Manuwarra Red Dog Highway

Environmental Review Document incorporating Additional Information Request Response

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Main Roads Western Australia

Manuwarra Red Dog Highway

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Document history and status

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A	9 May 2021	Draft for Client Review	Kate Thomson and Hannah Nichol	Lisa Boulden	Arne de Vos	Arne de Vos	
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3	05 July 2022	Final – address EPA comments	Arne de Vos	Lisa Boulden	Lisa Boulden	Max Goodwin	
4	15 July 2022	Final – address EPA comments	Arne de Vos	Lisa Boulden	Lisa Boulden	Max Goodwin	

Invitation to make a submission

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

Main Roads Western Australia proposes to revise the current authorised extent of MS 677 for the Manuwarra Red Dog Highway to provide for the additional disturbance required to incorporate changes to the alignment and allow for current road design standards. The Environmental Review Document (ERD) has been prepared in accordance with the EPA's *Procedure Manual*. The ERD is the report by the proponent on their environmental review which describes this proposal and its likely effects on the environment.

The ERD is available for a public review period of four weeks from 8 August 2022, closing on 5 September 2022.

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

Why write a submission?

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

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

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

Why not join a group?

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

Developing a submission

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

When making comments on specific elements in the ERD:

- clearly state your point of view and give reasons for your conclusions
- reference the source of your information, where applicable
- suggest alternative to improve environmental outcomes.

What to include in your submission

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

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

The closing date for public submission is: 5 September 2022

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

Alternatively, submissions can be:

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

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

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Glossary

Term/Abbreviation/Acronym	Definition
Approved Proposal	The Proposal as described in Ministerial Statement 677
ACH Act	*Aboriginal Cultural Heritage Act* 2021
AH Act	*Aboriginal Heritage Act* 1972
AHIS	Aboriginal Heritage Inquiry System
ARI	Average Recurrence Interval
ASRIS	Australian Soil Resource Information System
ASS	Acid Sulfate Soils
CER	Consultative Environmental Review
CME	Chamber of Commerce and Energy
CSES	Community and Stakeholder Engagement Strategy
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAWE	Department of Agriculture, Water and the Environment
DBCA	Department of Biodiversity, Conservation and Attractions
Development Envelope	The maximum area within which the footprint for Stage 4 of the Revised Proposal will be located
Indicative Disturbance Footprint	The indicative location where ground disturbance for the physical elements of Stage 4 of the Revised Proposal will occur. The extent of this footprint is used to determine impacts. The spatial location of this footprint may vary as the design is refined.
DMIRS	Department of Mines, Industry Regulation and Safety
DPIRD	Department of Primary Industries and Regional Development
DPLH	Department of Planning, Lands and Heritage
DOT	Department of Transport
DWER	Department of Water and Environmental Regulation
DFES	Department of Fire and Emergency Services
DAC	Don Aitken Centre
EPA	Environmental Protection Authority
EP Act	*Environmental Protection Act* 1986
EPBC	*Environment Protection and Biodiversity Conservation Act 1999*
ERD	Environmental Review Document
GHG	Greenhouse Gas
ha	Hectare
IBRA	Interim Biogeographic Regionalisation for Australia
ISCA	Infrastructure Sustainability Council of Australia

Term/Abbreviation/Acronym	Definition
KTP	Karratha – Tom Price Road
LGA	Local Government Authority
MS 677	Ministerial Statement 677
Main Road	Main Roads Western Australia
MSE	Mechanically stabilised earth
MNES	Matter of National Environmental Significance
NEPM	National Environment Protection Measure for Ambient Air Quality
NPI	National Pollutant Inventory
PASS	Potential Acid Sulfate Soils
PDC	Pilbara Development Commission
PEC	Priority Ecological Community
PMST	Protected Matters Search Tool
PKEF	Preliminary Key Environmental Factor
Proposed changes	The changes to the Proposal due to changes to the alignment for Stage 4
RAV	Restricted Access Vehicle
Revised Proposal	The Approved Proposal together with the proposed changes
RIWI Act	*Rights in Water and Irrigation Act 1914*
SPRAT	Species Profile and Threats Database
SRE Fauna	Short Range Endemic Fauna
TEC	Threatened Ecological Community
TSSC	Threatened Species Scientific Committee
WGAC	Wintawari Garuma Aboriginal Corporation
WONS	Weed of National Significance
YAC	Yindjibarndi Aboriginal Corporation

Executive Summary

Introduction

Main Roads Western Australia (Main Roads) referred the Manuwarra Red Dog Highway (then known as the Karratha – Tom Price Road) to the WA Environmental Protection Authority, under section 38 of the *Environmental Protection Act 1986 (*EP Act*)*, in September 1998. The Proposal was granted conditional Ministerial approval via Ministerial Statement (MS) 677 in April 2005.

Since this time there have been changes to road design standards and community expectations regarding safety of regional roads resulting in a larger footprint for Stage 4 of the road than was originally envisaged. A review of the alignment for Stage 4 has also been undertaken, informed by ongoing consultation with stakeholders, including Traditional Owners and the owners of both Hamersley Homestead and Coolawanyah Station. This review has resulted in substantial modifications to the alignment of Stage 4 in order to avoid areas of significance to the Traditional Owners, avoid or minimise potential social and amenity impacts, and minimise interactions between existing infrastructure and other landowners/managers.

Main Roads is proposing changes to Stage 4 of the Manuwarra Red Dog Highway to provide for the additional disturbance required to incorporate these changes to the alignment and allow for current road design standards and expectations. Following initial discussions with the EPA, it was determined that the changes and additional disturbance should be referred under section 38 of the EP Act as a Revised Proposal, as the changes have the potential to result in significant additional environmental impacts to flora and vegetation, terrestrial fauna, inland waters, social surroundings and air quality.

Main Roads referred the Revised Proposal to the EPA in October 2020. In December 2020, the EPA determined the Revised Proposal required assessment at the level of "Referral Information with additional information required" and a four week public review period.

The purpose of this Environmental Review Document (ERD) is to provide the additional information requested by the EPA on 7 January 2021 to assist the EPA in its assessment of the Revised Proposal.

Background and context

The requirement for a direct sealed road between the Pilbara coastal communities and inland communities was identified in the 1990s. Prior to the commencement of construction of Stages 1 to 3 of the Karratha – Tom Price Road (now known as the Manuwarra Red Dog Highway), access between the Karratha/Dampier and Roebourne coastal communities to Tom Price/Paraburdoo on the public road system was via the Roebourne – Wittenoom Road, the Nanutarra – Munjina Road, and the Tom Price Spur Road. However, historical traffic data showed that most vehicles commuting between Karratha and Tom Price were using the shorter Pilbara Rail Company's Dampier to Paraburdoo railway access road rather than the public roads.

The 'Roads 2020 Regional Road Development Strategy: Pilbara Region', developed by Main Roads Western Australia (Main Roads) together with local government authorities (Main Roads, 1997), and the 'Pilbara Regional Transport Strategy', developed by the Department of Transport (DoT), recognised there was a requirement for a more direct link between Karratha and inland Pilbara

communities. The completed road will ultimately provide a sealed link that will best meet the needs of all stakeholders.

Overview of Proposed Changes and Revised Proposal

The Proposed Changes seek approval to modify the approved extents of disturbance for Stage 4 (only) of the Manuwarra Red Dog Highway, as approved in MS 677, to incorporate changes to road design standards, community expectations regarding safety of regional roads and modifications resulting from stakeholder engagement.

Table 0-1 provides a summary of the Revised Proposal, while the proposed changes to the key characteristics and the key characteristics of the Revised Proposal are detailed in Table 0-2.

Table 0-1 Summary of Revised Proposal

Proposal Title	Manuwarra Red Dog Highway
Proponent Name	Main Roads Western Australia
Short Description	The Revised Proposal is to construct and maintain a new sealed road from the North West Coastal Highway, near Karratha, to the Nanutarra-Munjina Road, north of Tom Price (Figure 1). The Revised Proposal is comprised of three stages: • a new 93 km section from the North West Coastal Highway near Karratha to about 20km north of the Millstream turn-off on the existing Roebourne – Wittenoom Road (Stage 2); • a 46 km section in common with the existing Roebourne – Wittenoom Road (Stage 3); and • a 112 km section from Wallyinya Pool (on the existing Roebourne – Wittenoom Road) to the Nanutarra – Munjina Road (Stage 4) adjacent to the existing Pilbara Rail Company railway. Note that Stage 1 of the Manuwarra Red Dog Highway, completed in 2003, was not included in the Approved Proposal. The Revised Proposal has a greater area of vegetation clearing than the original, Approved Proposal.

Table 0-2 Key Characteristics of the Revised Proposal

Proposed element	Location / description	Existing Proposal extent (MS 677 Current Authorised Extent)[1]	Proposed amendment	Combined extent, capacity or range
Physical elements				
Length	North West Coastal Highway, near Karratha, to the Nanutarra-Munjina Road, north of Tom Price (Figure 1)	Approximately 245 km.	Increase in length by approximately 6 km.	Approximately 251 km.
Connections to existing roads		North West Coastal Highway; Roebourne-Wittenoon Road; Millstream-Yaraloola Road; Mt Bruce Road; and Nanutarra-Munjina Road.	Removed[2]	
Area of Disturbance		Clearing and disturbance of no more than 574 ha – of this no less than 137 ha will be rehabilitated following construction of the road formation.[3]	Additional clearing and disturbance of no more than 665 ha within a Development Envelope (Figure 2) of 7,142 ha located within the Stage 4 Section, of which no less than 100 ha will be rehabilitated following construction of the road formation.	Clearing and disturbance of no more than 1,239 ha of which no less than 237 ha will be rehabilitated following construction of the road formation. All clearing and disturbance for Stage 4 of the Proposal is to occur within a Development Envelope (Figure 2) of 7,142 ha.
Formation width		Approximately 9 m.	Removed[4]	
Waterway crossings		Up to nine bridges across major	No change	Up to nine bridges across major

[1] Since approval of the Original Proposal in April 2005, two minor changes to the Proposal Key Characteristics have been approved via the Section 45C process being creation of a total area of disturbance of 574 ha by combining the two areas of disturbance described in the Original Proposal; and removal of elements that were no longer considered key characteristics for the purposes of environmental approval (i.e. design speed and railway crossings). Note the previous Section 45C process did not remove formation width and connections to existing roads.

[2] Road connections are no longer considered a key characteristic for the purposes of environmental approval as this area is accounted for in the Proposal Element "Area of disturbance"

[3] No Development Envelope is defined in the Approved Proposal

[4] Formation width is no longer considered a key characteristic for the purposes of environmental approval as this area is accounted for in the Proposal Element "Area of disturbance"

Proposed element	Location / description	Existing Proposal extent (MS 677 Current Authorised Extent)1	Proposed amendment	Combined extent, capacity or range
		watercourses and railway lines. Culverts and low-level floodways will be used for all other waterway crossings.		watercourses and railway lines. Culverts and low-level floodways will be used for all other waterway crossings.
Fencing of road reserve	Road reserve outside the Millstream-Chichester National Park	Approximately 200 km of fence will be erected along the road reserve outside the Millstream-Chichester National Park.	No change	Approximately 200 km of fence will be erected along the road reserve outside the Millstream-Chichester National Park.
Proposal construction elements with greenhouse gas emissions				
Scope 1:	Not specified in Approved Proposal		Total of 108,154 tCO2e for Stage 4 over 30-month construction period (43,262 tCO2e/annum) comprising: • Construction Fuel Consumption: 51,735 tCO2e • Vegetation Clearance: 56,419 tCO2e	
Scope 2:	Not specified in Approved Proposal		No Scope 2 emissions	
Scope 3:	Not specified in Approved Proposal		Total of 91,984 tCO2e for Stage 4 comprising: • Supply of construction fuel: 2,673 tCO2e • Supply of construction materials: 79,415 tCO2e • Associated haulage: 9,896 tCO2e	
Operation elements:				
Scope 1:	Not specified in Approved Proposal		Total of 30,983 tCO2e for maintenance of Stage 4 (50-year life)	
Scope 2:	Not specified in Approved Proposal		Total of 30,983 tCO2e for maintenance of Stage 4 (50-year life)	
Scope 3:	Not specified in Approved Proposal		Total of 1,012,602 tCO2e for Stage 4 comprising: • Supply of maintenance materials (50-year life): 7,499 tCO2e	

Proposed element	Location / description	Existing Proposal extent (MS 677 Current Authorised Extent)1	Proposed amendment	Combined extent, capacity or range
			• Road Users (50-year life): 1,005,103 tCO2e	

Development Envelope, Indicative Disturbance Footprint and Indicative Temporary Clearing Areas

Consistent with the EPA guidance, Main Roads is proposing a Development Envelope for Stage 4 of the Revised Proposal[5] to provide flexibility as to the location of the ultimate footprint. This is because the design of Stage 4 of the Revised Proposal is in the alignment definition phase and is being further refined based on planning, stakeholder consultation and investigations, particularly in relation to Aboriginal heritage. An Indicative Disturbance Footprint and Indicative Temporary Clearing Areas (both for Stage 4) has been provided as the basis of this ERD and to enable the determination of the significance of potential impacts. The Indicative Disturbance Footprint and Indicative Temporary Clearing Areas are subject to change; however, they will remain within the Development Envelope and impacts such as disturbance to vegetation and habitats for significant species will be will not exceed the limits detailed in this document, and the environmental outcomes described in this document will be achieved.

The EPA guidance requires that 'the assessment must be carried out for environmental impacts in all areas within the relevant development envelope where development may proceed, not just within, for example, any indicative proposal footprint)'. Given this, Main Roads has:

- Identified areas within the Development Envelope (for example, caves with evidence of Ghost Bat use) that Main Roads will ensure will not be impacted regardless of the final disturbance footprint
- Identified areas within the Development Envelope that lie outside the Indicative Disturbance Footprint that may be impacted if the disturbance footprint is realigned with the Development Envelope (for example, active Western Pebble Mound Mouse mounds).
- Included an allowance of approximately 10% more clearing than the habitat area mapped within the Indicative Disturbance Footprint. This provides flexibility in the location of the road and construction areas for access and laydown.
- Provided a comparison with potential alternative alignments that demonstrates that the revisions can be made to the Indicative Disturbance Footprint without increasing the magnitude or significance of the impact described in the ERD.

The comparison with potential alternative alignments was undertaken to confirm that refinements to the alignment (within the Development Envelope) can be made without resulting in a significantly different environmental outcome. Main Roads undertook an analysis of the impact of a series of refinements that are currently under consideration. This analysis includes a comparison of the predicted environmental impacts to vegetation, threatened and priority ecological communities; and

[5] No Development Envelope is defined in the current Approved Proposal. As such, all references to 'Development Envelope' within this document refer to the Development Envelope for Stage 4 of the Revised Proposal unless stated otherwise

threatened and priority flora and fauna for the Indicative Disturbance Footprint and two alternate alignments (Figure 17 for flora and vegetation) and Figure 26 (for fauna and fauna habitat).

The comparison showed that:

- While the refinements currently under consideration would result in a slight increase in the total permanent clearing requirements when compared to the Indicative Disturbance Footprint, the total permanent clearing and the total permanent clearing of vegetation in Good to Excellent condition remains with the extents presented within this impact assessment.
- Minor alignment refinements can be made without significantly changing the outcomes of the impact assessment in relation to Threatened Ecological Communities.
- Required clearing of Priority Ecological Communities does not differ significantly between the Indicative Disturbance Footprint and alternate disturbance footprints.
- The potential refinements do not result in impacts to the single specimen of Critically Endangered Fringed Fire-bush recorded in the Development Envelope.
- The potential refinements do not result in any new priority flora species being impacted or a significant increase in the clearing of priority flora species.
- While the refinements currently under consideration would result in a slight increase in the total permanent habitat clearing requirements when compared to the Indicative Disturbance Footprint the total habitat clearing for each significant fauna species remains within the extents assessed within this impact assessment.
- There is a slight reduction in clearing required for habitat critical to the survival of the Northern Quoll for alternate disturbance footprints when compared to the Indicative Disturbance Footprint. The required clearing of this habitat remains within the limits presented in this impact assessment.
- Stage 4 of the Revised Proposal may require the removal of two active Western Pebble-mound Mouse mounds. These are not located in the Indicative Disturbance Footprint and would only be removed if the Indicative Disturbance Footprint is adjusted. The refinements under consideration would result in the requirement to remove the two active Western Pebble-mound Mouse mounds. The removal of these mounds has been considered within the impact assessment.

Note the Indicative Temporary Clearing Areas will be required irrespective of whether the Indicative Disturbance Footprint or a potential alternative alignment is adopted. The environmental outcomes presented in this ERD account for the combined effect of both the Indicative Disturbance Area (or an alternative alignment) and the Indicative Temporary Clearing Area. Refinements to the location, extent and orientation of the Indicative Temporary Clearing Area may also be required. These refinements will be made such that the environmental outcome of the Revised Proposal remains within the limits described in this ERD.

Summary of potential impacts, proposed mitigation and outcomes

Table 0-3 provides a summary of the potential impacts, proposed mitigation and predicted outcomes for the Revised Proposal.

Table 0-3 Summary of Potential Impacts, Proposed Mitigation and Outcomes

Flora and Vegetation	
EPA objective	To protect flora and vegetation so that biological diversity and ecological integrity are maintained.
Policy and guidance	• Statement of Environmental Principles, Factors and Objectives (EPA, 2020a); • Environmental Factor Guideline – Flora and Vegetation (EPA, 2016a); • Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016b); and • Threatened Ecological Community (TEC) Fact Sheet - *Themeda* grasslands on cracking clays (Hamersley Station, Pilbara) (DBCA, 2020d).
Potential impacts	Potential direct impacts to flora and vegetation in relation to the Revised Proposal have been identified as clearing of vegetation including TECs, PECs, vegetation associated with drainage lines, vegetation of local significance, vegetation within the Millstream-Chichester National Park and threatened and priority flora species. Potential indirect impacts to flora and vegetation in relation to the Revised Proposal have been identified as: • impacts to groundwater dependent vegetation as a result of groundwater abstraction; • impacts to flora and vegetation due to changes to surface water flow as a result of the construction and presence of the road (particularly grove-intergrove mulga communities, the *Themeda* Grasslands TEC; and the Brockman Iron PEC); and • introduction of new weed species or spread of existing weed species as a result of vehicle movements and earthmoving activities.
Mitigation	Construction of Stage 2 and 3 of the Revised Proposal is completed. Therefore, mitigation is focussed on Stage 4 of the Revised Proposal. Design measures have been incorporated into the route alignment selection to minimise clearing of significant flora, the Brockman Iron PEC and the *Themeda* Grasslands TEC required for Stage 4 of the Revised Proposal. Further measures will be implemented during detailed design of Stage 4 to reduce the extent of significant flora, Brockman Iron PEC and *Themeda* grasslands TEC clearing required. The following mitigation measures will be implemented during construction of Stage 4 to reduce the impacts of the Revised Proposal on significant flora, Brockman Iron PEC and *Themeda* grasslands TEC: • the extent of the approved clearing will be clearly communicated in documentation and all clearing areas will be clearly demarcated on site; • to minimise impacts to significant flora, Brockman Iron PEC and *Themeda* grasslands TEC, the selection of areas where temporary clearing will be required for construction activities such as camps, laydown areas, stockpile areas and vehicle turnarounds has been based on the vegetation type (within the constraints of factors such as heritage). Existing cleared areas and areas of lower environmental value have been prioritised and TECs, PECs and vegetation associated with drainage lines avoided; and

	• use of existing cleared areas (existing tracks and pits) will occur where practicable to avoid clearing of vegetation. Detailed design of Stage 4 will prioritise the following in order to minimise vegetation clearing impacts as far as practicable: • avoidance of significant flora and ecological communities where practicable; • where safe to do so, batters will be steepened to reduce the width of the clearing footprint; and • safety barriers will be installed where practicable to allow roadside batters to be steepened to reduce the width of the clearing footprint. Identification of material sources for construction will consider the following to minimise vegetation clearing impacts: • use of existing material pits where available; • use of spent ballast from Rio Tinto Iron Ore (RTIO) rail, pending agreement with RTIO and confirmation of suitability and no contamination issues; and • sourcing materials from within the infrastructure footprint (such as from areas of cut).
Outcomes	Main Roads will implement the Revised Proposal to achieve the following environmental outcomes in relation to flora and vegetation: • No more than 1,239 ha will be cleared of which no less than 237 ha will be rehabilitated. • All clearing and disturbance for Stage 4 of the Proposal is to be confined within a Development Envelope (Figure 2) of 7,142 ha. • No more than 650 ha of vegetation in Good to Excellent condition will be cleared within the Stage 4 Development Envelope of which at least 100 ha will be rehabilitated. • No more than 145 ha of the Millstream-Chichester National Park will be cleared. • No vegetation types will be reduced to below the 'threshold level' of 30% of their pre-clearing extent. • No more than 15 ha of the Themeda Grasslands TEC will be cleared. • No impacts on TECs will occur outside of the Development Envelope. • No indirect impacts on TECs will occur. • No more than 12 ha of the Brockman Iron Cracking Clay Communities of the Hamersley Range PEC will be cleared. • No impacts on PECs will occur outside of the Development Envelope. • No indirect impacts on PECs will occur. • For Stage 4, clearing and disturbance of vegetation type C2 will be limited to 15.1 ha of which 8.6 ha is temporary clearing which will be rehabilitated and clearing and vegetation type M1 and M2 (combined) will be limited to 77.5 ha of which 14.3 ha is temporary clearing that will be rehabilitated • No impacts on vegetation of local significance will occur outside of the Development Envelope. • No indirect impacts on vegetation of local significance will occur. • No more than 30 ha of vegetation associated with drainage lines will be cleared. • No impacts on vegetation associated with drainage lines will occur outside of the Development Envelope. • No indirect impacts on vegetation associated with drainage line will occur. • No indirect impacts on groundwater dependent vegetation will occur. • No indirect impacts on banded mulga vegetation will occur.

	• No clearing will occur in the exclusion zone around the single Fringed Fire-bush plant identified within the Stage 4 Development Envelope will occur. • Clearing Priority flora to be limited to individuals of five Priority flora species as follows: o *Euphorbia australis* var. glabra (P3); o *Sida* sp. Hamersley Range (K. Newbey 10692) PN (P3); o *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) (P3); o *Eremophila magnifica* subsp. Magnifica (P4); and o *Goodenia nuda* (P4). No introduction of weeds into Stage 2 and 3 Project Area or Stage 4 Development Envelope. Offsets: The significant residual impacts to flora and vegetation resulting from Stage 4 of the Revised Proposal will be offset. This includes: • permanent clearing of 437 ha of vegetation for Stage 2 and 3 of the Revised Proposal. This clearing has been offset in accordance with the implementation conditions for the Approved Proposal; • permanent clearing of up to 550 ha of Good to Excellent condition vegetation for Stage 4 of the Revised Proposal; • temporary clearing of up to 100 ha of Good to Excellent condition vegetation which will be rehabilitated for Stage 4 of the Revised Proposal; • clearing of 15 ha of the Themeda Grasslands TEC (all within Stage 4); and • clearing of up to 12 ha of the Brockman Iron Cracking Clays PEC (all within Stage 4). Assessment against EPA's Environmental Objective: While there is expected to be a change in the extent/magnitude of impact of the Revised Proposal when compared to the Approved Proposal, the overall significance of the impact is unlikely to be greater than that identified for the Approved Proposal, particularly as significant residual impacts will be offset. Main Roads will implement the Revised Proposal so as to achieve the environmental outcomes outlined in above and will offset all significant residual impacts. Doing so will ensure that the Revised Proposal avoids and minimises impacts to flora and vegetation as far as reasonably practicable. This avoidance and minimisation of impacts, together with the offsetting of significant residual impacts will result in the biological diversity and ecological integrity of the study area being preserved, meaning that the Revised Proposal is consistent with the EPA's environmental objective for Flora and Vegetation.
Terrestrial Fauna	
EPA objective	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.
Policy and guidance	• Statement of Environmental Principles, Factors and Objectives (EPA, 2020a); • Environmental Factor Guideline – Terrestrial Fauna (EPA, 2016c); • Technical Guidance – Terrestrial Fauna Surveys (EPA, 2020b); • EPBC Act referral guideline for the endangered northern quoll (DoE, 2016); • Survey Guidelines for Australia's Threatened Birds (DEWHA, 2010a); • Survey Guidelines for Australia's Threatened Bats (DEWHA, 2010b); and • Survey Guidelines for Australia's Threatened Mammals (DSEWPaC, 2011).

