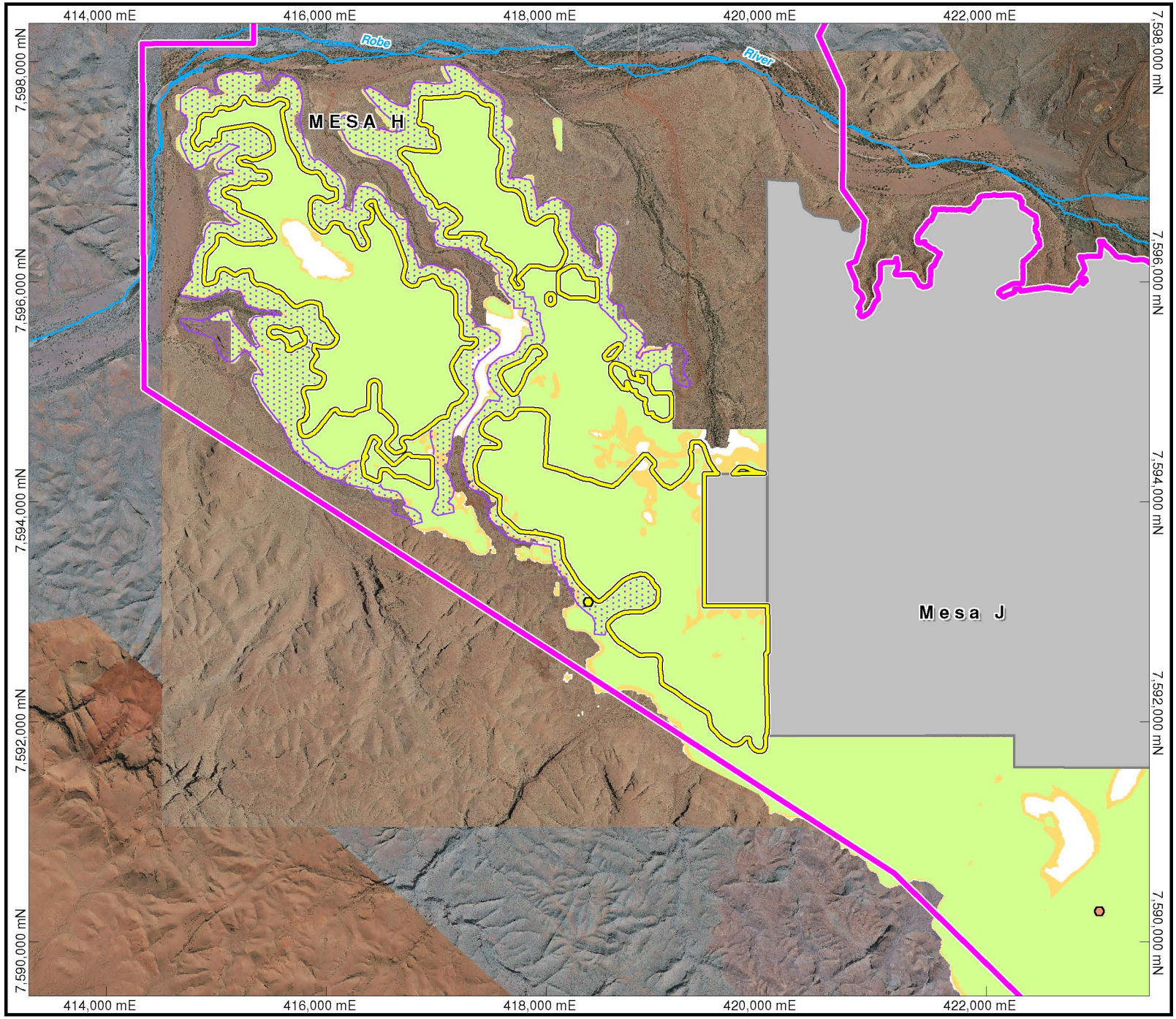
The six troglofauna species with records outside of the Proposed Change Area are considered to still have only have relatively restricted distributions in the Robe Valley, most of which are potentially subject to potential impacts from other proposals (see Table 7-4). To provide a conservative assessment, 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 km^2
Coleoptera (Beetles)	*Curculionidae* sp. 'CCU014'	Potential SRE	✓	✓	×	0.7 km^2
	Ptilidae sp. 1/'CP003'	Potential SRE	✓	✓	✓ Warramboo	35 km^2
	Ptilidae sp. 'Robe Valley'/'CP002'	Potential SRE	✓	×	✓ Robe Valley, Middle Robe	19 km^2
Diplura	*Parajapygidae* sp. 'DPA001'	Potential SRE	×	×	✓	
	Parajapygidae sp. 'DPA009'	Potential SRE	×	✓	×	
	Projapygidae sp. 'DPR008/DPR009/DPR011'	Potential SRE	✓	×	✓	5 km^2
	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	×	✓	×	


414,000 mE
416,000 mE
418,000 mE
420,000 mE
422,000 mE
7,598,000 mN
7,596,000 mN
7,594,000 mN
7,592,000 mN
7,590,000 mN
Robe
River
MESA H
Mesa J
Araneae
Gnaphosidae sp. indet.
Prethopalpus sp. 'ARA052'
Blattodea
?Nocticola sp. 'West Pilbara Complex'
Coleoptera
Curculionidae sp. 'CCU014'
Ptiliidae sp. 'Robe Valley'/'CP002'
Ptiliidae sp. 1/ 'CP003'
Diplura
Campodeidae sp. 'DCA005'
Japygidae sp. 'DJA003'
Japygidae sp. 'DJA011'
Parajapygidae sp. 'DPA001'
Parajapygidae sp. 'DPA009'
Projapygidae sp. 'DPR008/DPR009/DPR011'
Projapygidae sp. 'DPR010'
Isopoda
Armadillidae sp 'ISA056/ISA057'
Troglarmedillo sp. 'ISA046'
Philosciidae sp. 'ISP047'
Philosciidae sp. 'ISP055'
Troglarmedillo sp. 1
Pseudoscorpiones
Atemnidae sp. 'PA004'
Chthoniidae sp. 'PC055'
Hyidae sp. 'PH017/PH027'
Hyidae sp. 'PH026'
Olpiidae sp. 'PO008'
Beieropium sp. 'PO014'
Beieropium sp. 'PO015'
Chthoniidae sp.'PC014/PC015'
Schizomida
Hubbardiidae sp. 'SCH011'
Hubbardiidae sp. 'SCH015/SCH016'
Paradraculoides sp. 'SCH038'
Paradraculoides sp. 'SCH039'
Scolopendromorpha
Cryptopidae sp. 'SC018'
Zygentoma
Nicoletiidae sp. 'TN019'
Nicoletiidae sp. 'TN020'
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
N
SCALE
0 0.5 1 1.5 2km
1:50 000 @ A4
RioTinto
Iron Ore (WA)
Figure 7-5:
Troglomorphic species recorded at Mesa H - Overview
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

Araneae

- Gnaphosidae sp. indet.
- Prethopalpus sp. 'ARA052'

N

SCALE

0 0.5 1 1.5 2km

1:50 000 @ A4

RioTinto

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