Potential impacts	Potential impacts to terrestrial fauna in relation to the Proposed Changes have been identified as: • habitat loss as a result clearing activities; • injury or mortality to significant species as a result of interaction with construction activities; • injury or mortality to significant species as a result of vehicle strike during operation of the Revised Proposal; • collision of bats and birds with fencing, if required for the Revised Proposal; • disturbance to significant species from light emissions; • disturbance to significant species from noise and vibration emissions; • habitat fragmentation and significant species population isolation; • habitat degradation, increased predation and/or increased competition due to the introduction and/or exacerbation of the presence of introduced species; and • illegal dumping and littering.
Mitigation	Construction of Stage 2 and 3 of the Revised Proposal is completed. Therefore, mitigation is focussed on Stage 4 of the Revised Proposal. Design measures have been incorporated into the route alignment selection to minimise the extent of significant fauna habitat clearing required for Stage 4 of the Revised Proposal. Further measures will be implemented during detailed design to further reduce the extent of significant fauna habitat clearing required. The following mitigation measures will be implemented during construction to reduce the impacts of Stage 4 of the Revised Proposal on significant species: • the extent of the approved clearing will be clearly communicated in documentation and all clearing areas will be clearly demarcated on site; • to minimise impacts within areas of high value habitat, the selection of areas where temporary clearing will be required for construction activities such as camps, laydown areas, stockpile areas and vehicle turnarounds has been based on the habitat type (within the constraints of factors such as heritage). Existing cleared areas and areas of lower environmental value have been prioritised, and habitat critical to the survival of the Northern Quoll, Northern Quoll habitat within 1 km of critical habitat and Ghost Bat foraging habitat within 5 km of the possible Ghost Bat maternity roost avoided; and • site rules such as speed limits and waste management requirements will be implemented and clearly communicated in inductions and toolbox meetings. The following key mitigation measures will be implemented to reduce the risk of impacts to Northern Quolls: • clearing of habitat critical to the survival of the Northern Quoll (i.e. denning habitat) will be limited to between 1 April and 30 September to prevent coinciding with Northern Quoll when they have large pouch or denned young; and • prior to clearing any Northern Quoll denning habitat, undertake preclearance surveys. If individuals are identified in the area to be cleared, clearing in this area is not to commence until it has been confirmed that the identified quoll is no longer present. Relocation of individuals will be considered where appropriate and in consultation with a wildlife specialist. The following key mitigation measures will be implemented to reduce the risk of impacts to Ghost Bats: • an activity buffer of 400 m will be created within which monitoring of caves identified by Biota (2021) as Ghost Bat roosting caves is required;

	• a 150 m no-go zone will be created between construction activities and caves that have been identified as having evidence of Ghost Bat use (Figure 18). These no-go zones will be clearly shown on all project drawings and communicated in construction documentation, inductions and at toolbox meetings; • confined blasting techniques (where inert material such as crushed stone is used to seal off blast holes and contain energy released) will be used within 400 m of caves known to be used by Ghost Bats in preference to unconfined methods; and • Main Roads will prepare a Blasting Noise and Vibration Management Plan to address any risks to Ghost Bats. This plan will be implemented for any blasting occurring within 400 m of a cave with evidence of Ghost Bat usage. The following mitigation measures will be implemented to reduce the risk of impacts to the Western Pebble-mound Mouse: • a no-go zone will be created between the construction activities and known active Western Pebble-mound Mouse mounds that are located outside of the final disturbance footprint; and • where active Western Pebble-mound Mouse mounds are required to be cleared, displacement methods will be used to encourage the individuals using the mounds to relocate within their home range.
Outcomes	Main Roads will implement Stage 4 of the Revised Proposal to achieve the following environmental outcomes: • No more than 178.3 ha of potential Northern Quoll denning, foraging and dispersal habitat within the Stage 4 Development Envelope will occur. Of this clearing, no more than 4.0 ha is of habitat identified as being critical to the survival of the Northern Quoll and 42.3 ha of important foraging and dispersal habitat within 1 ha of habitat critical to the survival of the Northern Quoll will be cleared. • No more than 178.2 ha of potential Pilbara Leaf-nosed Bat foraging, flyway and drinking habitat within the Stage 4 Development Envelope will be cleared. • No more than 313.4 ha of potential Ghost Bat potential roosting, foraging, flyway and drinking habitat within the Stage 4 Development Envelope will be permanently cleared. Of this clearing no more than 18.7 ha of Ghost Bat foraging habitat within 5 km of the possible maternity roost and 92.7 ha of Ghost Bat foraging habitat within 5 km of the cave with evidence of Ghost Bat usage within the Development Envelope will be cleared. • No more than 48.3 ha of Ghost Bat foraging habitat (Floodplains) will be cleared temporarily. This area will be rehabilitated post construction. The Temporary Clearing Areas have been placed to avoid Ghost Bat foraging habitat within 5 km of the possible Ghost Bat maternity roost. Any refinement to these areas will maintain this avoidance • No direct or indirect impacts to Ghost Bat caves will occur. • No clearing activities will occur in the exclusion zone around caves with evidence of Ghost Bat usage. • No more than 313.3 ha of potential Pilbara Olive Python foraging habitat in the Stage 4 Development Envelope will be permanently cleared. • No more than 48.3 ha of Pilbara Olive Python foraging habitat (Floodplains) may be cleared temporarily. This area will be rehabilitated post construction. • No more than 29.3 ha of potential Night Parrot foraging habitat within the Stage 4 Development Envelope will be cleared. • No more than 596.1 ha of potential Grey Falcon foraging and drinking habitat in the Stage 4 Development Envelope will be permanently cleared.

	• No more than 100.0 ha of Grey Falcon nesting, foraging and drinking habitat will be temporarily cleared. This area will be rehabilitated post construction. Large trees suitable for nesting for Grey Falcons will not be cleared for the temporary clearing. • Clearing of Other Specially Protected Fauna and Priority Fauna habitat will be avoided where possible and otherwise minimised. • Removal of active Pebble Mound Mouse Mounds will be avoided where possible and otherwise minimised. • Direct and indirect impacts to terrestrial fauna will be avoided where possible and otherwise minimised. Offsets: Offsets are proposed to counterbalance the: • clearing of up to 4 ha of habitat critical to the survival of the Northern Quoll. • clearing of up to 42.3 ha of important foraging and dispersal habitat for the Northern Quoll (defined as Northern Quoll habitat within 1 km of habitat critical to the survival of the Northern Quoll); and • clearing of up to 18.7 ha of Ghost Bat foraging habitat within 5 km of the possible maternity roost identified by Biota (2021). Assessment against EPA's Environmental Objective: While there is expected to be a change in the extent/magnitude of impact of the Revised Proposal when compared to the original proposal, the overall significance of the impact is unlikely to be greater than that identified for the original proposal, particularly as significant residual impacts will be offset. Main Roads will implement the Revised Proposal so as to achieve the environmental outcomes outlined above and will offset all significant residual impacts. Doing so will ensure that the Revised Proposal avoids and minimises impacts to terrestrial fauna as far as reasonably practicable. This avoidance and minimisation of impacts, together with the offsetting of significant residual impacts will result in the biological diversity and ecological integrity of the study area being preserved, meaning that the Revised Proposal is consistent with the EPA's environmental objective for Terrestrial Fauna.
Inland Waters	
EPA objective	To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected
Policy and guidance	• Statement of Environmental Principles, Factors and Objectives (EPA, 2020a); • Environmental Factor Guideline – Inland Waters (EPA, 2018); • Water Quality Protection Note no.25. Land use compatibility tables for public drinking water source areas (DoW 2016a); • Water Quality Protection Note no.44. Roads near sensitive water resources (DoW 2006); • Water Quality Protection Note no.65. Toxic and hazardous substances (DoW 2015); • Water Quality Protection Note no.83. Infrastructure corridors near sensitive water Resources (DoW 2007); • Water Quality Protection Note no.84. Rehabilitation of disturbed land in public drinking water source areas (DoW 2009); • Millstream Water Reserve. Drinking water source protection plan (DoW, 2010); and • Contaminated Sites Guidelines (DWER, 2020).

Potential impacts	Direct impacts to surface and/or groundwater quality in relation to the Revised Proposal may include: • changes to surface water flows as a result of the physical presence of the road and subsequent impacts to third party infrastructure, environmental receptors and cultural heritage values; • changes to groundwater levels as a result of groundwater abstraction, dewatering and reduced infiltration due to the creation of new road surface; and • change to groundwater or surface water quality as a result of – accidental contamination of surface and/or groundwater sources as result of spills during construction; – accidental contamination of surface and/or groundwater sources during operation of the road; and – clearing and earthworks during construction and/or maintenance activities potentially result in a temporary increase to sediment loads entering watercourses.
Mitigation	Construction of Stage 2 and 3 of the Revised Proposal is completed. Therefore, mitigation is focussed on Stage 4 of the Revised Proposal. Design measures have been incorporated into the route alignment selection to minimise the requirements for waterway crossing. The detailed design of the road will be undertaken so as to maintain the existing hydrological regime of the area. Mitigation measures will include: • best practice culvert and floodway design; • development of surface water management measures to maintain existing drainage patterns and prevent soil erosion and sedimentation; • design of creek crossings to minimise potential changes to surface water flows and design of road drainage to consider potential for drainage shadows or pooling; • investigation during detailed design at relevant locations to determine and assess any increase in backwater, with consultation with third party infrastructure owners undertaken to confirm acceptability and change made to the design if required; • road alignment will generally match the direction of the natural flow in the area where Grove – intergrove Mulga communities are present; • implementation of the Millstream Water Reserve Drinking Water Source Protection Plan recommended protection strategies; • adherence to the relevant recommendations included in the relevant Water Quality Protection Notes; and • impacts on cultural heritage receptors for high probability events will be assessed during detailed design, with consultation with stakeholders undertaken to confirm acceptability and change made to the design if required.
Outcomes	Main Roads will implement Stage 4 of the Revised Proposal to achieve the following environmental outcomes in relation to inland waters: • No change to surface flows resulting in significant impacts to environmental values, Aboriginal heritage values or existing infrastructure will occur. • No significant change to surface water quality will occur. • No change to groundwater levels resulting in significant impacts to groundwater dependent vegetation will occur. • Implementation of the Revised Proposal will not negatively affect the likelihood that the objectives of the Millstream Water Reserve Priority 1 and Priority 2 protection areas will be met.

	• No significant impacts to vegetation, including the grove – intergrove mulga communities, as a result in changes to surface water flows or quality due to implementation of Stage 4 of the Revised Proposal will occur. • Changes to the cultural heritage values of waterways as a result of the Revised Proposal will not occur. While there is expected to be a change in the extent/magnitude of impact of the Revised Proposal when compared to the Approved Proposal, the overall significance of the impact is unlikely to be greater than that identified for the Approved Proposal. No significant residual impacts to Inland Waters have been identified. Main Roads will implement the Revised Proposal so as to achieve the environmental outcomes outlined above. Doing so will ensure that the Revised Proposal avoids and minimises impacts to Inland Waters as far as reasonably practicable. This avoidance and minimisation of impacts will ensure that the Revised Proposal does not significantly impact the hydrological regimes, groundwater quality or surface water quality, and ensure that the environmental values of the area are preserved. As such the Revised Proposal is consistent with the EPA's environmental objective for inland waters.
Social Surroundings	
EPA objective	To protect social surroundings from significant harm.
Policy and guidance	• Statement of Environmental Principles, Factors and Objectives (EPA, 2020a); • Environmental Factor Guideline – Social Surroundings (EPA, 2016d); • Environmental Protection (Noise) Regulations 1997 (Noise Regulations); • State Planning Policy 5.4 Road and Rail Noise; • *Aboriginal Heritage Act 1972* (AH Act); and • *Aboriginal Cultural Heritage Act* 2021.
Potential impacts	Potential impacts to the social surrounds of the Development Envelope include: • physical damage to Aboriginal heritage sites (physical artefacts including artistic creations, built heritage such as buildings and monuments, and other physical or tangible products of human creativity); • impacts to anthropological values of heritage sites (Country – spiritual, physical, emotional values inherent to the identity of the Traditional Owners); and • impacts to amenity during construction or operation of Stage 4 of the Revised Proposal as a result of noise and dust emissions.
Mitigation	Construction of Stage 2 and 3 of the Revised Proposal is completed. Therefore, mitigation is focussed on Stage 4 of the Revised Proposal. Mitigation measures will include: • construction noise will be managed in accordance with the Environmental Protection (Noise) Regulations 1997; • consultation with Traditional Owners will continue to be undertaken to understand the significance of the area and specific sites to the relevant Traditional Owners; • the selection of areas where temporary clearing will be required for construction activities such as camps, laydown areas, stockpile areas and vehicle turnarounds will avoid registered heritage places; • where practicable heritage sites identified during surveys will be protected from disturbance during construction;

	• where disturbance to Aboriginal heritage sites is unavoidable, approval under the ACH Act will be sought to disturb these sites; • a buffer of 1.2 km will be implemented around the Hamersley Homestead to minimise amenity impacts; • all personnel and contractors will undergo an induction which includes requirements with respect to cultural heritage; • all personnel and contractors will complete cultural awareness training with the local Traditional Owners; and • Aboriginal Cultural Heritage Monitors will be engaged to observe ground disturbance as it is occurring in order to prevent or mitigate possible harm to Aboriginal cultural heritage.
Outcomes	Main Roads will implement Stage 4 of the Revised Proposal to achieve the following environmental outcomes: • No change to the social values of the Millstream-Chichester National Park will occur. • No significant impacts to amenity will occur. • No unapproved disturbance in an Aboriginal heritage site will occur. • No impacts to historic heritage will occur. The Proposed Changes are not expected to significantly alter the extent of magnitude of impacts currently considered in the Approved Proposal. No significant residual impacts to Social Surrounds have been identified. Main Roads will implement the Revised Proposal so as to achieve the environmental outcomes outlined above. Doing so will ensure that the Revised Proposal avoids and minimises impacts to Social Surrounds as far as reasonably practicable. Approvals with respect to impacts to Aboriginal heritage sites for Stage 4 will be managed via an Aboriginal Cultural Heritage Management Plan in accordance with Division 6 of the Aboriginal Cultural Heritage Act 2021. This avoidance and minimisation of impacts will ensure that the Revised Proposal does not cause significant harm to social surroundings. As such the Revised Proposal is consistent with the EPA's environmental objective for Social Surroundings.
Air Quality	
EPA objective	To maintain air quality and minimise emissions so that environmental values are protected.
Policy and guidance	• Environmental Factor Guideline: Air Quality (EPA, 2016); • National Environment Protection Council Act 1994 (Cth) and National Environment Protection Measure for Ambient Air Quality (Air NEPM); and • National Environment Protection (National Pollutant Inventory) Measure (NPI).
Potential impacts	• reduction in air quality due to dust generated during construction; • exposure of the community and construction work force to historical asbestos; and • exposure of the community and construction work force to naturally occurring asbestos
Mitigation	Construction of Stage 2 and 3 of the Revised Proposal is completed. Therefore, mitigation is focussed on Stage 4 of the Revised Proposal. Main Roads standard dust mitigation measures which will be implemented as part of the Proposal, including: • use of dust suppression to manage dust generation from construction activities, access roads and cleared areas; • use of water sprays to manage dust generation from material transport and stockpiling;

	• limit the number and height of stockpiles; and • vehicles confined to designated routes with speed limits strictly enforced. Prior to construction in areas indicated to have a high risk in relation to naturally occurring asbestos (NOA), Main Roads will undertake targeted soil and rock sampling to define areas where road construction will intersect NOA. Further risk assessment may be undertaken prior to sampling to confirm the high-risk areas for sampling. An Asbestiform Materials Management Plan will be implemented by the construction contractor where sampling determines NOA is present.
Outcomes	Main Roads will implement Stage 4 of the Revised Proposal to achieve the following environmental outcomes: • No impacts to remote communities and other dust sensitive receptors as a result of construction dust will occur. • No significance change to air quality will occur as a result of operation of the Revised Proposal. No impacts to human health will occur as a result of air emissions. Given the remote location of the Proposal and the lack of sensitive receptors, which is limited to the construction site work force and given appropriate management, Main Roads considers that dust emissions and impacts associated with fibrous minerals can be controlled using existing environmental and OHS Management Procedures and that the EPA's objective for Air Quality (dust) will be met.

1 Introduction

Main Roads Western Australia (Main Roads) referred the Manuwarra Red Dog Highway (then known as the Karratha – Tom Price Road) to the WA Environmental Protection Authority (EPA), under section 38 of the *Environmental Protection Act 1986* (EP Act), in September 1998. The Proposal was granted conditional Ministerial approval via Ministerial Statement (MS) 677 in April 2005.

Since this time there have been changes to road design standards and community expectations regarding safety of regional roads resulting in a larger footprint for Stage 4 of the road than was originally envisaged. A review of the alignment for Stage 4 has also been undertaken, informed by ongoing consultation with stakeholders, including Traditional Owners and the owners of both Hamersley Homestead and Coolawanyah Station. This review has resulted in substantial modifications to the alignment of Stage 4 in order to avoid areas of significance to the Traditional Owners, avoid or minimise potential social and amenity impacts, and minimise interactions between existing infrastructure and other landowners/managers.

Main Roads is proposing changes to Stage 4 of the Manuwarra Red Dog Highway to provide for the additional disturbance required to incorporate these changes to the alignment and allow for current road design standards. Following initial discussions with the EPA, it was determined that the changes and additional disturbance should be referred under section 38 of the EP Act as a Revised Proposal, as the changes have the potential to result in significant additional environmental impacts to flora and vegetation, terrestrial fauna, inland waters, social surroundings and air quality.

Main Roads referred the Revised Proposal to the EPA in October 2020. In December 2020, the EPA determined the Revised Proposal required assessment at the level of "Referral Information with additional information required" and a four week public review period.

1.1 Purpose and Scope

The purpose of this Environmental Review Document (ERD) is to provide the additional information requested by the EPA on 7 January 2021 (Appendix A.1) to assist the EPA in its assessment of the Revised Proposal. Table 1-1 outlines the information required and how it has been addressed in this ERD.

Item 5 of the information request recommended a single report is prepared to consolidate information submitted in the referral information documentation with the additional information requested, as both the referral information and additional information will need to be published for public review. Accordingly, this document was prepared to consolidate the relevant information.

The document details:

- the EPA preliminary key environmental factors (PKEF) that may be impacted;
- the EPA Policy and Guidance that has been considered;
- outcomes of consultation that has been undertaken;
- the condition of the receiving environment;
- the Revised Proposal activities that may impact the environment along with proposed management and mitigation; and

- an assessment of the potential impacts against the EPA objectives together with any assumptions that have been made in the assessment.

The ERD has been prepared in accordance with the EPA's 'Instructions on how to prepare an Environmental Review Document' (ERD) (EPA, 2020c) and is based on project and study information available at the time of writing.

Main Roads has consulted with government agencies and key stakeholders to obtain feedback for input into this document to inform the environmental impact assessment of the Revised Proposal.

Table 1-1 EPA Notice Requiring Information for Assessment

Information required from EPA	How this has been addressed	ERD Section
Issue 1 – Finalised Environmental Investigations and Assessment		
Completed surveys and assessment of impacts in the Development Envelope (DE) for Flora and Vegetation (including weeds), Terrestrial Fauna, Social Surroundings (Aboriginal Heritage), a hydrological assessment for Inland Waters, and an assessment of potential impacts from degradation of Air Quality due to potential historical and naturally occurring asbestos that may be present in construction dust.	• A biological survey has been completed by Biota (2021) consisting of flora, vegetation and fauna. • Assessment of impacts to these PKEF are provided in Section 5.1 and Section 5.2. • Hydrological studies have been undertaken and assessment of this PKEF is provided in Section 5.3. • Aboriginal Heritage surveys have been undertaken and an assessment of this PKEF is provided in Section 5.4. • An assessment of potential impacts from degradation of Air Quality due to potential historical and naturally occurring asbestos that may be present in construction dust is provided in Section 5.5.	Section 5.1 Section 5.2 Section 5.3 Section 5.4 Section 5.5
The EPA requires these investigations to be undertaken in accordance with the EPA's Framework for Environmental Considerations in EIA, the EPA's Framework for Advice and Reference Material and other appropriate technical guidance documents where relevant to this proposal. The framework is available here https://www.epa.wa.gov.au/pages/framework-environmental-considerations-eia	All surveys have been undertaken in line with EPA Guidance.	Appendix A.2
For each Preliminary Key Environmental Factor (PKEF) information and assessment is required to better define the extent and severity of the proposal's potential impacts by addressing the direct, indirect and cumulative impacts.	Direct and indirect impacts to each PKEF specific to Stage 4 of the Revised Proposal are addressed in their respective Assessment of Impact Section.	Section 5.1.6 Section 5.2.6 Section 5.3.6 Section 5.4.6 Section 5.5.6

For each PKEF, information is needed to show the application of the mitigation hierarchy (including "avoid") to reduce environmental impacts.	The mitigation hierarchy has been applied to each PKEF and is addressed in the respective Mitigation Section.	Section 5.1.5 Section 5.2.5 Section 5.3.5 Section 5.4.5
A holistic environmental assessment.	Holistic environmental assessment has been addressed in the Holistic Impact Assessment and Conclusion Section.	Section 10
Issue 2 – Environmental Outcomes and Management		
The EPA requires environmental outcomes be established where practicable, or otherwise EMP's, to be prepared and submitted that detail adequate outcomes and/or objectives, monitoring, evaluation and indicators to meet the EPA's objectives for each relevant Preliminary Key Environmental Factor (PKEF). Any management plans are required to be in accordance with the EPA's Instructions on how to prepare EP Act Part IV Environmental Management Plans. The instructions are available here https://www.epa.wa.gov.au/forms-templates/instructions-part-iv-environmentalmanagement-plans.	Main Roads has adopted an outcome based approach for the Revised Proposal. Acceptable environmental outcomes have been established in Section 5. Environmental management measures have been prepared for the Stage 4 of the Revised Proposal and are detailed in: • Flora and Vegetation (Table 5-7) • Terrestrial Fauna (Table 5-21) • Inland Waters (Table 5-31) • Social Surroundings (Table 5-34) • Air Quality (Table 5-37). These environmental management measures detail outcomes and/or objectives, monitoring, evaluation and indicators to meet the EPA's objectives for each PKEF	Section 5.1 Section 5.2 Section 5.3 Section 5.4
The EMP's are required to be relevant to the construction and operation phases of the proposal and are to be practical and achievable based on detailed characterisation of the surrounding environment informed by (but not limited to) the environmental investigations discussed above in Issue 1.	As described above, Main Roads has adopted an outcome based approach for the Revised Proposal. Where required, EMPs will be developed the during detailed design phase of Stage 4 of the Revised Proposal to achieve the adopted outcomes. The management measures presented in Section 5 are relevant to construction and operations phases of Stage 4 of the Revised Proposal and are practical and achievable.	Section 5.1 Section 5.2 Section 5.3 Section 5.4
Issue 3 – Offsets Strategy		
Please provide an Offsets Strategy in accordance with the Western Australian State Government Environmental Offsets Policy (2011) and Guidelines. Please also include detailed offsets information, in the requested revised Referral Information document discussed in Issue 5 below, providing an assessment of whether the proposed offset is likely to counter-balance any	Main Roads will contribute to the Pilbara Environmental Offset Fund to counter-balance significant residual impacts of Stage 4 of the Revised Proposal and meet the EPA's environmental factor objective, over all relevant timeframes. Information regarding the Offsets Strategy is provided in Section 6. This has been prepared in	Section 6

significant residual impact, and whether the EPA's environmental factor objective will be met, over all relevant timeframes. Guidance on how to adequately prepare environmental offsets information is available here https://www.epa.wa.gov.au/policies-guidance/wa-environmental-offsets-policy2011-and-guidelines.	accordance with the Western Australian State Government Environmental Offsets Policy (2011) and Guidelines.	
Issue 4 – Traditional Owner Consultation		
Please provide evidence of further consultation, including agreed outcomes, with the Wintawari Garuma Aboriginal Corporation and the Yindjibarndi Aboriginal Corporation including matters raised during the referral's 7 day public comment period (provided to Main Roads Western Australia via email on 9 December 2020).	Consultation with Traditional Owners has been undertaken and is outlined in the Stakeholder Consultation Section.	Section 3
Issue 5 – Preparation of a consolidated report		
Where appropriate, it is recommended that the submitted Referral Information documentation and the Additional Information requested in this notice be consolidated into a single report package, as both the referral information and additional information will be required to be published for public review.	The submitted Referral Information document has formed the basis of this ERD. The additional information requested in the Notice Requiring Information For Assessment has been provided as outlined in this table.	All Sections
Please append the requested Environmental Management Plans and Offsets Strategy to the consolidated report.	As described above, Main Roads has adopted an outcome based approach for the Revised Proposal. Where required, EMPs will be developed during detailed design and construction phases of Stage 4 of the Revised Proposal to achieve the adopted outcomes. The Offsets Strategy is detailed in Section 6.	Section 5.1 Section 5.2 Section 5.3 Section 5.4 Section 6
Issue 6 – IBSA Data Package		
Please provide an Index of Biodiversity Surveys for Assessments (IBSA) data package for each biodiversity survey report undertaken in accordance with the Instructions and Form: IBSA Data Packages. These instructions and forms are available on the EPA's website https://www.epa.wa.gov.au/formstemplates/instructions-preparing-data-packages-index-biodiversity-surveysassessments-ibsa.	The IBSA data package accompanies this environmental review document.	n.a.

Issue 7 – Spatial Data		
The EPA notes the Referral Documentation included spatial data for the DE but footprint figures and associated spatial data was unable to be provided at the time due to detailed design not being completed. The EPA requires footprint/s spatial data to identify and verify where any disturbance and the location of physical proposal elements occur.	The Indicative Disturbance Footprint for Stage 4 of the Revised Proposal is shown on the relevant figures and Spatial data for this Indicative Disturbance Footprint is provided with this ERD.	All Sections
Please provide footprint figures and spatial data in accordance with the EPA's spatial data requirements, this requirement is geo-referenced data and conforms to the following parameters: • Data type: closed polygons that represent the proposal boundary (Development Envelope) and the activity areas for all physical elements of the proposal (footprint); • Attribution: Name the Development Envelope and each activity area in the attribute table of the spatial data; • Format: ESRI geodatabase or shapefile; and • Coordinate System: GDA94 (datum) and projected into the appropriate Map Grid of Australia (MGA) zone.	Figures have been provided to support the information in this ERD and have been prepared in accordance with the EPA's spatial data requirements and parameters.	Section 13

1.2 Proponent

The proponent for this Revised Proposal is Main Roads Western Australia. The Proponent's details are:

Commissioner of Main Roads Western Australia
ABN: 50 860 676 021
PO Box 6202
East Perth WA 6004

The contact in relation to the environmental approvals process for this Revised Proposal is:

Martine Scheltema – Manager Environment
Main Roads Western Australia
Don Aitken Centre (DAC)
East Perth WA 6004

1.3 Environmental Impact Assessment Framework

1.3.1 Environmental Protection Act 1986

The EP Act is the key legislative tool for environmental protection in Western Australia. The EP Act provides for the prevention, control and abatement of pollution and environmental harm; and for the conservation, preservation, protection, enhancement, and management of the environment. The

Revised Proposal has been referred under Part IV of the EP Act (environment impact assessment), which is administered by the Environmental Protection Authority (EPA) and the WA Minister for the Environment.

1.3.2 Environmental Protection and Biodiversity Conservation Act 1999

An action that may have a significant impact on a Matter of National Environmental Significance (MNES) requires approval from the Commonwealth under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Stage 4 of the Manuwarra Red Dog Highway has been referred to the Commonwealth under the EPBC Act due to potential to impact on MNES (listed threatened species and ecological communities) and is currently undergoing assessment at the level of Preliminary Documentation.

1.4 Other Approvals and Regulation

The Revised Proposal will be required to comply with the requirements of other relevant State legislation and regulation. Table 1-2 provides an overview of other approvals that may be required to implement the Revised Proposal.

Table 1-2 Other Approvals – Stage 4

Proposal activities	Land tenure/access	Type of approval	Legislation regulating the activity	Decision-making authority	Influence on Environmental Outcome
Groundwater abstraction for dewatering during construction and abstraction of construction water	Crown land and Freehold land.	5C and 26D Licence.	*Rights in Water and Irrigation Act 1914*	Department of Water and Environmental Regulation (DWER)	Sets limits on the location and quantity of water abstraction to ensure impacts to groundwater levels and quality are minimised.
Clearing of a Threatened Ecological Community (TEC)	Crown land and Freehold land.	S 45 authorisation	*Biodiversity Conservation Act 2016*	Department of Biodiversity, Conservation and Attractions (DBCA)	Sets limits on the location and extent of clearing of TECs to ensure impacts to flora and vegetation are within approved limits.
Construction of bridges and/or floodways which will disturb the banks of the Fortescue River and multiple creeks	Crown land and Freehold land.	Bed and Banks Permit	*Rights in Water and Irrigation Act 1914* *Rights in Water and Irrigation Regulations 2000*	DWER	Sets conditions with respect to the disturbance of waterway beds and banks (including vegetation clearing).

Proposal activities	Land tenure/access	Type of approval	Legislation regulating the activity	Decision-making authority	Influence on Environmental Outcome
Disturbance of Aboriginal heritage sites	Crown land and Freehold land.	Aboriginal Cultural Heritage Management Plan.	*Division 6 of the Aboriginal Cultural Heritage Act 2021*	Department of Planning, Lands, and Heritage (DPLH)	Set limits on the location, extent and magnitude of impacts to Aboriginal Heritage sites where disturbance cannot be avoided.
Construction and operation of a concrete batching plant	Crown land and Freehold land.	Works approval Licence or Registration, depending on size	*Environmental Protection Act 1986*	DWER	Set limits on the emissions associated with the construction and operation of concrete batching plants.
Operation of wastewater treatment facilities at construction camps	Crown land and Freehold land.	Health approvals EP Act Part V Registration	*Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974* *Environmental Protection Act 1986*	Department of Health DWER	Sets conditions with respect to the construction and operation of wastewater treatment facilities to maintain human health standards and minimise impacts to the environment.

2 Revised Proposal

2.1 Background

The requirement for a direct sealed road between the Pilbara coastal communities and inland communities was identified in the 1990s. Prior to the commencement of construction of Stages 1 to 3 of the Karratha – Tom Price Road (now known as the Manuwarra Red Dog Highway), access between the Karratha/Dampier and Roebourne coastal communities to Tom Price/Paraburdoo on the public road system was via the Roebourne – Wittenoom Road, the Nanutarra – Munjina Road, and the Tom Price Spur Road. However, historical traffic data showed that most vehicles commuting between Karratha and Tom Price were using the shorter Pilbara Rail Company's Dampier to Paraburdoo railway access road rather than the public roads.

The 'Roads 2020 Regional Road Development Strategy: Pilbara Region', developed by Main Roads Western Australia (Main Roads) together with local government authorities (Main Roads, 1997), and the 'Pilbara Regional Transport Strategy', developed by the Department of Transport (DoT), recognised there was a requirement for a more direct link between Karratha and inland communities such as Tom Price and Paraburdoo. The completed road will ultimately provide a sealed link between the coastal and inland communities of the central Pilbara that will best meet the needs of all stakeholders.

Main Roads referred the Manuwarra Red Dog Highway (then known to as the Karratha – Tom Price Road) to the WA Environmental Protection Authority (EPA), under section 38 of the *Environmental Protection Act 1986* (EP Act), in September 1998. The EPA determined that the potential environmental impacts were sufficient to warrant formal assessment of the Proposal. In October 1998, the EPA determined the level of assessment to be a Consultative Environmental Review (CER – Assessment Number 1244). The CER was prepared by Main Roads and released for public review in January 2003. In January 2005, the EPA finalised its decision report and recommended conditional approval of the Proposal to the Minister for the Environment. Subsequent to this, the Proposal was granted conditional Ministerial approval via Ministerial Statement (MS) 677 in April 2005.

Since approval of the original Proposal in April 2005, two changes to the Approved Proposal have been made:

- a section 46C request to change implementation conditions resulting in modification of Condition 7-2 to allow an increase in the total amount of clearing within Millstream-Chichester National Park to not more than 145 ha (originally 110 ha); and
- a section 45C request for minor changes to the Approved Proposal's key characteristics to:
  - create a total area of disturbance of 574 ha by combining the two areas of disturbance described in the original approval; and
  - remove elements that were no longer considered key characteristics for the purposes of environmental approval (i.e. design speed and railway crossings). Note the previous section 45C process did not remove formation width and connections to existing roads.

2.1.1 Approved Proposal

The Approval Proposal is to construct and maintain a new road from the North West Coastal Highway, near Karratha, to the Nanutarra-Munjina Road, north of Tom Price (Figure 1) comprised of:

- a new 93 km section from the North West Coastal Highway near Karratha to about 20km north of the Millstream turn-off on the existing Roebourne – Wittenoom Road (Stage 2);
- a 46 km section in common with the existing Roebourne – Wittenoom Road (Stage 3); and
- a 109 km section from Wallyinya Pool (on the existing Roebourne – Wittenoom Road) to the Nanutarra – Munjina Road (Stage 4) adjacent to the existing Pilbara Rail Company railway.

Note that Stage 1 of the Manuwarra Red Dog Highway which was completed in 2003, was not included in the Approved Proposal for Stages 2-4. Construction of Stage 2 was completed in 2008 with Stage 3 completed in 2020. During the construction of Stage 3, Main Roads became aware that the area of disturbance required to construct the road had been underestimated in the original assessment. This, combined with changed road design standards since the 2005 approval, meant that the majority of the 574 ha area of disturbance approved under MS 677 and the associated section 45C was exhausted.

The alignment for Stage 4 of the Approved Proposal starts at Wallyinya Pool, traverses the Fortescue River Valley and Hamersley Range, ending at the junction with the Nanutarra – Munjina Road (Figure 2). This alignment is adjacent to the existing Rio Tinto (Pilbara Rail Company) railway. Between Wallyinya Pool and the crossing of Weelumurra Creek, the alignment is to the east of the railway. At the Weelumurra Creek crossing, the alignment moves to the west of the railway.

Due to the different requirements and expectations of environmental assessment documentation in the early 2000s, it is difficult to quantify the disturbance and potential impacts of Stage 4 of the Approved Proposal in isolation. Information presented in the CER suggests the following impacts were expected for Stage 4 of the Approved Proposal:

- area of disturbance of approximately 250 ha;
- clearing of 17.5 ha of the *Themeda* Grasslands Threatened Ecological Community (TEC), based on a 7 km long corridor intersecting the community;
- no clearing was stated for the Brockman Iron Cracking Clay Communities of the Hamersley Range Priority Ecological Community (PEC); and
- clearing of habitat for the Pilbara Olive Python was noted in the CER but not quantified.

2.1.2 Proposed Changes

The Proposed Changes seek approval to modify the design for Stage 4 (only) of the Manuwarra Red Dog Highway approved by MS 677, to incorporate changes to road design standards and community expectations regarding safety of regional roads. No changes to Stages 2 or 3 are proposed and these stages will continue to be operated in accordance with MS 677.

Stage 4 involves construction of 112 km of new road from the southern end of Stage 3 of the Manuwarra Red Dog Highway (Wallyinya Pool) to the intersection with Nanutarra - Munjina Road. The road will be a standard two-lane single carriageway with associated waterway crossings and fencing

where required or agreed with landowners/managers. Construction works will involve additional clearing that is not currently part of the Approved Proposal.

Figure 4 shows the original alignment for Stage 4 approved under MS 677, and the Development Envelope that would apply for Stage 4 of the Revised Proposal noting that no Development Envelope is defined in the current Approved Proposal. As such, all references to 'Development Envelope' within this document refer to the Development Envelope for Stage 4 of the Revised Proposal unless stated otherwise. Figure 4 shows a shift in the alignment from the eastern side of the Rio Tinto Railway (as per the Approved Proposal) to the western side between Wallyinya Pool and the rail crossing at Weelemurra Creek. A deviation to the west of Hamersley Homestead is also proposed as part of the Proposed Changes in order to minimise potential amenity impacts to the homestead.

To construct the road in accordance with contemporary design standards and community expectations, previous stages of the road needed to use a larger percentage of the disturbance approved in MS 677 than originally envisaged. Consequently, at completion of Stage 3 of the Manuwarra Red Dog Highway in August 2020, most of the 574 ha area of disturbance approved in MS 677 was exhausted. Additional disturbance is therefore required to construct and operate Stage 4.

A review of the alignment for Stage 4 has been undertaken, informed by ongoing consultation with stakeholders, including Traditional Owners and the owners of both Hamersley Homestead and Coolawanyah Station. This review has resulted in substantial modifications to the alignment of Stage 4 in order to avoid areas of significance to the Traditional Owners, avoid or minimise potential social and amenity impacts, and minimise interactions between existing infrastructure and other land owners/managers.

The Development Envelope for Stage 4 of the Revised Proposal is 7,142 ha. All disturbance including that for laydown areas, site offices, side tracks, turnaround locations and other construction activities will occur within the Development Envelope. The Indicative Disturbance Footprint within the Development Envelope is approximately 665 ha. Of this area, approximately 565 ha will be permanent clearing (e.g. road, drainage infrastructure) and approximately 100 ha will be temporary clearing that will be rehabilitated. Note that all references to 'Indicative Disturbance Footprint' within this document refer to the Indicative Disturbance Footprint for Stage 4 of the Revised Proposal unless stated otherwise

Originally, the CER anticipated 250 ha of disturbance, based on an average width of 20 – 25 m, whereas the disturbance required for Stage 4 of the Revised Proposal has been based on an average width of 70 – 75 m. This increase allows for the increased formation width (changed from 9 m to 12 m) and larger Indicative Disturbance Footprint required in areas of cut and fill through the Hamersley Ranges.

A layout plan for Stage 4 of the Revised Proposal is provided in Figure 2. The design is in the alignment definition phase and is being further refined based on planning, stakeholder consultation and investigations. The alignment shown in the layout plan is therefore subject to change; however, it will remain within the proposed Development Envelope and impacts such as disturbance to vegetation and habitats for significant species will be will not exceed the limits detailed in this document.

2.1.3 Revised Proposal

Table 2-1 provides a summary of the Revised Proposal, while the proposed changes to the key characteristics and the key characteristics of the Revised Proposal are detailed in Table 2-2.

Table 2-1 Summary of Revised Proposal

Proposal Title	Manuwarra Red Dog Highway
Proposal Title	Manuwarra Red Dog Highway
Proponent Name	Main Roads Western Australia
Short Description	The Revised Proposal is to construct and maintain a new sealed road from the North West Coastal Highway, near Karratha, to the Nanutarra-Munjina Road, north of Tom Price (Figure 1). The Revised Proposal is comprised of three stages: • a new 93 km section from the North West Coastal Highway near Karratha to about 20km north of the Millstream turn-off on the existing Roebourne – Wittenoom Road (Stage 2); • a 46 km section in common with the existing Roebourne – Wittenoom Road (Stage 3); and • a 112 km section from Wallyinya Pool (on the existing Roebourne – Wittenoom Road) to the Nanutarra – Munjina Road (Stage 4) adjacent to the existing Pilbara Rail Company railway. Note that Stage 1 of the Manuwarra Red Dog Highway, completed in 2003, was not included in the Approved Proposal. The Revised Proposal has a greater area of vegetation clearing than the original, Approved Proposal.

Table 2-2 Proposed Changes and Key Characteristics of the Revised Proposal

Proposed element	Location / description	Existing Proposal extent (MS 677 Current Authorised Extent)[6]	Proposed amendment	Combined extent, capacity or range
Physical elements				
Length	North West Coastal Highway, near Karratha, to the Nanutarra-Munjina Road, north of Tom Price (Figure 1)	Approximately 245 km.	Increase in length by approximately 6 km.	Approximately 251 km.
Connections to existing roads		North West Coastal Highway; Roebourne-Wittenoon Road;	Removed[7]	

[6] Since approval of the Original Proposal in April 2005, two minor changes to the Proposal Key Characteristics have been approved via the Section 45C process being creation of a total area of disturbance of 574 ha by combining the two areas of disturbance described in the Original Proposal; and removal of elements that were no longer considered key characteristics for the purposes of environmental approval (i.e. design speed and railway crossings). Note the previous Section 45C process did not remove formation width and connections to existing roads.

[7] Road connections are no longer considered a key characteristic for the purposes of environmental approval as this area is accounted for in the Proposal Element "Area of disturbance"

Proposed element	Location / description	Existing Proposal extent (MS 677 Current Authorised Extent)[6]	Proposed amendment	Combined extent, capacity or range
		Millstream-Yaraloola Road; Mt Bruce Road; and Nanutarra-Munjina Road.		
Area of Disturbance		Clearing and disturbance of no more than 574 ha – of this no less than 137 ha will be rehabilitated following construction of the road formation.[8]	Additional clearing and disturbance of no more than 665 ha within a Development Envelope (Figure 2) of 7,142 ha located within the Stage 4 Section, of which no less than 100 ha will be rehabilitated following construction of the road formation.	Clearing and disturbance of no more than 1,239 ha of which no less than 237 ha will be rehabilitated following construction of the road formation. All clearing and disturbance for Stage 4 of the Proposal is to occur within a Development Envelope (Figure 2) of 7,142 ha.
Formation width		Approximately 9 m.	Removed[9]	
Waterway crossings		Up to nine bridges across major watercourses and railway lines. Culverts and low-level floodways will be used for all other waterway crossings.	No change	Up to nine bridges across major watercourses and railway lines. Culverts and low-level floodways will be used for all other waterway crossings.
Fencing of road reserve	Road reserve outside the Millstream-Chichester National Park	Approximately 200 km of fence will be erected along the road reserve outside the Millstream-Chichester National Park.	No change	Approximately 200 km of fence will be erected along the road reserve outside the Millstream-Chichester National Park.

[8] No Development Envelope is defined in the Approved Proposal

[9] Formation width is no longer considered a key characteristic for the purposes of environmental approval as this area is accounted for in the Proposal Element "Area of disturbance"

Proposed element	Location / description	Existing Proposal extent (MS 677 Current Authorised Extent)[6]	Proposed amendment	Combined extent, capacity or range
Proposal construction elements with greenhouse gas emissions				
Scope 1:	Not specified in Approved Proposal		Total of 108,154 tCO2e for Stage 4 over 30-month construction period (43,262 tCO2e/annum) comprising: • Construction Fuel Consumption: 51,735 tCO2e • Vegetation Clearance: 56,419 tCO2e	
Scope 2:	Not specified in Approved Proposal		No Scope 2 emissions	
Scope 3:	Not specified in Approved Proposal		Total of 91,984 tCO2e for Stage 4 comprising: • Supply of construction fuel: 2,673 tCO2e • Supply of construction materials: 79,415 tCO2e • Associated haulage: 9,896 tCO2e	
Operation elements:				
Scope 1:	Not specified in Approved Proposal		Total of 30,983 tCO2e for maintenance of Stage 4 (50-year life)	
Scope 2:	Not specified in Approved Proposal		Total of 30,983 tCO2e for maintenance of Stage 4 (50-year life)	
Scope 3:	Not specified in Approved Proposal		Total of 1,012,602 tCO2e for Stage 4 comprising: • Supply of maintenance materials (50-year life): 7,499 tCO2e • Road Users (50-year life): 1,005,103 tCO2e	

2.2 Justification

Since the Manuwarra Red Dog Highway Project was originally approved by the Minister for the Environment in 2005, there have been significant changes to road design standards and community expectations regarding safety of regional roads. As a result, design standards that were acceptable in the early and mid-2000's are now outdated and no longer considered appropriate. In order to meet the requirements of the current design standards (as detailed in the 'AustRoads Guide to Road Design' (2020) and Main Roads' supplements to this) a larger area of disturbance has been required than originally anticipated for the previous stages of construction, and will also be required for construction of Stage 4 of the Revised Proposal.

Specific areas where design and safety standards have increased the design footprint include:

- increased width of formation - Main Roads standard formation is now 12 m width whereas the approved design was based on a 9 m wide formation;
- changes to vertical geometry that aim to reduce the angle (grade) roads traverse hills and steep terrain - this may increase the amount of cut and fill required, thereby increasing the footprint;
- updated Restricted Access Vehicle (RAV) requirements for roads; and
- updated clear zone requirements to provide a runoff area for errant vehicles which is clear of hazardous obstructions (such as trees).

In addition, the specific alignment of Stage 4 of the Revised Proposal has changed as a result of stakeholder feedback and other considerations as detailed in Section 3. This has led to reduced amenity impacts to the Hamersley Homestead, and avoidance of Aboriginal heritage sites where practicable.

2.2.1 Rapid Options Assessment

For the purposes of identification and assessment of alignment options for Stage 4 of this Revised Proposal, the route was divided into three sections based on topographical, geological and site conditions as follows:

- Coolawanyah Section: starting at the Roebourne Wittenoom Road, this section crosses the Fortescue River, traversing its associated floodplains and channels originating from the Chichester Range. The Coolawanyah Section is topographically flat.
- Hamersley Section: traverses the Hamersley Ranges which are characterised by steep slopes and cliffs, crossing of Weelumurra Creek and its incised tributaries.
- Tom Price Section: traverses a small portion of the Hamersley Ranges before crossing the southern Hamersley Plateau flats – an extensive floodplain with clay soils – and finishing at the Nanutarra - Munjina Road.

A rapid options assessment was undertaken by Main Roads (Cardno (2020)) to evaluate the potential alignments and identify a preferred corridor. The criteria against which each option was assessed were:

- earthworks – cut fill volumes, rock potential and route length;
- serviceability – risk of flood water inundation and/or backwater effects;
- infrastructure impacts – interactions between the option and existing assets;
- railway and mining leases – severance;
- heritage – presence of known sites; and
- environmental – presence of known values/sites (threatened flora and fauna species and their habitats, ecological communities).

2.2.2 Alignment Development

Further analysis of the options for each section was undertaken to produce a preferred alignment. The preferred alignment addressed key constraints, such as the mitigation of impacts on other land users, environmental constraints and heritage constraints, including:

- the existing Rio Tinto Dampier to Paraburdoo rail line;
- existing infrastructure such as 220kV overhead power line cables, the existing Telstra fibre optic cable and existing high-pressure gas line;
- existing land uses such as the Coolawanyah and Hamersley pastoral leases, the Hamersley Homestead, crown reserves and mining tenements;
- numerous floodways and creek crossings;
- major watercourse crossings (Fortescue River and Weelamurra Creek);
- heritage constraints including Aboriginal heritage sites; and
- environmental constraints including:
  - State listed Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs); and
  - State and Commonwealth listed protected flora, fauna and fauna habitat.

2.2.2.1 Coolawanyah Section

Two options were considered for the Coolawanyah Section. Both options are adjacent to and follow the Rio Tinto railway with Option 1 being on the eastern side of the rail and Option 2 on the western side. For the Coolawanyah Section, the preferred alignment is Option 2 (western side of the railway) as Option 1 required a crossing of the railway and would impede any potential future expansion of the Rio Tinto rail line. The environmental and heritage risks were considered to be similar for each option. Table 2-3 details the options consideration process for the Coolawanyah section.

Table 2-3 Coolawanyah Section – Options Considered (Cardno (2020)

Study	Identified Road Corridor	Assessment Criteria	Road Corridor Flaw Criteria	Preferred option/ options
Feasibility Study	Two options: • adjacent to Rio Tinto rail; and • existing local road network.	• earthwork requirements; and • length of travel.	• poor geometry; and • additional travel time for route.	Adjacent to Rio Tinto rail (maintenance access track)
Corridor Selection - Rapid Assessment	Eastern or western side of Rio Tinto rail alignment	• impacts to Rio Tinto rail line; • intersection with State Agreement mining lease areas; and • technical risks.	• no crossing of the main Rio Tinto rail line; and • increased hydrological risk profile.	Western side of Rio Tinto main line rail alignment
Corridor Selection - Detailed Assessment	Not required. The outcome of the Rapid Assessment resulted in a single preferred corridor alignment			

Study	Identified Road Corridor	Assessment Criteria	Road Corridor Flaw Criteria	Preferred option/ options
Final Development corridor	Development Corridor with a minimum width of 400 m running on the western side of the Rio Tinto main line rail alignment			

2.2.2.2 Hamersley Section

Within the Hamersley Section 15 options were considered. The majority of these are on the western side of the railway with a single option on the eastern side. The presence of Rio Tinto's Mining Lease ML4SA is a major constraint for the Hamersley Range alignments as Rio Tinto has stipulated that this lease must be avoided. Six of the 15 options were ruled out as they intersected ML4SA. The option to the east of the railway was ruled out due to high flood and other hydrological risks and the need for a rail crossing to join the preferred Coolawanyah option on the western side of the rail. The westernmost option was excluded as it would result in significantly longer travel time. The environmental and heritage risks are similar for all options. Table 2-4 details the options consideration process for the Hamersley section.

Table 2-4 Hamersley Section – Options Considered (Cardno (2020)

Study	Identified Road Corridor	Assessment Criteria	Road Corridor Flaw Criteria	Preferred option/ options
Feasibility Study	Two options: • adjacent to Rio Tinto rail; and • existing local road network.	• earthwork requirements; and • length of travel.	• poor geometry; and • additional travel time for route.	Adjacent to Rio Tinto rail (maintenance access track)
Corridor Selection Rapid Assessment	Fifteen Development Corridor options through the Hamersley Ranges	• impacts to Rio Tinto rail line; • intersection with State Agreement mining lease areas; and • technical risks.	• severance of mining lease ML4SA; • no crossing of the main Rio Tinto rail line; and • increased hydrological risk profile.	Seven options carried through for further assessment
Corridor Selection Detailed Assessment	Seven Development Corridor options through the Hamersley Ranges	• earthwork requirements; and • technical risks.	• increased hydrological risk profile – major crossings and catchments; and • earthwork requirements – orders of magnitude comparison.	Single Development Corridor with a minimum width of 400 m identified

Study	Identified Road Corridor	Assessment Criteria	Road Corridor Flaw Criteria	Preferred option/ options
Final Development corridor	Development Corridor with a minimum width of 400 m running through the Hamersley Ranges			

2.2.2.3 Tom Price Section

Two options have been considered for the Tom Price Section, both options being adjacent to and following the Rio Tinto railway with Option 1 being on the eastern side of the rail and Option 2 on the western side, with a deviation to the west of Hamersley Homestead. The preferred option for the Tom Price section is the option to the western side of the railway. The eastern alignment would require a crossing of the Rio Tinto railway as well as the future FMG Eliwana Railway. The environmental and heritage risks were considered to be similar for each option. Table 2-5 details the options consideration process for the Tom Price section.

Table 2-5 Tom Price Section – Options Considered (Cardno (2020)

Study	Identified Road Corridor	Assessment Criteria	Road Corridor Flaw Criteria	Preferred option/ options
Feasibility Study	Two options: • adjacent to Rio Tinto rail; and • existing local road network.	• earthwork requirements; and • length of travel.	• poor geometry; and • Additional travel time for route.	Adjacent to Rio Tinto rail (maintenance access track)
Corridor Selection - Rapid Assessment	Eastern or western side of Rio Tinto rail alignment	• impacts to Rio Tinto rail line; • intersection with State Agreement mining lease areas; and • technical risks.	• no crossing of the main Rio Tinto rail line; and • increased hydrological risk profile.	Western side of Rio Tinto main line rail alignment
Corridor Selection - Rapid Hamersley Homestead	Three options diverting around the Hamersley Homestead community	• Western Guruma Aboriginal Corporation advice on preferred options.	• Visual intrusion into the Hamersley Homestead community	Two options to the west of Hamersley Homestead
Corridor Selection - Detailed Assessment	Two options to the west of Hamersley Homestead on the western side of the Rio Tinto	• cultural significance of the land	• increased hydrological risk profile – major crossings and catchments; and	Single Development Corridor with a minimum width of 400 m identified

Study	Identified Road Corridor	Assessment Criteria	Road Corridor Flaw Criteria	Preferred option/ options
	mail line rail alignment	• earthwork requirements; and • technical risks.	• earthwork requirements – orders of magnitude comparison.	
Final Development corridor	Development Corridor with a minimum width of 400 m running through the Hamersley Ranges.			

2.3 Description of Stage 4 of the Revised Proposal

Stage 4 of the Revised Proposal consists of 112 km of road between Wallyinya Pool (on the existing Roebourne – Wittenoom Road) to the Nanutarra – Munjina Road. The road has a formation width of 12 m and includes up to nine bridges across major waterways and railway lines.

2.3.1 Construction

Construction of Stage 4 of the Revied Proposal will be undertaken using traditional earth-moving equipment and construction techniques. Blasting is likely to be required in areas of cut where excavation is not practicable using standard earthmoving machinery, particularly though the Hamersley Ranges.

The road formation will be built using both imported fill and fill material generated on site from areas of cut (also referred to as cut to fill), where this material is deemed suitable for use. Where practicable, the Revised Proposal will seek to balance the cut to fill requirements during construction to minimise any net import or export of material from the Revised Proposal. This will minimise the requirement to import additional material, thus minimising costs and environment impacts (e.g. carbon dioxide (CO_2) emissions) associated with transport.

There is insufficient design detail at this stage to confirm the design and construction method for any bridges that may be included in the design. However, the design is expected to be industry standard, such as pre-cast concrete or steel, supported on piled foundations or spread footings with mechanically stabilised earth (MSE) walls at the abutments. A high-level construction methodology for bridges would typically comprise (noting this is subject to detailed design):

- piling works for foundation construction;
- construction of concrete pier columns;
- construction and installation of MSE walls at abutments;
- construction of concrete beams and slab; and
- completion of ancillary works, such as landscaping.

Laydown and stockpiling areas (and potential access tracks) for material and equipment will be required during construction, as will areas for facilities such as site offices and construction camps. Indicative locations for these areas are shown in Figure 3. These locations have been placed to avoid habitat critical to the survival of the Northern Quoll, important Northern Quoll dispersal habitat and

Ghost Bat foraging habitat within 5 km of the possible Ghost Bat maternity roost. Any refinement to these areas will maintain this avoidance. The location of these will be confirmed by Main Roads prior to construction. All such areas will be located within the Development Envelope. Clearing for laydown areas, stockpiling and other facilities is expected to result in approximately 100 ha of temporary vegetation clearing, which will be rehabilitated as part of the Stage 4 of the Revised Proposal.

Water required for construction of Stage 4 of the Revised Proposal will be sourced from new or existing bores. It is estimated that between 148,000 and 412,000 kL will be required. It is likely that the majority of water will be sourced from existing bores within the existing allowance under the 5C license for the well in accordance with the WA *Rights in Water and Irrigation Act 1914* (RIWI Act). Should new bores be required or where extraction greater than allowed in an existing licence be required, Main Roads will seek the required licenses in accordance with the RIWI Act. Main Roads anticipates that the need to gain new licences or extend existing licenses, if required, would be for a small number of bores (probably not more than three). Any water abstraction required for construction will be undertaken to minimise drawdown and potential impacts on vegetation or fauna.

2.3.2 Operation

Stage 4 of the Revised Proposal will operate as a two-lane single carriageway (one lane in each direction) road. Traffic modelling indicates a likely maximum of 635 vehicles per day will use the road, of which up to 230 will be heavy vehicles. The road will be operated by Main Roads, using standard management and maintenance practices. Stage 4 of the Revised Proposal will be subject to routine, recurrent and periodic maintenance during its operation. The maintenance activities are confined to the road corridor and the road itself, typically including vegetation management, drainage, road markings, signs and the road pavement. Repairs are likely to be required following major weather events, however Main Roads are seeking to "Pilbara proof" the road in order to reduce closure time following events such as flooding, and provide a high level of reliability for road users. 'Pilbara Proofing' involves the use of design criteria focussed on serviceability and resilience outcomes based on local hydrological conditions and stakeholder expectations. Community consultation established two key expectations:

- short road closures (less than a week) are acceptable during major storm events due to the availability of alternative routes between major towns; and
- closures are not acceptable to accommodate works as a result of weather which is considered within a normal range for the area (including cyclones).

2.3.3 Timing

Construction of Stage 4 of the Revised Proposal is planned to commence in mid to late 2023 for a period of up to three years.

Once constructed and open for public use, operation of the MRDH Stage 4 will be ongoing. The completed road will be subject to routine, recurrent and periodic maintenance during operation. The road has an operating life of at least 40 years, road pavement has a design life of 40 years and bridges have a design life of 100 years.

2.3.4 Rehabilitation

Temporary vegetation clearing such as for the purpose of laydown and stockpile areas, site offices, or construction camps will be rehabilitated using locally native species to reflect the surrounding vegetation and fauna habitat. Vegetation will be resilient within three years after the rehabilitation works are completed.

Revegetation along the Stage 4 Development Envelope will comply with *Main Roads Vegetation Placement within the Road Reserve* Doc. No. 6707/022 (Main Roads, 2013). This guide defines the recommended setbacks and clearance requirements that apply to all revegetation or landscaping associated with new road construction.

2.3.5 Greenhouse Gas (GHG) Emissions

In April 2020, the EPA released its Environmental Factor Guideline – Greenhouse Gas Emissions. As the construction of the MRDH project is an infrastructure development and a development that clears vegetation, it is an activity that may be considered under the Greenhouse Gas Emissions Factor (EPA, 2020b).

An estimate of Stage 4 of the Revised Proposals greenhouse gas emissions footprint has been undertaken, covering the most significant contributions. Refer to Appendix A.6 for methodology and GHG emission calculations.

Stage 4 of the Revised Proposal is expected to result in the following emissions over its life:

- Scope 1 = 139,138tonnes CO2e;
- Scope 2 = 0 tCO2e; and
- Scope 3 = 1,104,585 tCO2e.

The emissions source breakdowns are summarised in Table 2-6.

Table 2-6 Emissions Breakdown from Stage 4 of the Revised Proposal

Source	Scope 1 Emissions (tCO2e)	Scope 2 Emissions (tCO2e)	Scope 3 Emissions (tCO2e)	Total Emissions Proportion
Construction				
Construction Fuel Consumption	51,735	0	2,673	4%
Vegetation Clearance	56,419	0	0	5%
Construction Materials	0	0	79,415	6.4%
Haulage	0	0	9,896	0.8%
Operations				
Maintenance (50-year life)	30,983	0	7,499	3%
Road Users (50-year life)	0	0	1,005,103	81%

Source	Scope 1 Emissions (tCO2e)	Scope 2 Emissions (tCO2e)	Scope 3 Emissions (tCO2e)	Total Emissions Proportion
Total Emissions (tCO2e)	1,243,723			

Based on an expected 30-month duration of construction, the annual Scope 1 emissions are 43,262 tCO2e/annum during construction and (including land clearing) and 620 tCO2e/annum during operations (based on 50 year life). This is below the 100,000 tCO2e/annum Scope 1 emissions threshold within the EPA Environmental Factor Guideline – Greenhouse Gas Emissions.

2.4 Local and Regional Context

2.4.1 Overview and Socio-Economic Environment

The Revised Proposal is located in the Pilbara region of WA within the Shire of Ashburton (Figure 1). In 2017, the Shire had a population of 13,261 people with about half living in the towns of Onslow (848), Pannawonica (695), Paraburdoo (1,359) and Tom Price (2,956).

In 2018, over 40 million tonnes of iron ore were produced by mines located within the Shire, with the Shire's mining sector representing over 18% of WA's mining industry value (Shire of Ashburton, 2019) (Shire of Ashburton, 2019). The strong presence of the resource sector is reflected in the Shire's high average personal income and low unemployment rate (the lowest of any local government area in Australia). The reliance on mining also presents risks for the community. The downturn in the mining sector in 2012 had a significant impact to the Shire's population with the sudden reduction in population having a flow-on impact resulting in many small businesses either shutting down or relocating (Shire of Ashburton, 2019).

The tourism market, which contributes almost $300 million to local expenditure, making up 1.3% of the economy and 6.5% of all jobs, also plays an important role in the economy of the Shire. For the year ending March 2018, it was estimated that there were over 330,000 visitors to the Shire of Ashburton. Most visits (61%) were for business purposes, with leisure visitors making up 35% of the total. Leisure visitation is dominated by older Australian visitors (55 years +), predominantly from Western Australia, travelling with a caravan (Shire of Ashburton, 2019).

2.4.2 Tenure and Land Use

The tenure in and around the Development Envelope is a combination of Crown land, pastoral leases and mining tenements. Land use in the wider Pilbara region includes mining and petroleum operations, pastoralism, tourism and recreation, and conservation. Existing land-uses within and adjacent to the Development Envelope for the Revised Proposal include pastoral activities, Crown reserves, mineral exploration, utilities, unsealed roads and mining railways.

The Development Envelope is situated partially within the Coolawanyah and Hamersley Pastoral Leases, with the remainder of the land designated as Unallocated Crown Land. A number of mining tenements also overlap the Development Envelope. Land use types are displayed in Figure 5.

Land in the Development Envelope is zoned Rural with the exception of a corridor along the existing rail line (zoned Other Purposes: Infrastructure), and the area reserved for water protection associated with the Millstream water supply wellfield (zoned Public Purposes: Water and Drainage).

The majority of the proposed road alignment for Stage 4 is located approximately 100 m from the existing Rio Tinto Dampier to Paraburdoo rail line.

The following Crown Reserves are within or near to the Development Envelope for the Revised Proposal (Figure 6):

- 38991 – the Millstream Water Reserve, managed by DWER and Water Corporation;
- 40743 – owned by Australian Telecommunications Commission (Telstra) and is for a repeater station;
- 39013 – owned by Telstra and is for a repeater station; and
- 27915 – owned by the Department of Primary Industries and Regional Development (DPIRD) and is for a Resting Place.

There are no formally recognised conservation lands within the Development Envelope for Stage 4. The nearest conservation estates are Karijini National Park, located approximately 18 km south-east of the Development Envelope, and Millstream – Chichester National Park, located approximately 14 km north of the northern extent of the Development Envelope (Figure 6). The road reserve for Stage 3 was excised from Millstream – Chichester National Park. Additionally, the DBCA has purchased areas of the Mt Florence and Hamersley pastoral leases adjacent to Karijini National Park. These areas are proposed for conservation in the future through addition to the national park.

2.4.3 Native Title

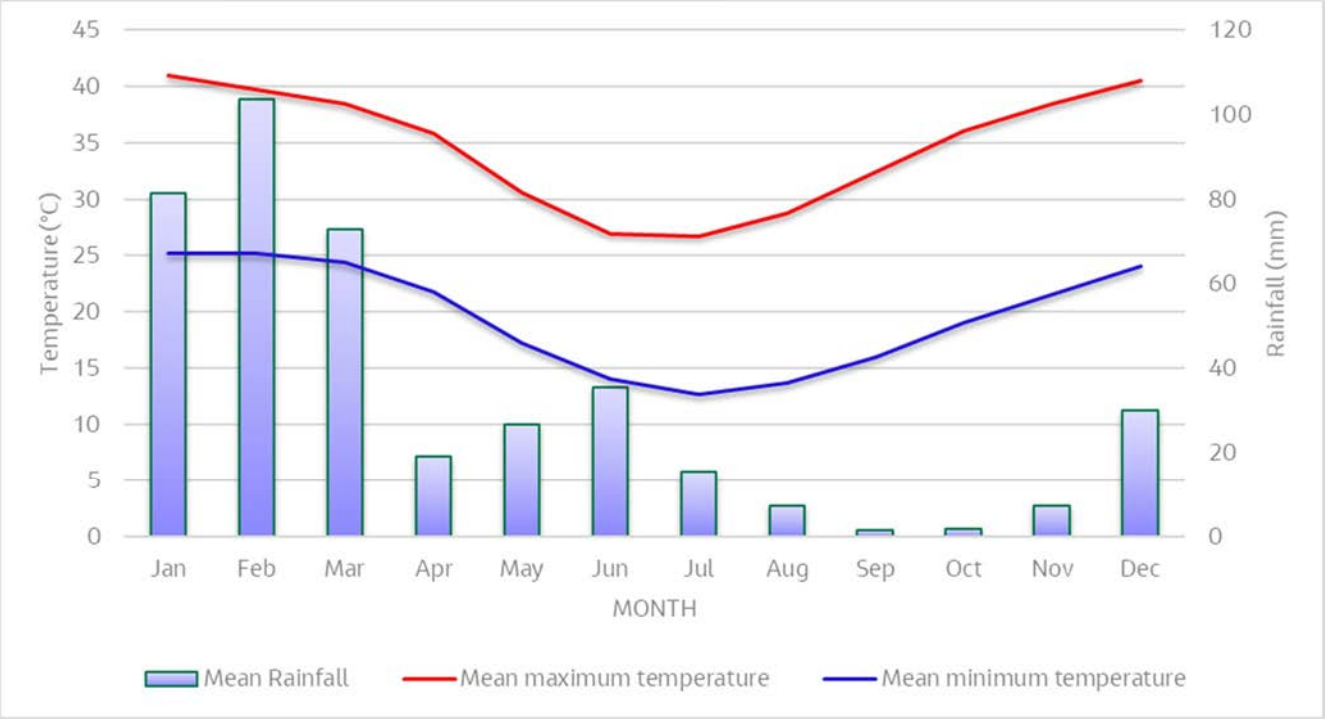
Native Title exists across the Development Envelope for Stage 4 with the Yindjibarndi People having Native Title rights in the northern portion of the Development Envelope (determination WCD2017/010 – Yinjibarndi #1, 13 September 2017, and determination WCD2005/001 – Ngarluma Yindjibarndi, 02/05/2005) and the Wintawari Guruma People having Native Title rights in the southern portion (determination WCD2007/001 – Eastern Guruma, 1 March 2007) (Figure 7). Registered aboriginal heritage sites are shown in Figure 8.

2.4.4 Climate

The Pilbara is a semi-arid and arid region with a monsoonal climate. Peak rainfalls occur in the warmer summer months between December and March (i.e. the wet season) as a result of monsoonal thunderstorm activity (Graph 1; Sudmeyer, 2016). Tropical lows or cyclones may occur during these months also. Climate data has been collected by the Bureau of Meteorology (BoM) weather station at Pannawonica (Station Number 005069), about 110 km due west of the Development Envelope, since November 1971. Temperature data is available for a period of 33 years (2071 – 2005) while rainfall data is available for a period of 47 years (1971 – 2020). Review of the available data indicates mean maximum monthly temperatures vary between 26.9°C (June) and 41.2°C (January) and mean minimum temperatures range between 12.6 (July) and 25.2°C (January and February) (BoM, 2020).

Temperature ranges are generally greater in inland districts away from the moderating effects of the onshore winds common to the coastal districts. Temperatures within the local area of the

Development Envelope are, therefore, likely to be more variable than those at Pannawonica. For comparison, mean monthly maximum temperatures at the BoM weather station located in Paraburdoo (Station Number 007185) about 77 km south of the Development Envelope, vary between 24.9°C (June) and 40.7°C (January) and mean minimum temperatures range between 9.8°C (July) and 26°C (January) (BoM, 2020). Mean annual rainfall is lower; 317 mm compared with 407.2 mm at Pannawonica (BoM, 2020). Pannawonica has been used as the primary source of climate data as the station at Paraburdoo has only been collecting temperature data since 1996.



Graph 1 Climate Data Recorded at the Pannawonica BoM Climate Station (BoM, 2020)

2.4.5 Bioregional Context

The Development Envelope sits within the Pilbara Bioregion and the Chichester, Fortescue and Hamersley subregions as defined by the Interim Biogeographic Regionalisation for Australia (IBRA) Version 7 (DAWE, 2020). A description of these subregions is provided in Table 2-7.

The Pilbara bioregion is a major centre for biodiversity in WA. The Hamersley subregion is recognised as a biodiversity hotspot due to the high species diversity and high levels of endemism in the region.

Table 2-7 Description of the IBRA Subregions Within or Adjacent to the Development Envelope (DAWE, 2020)

IBRA Subregion	Description
Hamersley subregion (PIL 3)	Mountainous area of Proterozoic sedimentary ranges and plateaux with mulga low woodland over bunch grasses on fine textured soils and snappy gum over *Triodia brizoides* on skeletal sandy soils of the ranges

Chichester subregion (PIL 1)	Archaean granite and basalt plains supporting shrub steppe characterised by *Acacia pyrifolia* over *Triodia pungens* hummock grasses. Snappy gum tree steppes occur on ranges.
Fortescue subregion (PIL 2)	Alluvial plains and river frontages; salt marsh, mulga-bunch grass and short grass communities on alluvial plains; river gum woodlands fringe the drainage lines; this is the northern limit of mulga (*Acacia aneura*).

2.4.6 Landforms and Land Systems

The topography within and adjacent to the Development Envelope is heavily governed by the underlying geology, the majority of which is extremely ancient and very hard (GHD, 2003), leading to relief as a result of long term weathering. The landforms that the proposed route will traverse can be divided into broad units, defined as follows:

- foothills and ranges of the Chichester and Hamersley Ranges, which rise to approximately 350 metres (m) and 580 m respectively in the Development Envelope and consist of highly dissected, weathered plateau remnants;
- Fortescue River valley which is a wide, relatively flat valley incorporating numerous creeks and drainage lines as part of the Fortescue River system; and
- eastern outwash plain of the Hamersley Range, which is dominated by very low alluvial ridges with scattered outcrops.

The Development Envelope intersects 11 land systems as mapped by van Vreeswyk et. Al. (2004 – Table 2-8) (Figure 9).

Table 2-8 Land Systems Within and Adjacent to the Development Envelope (Biota, 2021; van Vreeswyk et al., 2004)

Land System	Description
Boolgeeda (RGEBGD)	Stony lower slopes, level stony plains and narrow sub-parallel drainage floors, relief up to 20 m. A common system in shallow valleys below hill systems such as Newman and Rocklea.
River (RGERIV)	Narrow floodplains and major channels.
Urandy (RGEURY)	Alluvial plains with or without stony mantles and river channels.
Nooingnon (RGENON)	Level hardpan wash plains characterised by parallel bands of very large (up to 5 km long by 40 m wide) groves of dense vegetation with much wider and sparsely vegetated intergrove areas with variable density mantles of ironstone pebbles and shallow loamy soils over hardpan; minor sandy banks and plains receiving more concentrated through flow.
Hooley (RGEHOY)	Broad alluvial plains with clay soils and a mosaic of stony non-gilgaied and less stony gilgaied surfaces.
Platform (RGEPLA)	Narrow, raised plains and highly dissected slopes on partly consolidated colluvium below the footslopes of hill systems such as Newman, relief mostly up to about 30 m but occasionally considerably greater.
Newman (RGENEW)	Rugged high mountains, ridges and plateaux with near vertical escarpments of jaspilite, chert and shale, the second largest system in the survey area of Van Vreeswyk et al., (2004) and prominent in southern parts (e.g. Ophthalmia Range, Hamersley Range), relief up to 450 m.
Brockman (RGEBRO)	Level alluvial plains with clay soils and gilgai microrelief.
Jurrawarrina (RGEJUR)	Level alluvial plains with loamy soils over hardpan, broad alluvial tracts receiving more concentrated sheet and channelled through flow and with deeper more clayey soils.
McKay (RGEMCK)	Hills, ridges, plateaux remnants and minor breakaways of sedimentary and meta sedimentary rocks, relief up to 100 m.
Pindering (RGEPDG)	Level to gently undulating hardpan wash plains with surface mantles of ironstone pebbles and gravel, some patterns of small groves and minor tracts receiving more concentrated through flow; relief up to 10 m.

2.4.7 Geology

Six geological units occur within or adjacent to the Development Envelope, with Qrc (colluvium) and Qa (alluvium) being the dominant surface geology types (Table 2-9).

Table 2-9 Description and Extent of Geological Units within the Development Envelope (Biota, 2021; Stewart et al., 2008)

Geological unit	Description
Qrc – colluvium	Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite
Qa – alluvium	Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted
Lchk – Brockman Iron Formation	Banded iron-formation, chert, mudstone and siltstone
Ashm – Mt. McRae Shale and Mt. Sylvia Formation	Interbedded shale, chert, banded iron-formation
Alhw – Wittenoom Formation	Calcitic dolomite, interbedded chert and shale in upper and lower parts, volcaniclastic sandstone
Achm – Marra Mamba Iron Formation	Chert, ferruginous chert, jaspilite, banded iron-formation, minor shale, siltstone, mudstone

2.4.8 Soils

Eight broad soil types were identified within the Development Envelope. The dominant units in the survey area comprise the valley plain unit associated with Fortescue River, Ja1, and Fa13, which represented shallow, stony soils associated with the Hamersley Range.

Acid Sulfate Soils (ASS) are naturally occurring soils and sediments containing iron sulphides. When potential ASS (PASS) are exposed to air, the iron sulphides in the soil react with oxygen and water to produce a variety of iron compounds and sulphuric acid. ASS and PASS commonly occur in coastal wetlands as layers of marine muds and sands which are deposited in low energy environments such as low-lying wetlands, back swamps, estuaries, salt marshes and tidal flats although they are not limited to coastal regions. They also occur at former beachfronts where heavy-mineral accumulations can occur, within areas of high groundwater table and inland in response to rising water tables and land salinisation.

In accordance with the Atlas of Australian ASS, the Site is predominantly categorised as being within Class C areas; an extremely low probability of ASS occurrence, with a 1-5% chance of occurrences in small, localised areas. Within the central Hamersley Ranges this area is categorised as having a low probability (6-70%) and therefore could potentially provide a risk considering the broad classification. One area localised to the Fortescue River crossing has been identified as high risk with a >70% chance of occurrence between chainage 30000 and 31200 of the Coolawayna Section.

ASS testing in accordance with DWER guidance and the National Acid Sulfate Soils Sampling and Identification Methods Manual (Sullivan et al., 2018) will be undertaken at existing river or creek crossings..

An area of historic asbestos contamination near the northern end of Stage 4 has been cleaned up as part of the works for Stage 3. Given previous land use historic asbestos contamination is not expected in the Development Envelope. If encountered asbestos contamination it will be remediated.

A search of the DWER Contaminated Sites Database (DWER, 2021) indicated that there are no known contaminated sites within the Development Envelope.

3 Stakeholder Consultation

3.1 Stakeholder Engagement Process

Stakeholder consultation for Stage 4 of the Manuwarra Red Dog Highway has been undertaken since 2019 and will continue throughout the project life. Consultation is guided by a project Community and Stakeholder Engagement Strategy (CSES). The CSES outlines the likely level of community interest and the potential stakeholder groups. Objectives of the CSES are to:

- generate awareness of and support (where possible) for Stage 4 of the Revised Proposal;
- provide opportunity for stakeholders to input into Stage 4 of the Revised Proposal, identifying stakeholder aspirations, opportunities and concerns with Stage 4 of the Revised Proposal;
- use stakeholder input to guide decision making; and
- obtain stakeholder buy-in to the design and construction method, ensuring where possible that the concerns are addressed, and if not, explain why not.

3.2 Stakeholder Consultation Conducted

Stakeholders for Stage 4 of the Revised Proposal were identified through a review of the previous road stage upgrades, consultation with the project team and a Preliminary Sustainability Stakeholder Workshop held in 2019. Key stakeholders identified are listed in Table 3-1.

Table 3-2 provides a summary of the stakeholder engagement undertaken for Stage 4 of the Revised Proposal. Main Roads also conducts ongoing consultation with Traditional Owners through scheduled meetings and workshops.

Table 3-1 Key Stakeholders Identified for Stage 4 of the Manuwarra Red Dog Highway

Stakeholder	Relevance to Stage 4 of the Revised Proposal
State Government Agencies ▪ Department of Transport (DoT) ▪ Department of Planning, Lands and Heritage (DPLH) ▪ Department of Biodiversity, Conservation and Attractions (DBCA) ▪ Department of Health (DoH) ▪ Department of Water and Environmental Regulation (DWER) ▪ Pilbara Development Commission (PDC) ▪ Department of Mines, Industry, and Safety (including Worksafe) (DMIRS) ▪ Water Corporation/Service providers	▪ Responsible for various elements of project ▪ Endorsement in line with existing and future planning requirements ▪ Approvals (i.e. DBCA) ▪ Millstream Water Protection – DWER ▪ DoH & DMIRS – Asbestos ▪ Cost implications (services relocation if required)
Federal Government Agencies ▪ Department of Agriculture, Water and the Environment (DAWE)	▪ Responsible for environmental approvals
Mining Companies ▪ Rio Tinto	▪ Future access/ construction impacts ▪ Rail maintenance track usage & rail arch

▪ Balla Balla Infrastructure Group (BBI) ▪ Fortescue Metals Group (FMG)	▪ Rail arch
Local Governments ● Shire of Ashburton ● City of Karratha	▪ Collaboration and engagement with Local Governments required around design development and communications ▪ Future access/ construction impacts ▪ Road ownership and maintenance
Road Users ▪ Residents within Karratha/Tom Price/Paraburdoo who may use the road ▪ Tourists/Visitors	▪ Future access/ construction impacts ▪ Detours and restricted access during construction
Pastoral Stations ▪ Coolawanyah Station ▪ Hamersley Station	▪ Future access/ construction impacts
Aboriginal Communities ▪ Wintawari Garuma Aboriginal Corporation (WGAC) ▪ Yindjibarndi Aboriginal Corporation (YAC)	▪ Future Access/ construction impacts ▪ Ethnographic and archaeological sites ▪ Construction opportunities

Table 3-2 Stakeholder Consultation Undertaken for Stage 4 of the Manuwarra Red Dog Highway

Stakeholder	Date	Consultation Type	Consultation Topic/Outcome
Commonwealth Government			
Department of Agriculture, Water and the Environment (DAWE)	24/02/2021	Meeting	Main Roads updated DAWE on the project in terms of: • Project design, biological survey and timing of further surveys • Potential changes to the project Development Envelope. Main Roads advised there may be changes to the project and Development Envelope during the assessment which would be communicated to DAWE though a request to vary Proposed Action under section 156A of the EPBC Act. It was agreed that the revised/final Development Envelope would be provided at the end of the assessment process. The current Development Envelope will be used in the response to the DAWE information request.
Department of Agriculture, Water and the Environment (DAWE)	Ongoing monthly meetings with DAWE updating progress on projects having major project status. Most recent meeting 6th October 2021	Meeting	John Braid provided update on the status of the MRDH Preliminary Documentation and advised that submission was expected by 15th October 2021.

Stakeholder	Date	Consultation Type	Consultation Topic/Outcome
State Government			
DWER (EPA Services)	February 2021 September 2021	MS Teams Meeting	Information on potential changes to the Development Envelope provided to EPA Services. Likely date for submission of ERD (late October 2021 or early November 2021) provided to EPA Services.
Pilbara Development Commissions (PDC)	17/04/2020	Video Conference	Project update provided and discussions on demand assessment considerations (i.e. current and future potential road users). Input provided by the PDC into the demand assessment for regional travel movements.
DWER (EPA Services)	26/03/2020	Video Conference	Briefed new EPA Services Officer on the project and sought advice /agreement on the State approvals process for the project
DWER (EPA Services)	28/02/2020	Email	Email advising that for the purposes of the State approvals process, the project should be referred as a 'Revised Proposal' (using section 38 referral form) for EPA consideration. The email provided some examples of other projects (e.g. Mesa A and H) that may offer guidance in relation to the referral, approval and characterisation of 'Revised Proposals' in a table.
DWER (EPA Services)	23/01/2020	Face to Face Meeting	Overview of the project and key environmental issues provided. Main Roads advised EPA it is of the view that the Project will require referral to the EPA (and Commonwealth Department of the Environment and Energy, now DAWE) for assessment. Main Roads advised to: • Demonstrate that the Proposal does not meet the criteria for a section 45c amendment to the existing Ministerial Statement; and • Then, should the Proposal not meet the criteria for a section 45c, it is most likely the Proposal would be assessed as a Revised Proposal.
DBCA	01/11/2019	Phone Conversation	Phone conversation to offer to brief DBCA on the proposed project. DBCA expressed a preference for a preliminary project meeting to be held in conjunction with the EPA Services team.
DWER (Water)	28/10/2019	Face to Face Meeting	Discussion of the project and expected approvals pathways.

Stakeholder	Date	Consultation Type	Consultation Topic/Outcome
			DWER advised Main Roads that: • DWER recommended early engagement and involvement with the EPA; • There are four Water Quality Protection Notes (WQPNs) that should be referenced in the development of the project: WQPNs 44, 65, 83 and 84; • That new roads are compatible activities in Priority (P) 1, P2 and P3 areas of public drinking water source areas, with conditions; • Beds and banks permits are required; and • Borrow pits must be free draining. Main Roads were advised that Justine Shailes (Program Manager in the Karratha Office) will be the main point of contact for the Project.
Water Corporation	24/08/2020	Email Correspondence	Requested Water Corporation comments on preferred alignment within proposed corridors.
Local Government			
Shire of Ashburton	09/06/2020	Video Conference (Elected Members Forum)	Main Roads provided an update on the progress of Revised Proposal.
Shire of Ashburton	19/05/2020	Meeting	Discussion of the term “Pilbara Proof” and its meaning to the Shire of Ashburton (e.g. impact on the road from cyclonic weather/flooding); the Shire’s expectations for the design of the road and for ongoing communications / engagement with the council and wider community.
Shire of Ashburton	14/07/2020	Meeting	The Shire of Ashburton requested: • Electronic copies of corridor maps • Requested that the Project Team consult with the MP for SoA • Requested to send summary notes of the ministerial briefing content.
Community			
Yindjibarndi Aboriginal Corporation (YAC)	27/05/2020	Video Conference	Discussion on heritage survey access; project update; discussed potential development of an Indigenous Reference Group.

Stakeholder	Date	Consultation Type	Consultation Topic/Outcome
Wintawari Guruma Aboriginal Corporation (WGAC)	08/05/2020	Video Conference	Discussion of a preferred Hamersley Homestead corridor alignment; heritage survey access; project update; potential development of an Indigenous Reference Group.
WGAC and Wintawari Guruma Traditional Owners	27/02/2020	Face to Face Meeting	Drive-through of alignment options and discussion of least impact option for Hamersley Station Homestead and Weelumurra Law Ground. Feedback received from stakeholders as to possible impacts and areas to be avoided. Further conversation required regarding alignment options at the next WGAC board meeting before decision made.
WGAC	28/01/2020	Office-based Face to Face Meeting	Alignment options and concerns related to the Hamersley Station Homestead discussed. Focus on least impact option for the homestead. In-field walk-over of alignment options to the west of the homestead with Wintawari Guruma Traditional Owners requested by WGAC.
WGAC	14/11/2019	Face to Face Meeting	Discussion of options for the corridor alignment with regards to heritage issues. WGAC advised that: • Preferred option was a corridor to the east of the current railway • That the Weelumurra Creek is now a lodged site under the *Aboriginal Heritage Act 1972* (AH Act) • Expressed concerns regarding social impacts to the Hamersley Station Homestead. WGAC requested more information regarding alignment options around the homestead.
YAC	13/11/2019	Face to Face meeting	Discussion of potential heritage and other impacts of proposed alignment options. The YAC: • Advised Main Roads of the importance of Weelumurra Creek and asked for the least impact possible; • Discussed the importance of Millstream as a public drinking water source area; and • Looks forward to a heritage survey over the proposed corridor to determine heritage issues more clearly.

Stakeholder	Date	Consultation Type	Consultation Topic/Outcome
Landowners			
Coolawanyah Station	18/06/2020 and 15/07/2020	Email and Meeting	Updates provided on heritage survey dates. Requested input on proposed corridors. Provided maps of 400 to 800 m wide corridor through Coolawanyah. Requested a topographical map of the area of the corridor, to check change in flow due to infilling of corrugated culverts vs narrower smooth culverts, and to send aerial data from the flyover.
FMG	15/06/2020	Video Conference	Discussion of the corridor alignment and potential implications for tenure/FMG use of the sealed road. FMG requested files on proposed corridor to assess against future tenement considerations.
Rio Tinto	20/05/2020	Email	Main Roads contacted Rio Tinto Tenure Specialists to provide current corridor information and propose further discussions.
Balla Balla Infrastructure	19/05/2020	Email	Main Roads contacted BBI to provide a project update, discussed traffic demand and the sharing of information.
Coolawanyah Station	28/04/2020	Phone Conversation	Discussion of current corridor alignment, including key changes to the corridor and next phases of refining the alignment. An email with the current corridor alignment was provided as follow up.
FMG	24/04/2020	Video Conference	Discussion of FMG land tenure and any implications of the currently proposed corridors. Discussions regarding potential transport needs for FMG to provide context to the demand assessment report.
Balla Balla Infrastructure	23/04/2020	Phone Conversation	Update that alignment corridor would be provided to stakeholder once approved. Stakeholder may then commence further discussion with Main Roads. Main Roads to investigate challenges of the stakeholder's confidentiality agreement.
Rio Tinto	20/04/2020	Meeting	Discussion of synergies with Rio Tinto's ongoing rail renewal project for potential sourcing of construction materials; and potential synergies with future quarries or borrow pits.

Stakeholder	Date	Consultation Type	Consultation Topic/Outcome
Rio Tinto	17/04/2020	Meeting	Discussion of environmental surveys (location and schedule), geotechnical investigations and accommodation for local contractors; synergies in resources (e.g. ballast); traffic demand and crossing information.
FMG	Dec 2019 – Feb 2020	Various Electronic Correspondence	Correspondence to achieve alignment on suitable locations and design for the future MRDH Stage 4 intersection with FMG infrastructure; Eliwana rail arch (Bridge number 1870). FMG provided the 100% design report for this infrastructure to Main Roads.
Coolawanyah Station	05/01/2020	Email	Input received from Coolawanyah Station Owner and Manager Kim Parsons regarding specific concerns for the station.
Coolawanyah Station	09/10/2019	Email	Email communication to station owner and Manager to introduce Main Roads Project Manager and invite consultation on the project for which alignment selection has now commenced.
Committees and Reference Groups			
Chamber of Minerals and Energy (CME) Members	20/04/2020	Email	Email to CME Members providing an overview of the MRDH Stage 4 Project and seeking input from CME Members.
▪ Rio Tinto ▪ Coolawanyah Station ▪ PDC ▪ DWER ▪ City of Karratha ▪ Karratha and Districts Chamber of Commerce and Industry (KDCCI) ▪ Shire of Ashburton	10/12/2019	Face to Face Workshop (Karratha Tom Price (now MRDH) Stage 4 Preliminary Sustainability Workshop)	A Preliminary Sustainability Workshop was held to define the main issues and opportunities associated with Stage 4 of the MRDH.

Stakeholder	Date	Consultation Type	Consultation Topic/Outcome
▪ Balla Balla Infrastructure.			
Public Consultation – Tom Price Shopping Centre	15/07/2020	Public Information Booth	Two key themes of feedback focused on when the project will be completed, and scepticism that the works will go ahead as the works had been discussed for some 30 years. No negative feedback on Stage 4 of the Revised Proposal was received from local Tom Price residents. Strong interest received from visitors to the region.
▪ City of Karratha ▪ Greening Australia ▪ Rangelands NRM	4/11/2020	Virtual (Environmental Legacy Workshop)	An Environmental Legacy Workshop was held to define the main environmental legacy needs and opportunities associated with Stage 4 of the Manuwarra Red Dog Highway. The following legacy opportunities were identified in the workshop: • Enhance biodiversity and maximise positive environmental outcomes Maximise network resilience; • Maximise 'on alignment' materials/resources; • Maximise local employment and skills legacy; • Maximise shared land use and infrastructure; • Maximise social and cultural capital; and • Maximise innovation and challenge beyond business as usual.
• City of Karratha ▪ PDC ▪ Shire of Ashburton ▪ SMEC	24/11/2020	Virtual (Resilience and Climate/Natural Hazard Workshop)	A Resilience and Climate/Natural Hazard Workshop was held to develop a shared understanding of resilience and how it applies to Manuwarra Red Dog Highway and the Pilbara Region. The following opportunities were discussed in the MRDH Stage 4 Resilience Workshop to reduce the impact of identified stressors: • Health infrastructure and services; • Social cohesion/ social stability; and • Opportunities for reuse of materials.
▪ FMG ▪ Rio Tinto ▪ PICCI	26/11/2020	Face to Face Workshop	A Social and Community Legacy Workshop was held in Tom Price to define the main social legacy needs and opportunities associated with Stage 4 of the Manuwarra Red Dog Highway. The following legacy opportunities were identified in the workshop: • Maximise social and cultural capital;

Stakeholder	Date	Consultation Type	Consultation Topic/Outcome
		(Tom Price Social and Community Legacy Workshop)	• Maximise local employment and skills legacy; • Maximise shared land use and infrastructure; • Maximise 'on alignment' materials/resources; • Maximise network resilience; • Enhance biodiversity and maximise positive environmental outcomes; and • Maximise innovation and challenge beyond business as usual.
Shire of Ashburton • PDC • Rio Tinto • Karratha Visitors Centre • Coolawanyah Station • FMG • Tom Price Arts Hub • BBI • Velocity Motel • Tourism Naturally.	15/12/2020	Virtual (Social and Community Legacy Workshop)	A virtual Social and Community Legacy Workshop was held to define the main social legacy needs and opportunities associated with Stage 4 of the Manuwarra Red Dog Highway.

3.2.1 Yindjibarndi and Wintawari Guruma People Community Consultation

The following consultation has been undertaken:

- Two meetings were held with the YAC on 13 November 2019 and 27 May 2020. The purpose of meetings was to discuss the MRDH Stage 4 alignment corridor options with the YAC who are the representative body for the Yindjibarndi Native Title holders.
- Four meetings have been held with the WGAC on 14 November 2019, 28 January 2020, 27 February 2020 and 08 May 2020. The purpose of the meetings was to discuss the MRDH Stage 4 alignment corridor options with the WGAC who are the representative body for the Guruma Native Title holders.
- One meeting was held with the Wintawari Guruma Traditional Owners on 27 February 2020. This meeting was held in conjunction with the meeting with WGAC on the same date.

Further details of these meetings are provided in Table 3-2.

The Stage 4 Aboriginal procurement and employment targets are being finalised. These targets are likely to be similar to the targets for Stage 3, which were:

- Aboriginal employment – 13 percent, including 5 percent local; and
- local Aboriginal businesses – 15 percent target with a total contract spend of 5 percent.

4 Environmental Principles and Factors

4.1 Environmental Principles

The five core principles of environmental protection are embedded in the EP Act. These principles align with the principles of Ecologically Sustainable Development outlined in section 3A of the Commonwealth EPBC Act. Table 4-1 describes how each of the five principles of the EP Act has been applied to the Revised Proposal.

Table 4-1 Principles of Environmental Protection

Principle	Consideration of Principle in the Revised Proposal
The precautionary principle Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, decision should be guided by: a) careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and b) an assessment of the risk-weighted consequences of various options.	A wide range of comprehensive desktop and field studies have been undertaken within the Development Envelope to assess the impact of Stage 4 of the Revised Proposal. Studies undertaken include: • Flora and vegetation surveys; • Terrestrial fauna surveys; • Hydrology assessment; • Aboriginal Heritage studies (undertaken with representatives of the Yindjibarndi and Wintawari people); and • Historic Heritage studies. Potential impacts have been identified and described under each PKEF in the following sections. Information gathered during these studies has been used to inform the Revised Proposal and has reduced the uncertainty surrounding prediction of impacts for the assessment. Mitigation and management measures have been proposed to ensure impacts are environmentally acceptable. Significant residual impacts that result from Stage 4 of the Revised Proposal will be offset using the Pilbara Environmental Offsets Fund.
The principle of intergenerational equity The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	The Revised Proposal will ensure the health, diversity and productivity of the environment is maintained by retaining as much habitat as possible and by minimising environmental impacts where practicable.
The principle of the conservation of biological diversity and ecological integrity Conservation of biological diversity and ecological integrity should be a fundamental consideration.	Main Roads will seek to preserve as much of the biodiversity identified within the Development Envelope as possible by reducing clearing of native vegetation where practicable.
Principles relating to improved valuation, pricing and incentive mechanisms	Main Roads acknowledges the need for improved valuation, pricing and incentive mechanisms and endeavours to pursue these principles when appropriate. For example,

Principle	Consideration of Principle in the Revised Proposal
a) Environmental factors should be included in the valuation of assets and services. b) The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement. c) The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any wastes. d) Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.	environmental factors will be considered in the determination of the location of the road alignment within the Development Envelope and there will be a strong focus on reducing direct and indirect clearing impacts. Main Roads accepts that the cost of the Revised Proposal must include environmental impact mitigation, management and maintenance activities. These requirements will be incorporated into the overall Revised Proposal costs. Stage 4 of the Revised Proposal will be subject to an Infrastructure Sustainability Council of Australia (ISCA) sustainability rating, which will assess the environmental, social and economic impacts of Stage 4 of the Revised Proposal, including its waste streams and the resources used for construction. The ISCA rating scheme is designed to establish goals and assess achievement of those goals. Main Roads have established a sustainability charter for Stage 4 of the Revised Proposal, including commitments to use sustainability principles to guide decision-making throughout the project lifecycle, enhance biodiversity and maximise positive environmental outcomes and integrate sustainability into procurement, product life cycles and supply chains.
The principle of waste minimisation All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.	Stage 4 of the Revised Proposal will be subject to an ISCA sustainability rating, which will assess the environmental, social and economic impacts including waste minimisation and associated discharges. Where practicable, fill materials will be sourced from areas of cut along the road alignment to minimise the requirement to import additional material. Main Roads have established a sustainability charter for the Revised Proposal, including commitments to maximise the use of 'on alignment' materials/resources and promote circular economy to drive innovation in waste reduction.

4.2 Identification of Environmental Factors

Environmental factors are those parts of the environment that may be impacted by a Proposal (EPA, 2020a). The EPA has 14 environmental factors, organised into five themes (Sea, Land, Water, Air and People) as detailed in Table 4-2, which allow for a systematic approach to organising environmental information for the purpose of impact assessment. Each of the 14 environmental factors has an associated objective which is used to determine whether the potential environmental impacts of a Proposal or scheme may be significant. The EPA environmental factors and objectives, and their relevance to the Revised Proposal, are summarised in Table 4-2.

Table 4-2 WA EPA Environmental Factors (EPA, 2020a) and their Relevance to the Revised Proposal

Theme	Factor	Objective	Relevance to the Revised Proposal	Preliminary Key Environmental Factor
Sea	Benthic Communities and Habitats	To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained.	The Revised Proposal is not located in or near the marine environment	×
	Coastal Processes	To maintain the geophysical processes that shape coastal morphology so that the environmental values of the coast are protected.		
	Marine Environmental Quality	To maintain the quality of water, sediment and biota so that environmental values are protected.		
	Marine Fauna	To protect marine fauna so that biological diversity and ecological integrity are maintained.		
Land	Flora and Vegetation	To protect flora and vegetation so that biological diversity and ecological integrity are maintained.	Construction requires vegetation clearing, including up to 15 ha of the *Themeda* Grasslands TEC and up to 12 ha of the Brockman Iron PEC.	✓
	Landforms	To maintain the variety and integrity of significant physical landforms so that environmental values are protected.	Distinctive, unique or important landforms are not present.	×
	Subterranean Fauna	To protect subterranean fauna so that biological diversity and ecological integrity are maintained.	No conservation significant subterranean fauna identified within the Development Envelope for the Revised Proposal. The “Stygofaunal community of the Western Fortescue Plains freshwater aquifer” PEC occurs within the nearby Millstream-Chichester National Park. No impacts to this PEC are anticipated from the Revised Proposal given the limited interaction between the Revised Proposal and groundwater.	×

	Terrestrial Environmental Quality	To maintain the quality of land and soils so that environmental values are protected.	Likelihood of Acid Sulfate Soils (ASS) is considered low throughout most of the p Revised Proposal according to the Australian Soil Resource Information System (ASRIS) database. Testing will be undertaken where risk is elevated (Section 2.4.8). Historic asbestos contamination in Stage 3 (close to Stage 4) was cleaned up as part of the Stage 3 works.	×
	Terrestrial Fauna	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.	Construction will result in clearing of potential significant fauna habitat.	✓
Water	Inland Waters	To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.	The Revised Proposal crosses several watercourses, including the Fortescue River downstream of the Fortescue Marshes. The Revised Proposal is partially located within the Millstream Water Reserve, in both Priority 1 and Priority 2 protection areas.	✓
Air	Air Quality	To maintain air quality and minimise emissions so that environmental values are protected.	Air emissions, largely in the form of dust, will be generated during construction. In the RFI, the EPA requested “an assessment of potential impacts from degradation of Air Quality due to potential historical and naturally occurring asbestos that may be present in construction dust”.	✓
	Greenhouse Gas (GHG) Emissions	To reduce net greenhouse gas emissions in order to minimise the risk of environmental harm associated with climate change	Based on GHG emissions calculated for Stage 4 of the Revised Proposal, Scope 1 GHG emissions associated with the Revised Proposal are estimated to be 55,655 tCO_2e/annum, well below the 100,000 tonnes CO_2-equivalent per annum threshold defined in the Environmental Factor Guideline (EPA, 2020a). A copy of the GHG emissions estimate is provided in A.6	×
People	Social Surroundings	To protect social surroundings from significant harm.	The CER for the Approved Proposal did not identify any specific registered Aboriginal heritage sites.	✓

			Five registered Aboriginal heritage sites occur within the Stage 4 Development Envelope for the Revised Proposal with a further 28 occurring within 2.5 km of the Development Envelope. There has been and continues to be interest from the Traditional Owners, as evidenced by submissions on the referral, ongoing consultation with the Traditional Owners and outcomes of heritage surveys undertaken to date.	
	Human Health	To protect human health from significant harm.	No human health impacts are expected. No radiation emissions will result from the Revised Proposal.	×

5 Key Environmental Factors

The following subsections discuss the predicted impacts of Stage 4 of the Revised Proposal to PKEF identified in the EPA determination on the proposal and detailed in Table 4-2.

Spatial extent terminology used to quantify surveys and impacts is detailed in Table 5-1.

Table 5-1 Spatial Extent Terminology

Term	Definition	Size (ha)	Flora Survey	Fauna Survey
Indicative Disturbance Footprint	The indicative location where ground disturbance for the physical elements of Stage 4 of the Revised Proposal will occur. The extent of this footprint is used to determine impacts. The spatial location of this footprint may vary as the design is refined. Note that all references to 'Indicative Disturbance Footprint" within this document refer to the Indicative Disturbance Footprint for Stage 4 of the Revised Proposal unless stated otherwise	565	*Within the surveys of the Survey Area*	
Indicative Temporary Clearing Area	The indicative location where temporary clearing will be required for construction activities such as camps, laydown areas, stockpile areas and vehicle turnarounds. These areas will be rehabilitated when they are no longer need for construction	100	*Within the surveys of the Survey Area*	
Development Envelope (termed 'Survey Area' in biological reports)	The planning corridor for Stage 4 of the Revised Proposal. Nominally 400 m wide the planning corridor encompasses the alignment. No Development Envelope is defined in the current Approved Proposal. As such, all references to 'Development Envelope' within this document refer to the Development Envelope for Stage 4 of the Revised Proposal unless stated otherwise.	7,142	*Within the surveys of the Survey Area*	
Survey Area	The primary survey area for the Biota (2021) survey.	7,142	Detailed and Targeted flora and vegetation survey.	Basic and targeted fauna survey[10].

[10] The fauna survey extended into adjacent habitats of the contextual area to inform the use or potential use of habitats within the survey area, given that fauna are mobile.

Contextual Area	A 500 m buffer on the centreline of the Development Envelope. Mapping was inferred in the contextual area where the Development Envelope was narrower than this overall 1 km corridor.	11,986	Not surveyed sections wider than the Development Envelope, with vegetation and fauna habitat mapping was extrapolated from Development Envelope data and aerial imagery.
Study Area	An 18 km buffer from the centreline of the Development Envelope, within which a desktop review was carried out to determine a potential species list and identify any significant species that may occur within the Development Envelope.	505,809	Desktop background information gathered from database and literature sources.

5.1 Flora and Vegetation

5.1.1 EPA Objective

The WA EPA defines flora as 'native vascular plants', and vegetation as 'groupings of different flora patterned across the landscape that occur in response to environmental conditions' (EPA, 2016a). The EPA views vegetation as a surrogate for ecological processes in terrestrial ecosystems.

The WA EPA objective for the flora and vegetation environmental factor is 'To protect flora and vegetation so that biological diversity and ecological integrity are maintained'.

5.1.2 Policy and Guidance

The following EPA policies and guidelines have been considered for Stage 4 of the Revised Proposal in order to meet the EPA's objective in relation to this factor:

- *Statement* of *Environmental Principles, Factors and Objectives* (EPA, 2020a);
- *Environmental Factor Guideline – Flora and Vegetation* (EPA, 2016a);
- *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA, 2016b);
- *EPA Strategic Advice for Cumulative Environmental Impacts of Development in the Pilbara Region* (EPA, 2014); and
- *Threatened Ecological Community Fact Sheet - Themeda grasslands on cracking clays (Hamersley Station, Pilbara)* (DBCA, 2020d).

The Environmental Factor Guideline has been considered during the identification of flora and vegetation values within the Development Envelope and the issues identified in the guideline considered in relation to potential impacts from the Stage 4 of the Revised Proposal.

Flora and vegetation surveys for Stage 4 of the Revised Proposal have been planned and executed in accordance with the EPA's (2016b) technical guidance for this factor.

5.1.3 Receiving Environment

5.1.3.1 Stage 4 Surveys and Studies

To support project planning and environmental impact assessment for Stage 4 of the Revised Proposal, Main Roads commissioned Biota (2021) to conduct a detailed and targeted flora surveys in accordance EPA technical guidance for flora surveys (EPA, 2016b) and the EPA Environmental Factor Guidelines for Flora and Vegetation (EPA, 2016a).

Biota (2021) assessed the Development Envelope using a scope that included:

- A desktop assessment and literature review to identify flora and vegetation of significance potentially occurring within the study area; and
- A single-phase detailed and targeted flora and vegetation survey conducted over three field expeditions between 19 April and 26 October 2020. The survey used quadrats and relevés, as well as targeted searches for significant flora and weeds along traverses (Biota, 2021).

This approach provided up to date and accurate information to enable assessment and management of potential impacts. The Biota (2021) report is provided in Appendix A.2.

5.1.3.2 Vegetation

The Development Envelope lies within the Fortescue Botanical District (Pilbara Region) as described by Beard (1975). The Fortescue Botanical District is divided into the Fortescue River and Valley and Hamersley Plateau subdivisions. The characteristics of these vegetation associations are described below.

Fortescue River and Valley

The Fortescue River and Valley are located between the high points of the Chichester and Hamersley Ranges and Plateaux. The soil types found in the valley are predominantly Quaternary alluvial and colluvial deposits. The sand plain areas of the Fortescue Valley are mostly vegetated with Acacia shrubs of various species (*Acacia ancistrocarpa*, *A. acradenia*, *A. inaequilatera* and *A. tumida/colei*) over Spinifex (*Triodia pungens* and/or *T. wiseana*).

Major drainage lines are wide and support River Gums (*Eucalyptus camaldulensis*) over Paperbarks (*Melaleuca glomerata* and *M. linophylla*) over small shrubs, herbs and grass species. The smaller drainage channels have scattered trees of *E. camaldulensis* and/or *E. victrix* (Coolibah) over a denser cover of *Acacia citrinoviridis* and a mixture of small shrubs, herb and grass species in the understorey.

Hamersley Plateau and Range to the intersection with the Nanutarra – Wittenoom Road

The vegetation of the Hamersley Ranges is characteristically *Eucalyptus leucophloia* (Snappy Gum) and *Corymbia hamersleyana* over Spinifex (*Triodia wiseana*). Small trees of *Eucalyptus gamophylla* and *Corymbia deserticola* are also present. The principal shrub species found on these areas are mostly of the Acacia genus; *A. inaequilatera*, *A. dictyophleba*, *A. monticola*, *A. tumida/colei*, *A. ancistrocarpa*, *A. pachyacra/tenuissima*, *A. adoxa*, *A. synchronicia* and *A. acradenia*.

Most of the valley plains support Mulga (*Acacia aneura*) low woodland, though some of the widest and flattest valley floors develop open grassland. Mulga is usually associated with another Acacia

species, *Acacia pruinocarpa*, a small tree of about four to five metres. Some other small tree and shrub species found growing in alluvial soils characterised by Mulga woodlands are *Acacia xiphophylla* (in localised small patches only), *A. tetragonophylla*, *Psydrax latifolia*, *Eremophila fraseri*, *E. latrobei, E. longifolia* and *Grevillea stenobotrya*.

The major and minor drainage lines are vegetated with principally the same species, but in varying proportions depending on the width and depth of the channels and their area. The main tree species recorded in areas with seasonally flowing water are *Corymbia hamersleyana*, *Eucalyptus camaldulensis* and *E. victrix*, over the shrub species *Gossypium robinsonii*, *G. australe*, *Acacia farnesiana*, and the grass species *Cymbopogon ambiguus* and *Cenchrus ciliaris* (an introduced pasture grass).

5.1.3.2.1 Pre-European Vegetation Associations

Pre-European vegetation mapping based on Beard (Shepherd et al., 2002; Government of Western Australia, 2018) shows the Development Envelope is characterised by nine pre-European vegetation associations (Table 5-2). These vegetation associations are mostly hummock grasslands, and dominated the Hamersley 565 and Chichester Plateau 607 vegetation associations, which represent 37% and 18% of the Development Envelope, respectively (Figure 10).

Table 5-2 Description of Beard (1975) Vegetation Associations Within and Adjacent to the Development Envelope

System	Vegetation Association	Description	Area in Development Envelope (ha)	Extent in the Pilbara Bioregion (ha)	Extent in the Development Envelope as Proportion of the Bioregion
Hamersley	565	Hummock grasslands, low tree steppe; bloodwood over soft spinifex.	1,945	108,874	1.8%
Chichester Plateau	607	Hummock grasslands, low tree steppe; snappy gum & bloodwood over soft spinifex & *Triodia wiseana*.	1,612	119,009	1.4%
Hamersley	175	Short bunch grassland - savanna/grass plain (Pilbara).	1,274	95,187	1.4%
Hamersley	644	Hummock grasslands, open low tree steppe; mulga & snakewood over soft spinifex & *Triodia basedowii*.	725	27,180	2.7%
Hamersley	82	Hummock grasslands, low tree steppe; snappy gum over *Triodia wiseana*.	570	2,168,072	0.03%
Chichester Plateau	646	Hummock grasslands, shrub steppe; snakewood over *Triodia basedowii*.	481	18,033	2.7%
Hamersley	645	Hummock grasslands, shrub steppe; kanji & snakewood over soft spinifex & *Triodia wiseana*.	247	151,142	0.2%
Hamersley	29	Sparse low woodland; mulga, discontinuous in scattered groups.	246	84,608	0.3%
Hamersley	18	Low woodland; mulga (*Acacia aneura* complex).	43	580,483	0.01%

5.1.3.2.2 Vegetation Types

Biota (2021) mapped 27 vegetation units within the Development Envelope (Table 5-3 and Figure 11). Vegetation units have been grouped into seven vegetation types based on the species composition and landscape preference. Vegetation types included:

- Vegetation of Stony Hillslopes, Hillcrests and Foothills;
- Vegetation of Cracking Clays;
- Mulga Vegetation;
- Vegetation of Stony Plains and Sloping Plains;
- Vegetation of Drainage Lines;
- Vegetation of Floodplains; and
- Other Mapping Units – cleared / disturbed land.

Further description of the vegetation units is provided in Appendix A.2.

5.1.3.2.3 Vegetation Condition

Vegetation condition in the Development Envelope ranged from Excellent to Completely Degraded. The Development Envelope contained 409 ha of Completely Degraded land, largely as a result of the Rio Tinto Rail Access Road, pastoral fencing, and current and historical mining activities. Weeds also impacted the condition of the vegetation, with dense infestations along drainage lines and in floodplain areas. Table 5-3 details the condition of vegetation units within the Development Envelope, and Figure 12 shows the distribution of vegetation condition.

Table 5-3 Vegetation Types and Units - Condition in the Development Envelope (Biota, 2021)

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Extent and Condition Within the Development Envelope (ha)	Observations	Extent in Local Area (Biota (2021) Survey Area + Contextual Area) (ha)	Extent in Development Envelope as Proportion of Local Area
Vegetation of Stony Hillslopes, Hillcrests and Foothills	H1	*Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Triodia wiseana* hummock grassland.	Excellent – 288.2 Good – 0.8	Excellent condition.	508.3	56.86%
	H2	*Corymbia hamersleyana* scattered low trees over *Acacia inaequilatera* scattered tall shrubs over *Triodia wiseana* open hummock grassland.	Excellent – 19.3	Excellent condition.	33.9	56.93%
	H3	*Eucalyptus leucophloia* subsp. *leucophloia*, (*Corymbia hamersleyana*) low open woodland over mixed Acacia shrubs over *Triodia wiseana* open hummock grassland	Excellent – 407.6	Excellent condition.	647.5	62.95%
	H4	*Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *E. gamophylla* scattered low mallees over *Triodia wiseana* open hummock grassland and *Eriachne mucronata* scattered tussock grasses.	Excellent – 8.4	Excellent condition.	44.0	19.09%
Vegetation of Cracking Clays	C1	*Eriachne benthamii*, *Eragrostis xerophila*, *Astrebla elymoides* very open tussock grassland over *Cynodon convergens* very open bunch grassland.	Excellent – 12.7 Very Good – 109.4	Very Good condition: occasional weeds; some cattle activity.	151.9	80.38%
	C2	*Acacia xiphophylla* low woodland over *Triodia epactia* very open hummock grassland over *Eragrostis xerophila* scattered tussock grasses.	Excellent – 1.7 Very Good – 205.0	Very Good condition: occasional weeds;	211.7	97.64%

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Extent and Condition Within the Development Envelope (ha)	Observations	Extent in Local Area (Biota (2021) Survey Area + Contextual Area) (ha)	Extent in Development Envelope as Proportion of Local Area
				some cattle activity.		
	C3	Mixed *Astrebla* tussock grassland over *Urochloa occidentalis* var. *occidentalis* bunch grassland. This vegetation type forms part of the Brockman Iron cracking clay communities of the Hamersley Range PEC.	Very Good – 88.1	Very Good condition: occasional weeds; some cattle activity.	225.1	39.14%
	C4	*Themeda* sp. Hamersley Station (M.E. Trudgen 11431) tussock grassland. This vegetation type forms part of the *Themeda* grasslands TEC.	Very Good – 72.7	Very Good condition: occasional weeds; some cattle activity.	197.7	36.77%
	C5	*Eucalyptus victrix* scattered low trees over *Eriachne benthamii*, (*Themeda* sp Hamersley Station (M.E. Trudgen 11431)) very open tussock grassland over mixed open herbland. This vegetation type forms part of the *Themeda* grasslands TEC.	Very Good – 4.4	Very Good condition: occasional weeds; some cattle activity	15.3	28.76%
Mulga Vegetation	M1	*Acacia aptaneura* (*A. pruinocarpa*) low woodland over *Triodia epactia* (*T. melvillei*) very open hummock grassland over *Chrysopogon fallax* scattered tussock grasses.	Excellent to Very Good – 166.7 Good – 3.1	Good to Excellent condition.	313.4	54.18%
	M2	*Acacia ?macraneura*, *A. aptaneura* over *Triodia epactia* scattered hummock grasses.	Excellent to Very Good – 492.0	Very Good to Excellent condition. Occasional weeds	1,156.4	42.59%

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Extent and Condition Within the Development Envelope (ha)	Observations	Extent in Local Area (Biota (2021) Survey Area + Contextual Area) (ha)	Extent in Development Envelope as Proportion of Local Area
			Good – 0.5	and evidence of cattle.		
	M3	*Acacia aneura*/*aptaneura*, (*A ?macraneura*,) low woodland over bunch grasses.	Very Good – 74.9	Good to Very Good condition. Presence of multiple weed species, evidence of cattle, old signs of disturbance.	260.4	28.76%
	M4	*Acacia aptaneura*, *A ?macraneura* (*Hakea lorea* subsp. *lorea*) low open woodland over mixed tussock grasses, bunch grasses and herbs.	Very Good – 47.8	Very Good condition; scattered weeds (mainly **Bidens bipinnata*); old cattle scats.	88.9	53.77%
Vegetation of Stony Plains and Sloping Plains	P1	*Corymbia deserticola* subsp. *deserticola*, *C. hamersleyana*, *Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Triodia wiseana* open hummock grassland.	Excellent – 333.4 Very Good – 0.4	Excellent condition.	935.9	35.67%
	P2	*Corymbia hamersleyana* low open woodland over mixed Acacia shrubland over *Triodia epactia* hummock grassland.	Excellent – 913.7 Very Good – 101.0 Good – 8.6	Good to Excellent condition; signs of historical disturbance, occasional weeds, signs of cattle.	1,918.7	53.33%

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Extent and Condition Within the Development Envelope (ha)	Observations	Extent in Local Area (Biota (2021) Survey Area + Contextual Area) (ha)	Extent in Development Envelope as Proportion of Local Area
	P3	*Hakea lorea* subsp. *lorea* low open woodland over shrubs over *Triodia epactia* very open hummock grassland with *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) very open tussock grassland.	Very Good to Good – 38.7 Good – 15.0	Good to Very Good condition; Signs of intense grazing, with weeds present.	141.0	38.09%
	P4	*Corymbia hamersleyana* scattered low trees over *Triodia epactia*, (*T. wiseana*) open hummock grassland and *Eulalia aurea* scattered tussock grasses.	Excellent – 3.4 Very Good – 11.1	Excellent condition.	14.5	100.00%
	P5	*Eucalyptus xerothermica* low open woodland over *Acacia bivenosa* scattered shrubs over *Triodia angusta* open hummock grassland with mixed tussock grasses.	Excellent – 24.0 Very Good – 85.1	Very Good condition; **Cenchrus ciliaris* and *C. setiger* often present in patches.	117.3	93.01%
	P6	*Hakea lorea* subsp. *lorea* low open woodland over **Vachellia farnesiana* scattered shrubs over *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) tussock grassland. This vegetation type forms part of the *Themeda* grasslands TEC.	Very Good – 11.8 Good – 26.4	Good to Very Good condition; evidence of cattle grazing, occasional weeds.	84.4	45.26%
	P7	*Triodia wiseana* hummock grassland with *Eriachne flaccida* scattered tussock grasses.	Excellent – 42.4 Good – 0.8	Excellent.	52.0	81.15%

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Extent and Condition Within the Development Envelope (ha)	Observations	Extent in Local Area (Biota (2021) Survey Area + Contextual Area) (ha)	Extent in Development Envelope as Proportion of Local Area
	P8	**Vachellia farnesiana* scattered tall shrubs over *Chrysopogon fallax* very open tussock grassland over mixed annual grassland and herbland.	Very Good – 81.5	Very Good condition; evidence of cattle grazing, presence of weeds.	191.6	42.54%
Vegetation of Drainage Lines	D1	*Eucalyptus victrix* (*E. camaldulensis* subsp. *refulgens*) woodland over *Melaleuca glomerata* tall open shrubland over *Triodia epactia* scattered hummock grasses over mixed tussock grasses and sedges.	Excellent – 156.5 Very Good – 328.7 Good – 15.1	Good to Excellent condition; evidence of cattle activity, weeds common throughout.	1,256.3	39.82%
	D2	*Eucalyptus camaldulensis* subsp. *refulgens*, *Melaleuca argentea* open forest over mixed scattered tussock grasses with *Cyperus vaginatus* scattered sedges.	Very Good – 6.6 Good – 14.6	Good to Very Good condition: low to moderate cover of **Cenchrus ciliaris* and **C. setiger* typically present, along with scattered other weeds; evidence of cattle.	65.6	32.32%
	D3	*Eucalyptus victrix* low open woodland over **Vachellia farnesiana* scattered tall shrubs over mixed tussock grasses and bunch grasses.	Very Good – 17.5 Good – 1.0	Good to Very Good condition: low to moderate cover of **Cenchrus ciliaris* and **C. setiger* typically present, along with	49.2	37.60%

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Extent and Condition Within the Development Envelope (ha)	Observations	Extent in Local Area (Biota (2021) Survey Area + Contextual Area) (ha)	Extent in Development Envelope as Proportion of Local Area
				scattered other weeds; evidence of cattle.		
Vegetation of Floodplains	F1	*Corymbia hamersleyana* low open woodland over *Acacia inaequilatera* tall open shrubland over *Triodia wiseana* (*T. epactia*) open hummock grassland with mixed tussock grasses.	Excellent – 783.7 Very Good – 712.9 Good to Poor – 0.6	Very Good to Excellent condition: evidence of cattle presence, scattered weeds.	2,289.7	65.39%
	F2	*Corymbia hamersleyana* low woodland over mixed Acacia tall open shrubland over *Triodia wiseana*, (*T. epactia*) open hummock grassland.	Excellent – 356.0 Excellent to Very Good – 5.9 Very Good – 74.4 Good – 0.4	Good to Excellent condition: occasional evidence of cattle presence; scattered weeds.	821.2	53.18%
	F3	*Corymbia hamersleyana* low open woodland over mixed Acacia open shrubland over *Triodia epactia* very open hummock grassland with *Chrysopogon fallax* very open tussock grassland.	Excellent – 48.5 Very Good – 166.3 Poor – 4.0	Poor to Excellent condition: multiple weed species; evidence of cattle presence.	444.9	49.18%
	F4	*Acacia citrinoviridis* low woodland over *Triodia epactia* open hummock grassland and *Chrysopogon fallax* scattered tussock grasses.	Very Good – 40.8 Good – 17.8	Good to Very Good condition: multiple weed species; evidence of cattle presence	197.2	29.72%

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Extent and Condition Within the Development Envelope (ha)	Observations	Extent in Local Area (Biota (2021) Survey Area + Contextual Area) (ha)	Extent in Development Envelope as Proportion of Local Area
	F5	*Corymbia hamersleyana* low open woodland over *Acacia bivenosa* tall shrubland over *Triodia epactia* scattered hummock grasses and **Cenchrus ciliaris* tussock grasses.	Excellent – 167.7 Excellent to Very Good – 71.0 Very Good – 13.2 Very Good to Good – 11.9 Good – 13.5 Poor – 4.0	Poor to Excellent condition: High cover of **Cenchrus species* in places, other scattered weeds; evidence of cattle presence.	308.8	91.09%
Other Mapping Units	Cleared	Cleared/disturbed	Cleared - 307.5 Disturbed – 101.1	Cleared/disturbed	845.1	48.35%

5.1.3.2.4 Threatened Ecological Communities

The desktop assessment undertaken by Biota (2021) identified one State-listed TEC previously recorded in the southern end of the Development Envelope, the '*Themeda* Grasslands on cracking clays (Hamersley Station, Pilbara)' (*Themeda* grasslands TEC). This TEC is described as, areas of grassland plains which are dominated by the perennial grass species *Themeda sp.* Hamersley Station (M.E. Trudgen 11431) and many annual herbs and grasses (DBCA, 2018). There are other species of trees, shrubs, herbs and grasses found growing on the clay soils of this vegetation community. The vegetation community has been endorsed as a Vulnerable (Category A) TEC by the WA Minister for the Environment but is not listed under the EPBC Act.

The *Themeda* grasslands TEC record was re-confirmed by Biota (2021) during the field survey, with vegetation units C4, C5 and P6 representing the ecological community (Figure 13). The vegetation condition of this TEC ranged from Good to Very Good (Biota, 2021). Mapping data obtained from DBCA indicated that approximately 203 ha of this community is within the Development Envelope. This was ground-truthed during the Biota (2021) field survey, which mapped approximately 115 ha of this TEC within the Development Envelope. The extent mapped by Biota (2021) differs from the DBCA mapping as the areas included in DBCA data are based on desktop assessment, rather than ground surveys, and include a buffer zone. Therefore, the Biota (2021) mapped extent of the TEC provides a more accurate representation of the extent of the TEC within the Development Envelope.

No other State or Commonwealth listed TECs occur within the Development Envelope (Biota, 2021).

5.1.3.2.5 Priority Ecological Communities

The desktop assessment identified three PECs with potential to occur within the vicinity of the Development Envelope:

- Brockman Iron cracking clay communities of the Hamersley Range - Priority 1

  'Rare tussock grassland dominated by *Astrebla lappacea* (not every site has presence of *Astrebla*) in the Hamersley Range, on the Brockman land system. Tussock grassland on cracking clays-derived in valley floors, depositional floors. This is a rare community and is known from near West Angeles, Newman, Tom Price and boundary of Hamersley and Brockman Stations'.

- Kanjenjie Land System – Priority 3

  'Stony clay plains supporting snakewood shrublands with tussock grasses. Supports tall shrublands of mulga, snakewood and other acacias with understorey of low shrubs or perennial grasses. Some parts support tussock grasslands of Mitchell grass or Roebourne Plains grass with few shrubs'.

- Kumina Land System – Priority 3

  'Ferricrete duricrust plains, uplands and plateaux remnants, relief up to 15 m. Duricrust plains and plateau remnants support hard spinifex grasslands'.

The field survey conducted by Biota (2021) identified the 'Brockman Iron cracking clay communities of the Hamersley Range' PEC as the only PEC within the Development Envelope. Approximately 88 ha of this PEC is within the Development Envelope, in areas mapped by Biota (2021) as vegetation unit C3 in Good condition (Figure 13).

5.1.3.2.6 Vegetation of Local Significance

Vegetation Communities on Cracking Clays

Biota (2021) noted that some areas of vegetation unit C2 (and an area of vegetation type P7), both on cracking clays in the north of the Development Envelope, included some grass species that are constituent species of the "Mitchell grass and Roebourne Plain grass (*Eragrostis xerophila*) plain on gilgai" Priority 3 PEC,". Although the mapped vegetation types do not meet all diagnostic criteria of the Wona Land System PEC, as they are located on the Hooley Land System, they are considered to be locally significant given their similarity and close proximity to the PEC, the closest occurrence of which is 15 km northeast (Biota, 2021). The species *Dipteracanthus* aff. *australasicus* (undescribed species) was also recorded by Biota (2021) as being restricted to these vegetation types.

Grove–intergrove Mulga Community

Aerial photography of the Tom Price section of the Development Envelope suggests the presence of Mulga vegetation growing in a distinct banded pattern, referred to as Grove-intergrove Mulga, Banded Mulga or Tiger bush. Mapping undertaken by Biota (2021) confirms the denser bands are vegetation type M1 (*Acacia aptaneura* (*A. pruinocarpa*) low woodland over *Triodia epactia* (*T. melvillei*) very open hummock grassland over *Chrysopogon fallax* scattered tussock grasses) with the less dense inter-grove areas being vegetation type M2 (*Acacia ?macraneura*, *A. aptaneura* over *Triopia epactia* scattered hummock grasses). Maslin et al. (2010) notes that these Grove–intergrove Mulga communities are susceptible to changes in surface water hydrology, particularly overland flows, and the flow of nutrients both into and out of the groves. Areas where the Mulga vegetation displays this banded patterning are considered locally significant due to their restricted nature, sensitivity to changes in surface water flows and similarity to other Grove–intergrove Mulga communities that have been listed as PECs (i.e. Frederick Land System Priority 3 PEC).

5.1.3.2.7 Groundwater dependent vegetation

Eucalyptus and Melaleuca species that depend on groundwater have been identified by Biota (2021) as being present in and around the Development Envelope. This vegetation is restricted to the major drainage lines (Fortescue River, Weelumurra Creek and its tributaries; and Barnett Creek (Biota, 2021)). *Melaleuca argentea* which is present along Weelumurra Creek and its tributaries as well as in a small area of the Hamersley section is highly dependent on groundwater, while *Eucalyptus camaldulensis, E.s victrix and Melaleuca glomerata* have a low to moderate dependency on groundwater (Rio Tinto, 2018).

5.1.3.3 Flora

Biota (2021) recorded a total of 590 native vascular flora species from 190 genera and 56 families in the Development Envelope. The dominant native plant families and genera, and a full list of flora species is provided in Appendix A.2. The number of species was similar to, or higher than most other survey areas of a similar size. The slightly higher number of species is likely due to:

- the linear shape of the survey area which lead to an inclusion of a diversity of habitats;
- the length of the corridor leading to an opportunity to cross the range of a greater number of species; and
- higher than average rainfall prior to survey.

5.1.3.3.1 Threatened Flora

One flora species Fringed Fire-bush (*Seringia exastia*) currently listed as Critically Endangered under the *Biodiversity Conservation Act 2016* (BC Act), and Critically Endangered under the EPBC Act, was recorded from the Development Envelope (Figure 14). The location of the recorded specimen is approximately 115 m from the centre line of the current alignment and outside the Indicative Disturbance Footprint. Three further specimens were recorded by Biota (2021) in the contextual area but outside of the Development Envelope.

Seringia exastia has recently been combined with the common and widespread species *Seringia elliptica* due to newly discovered genetic similarity (Binks et al., 2020). Following the formalised combination of these two species, *Seringia exastia* will represent a common, widespread species and would no longer be considered to be of conservation significance (Biota, 2021). However, the current listing will remain in force until the Threatened Species Scientific Committee (TSSC) reviews recommended changes to the Threatened Flora List and the revised list is then signed by the WA Minister for the Environment. *Seringia exastia* is, therefore, expected to be de-listed in the near future.

Five flora species, *Aluta quadrata, Quoya zonalis, Seringia exastia* and *Thryptomene wittweri*, are listed as Threatened for the Pilbara bioregion. None of these have previously been recorded from the Development Envelope and none were recorded during the Detailed and Targeted Flora survey (Biota 2021). Based on known distribution, none would be expected to occur within the Development Envelope or surrounding areas.

5.1.3.3.2 Priority flora

The desktop assessment identified 66 Priority flora species listed by DBCA that have previously been recorded in the Development Envelope or the broader study area. Three of these Priority species were considered 'Likely to Occur' within the Development Envelope and/or immediate surrounds and 40 were considered 'May Occur' based on presence of habitat in the Development Envelope, and the proximity of known occurrences of the species.

Biota (2021) recorded twenty Priority flora species listed by DBCA in the Development Envelope (Table 5-4 and Figure 14). These species are described in Appendix A.2.

Table 5-4 Listed Priority flora recorded in the Development Envelope (Biota, 2021)

Species	Conservation Status	Records in Development Envelope
Hibiscus sp. Mt Brockman (E. Thoma ET 1354)	Priority 1	7
Josephinia sp. Woodstock (A.A,. Mitchell PRP 989)	Priority 1	1
Vittadinia sp. Coondewanna Flats (S. van Leeuwen 4684)	Priority 1	1
Aristida lazaridis	Priority 2	1
Euphorbia inappendiculata var. *inappendiculata,*	Priority 2	5
Euphorbia inappendiculata var. *queenslandica,*	Priority 2	8
Aristida jerichoensis var. *subspinulifera,*	Priority 3	1
Astrebla lappacea,	Priority 3	5

Dolichocarpa sp. Hamersley Station (A.A. Mitchell PRP 1479)	Priority 3	9
Euphorbia australis var. *glabra,*	Priority 3	28
Glycine falcata	Priority 3	7
Gymnanthera cunninghamii	Priority 3	1
Rhagodia sp. Hamersley (M. Trudgen 17794)	Priority 3	7
Sida sp. Hamersley Range (K. Newbey 10692) PN	Priority 3	19
Swainsona thompsoniana	Priority 3	3
Themeda sp. Hamersley Station (M.E. Trudgen 11431)	Priority 3	20
Triodia basitricha	Priority 3	1
Eremophila magnifica subsp. *magnifica*	Priority 4	7
Goodenia berringbinensis	Priority 4	2
Goodenia nuda	Priority 4	40

Most of the specimens recorded (approximately 94%) were able to be resolved to the lowest level possible within the current taxonomic framework. The remaining mostly comprised those specimens for which insufficient material was present to confirm the species. Some problematic taxa that have remained unresolved in the Biota (2021) report include the following. Further details with respect to unresolved taxa are provided in Appendix A.2.

- *Dipteracanthus aff. Australasicus*;
- *Polymeria sp*;
- *Tephrosia rosea*;
- *Acacia aneura/aptaneura*;
- *Amaranthus aff. Undulatus*; and
- *Cynanchum ?floribundum*.

5.1.3.4 Weeds

The DAWE Protected Matters Search Tool (PMST) report (Biota, 2021) indicated that two invasive flora species may occur within the Development Envelope and/or the immediate surrounds; *Aluta quadrata, Quoya zonalis, Seringia exastia* and *Thryptomene wittweri*, are listed as Threatened *Parkinsonia aculeata* is listed as a Weed of National Significance (WONS).

Biota (2021) recorded the following 15 introduced flora species within the Development Envelope (Figure 15):

- Kapok Bush (*Aerva javanica*);
- Bipinnate Beggartick (*Bidens bipinnata*);
- Buffel Grass (*Cenchrus ciliaris*);
- Birdwood Grass (*Cenchrus setiger*);
- Feathertop Rhodes Grass (*Cynodon dactylon*);

- Native Thornapple (*Datura leichhardtii subsp. leichhardtii*);
- Awnless Barnyard Grass (*Echinochloa colona*);
- Speedy Weed (*Flaveria trinervia*);
- Spiked Malvastrum (*Malvastrum americanum*);
- Djanggara (*Portulaca pilosa*);
- Ruby Dock (*Rumex vesicarius*);
- Whorled Pigeon Grass (*Setaria verticillata*);
- Common Sowthistle (*Sonchus oleraceus*);
- Caltrop (*Tribulus terrestris*); and
- Mimosa Bush (*Vachellia farnesiana*).

None of the above species are listed as WONS or as declared pests for the Pilbara region listed under the WA *Biosecurity and Management Act* 2007 (Biota, 2021; DPIRD, 2020). However, Buffel Grass, Birdwood Grass, Mimosa Bush and Ruby Dock are all considered to be serious environmental weeds in WA (CALM, 1999). It is noted that much of Stage 4 of the Revised Proposal is on pastoral leases, so many weeds (especially Buffel Grass) would have been introduced for stock grazing. Ruby Dock was historically used in mining rehabilitation across the Pilbara, though no longer is.

5.1.4 Potential Impacts

Potential impacts to flora and vegetation may result from the following project activities:

- clearing for construction of the road and ongoing maintenance activities;
- clearing for associated construction activities such as site offices, laydown, side-tracks and so on;
- construction dewatering for the Fortescue River crossing and potentially other watercourse crossings;
- abstraction of water for construction purposes;
- disruption of surface water flow;
- construction of roadside drainage; and
- movement of construction vehicles and machinery around the site, as well as into and out of the site.

Potential direct impacts to flora and vegetation in relation to Stage 4 of the Revised Proposal have been identified as clearing of vegetation including TECs, PECs, vegetation associated with drainage lines, vegetation of local significance and threatened and priority flora species. The extent of disturbance to vegetation types within the Indicative Disturbance Footprint for Stage 4 is outlined in Table 5-5.

Potential indirect impacts to flora and vegetation in relation to the Revised Proposal have been identified as:

- impacts to groundwater dependent vegetation as a result of groundwater abstraction;

- impacts to flora and vegetation due to changes to surface water flow as a result of the construction and presence of the road (particularly grove-intergrove mulga communities, the *Themeda* Grasslands TEC; and the Brockman Iron PEC); and
- introduction of new weed species or spread of existing weed species as a result of vehicle movements and earthmoving activities.

Table 5-5 Extent of Permanent Disturbance to Vegetation Types and Mapping Units in the Indicative Disturbance Footprint (Biota, 2021)

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Indicative Disturbance Footprint (ha)	Indicative Temporary Clearing Area (ha)	Extent in Development Envelope (ha)	Proportion of Development Envelope Extent to be Disturbed (%) (including temporary clearing)	Extent in Contextual Area (ha)	Proportion of Contextual Area Extent to be Disturbed (%) (including temporary clearing)
Vegetation of Stony Hillslopes, Hillcrests and Foothills	H1	*Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Triodia wiseana* hummock grassland.	35.0	0.0	288.9	12%	499.1	7%
	H2	*Eucalyptus leucophloia subsp. leucophloia, (Corymbia hamersleyana*) low open woodland over mixed Acacia shrubs over *Triodia wiseana* open hummock	0.0	0.0	19.3	0%	33.9	0%
	H3	*Eucalyptus leucophloia* subsp. *Leucophloia*, (*Corymbia hamersleyana*) low open woodland over mixed Acacia shrubs over *Triodia wiseana* open hummock grassland	49.0	0.0	407.6	12%	621.2	8%
	H4	*Eucalyptus leucophloia* subsp. *Leucophloia* scattered low trees over *E. gamophylla* scattered low mallees over *Triodia wiseana* open hummock grassland and *Eriachne mucronata* scattered tussock grasses.	0.12	0.0	8.4	2%	43.6	>1%

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Indicative Disturbance Footprint (ha)	Indicative Temporary Clearing Area (ha)	Extent in Development Envelope (ha)	Proportion of Development Envelope Extent to be Disturbed (%) (including temporary clearing)	Extent in Contextual Area (ha)	Proportion of Contextual Area Extent to be Disturbed (%) (including temporary clearing)
Vegetation of Cracking Clays	C1	*Eriachne benthamii*, *Eragrostis xerophila*, *Astrebla elymoides* very open tussock grassland over *Cynodon convergens* very open bunch grassland.	3.0	0.7	122.2	2%	128.6	2%
	C2	*Acacia xiphophylla* low woodland over *Triodia epactia* very open hummock grassland over *Eragrostis xerophila* scattered tussock grasses.	6.5	8.6	206.8	7%	211.6	7%
	C3	Mixed *Astrebla* tussock grassland over *Urochloa occidentalis* var. *occidentalis* bunch grassland.	11.6	0.0	88.1	13%	225.1	5%
	C4	*Themenda sp.*. Hamersley Station (M.E. Trudgen 11431) tussock grassland	11.3	0.0	72.7	16%	197.7	6%
	C5	*Eucalyptus victrix* scattered low trees over *Eriachne benthamii*, *Themenda sp.*. Hamersley Station (M.E. Trudgen 11431)) very open tussock grassland over mixed open herbland.	0.6	0.0	4.3	14%	15.3	4%

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Indicative Disturbance Footprint (ha)	Indicative Temporary Clearing Area (ha)	Extent in Development Envelope (ha)	Proportion of Development Envelope Extent to be Disturbed (%) (including temporary clearing)	Extent in Contextual Area (ha)	Proportion of Contextual Area Extent to be Disturbed (%) (including temporary clearing)
Mulga Vegetation	M1	*Acacia aptaneura* (*A. pruinocarpa*) low woodland over *Triodia epactia* (*T. melvillei*) very open hummock grassland over *Chrysopogon fallax* scattered tussock grasses.	15.5	3.4	169.9	10%	300.0	6%
	M2	*Acacia ?macraneura*, *A. aptaneura* over *Triodia epactia* scattered hummock grasses.	47.7	10.9	492.5	12%	986.7	6%
	M3	*Acacia aneura*/*aptaneura*, (*A ?macraneura*,) low woodland over bunch grasses.	9.3	0.0	75.0	13%	153.8	6%
	M4	*Acacia aptaneura*, *A ?macraneura* (*Hakea lorea* subsp. *Lorea*) low open woodland over mixed tussock grasses, bunch grasses and herbs.	5.2	0.5	47.9	12%	88.9	6%
	P1	*Corymbia deserticola* subsp. *Deserticola*, *C. hamersleyana*, *Eucalyptus leucophloia* subsp. *Leucophloia* low open woodland	35.1	9.9	333.9	13%	736.8	6%

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Indicative Disturbance Footprint (ha)	Indicative Temporary Clearing Area (ha)	Extent in Development Envelope (ha)	Proportion of Development Envelope Extent to be Disturbed (%) (including temporary clearing)	Extent in Contextual Area (ha)	Proportion of Contextual Area Extent to be Disturbed (%) (including temporary clearing)
Vegetation of Stony Plains and Sloping Plains		over *Triodia wiseana* open hummock grassland.						
	P2	*Corymbia hamersleyana* low open woodland over mixed Acacia shrubland over *Triodia epactia* hummock grassland.	79.0	21.1	1,023.4	10%	1,750.1	6%
	P3	*Hakea lorea* subsp. *Lorea* low open woodland over shrubs over *Triodia epactia* very open hummock grassland with *Themeda sp.* Hamersley Station (M.E. Trudgen 11431) very open tussock grassland.	8.2	0.0	53.8	15%	141.0	6%
	P4	*Corymbia hamersleyana* scattered low trees over *Triodia epactia*, (*T. wiseana*) open hummock grassland and *Eulalia aurea* scattered tussock grasses.	0.8	0.7	14.6	10%	14.3	10%
	P5	*Eucalyptus xerothermica* low open woodland over *Acacia bivenosa* scattered shrubs over *Triodia angusta* open	9.4	0.0	109.1	9%	117.0	8%

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Indicative Disturbance Footprint (ha)	Indicative Temporary Clearing Area (ha)	Extent in Development Envelope (ha)	Proportion of Development Envelope Extent to be Disturbed (%) (including temporary clearing)	Extent in Contextual Area (ha)	Proportion of Contextual Area Extent to be Disturbed (%) (including temporary clearing)
		hummock grassland with mixed tussock grasses.						
	P6	*Hakea lorea* subsp. *Lorea* low open woodland over **Vachellia farnesiana* scattered shrubs over *Themeda sp.* Hamersley Station (M.E. Trudgen 11431) tussock grassland.	3.2	0.0	38.2	8%	84.4	4%
	P7	*Triodia wiseana hummock* grassland with *Eriachne flaccida* scattered tussock grasses.	0.0	0.0	43.23	0%	52.0	0%
	P8	**Vachellia farnesiana* scattered tall shrubs over *Chrysopogon fallax* very open tussock grassland over mixed annual grassland and herbland.	10.7	0.0	81.6	13%	191.7	6%
Vegetation of Drainage Lines	D1	*Eucalyptus victrix* (*E. camaldulensis* subsp. *Refulgens*) woodland over *Melaleuca glomerata* tall open shrubland over *Triodia epactia* scattered hummock	16.8	0.0	500.4	3%	767.4	2%

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Indicative Disturbance Footprint (ha)	Indicative Temporary Clearing Area (ha)	Extent in Development Envelope (ha)	Proportion of Development Envelope Extent to be Disturbed (%) (including temporary clearing)	Extent in Contextual Area (ha)	Proportion of Contextual Area Extent to be Disturbed (%) (including temporary clearing)
		grasses over mixed tussock grasses and sedges.						
	D2	*Eucalyptus camaldulensis* subsp. *Refulgens*, *Melaleuca argentea* open forest over mixed scattered tussock grasses with *Cyperus vaginatus* scattered sedges.	0.02	0.0	21.3	>1%	36.9	>1%
	D3	*Eucalyptus victrix* low open woodland over **Vachellia farnesiana* scattered tall shrubs over mixed tussock grasses and bunch grasses.	3.4	0.0	18.5	18%	48.1	7%
Vegetation of Floodplains	F1	*Corymbia hamersleyana* low open woodland over *Acacia inaequilatera* tall open shrubland over *Triodia wiseana* (*T. epactia*) open hummock grassland with mixed tussock grasses.	120.0	43.3	1,497.2	11%	2,099.1	8%
	F2	*Corymbia hamersleyana* low woodland over mixed Acacia tall open shrubland over *Triodia wiseana*, (*T. epactia*) open hummock grassland.	34.2	0.0	436.8	8%	764.7	4%

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Indicative Disturbance Footprint (ha)	Indicative Temporary Clearing Area (ha)	Extent in Development Envelope (ha)	Proportion of Development Envelope Extent to be Disturbed (%) (including temporary clearing)	Extent in Contextual Area (ha)	Proportion of Contextual Area Extent to be Disturbed (%) (including temporary clearing)
	F3	*Corymbia hamersleyana* low open woodland over mixed Acacia open shrubland over *Triodia epactia* very open hummock grassland with *Chrysopogon fallax* very open tussock grassland.	20.1	0.0	218.9	9%	439.6	5%
	F4	*Acacia citrinoviridis* low woodland over *Triodia epactia* open hummock grassland and *Chrysopogon fallax* scattered tussock grasses.	3.5	0.0	58.7	6%	165.1	2%
	F5	*Corymbia hamersleyana* low open woodland over *Acacia bivenosa* tall shrubland over *Triodia epactia* scattered hummock grasses and **Cenchrus ciliaris* tussock grasses.	2.7	0.6	281.4	1%	303.2	1%
Other Mapping Units		Cleared/ Disturbed	8.1	0.3	4,082.0	N/A	769.3	N/A

Table 5-6 Listed Priority Flora Recorded in the Development Envelope and Indicative Disturbance Footprint (Biota, 2021)

Species	Conservation Status	Individuals in Indicative Disturbance Footprint	Individuals in Development Envelope	Proportion of individuals in Development Envelope to be Disturbed (%)	Regional Distribution
Euphorbia australis var. *glabra*	Priority 3	24	753	3%	Distributed widely in the central Pilbara, with 25 vouchered records from the Chichester, Hamersley and Fortescue subregions.
Sida sp. Hamersley Range (K. Newbey 10692) PN	Priority 3	7	46	15%	*Sida* sp. Hamersley Range (K. Newbey 10692) occurs in the southern Pilbara, known only from the Hamersley subregion, from 27 vouchered records.
Themeda sp. Hamersley Station (M.E. Trudgen 11431)	Priority 3	Recorded in one quadrat within the Indicative Disturbance Footprint. The percent cover of this species within the quadrat was estimated at 1.5%. The number of individuals in the quadrat is not available	8,503+	14%[11]	The regional distribution of *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) is represented by 45 vouchered records in WA, and occurs over a range of approximately 400 km east-west and 300 km north-south through the Pilbara. This species is a dominant species of the *Themeda* grasslands TEC. DBCA records indicate that the TEC covers approximately 34,600 ha in the Pilbara region. The required clearing equates to 0.04% of this extent.
Eremophila magnifica subsp. *magnifica*	Priority 4	6	12	50%	A total of 42 records have been vouchered from the Fortescue and Hamersley subregions in the Pilbara.
Goodenia nuda	Priority 4	84	433	19%	This species has a broad distribution over 900 km east-west and 720 km north-south, and is known from 126 vouchered records in WA.

[11] Based on the mapped extent *Themeda* grasslands TEC within the Indicative Disturbance Footprint and Development Envelope.

5.1.5 Mitigation

Construction of Stage 2 and 3 of the Revised Proposal is completed. Therefore, mitigation is focussed on Stage 4 of the Revised Proposal.

Use of existing cleared areas (such as existing tracks and pits) will occur where practicable to avoid clearing of vegetation.

Detailed design will prioritise the following in order to minimise vegetation clearing impacts as far as practicable:

- avoidance of significant flora and ecological communities where possible;
- where safe to do so, batters will be steepened to reduce the width of the clearing footprint; and
- safety barriers will be installed where practicable to allow roadside batters to be steepened to reduce the width of the clearing footprint.

To minimise impacts to significant flora, Brockman Iron PEC and *Themeda* grasslands TEC, the selection of areas where temporary clearing will be required for construction activities such as camps, laydown areas, stockpile areas and vehicle turnarounds has been based on the vegetation type (within the constraints of factors such as heritage). Existing cleared areas and areas of lower environmental value will be prioritised and TECs, PECs and vegetation associated with drainage lines avoided.

Identification of material sources for construction will consider the following to minimise vegetation clearing impacts:

- use of existing material pits where available;
- use of spent ballast from RTIO rail, pending agreement with RTIO and confirmation of suitability and no contamination issues; and
- sourcing materials from within the infrastructure footprint (such as from areas of cut).

Project specific environmental management measures and monitoring requirements with respect to mitigating impacts to vegetation and flora are outlined in Table 5-7.

Table 5-7 Flora and Vegetation Management

EPA factor: Flora and vegetation
EPA objective: To protect flora and vegetation so that biological diversity and ecological integrity are maintained.
Proposal objective: To minimise as far as practicable the direct and indirect impacts to native vegetation and flora from Stage 4 of the Revised Proposal.
Key environmental values: Native vegetation including the presence of significant vegetation and flora.
Key impacts and risks: Vegetation and flora loss and degradation through direct and indirect impacts.

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
Prevent the unauthorised clearing of the single Fringed Fire-bush plant (*Seringia exastia*) identified during the Biota (2021a) survey.	Avoid	A 50 m 'No Go' exclusion zone will be demarcated on all relevant project maps. Note that in the event the species is delisted prior to construction, this management measure will no longer be implemented.	• Monthly site inspections; and Site inspection prior to and following clearing to confirm no-go areas are appropriately demarcated.	• Prior to commencement of clearing; and • During construction.	• Monthly construction reports including clearing amounts. • Incident will be reported to EPA along with the cause identified from an investigation.	• Drawings do not show no-go zones.	• Clearing will cease immediately if trigger is met and will not recommence until no-go areas have been reviewed and confirmed to be in place correctly, and Main Roads Superintendent provides approval to recommence; • Environmental incident will be recorded, and the cause investigated; and • Incident will be reported to EPA along with the cause identified from an investigation.	• Construction Contractor Environmental Management Representative. • Main Roads Superintendent.
	Avoid	A 50 m 'No Go' exclusion zone will be pegged out on site around the location of the single plant. Note that in the event the species is delisted prior to construction, this management measure will no longer be implemented.				• Clearing within the 50 m no-go zone occurs		
Prevent unauthorised impacts to PEC and TEC	Avoid	Areas of PEC and TEC that are not to be cleared will be demarcated on all relevant project maps.	• Monthly site inspections; and • Site inspection prior to and following clearing to confirm no-go areas are appropriately demarcated.	• Prior to commencement of clearing; and • During construction.	• Monthly construction reports including clearing amounts; and • Incident will be reported to EPA along with the cause identified from an investigation.	• Drawings do not show areas of PEC and TEC; and	• Clearing will cease immediately if trigger is met and will not recommence until no-go areas have been reviewed and confirmed to be in place correctly, and Main Roads Superintendent provides approval to recommence; • Environmental incident will be recorded, and the cause investigated; and • Incident will be reported to EPA along with the cause identified from an investigation.	• Construction Contractor Environmental Management Representative; and • Main Roads Superintendent.
	Avoid	Areas of PEC and TEC that are not to be cleared will be pegged out on site. Daily toolbox meetings to include reminders on presence of PEC and TEC.				▪ Unauthorised clearing of PEC or TEC occurs.		

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
Impacts to native flora and vegetation are avoided or minimised as far as practicable during implementation of Stage 4 of the Revised Proposal.	Avoid	• Site induction will include vegetation clearing requirements and procedures; • A ground disturbance permit process will be developed by the contractor and signed off by the Main Roads Superintendent. The process will include a review of the disturbance area against the approval boundary; • All clearing areas will be demarcated and approved by the Main Roads Superintendent prior to clearing commencing; • Vegetation to be retained will be clearly demarcated on site; • To minimise impacts to significant flora, Brockman Iron PEC and *Themeda* grasslands TEC, the selection of areas where temporary clearing will be required for construction activities such as camps, laydown areas, stockpile areas and vehicle turnarounds has been based on the vegetation type (within the constraints of factors such as heritage). existing cleared areas and areas of lower environmental value will be prioritised and TECs, PECs and vegetation associated with drainage lines avoided; • All clearing areas will be checked and confirmed post-clearing; • The extent of the approved clearing will be clearly communicated in contract documentation;	• Review detailed drawings showing vegetation retention / clearing line; and • • Monthly review of clearing records to monitor clearing rates against authorised limits.	• During construction.	• Clearing records; • Inspection results recorded and reported in the annual compliance report; and • Incident will be reported to EPA along with the cause identified from an investigation.	• Clearing occurs outside the approved disturbance area.	• Clearing will cease immediately if trigger is met and will not recommence until no-go areas have been reviewed and confirmed to be in place correctly, and Main Roads Superintendent provides approval to recommence; and • Environmental incident will be recorded, and the cause investigated.	• Construction Contractor Environmental Management Representative; and • Main Roads Superintendent.

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
	Minimise	• Dust generating activities will be suspended at the direction of the construction contractor's environmental representative if deemed too dusty and will not recommence without approval; • Main Roads standard dust mitigation measures which will be implemented throughout construction of Stage 4 of the Revised Proposal, including: - Use of dust suppression to manage dust generation from construction activities, access roads and cleared areas; - Use of water sprays to manage dust generation from material transport and stockpiling; - Limit the number and height of stockpiles; and - Vehicles confined to designated routes with speed limits strictly enforced.	• Visual inspection, pedestrian walkthrough (monthly); and Photographic record, GPS of non-conformance.	• During construction.	• All suspended works to be reported to the Main Roads Superintendent.	• Dust mitigation measures not implemented or not effective.	• Review mitigation measures and implementation procedure and revise if required.	• Construction Contractor Environmental Management Representative; and Main Roads Superintendent
	Minimise	• Vehicle speeds will be limited to between 40-80 km/hr on site for safety purposes and this will consequently reduce dust generated.	• *Not applicable*	• During construction.	• Incident reports.	• Vehicles observed exceeding speed limit.	• Environmental incident will be recorded, and the cause investigated.	• Construction Contractor Environmental Management Representative. • Main Roads Superintendent
Minimise impacts to mulga vegetation from changes in surface water flow	*Refer to mitigation measures, monitoring and corrective actions in the Inland Waters section*							

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
No introduction or spread of declared weeds, WONS or serious environmental weed species into surrounding native vegetation adjacent to the Development Envelope during and attributable to construction.	Minimise	• Environmental weeds within the construction site boundary will be treated according to the weed control management outlined by Weeds Australia with the aim of controlling off-site movement. Develop and maintain a weed register for declared weeds, WONS or serious environmental weed species (if identified). Register will include, for each species, details of distribution, abundance, relevant biological information and a history of control methods and their relative success; • Develop and implement vehicle and equipment clean on entry/exit procedures; • All personnel will be inducted prior to their commencement on site; • The induction will include weed identification and weed hygiene training; • Any machinery used in the removal of weed-infested topsoil will be cleaned down before entering or leaving the work site to prevent the introduction and spread of weeds into new areas; • Any soil or materials imported onto the worksite will be from weed-free areas; • Where roadworks directly impact known areas of serious environmental weeds, topsoil will be removed separately, heaps delineated and spoil disposed of as soon as possible through consultation with the Main Roads environmental management representative; • Weed contaminated topsoil stockpiles shall be quarantined from uncontaminated / clean topsoil stockpiles, clearly signed in the field and identified on a site plan; and • Areas temporarily disturbed are to be revegetated and stabilised.	• Visual inspection, pedestrian walkthrough (monthly); • Photographic record, GPS of non-conformance; and • Weed monitoring to be undertaken along the edge of the road reserve annually post-construction for a period of 3 years.	• Monthly during construction; and • For 3 years post-construction.	• Monthly site inspection reports; • Annual revegetation monitoring; • Weed monitoring reports. • Records of topsoil segregation and burial or licensed waste facilities; and • Records verifying plant and machinery arriving on site is clean	• New significant weed infestation (i.e. above existing background levels) identified.	• Where new weed infestation is evident, herbicide application shall be undertaken; and • Review C0E process.	• Construction Contractor Environmental Management Representative.

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
Rehabilitation of all temporary clearing not required for permanent infrastructure.	Rehabilitate	• Revegetation to re-establish pre-existing native vegetation on cleared areas not required for ongoing road usage will be undertaken in accordance with the Main Roads Revegetation Planning and Techniques Guideline (Main Roads WA, 2005); • For each site to be rehabilitated, a reference site will be established for comparison against the rehabilitation. This can be established either through a baseline survey of the vegetation prior to clearing, or a reference site; • Monitoring of rehabilitated areas to be undertaken at six-monthly intervals for the first year following completion of construction then annually for the following two years; and • Within 3 months of becoming aware that an area of revegetation no longer meets the completion criteria of >50% native vegetation cover, corrective actions will be undertaken to improve vegetation quality within the revegetated areas. Corrective actions may cease once the completion criteria have again been achieved.	• Monitoring of rehabilitated areas to be undertaken at six-monthly intervals for the first year following completion of construction then annually for the following three years.	• During and post construction.	• Construction reports detailing revegetation activities; and • Rehabilitation monitoring reports.	• Rehabilitation areas not self-sustaining after three years.	• Environmental incident will be recorded, and the cause investigated; and • Additional revegetation will be undertaken in consultation with EPA.	• Construction Contractor Environmental Management Representative. • Main Roads Superintendent.
Offset significant residual impacts to PEC and TEC	Offset	▪ Residual impacts to PEC and TEC will be managed via offsetting as appropriate (Section 6).	*Not applicable*					

5.1.6 Assessment of Impacts

An assessment of the potential impacts to flora and vegetation from the Revised Proposal, based on current knowledge, is provided in the Sections below.

5.1.6.1 Direct impacts from Stage 4 of the Revised Proposal

5.1.6.1.1 Vegetation

Table 5-8 details the expected approximate area of each native vegetation type to be cleared for Stage 4 of the Revised Proposal based on the Indicative Disturbance Footprint and Indicative Temporary Disturbance Areas, broken into vegetation condition. Vegetation condition in these areas ranges from 'Excellent' to 'Completely Degraded'.

As described in Section 5.1.6.3, ongoing design refinements may slightly increase the required clearing. As such up to 665 ha of clearing may be required including up to 550 ha of permanent clearing of native vegetation in Good to Excellent condition and 100 ha of temporary clearing of native vegetation in Good to Excellent condition. This temporary clearing will be revegetated once construction is complete and will avoid areas that contain significant flora or vegetation.

The permanent clearing includes up to 30 ha of vegetation associated with drainage lines. Temporary clearing areas will avoid vegetation associated with drainage line. The EPA considers clearing of Good or better condition vegetation to be a significant impact that requires offsetting (Government of Western Australia, 2014). As such, the proposed permanent clearing of Good to Excellent quality vegetation is considered a significant residual impact. This impact will be offset as detailed in Section 6.

Table 5-8 Vegetation Units and Types and Extent in the Indicative Disturbance Footprint and Indicative Temporary Clearing Areas (Biota, 2021)

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Vegetation Condition (ha)							Total (ha)
			Cleared	Completely	Good	Good to Very	Very Good	Very Good to Excellent	Excellent	
Vegetation of Stony Hillslopes, Hillcrests and Foothills	H1	*Eucalyptus leucophloia* subsp. *Leucophloia* scattered low trees over *Triodia wiseana* hummock grassland.							35.0	35.0
	H2	*Eucalyptus leucophloia subsp. leucophloia, (Corymbia hamersleyana*) low open woodland over mixed Acacia shrubs over *Triodia wiseana* open hummock								0.0
	H3	*Eucalyptus leucophloia* subsp. *leucophloia*, (*Corymbia hamersleyana*) low open woodland over mixed Acacia shrubs over *Triodia wiseana* open hummock grassland							49.0	49.0
	H4	*Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *E. gamophylla* scattered low mallees over *Triodia wiseana* open hummock grassland and *Eriachne mucronata* scattered tussock grasses.							0.12	0.12
Vegetation of Cracking Clays	C1	*Eriachne benthamii*, *Eragrostis xerophila*, *Astrebla elymoides* very open tussock grassland over *Cynodon convergens* very open bunch grassland.					1.3		2.4	3.7
	C2	*Acacia xiphophylla* low woodland over *Triodia epactia* very open hummock grassland over *Eragrostis xerophila* scattered tussock grasses.					15.1			15.1
	C3	Mixed *Astrebla* tussock grassland over *Urochloa occidentalis* var. *occidentalis* bunch grassland. This vegetation type forms part of the Brockman Iron cracking clay communities of the Hamersley Range PEC.					11.6			11.6
	C4	*Themeda* sp. Hamersley Station (M.E. Trudgen 11431) tussock grassland. This vegetation type forms part of the *Themeda* grasslands TEC.					11.3			11.3

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Vegetation Condition (ha)							Total (ha)
			Cleared	Completely	Good	Good to Very	Very Good	Very Good to Excellent	Excellent	
	C5	*Eucalyptus victrix* scattered low trees over *Eriachne benthamii*, (*Themeda* sp Hamersley Station (M.E. Trudgen 11431)) very open tussock grassland over mixed open herbland. This vegetation type forms part of the *Themeda* grasslands TEC.					0.6			0.6
Mulga Vegetation	M1	*Acacia aptaneura* (*A. pruinocarpa*) low woodland over *Triodia epactia* (*T. melvillei*) very open hummock grassland over *Chrysopogon fallax* scattered tussock grasses.			0.4			18.5		18.9
	M2	*Acacia ?macraneura*, *A. aptaneura* over *Triopia epactia* scattered hummock grasses.			0.1			58.5		58.6
	M3	*Acacia aneura*/*aptaneura*, (*A ?macraneura*,) low woodland over bunch grasses.					9.3			9.3
	M4	*Acacia aptaneura*, *A ?macraneura* (*Hakea lorea* subsp. *lorea*) low open woodland over mixed tussock grasses, bunch grasses and herbs.					5.7			5.7
Vegetation of Stony Plains and Sloping Plains	P1	*Corymbia deserticola* subsp. *deserticola*, *C. hamerslayana*, *Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Triodia wiseana* open hummock grassland.							45.0	45.0
	P2	*Corymbia hamersleyana* low open woodland over mixed Acacia shrubland over *Triodia epactia* hummock grassland.			0.3		10.2		89.6	101.
	P3	*Hakea lorea* subsp. *lorea* low open woodland over shrubs over *Triodia epactia* very open hummock grassland with *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) very open tussock grassland.			1.2	7.0				8.2
	P4	*Corymbia hamersleyana* scattered low trees over *Triodia epactia*, (*T. wiseana*) open hummock grassland and *Eulalia aurea* scattered tussock grasses.					1.5			1.5

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Vegetation Condition (ha)							Total (ha)
			Cleared	Completely	Good	Good to Very	Very Good	Very Good to Excellent	Excellent	
	P5	*Eucalyptus xerothermica* low open woodland over *Acacia bivenosa* scattered shrubs over *Triodia angusta* open hummock grassland with mixed tussock grasses.					9.4			9.4
	P6	*Hakea lorea* subsp. *lorea* low open woodland over **Vachellia farnesiana* scattered shrubs over *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) tussock grassland. This vegetation type forms part of the *Themeda* grasslands TEC.			1.8		1.4			3.2
	P8	**Vachellia farnesiana* scattered tall shrubs over *Chrysopogon fallax* very open tussock grassland over mixed annual grassland and herbland.					10.7			10.7
Vegetation of Drainage Lines	D1	*Eucalyptus victrix* (*E.camaldulensis* subsp. *refulgens*) woodland over *Melaleuca glomerata* tall open shrubland over *Triodia epactia* scattered hummock grasses over mixed tussock grasses and sedges.					10.0		6.8	16.8
	D2	*Eucalyptus camaldulensis* subsp. *refulgens*, *Melaleuca argentea* open forest over mixed scattered tussock grasses with *Cyperus vaginatus* scattered sedges.					0.02			0.02
	D3	*Eucalyptus victrix* low open woodland over **Vachellia farnesiana* scattered tall shrubs over mixed tussock grasses and bunch grasses.					3.4			3.4
Vegetation of Floodplains	F1	*Corymbia hamersleyana* low open woodland over *Acacia inaequilatera* tall open shrubland over *Triodia wiseana* (*T.epactia*) open hummock grassland with mixed tussock grasses.					62.3		101.0	163.3
	F2	*Corymbia hamersleyana* low woodland over mixed Acacia tall open shrubland over *Triodia wiseana*, (*T. epactia*) open hummock grassland.					5.5	0.5	28.2	34.2

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Vegetation Condition (ha)							Total (ha)
			Cleared	Completely	Good	Good to Very	Very Good	Very Good to Excellent	Excellent	
	F3	*Corymbia hamersleyana* low open woodland over mixed Acacia open shrubland over *Triodia epactia* very open hummock grassland with *Chrysopogon fallax* very open tussock grassland.					16.9		3.2	20.1
	F4	*Acacia citrinoviridis* low woodland over *Triodia epactia* open hummock grassland and *Chrysopogon fallax* scattered tussock grasses.					3.5			3.5
	F5	*Corymbia hamersleyana* low open woodland over *Acacia bivenosa* tall shrubland over *Triodia epactia* scattered hummock grasses and **Cenchrus ciliaris* tussock grasses.					1.7	1.7		3.4
Other Mapping Units	Cleared	Cleared/disturbed	8.4							8.4

5.1.6.1.2 Pre-European Vegetation Associations

The Revised Proposal will not result in a decrease in any of the Pre-European Vegetation Association extents (based on Beard (Shepherd et al., 2002; Government of Western Australia, 2018)) below 30% at state level, IBRA bioregion and subregion levels, or the LGA (Shire of Ashburton) level.

5.1.6.1.3 Threatened Ecological Communities and Priority Ecological Communities

The *Themeda* grasslands TEC is present within the Tom Price section of the Development Envelope (Biota, 2021), with vegetation units C4, C5 and P6 representing the ecological community (Table 5-3). Approximately 15 ha of the *Themeda* grasslands TEC is present within the Indicative Disturbance Footprint and will be cleared for construction of Stage 4 of the Revised Proposal (Biota, 2021) (Figure 13). DBCA records indicate that the TEC covers approximately 34,600 ha in the Pilbara region. The required clearing equates to 0.04% of this extent. It is noted that the current Approved Proposal allows for up to 17.5 ha of clearing of this TEC. Temporary clearing areas will avoid the *Themeda* grasslands TEC.

The “Brockman Iron cracking clay communities of the Hamersley Range” PEC is present in the Tom Price section of the Development Envelope and is represented by vegetation type C3 (Table 5-3). Approximately12 ha of the PEC is present within the Indicative Disturbance Footprint and will be cleared (Biota, 2021) (Figure 13). DBCA records indicate that the PEC covers approximately 31,805 ha within 50 km of the Development Envelope. The required clearing equates to 0.04% of this extent. Temporary clearing areas will avoid the “Brockman Iron cracking clay communities of the Hamersley Range” PEC.

Clearing of the PEC and TEC along the alignment is unlikely to further fragment the ecological communities, given the level of fragmentation already existing due to the presence of the RTIO railway. The railway and associated access roads sit within a 65 m corridor, resulting in the TEC being separated into an approximately 1,475 ha portion on the western side, with the remainder of the TEC to the east. Construction of Stage 4 of the Revised Proposal will require clearing of a 40 m – 60 m corridor to the west of the railway, reducing the western portion of the TEC by approximately 15 ha. Construction of the Revised Proposal is unlikely to increase the level of fragmentation of the TEC or change the existing edge effect impacts experienced by the western portion of the TEC.

Clearing of up to 12 ha of the PEC and 15 ha of the TEC is likely to be a significant residual impact and will be offset. Proposed offsets are defined in in Section 6.

5.1.6.1.4 Vegetation of Local Significance

As described in Section 5.1.3.2.6, some areas of vegetation unit C2 (and an area of vegetation type P7), both on cracking clays in the north of the Development Envelope, are considered to be locally significant given their similarity and close proximity to the “Mitchell grass and Roebourne Plain grass (*Eragrostis xerophila*) plain on gilgai” Priority 3 PEC”. Up to 15.1 ha of the C2 vegetation unit in the north of the Development Envelope will be cleared for Stage 4 of the Revised Proposal, which equates to approximately 7% of this vegetation unit mapped within the Development Envelope. Of this 8.6 ha is within the Indicative Temporary Clearing Area and will be rehabilitated. The P7 vegetation unit does not occur in the Indicative Disturbance Footprint or Indicative Temporary Clearing Areas. It should be noted that the proportion of the P7 vegetation unit that is of local significance is minor (Biota, 2021).

The Grove–intergrove Mulga communities (vegetation types M1 and M2) are also considered locally significant due to their restricted nature, sensitivity to changes in surface water flows and similarity to other Grove–intergrove Mulga communities that have been listed as PECs (i.e. Frederick Land System Priority 3 PEC). Up to 77.5 ha of these vegetation types will be cleared for the Stage 4 of the Revised Proposal, which equates to approximately 11.5% vegetation unit mapped within the Development Envelope. This includes 14.3 ha of temporary clearing that will be rehabilitated.

Given the small extent of the proposed clearing of these vegetation types, the clearing will not result in a significant residual impact.

5.1.6.1.5 Threatened Flora Species – Fringed Fire-bush (*Seringia exastia*)

As *Seringia exastia* does not fall within the Indicative Disturbance Footprint, no direct impacts to this species are anticipated as a result of Stage 4 of the Revised Proposal. Any refinement of the alignment will be undertaken in a manner that ensures no impact occurs to threatened flora species. A 50 m 'No Go' exclusion zone will be implemented around the location and demarcated on all relevant maps to minimise the potential inadvertent disturbance of the plant.

5.1.6.1.6 Priority Flora Species

The Biota (2021) survey recorded two Priority 3 and two Priority 4 flora species in the Indicative Disturbance Footprint (Table 5-6 and Figure 14). Table 5-6 details the Priority flora found in the Indicative Disturbance Footprint and Development Envelope. The Biota (2021) survey did not record any Priority flora species in the Indicative Temporary Clearing Areas. Impacts to priority flora as a result of clearing are as follows:

- 24 individuals of the species *Euphorbia australis var. glabra* (P3) were recorded within the Indicative Disturbance Footprint which represents 3% of this species recorded within the Development Envelope. This species is widely distributed in the central Pilbara region, with 25 vouchered records from the Chichester, Hamersley and Fortescue subregions. Given the small number of this species to be cleared compared to number of individuals in the local area (Development Envelope) and broader central Pilbara region, this clearing is not expected to change the conservation status of the species and will not result in a significant residual impact.
- Seven individuals of the species *Sida* sp*. Hamersley Range (K. Newbey 10692) PN* (P3) were recorded within the Indicative Disturbance Footprint which represents 15% of this species recorded within the Development Envelope. This species has been recorded 27 times in the Hamersley sub-region. Given the small number of this species to be cleared compared to number of individuals in the local area (Development Envelope) and the Hamersley sub-region, this clearing is not expected to change the conservation status of the species and will not result in a significant residual impact.
- *Themeda sp.* Hamersley Station (M.E. Trudgen 11431) (P3) was recorded in one quadrat within the Indicative Disturbance Footprint. The percent cover of this species within the quadrat was estimated at 1.5%. The number of individuals in the quadrat is not available. This species is a dominant species of the *Themeda* grasslands TEC. The quadrat where the species was recorded lies within the TEC and as such the associated impacts to this species are already described in Section 5.1.6.1.3. As described in Section 5.1.6.1.3, clearing of up to 15 ha of the TEC is likely to be a significant residual impact and will be offset.

- Six individuals of the species *Eremophila magnifica* subsp. *magnifica* (P4) are within the Indicative Disturbance Footprint, which represents 50% of this species recorded within the Development Envelope. A total of 42 records have been vouchered from the Fortescue and Hamersley subregions in the Pilbara, across a distribution range of approximately 350 km east-west. In the context of the known range and number of records of this species, the removal of six individuals is not expected to change the conservation status of the species and will not represent a significant residual impact.
- 84 individuals of the species *Goodenia nuda* (P4) are within the Indicative Disturbance Footprint, which represents 19% of this species recorded within the Development Envelope. This species has a broad distribution over 900 km east-west (Karlamilyi National Park to Onslow) and 720 km north-south (Pilbara coast to Kumarina), and is known from 126 vouchered records in WA. In the context of the known range and number of records of this species, the removal of 84 individuals is not expected to change the conservation status of the species and will not represent a significant residual impact.

5.1.6.2 Indirect impacts

Impacts from dust are considered to be short-term and temporary due to the nature of dust emissions in the Pilbara region, which has naturally occurring high levels of dust. Standard management measures will be implemented should excessive dust be observed

5.1.6.2.1 Changes to Surface Water Flows

Changes to surface water flows due to construction activities and the physical presence of the completed road may result in impacts to flora and vegetation due to shadowing (where water level is reduced or surface water availability is reduced as a result of infrastructure interrupting flow), flooding and waterlogging.

Grove-intergrove mulga communities are particularly vulnerable to changes in surface water flows due to their reliance on overland sheet flow. Mulga communities are present in the southern portion of the Tom Price Section. In this section the proposed road alignment has been selected to generally match the direction of the natural sheet flow in the area and as such there is not expected to be a substantial change to flow, or the health of the Mulga communities.

The *Themeda* Grassland TEC areas are generally flat, alluvial plains on cracking clay soils (DBCA, 2020d). Sheet flows and small drainage lines are likely to be significant in maintaining their viability. Minor channel flow in the area will be managed via the road and drainage design.

As detailed in Section 5.3, the detailed design of Stage 4 of the Revised Proposal will be undertaken in consideration of the hydrological risk factors identified in the preliminary hydrological assessments, to ensure that changes to surfaces flow, such that significant impacts occur to flora or vegetation, do not occur.

5.1.6.2.2 Groundwater Abstraction

As detailed in Section 5.1.3.2.7, *Eucalyptus* and *Melaleuca* species that depend on groundwater have been identified by Biota (2021) as being present in and around the Development Envelope. This

vegetation is restricted to the major drainage lines (Fortescue River, Weelumurra Creek and its tributaries; and Barnett Creek (Biota, 2021)).

Groundwater abstraction for water supply or dewatering during construction of water crossings for Stage 4 will be temporary and of a short duration. Abstraction will be managed to minimise groundwater drawdown in accordance with the applicable license and avoid impacts to TECs and PECs. The DoW (2016) undertook a groundwater assessment of the north-west Hamersley Ranges including in the Weelumurra Creek area. Much of the development envelope lies within this area. DoW (2016) estimated the groundwater storage in the area as 95 GL, with an average recharge rate of 7.8 GL/year. It is estimated that between 148,000 and 412,000 kL will be abstracted for the project over a 30 month period. Based on the water requirements and recharge rate, once abstraction activities have ceased, groundwater is expected to recover to pre-impact level with no long-term effects on vegetation.

Groundwater abstraction would be undertaken at a number of well locations (depending on the specific location of the construction activities at the time). This will further reduce the likelihood of impact to vegetation as a result of groundwater abstraction.

It is likely that the majority of water will be sourced from existing bores within the existing allowance under the 5C license for the well in accordance with the RIWI Act. Should new bores be required or where extraction greater than allowed in an existing licence be required, Main Roads will seek the required licenses in accordance with the RIWI Act. Main Roads anticipates that the need to gain new licences or extend existing licenses, if required, would be for a small number of bores (probably not more than three).

Before issuing a 5C license, DWER undertakes an assessment of the potential impacts of taking the groundwater on groundwater dependent ecosystems and vegetation. As such the potential impacts on groundwater dependent vegetation has already been determined to be acceptable by DWER for the majority of the proposed groundwater abstraction. The same assessment would be undertaken for any new bores with abstraction only to occur is approved by DWER via a 5C license.

5.1.6.2.3 Introduced Species

There is the potential for a range of introduced species to spread to the area as a result of construction and operational activities, such as the clearing activities, increased traffic movements and waste. Buffel Grass, Birdwood Grass, Mimosa Bush, and Ruby Dock are all considered to be serious environmental weeds in WA (CALM, 1999) and are present in the Development Envelope (Biota, 2021).

The area is not pristine and there are already weeds present. See management measures in Table 5-7 that will be implemented to reduce the risk of introduction or spread of weeds within the Development Envelope.

The Revised Proposal is unlikely to increase the presence or extent of weeds. As such, no significant impacts are expected to occur to native vegetation.

The DBCA *Themeda* grassland TEC Fact Sheet identifies weeds as a threat to the community (DBCA, 2020d). Competition from weeds impacting the *Themeda* grassland TEC may occur in the

Development Envelope. Particularly, invasion from Mimosa Bush has been identified as a threat to the *Themeda* grassland TEC (DBCA, 2020d).

Competition from weeds impacting the "Brockman Iron cracking clay communities of the Hamersley Range" PEC may occur in the Development Envelope.

Given the mitigation measures proposed to avoid the introduction of new or spread of existing weeds, and the existing background level of weeds in the area, the Revised Proposal is not expected to result in a significant increase in weeds in the area. As such, no significant impacts are expected to occur to the PEC or the TEC as a result of introduced species.

One of the main threats to the Fringed Fire-Bush is competition from weeds (Broome Botanical Society, 1995; DAWE, 2021a). Given the mitigation measures proposed to avoid the introduction of new or spread of existing weeds, and the existing background level of weeds in the area, the Revised Proposal is not expected to result in a significant increase in weeds in the area. As such, no significant impacts to the *Seringia exastia* or Priority flora are expected to occur as a result of the introduction or spread of weeds as a result of the Revised Proposal.

5.1.6.3 Impacts in the Context of Ongoing Refinements of Stage 4 of the Revised Proposal

The design of Stage 4 of the Revised Proposal is in the alignment definition phase and is being further refined based on planning, stakeholder consultation and investigations. The alignment, Indicative Disturbance Footprint and Indicative Temporary Clearing Areas are therefore subject to change. Main Roads will however manage these refinements in a manner that ensures the environmental outcomes presented in Section 5.1.7 are achieved.

To confirm that refinements to the alignment (within the Development Envelope) can be made without resulting in a significantly different environmental outcome, Main Roads has undertaken an analysis of the impact of a series of refinements that are currently under consideration. This analysis includes a comparison of the predicted environmental impacts to vegetation, TECs, PECs and threatened and priority flora for the Indicative Disturbance Footprint and two alternate alignments that include minor refinements to the Indicative Disturbance Footprint. Figure 17 shows the Indicative Disturbance Footprint and alternate disturbance footprints in the context of the vegetation mapping.

Table 5-9 and Table 5-10 presents the extent of each vegetation unit and vegetation condition present in the Indicative Disturbance Footprint and alternate disturbance footprints. Table 5-9 shows that while the refinements currently under consideration would result in a slight increase in the total permanent clearing requirements when compared to the Indicative Disturbance Footprint, the total permanent clearing and the total permanent clearing of vegetation in Good to Excellent condition remains with the extents presented within this impact assessment (Section 5.1.6.1.1) which includes an allowance for minor refinements to the Indicative Disturbance Footprint.

Table 5-9 also shows that required clearing of the *Themeda* grasslands TEC (vegetation units C4, C5 and P6) does not differ significantly between the Indicative Disturbance Footprint and alternate disturbance footprints (15 ha, 14.7 ha and 14.7 ha) respectively and minor alignment refinements can be made without significantly changing the outcomes of the impact assessment in relation to TECs. Likewise required clearing of the Brockman Iron PEC (vegetation unit C3) does not differ significantly between the Indicative Disturbance Footprint and alternate disturbance footprints (11.6 ha, 11.7 ha and 11.7 ha) respectively.

The potential refinements do not result in any new priority flora species being impacted or a significant increase in the clearing of priority flora species. The potential refinements also do not result in impacts to the single specimen of Critically Endangered Fringed Fire-bush recorded in the Development Envelope. Any refinement of the alignment will be undertaken in a manner that ensures no impact occurs to threatened flora species.

Refinements to the location, extent and orientation of the Indicative Temporary Clearing Areas may also be required. These refinements will be made such that the environmental outcomes for the Revised Proposal, including the extent of clearing of vegetation in Good to Excellent condition, impacts to TECs and PECs, vegetation of local significance, vegetation associated with drainage lines, groundwater dependent vegetation, banded mulga vegetation and threatened and priority species; remains within the limits described in Table 5-11.

Overall, the analysis shows that minor refinements can be made to the Indicative Disturbance Footprint without significantly altering the environmental outcomes for the Revised Proposal for the environmental factor Flora and Vegetation.

Table 5-9 Comparison of Vegetation Clearing Between Base Case and Alignment Refinements Under Consideration for Stage 4 of the Revised Proposal

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Indicative Disturbance Footprint (ha)	Refinement Case A Disturbance Footprint (ha)	Refinement Case B Disturbance Footprint (ha)
Vegetation of Stony Hillslopes, Hillcrests and Foothills	H1	*Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Triodia wiseana* hummock grassland.	35.0	36.9	36.9
	H2	*Eucalyptus leucophloia subsp. leucophloia, (Corymbia hamersleyana*) low open woodland over mixed Acacia shrubs over *Triodia wiseana* open hummock	0.0	0.0	0.0
	H3	*Eucalyptus leucophloia* subsp. *Leucophloia*, (*Corymbia hamersleyana*) low open woodland over mixed Acacia shrubs over *Triodia wiseana* open hummock grassland	49.1	45.6	45.6
	H4	*Eucalyptus leucophloia* subsp. *Leucophloia* scattered low trees over *E. gamophylla* scattered low mallees over *Triodia wiseana* open hummock grassland and *Eriachne 104hemed as* scattered tussock grasses.	0.2	0.04	0.04
Vegetation of Cracking Clays	C1	*Eriachne benthamii*, *Eragrostis xerophila*, *Astrebla elymoides* very open tussock grassland over *Cynodon convergens* very open bunch grassland.	3.0	2.1	2.1
	C2	*Acacia xiphophylla* low woodland over *Triodia epactia* very open hummock grassland over *Eragrostis xerophila* scattered tussock grasses.	6.5	4.6	4.6
	C3	Mixed *Astrebla* tussock grassland over *Urochloa occidentalis* var. *occidentalis* bunch grassland.	11.6	11.8	11.8
	C4	*hemed asp*. Hamersley Station (M.E. Trudgen 11431) tussock grassland	11.3	11.0	11.0

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Indicative Disturbance Footprint (ha)	Refinement Case A Disturbance Footprint (ha)	Refinement Case B Disturbance Footprint (ha)
	C5	*Eucalyptus victrix* scattered low trees over *Eriachne benthamii*, (*105hemed asp* Hamersley Station (M.E. Trudgen 11431)) very open tussock grassland over mixed open herbland.	0.6	0.6	0.6
Mulga Vegetation	M1	*Acacia aptaneura* (*A. pruinocarpa*) low woodland over *Triodia epactia* (*T. melvillei*) very open hummock grassland over *Chrysopogon fallax* scattered tussock grasses.	15.5	12.7	12.7
	M2	*Acacia ?macraneura*, *A. aptaneura* over *Triodia epactia* scattered hummock grasses.	47.8	54,6	54.6
	M3	*Acacia aneura*/*aptaneura*, (*A ?macraneura*,) low woodland over bunch grasses.	9.4	9.1	9.1
	M4	*Acacia aptaneura*, *A ?macraneura* (*Hakea lorea* subsp. *Lorea*) low open woodland over mixed tussock grasses, bunch grasses and herbs.	5.3	5.2	5.2
Vegetation of Stony Plains and Sloping Plains	P1	*Corymbia deserticola* subsp. *Deserticola*, *C. hamersleyana*, *Eucalyptus leucophloia* subsp. *Leucophloia* low open woodland over *Triodia wiseana* open hummock grassland.	35.1	36.2	36.2
	P2	*Corymbia hamersleyana* low open woodland over mixed Acacia shrubland over *Triodia epactia* hummock grassland.	79.0	80.5	79.5
	P3	*Hakea lorea* subsp. *Lorea* low open woodland over shrubs over *Triodia epactia* very open hummock grassland with *105hemed asp*. Hamersley Station (M.E. Trudgen 11431) very open tussock grassland.	8.3	8.3	8.3

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Indicative Disturbance Footprint (ha)	Refinement Case A Disturbance Footprint (ha)	Refinement Case B Disturbance Footprint (ha)
	P4	*Corymbia hamersleyana* scattered low trees over *Triodia epactia*, (*T. wiseana*) open hummock grassland and *Eulalia aurea* scattered tussock grasses.	0.9	0.0	0.0
	P5	*Eucalyptus xerothermica* low open woodland over *Acacia bivenosa* scattered shrubs over *Triodia angusta* open hummock grassland with mixed tussock grasses.	9.4	9.4	9.4
	P6	*Hakea lorea* subsp. *Lorea* low open woodland over **Vachellia farnesiana* scattered shrubs over *106hemed asp*. Hamersley Station (M.E. Trudgen 11431) tussock grassland.	3.3	3.1	3.1
	P7	*Triodia wiseana* hummock grassland with *Eriachne flaccida* scattered tussock grasses.	0.0	0.2	0.2
	P8	**Vachellia farnesiana* scattered tall shrubs over *Chrysopogon fallax* very open tussock grassland over mixed annual grassland and herbland.	10.7	10.8	10.8
Vegetation of Drainage Lines	D1	*Eucalyptus victrix* (*E. camaldulensis* subsp. *Refulgens*) woodland over *Melaleuca glomerata* tall open shrubland over *Triodia epactia* scattered hummock grasses over mixed tussock grasses and sedges.	16.8	16.9	16.8
	D2	*Eucalyptus camaldulensis* subsp. *Refulgens*, *Melaleuca argentea* open forest over mixed scattered tussock grasses with *Cyperus vaginatus* scattered sedges.	0.1	0.1	0.1
	D3	*Eucalyptus victrix* low open woodland over **Vachellia farnesiana* scattered tall shrubs over mixed tussock grasses and bunch grasses.	3.4	3.2	3.2

Vegetation Type	Vegetation Unit	Vegetation Unit Description	Indicative Disturbance Footprint (ha)	Refinement Case A Disturbance Footprint (ha)	Refinement Case B Disturbance Footprint (ha)
Vegetation of Floodplains	F1	*Corymbia hamersleyana* low open woodland over *Acacia inaequilatera* tall open shrubland over *Triodia wiseana* (*T. epactia*) open hummock grassland with mixed tussock grasses.	120.0	119.4	119.4
	F2	*Corymbia hamersleyana* low woodland over mixed Acacia tall open shrubland over *Triodia wiseana*, (*T. epactia*) open hummock grassland.	34.3	38.5	38.8
	F3	*Corymbia hamersleyana* low open woodland over mixed Acacia open shrubland over *Triodia epactia* very open hummock grassland with *Chrysopogon fallax* very open tussock grassland.	20.1	20.5	19.9
	F4	*Acacia citrinoviridis* low woodland over *Triodia epactia* open hummock grassland and *Chrysopogon fallax* scattered tussock grasses.	3.6	3.5	2.5
	F5	*Corymbia hamersleyana* low open woodland over *Acacia bivenosa* tall shrubland over *Triodia epactia* scattered hummock grasses and **Cenchrus ciliaris* tussock grasses.	2.8	2.8	2.8
Other Mapping Units		Cleared/ Disturbed	8.1	12.7	12.5

Table 5-10 Comparison of Vegetation Condition Between Base Case and Alignment Refinements Under Consideration for Stage 4 of the Revised Proposal

Vegetation Condition	Indicative Disturbance Footprint (ha)	Refinement Case A Disturbance Footprint (ha)	Refinement Case B Disturbance Footprint (ha)
Excellent	292.3	292.4	292.1
Very Good to Excellent	65.0	70.0	70.0
Very Good	174.9	174.5	173.8
Good to Very Good	7.0	7.1	7.1
Good	4.0	4.7	4.7
Good to Poor	0.0	0.0	0.0
Poor	00	0.0	0.0
Completely degraded	0.0	3.8	3.7
Cleared	8.1	8.9	8.8

5.1.7 Predicted Outcome

5.1.7.1 Environmental Outcomes

Table 5-11 details of the predicted environmental outcomes of the current Approved Proposal and Revised Proposal for Flora and Vegetation.

It should be noted that the CER for the Approved Proposal was prepared in 2003 and the EPA finalised its decision report in 2005. Requirements in environmental impact assessment have progressed significantly since the early 2000's and the EPA has released and updated a series of technical guidance with respect to the preparation of ERDs, the undertaking of biological surveys and the assessment of technical factors. Given this, direct comparison between the Approved Proposal and Revised Proposal is not possible in all cases. Note also that the wording of the environmental outcome may be different between the Approved Proposal and Revised Proposal so as to be consistent with current EPA guidance.

Table 5-11 Environmental Outcomes for the Revised Proposal – Flora and Vegetation

Element	Approved Proposal	Proposed Changes	Revised Proposal
Disturbance Area	Clearing and disturbance of no more than 574 ha – of this no less than 137 ha will be rehabilitated following 250 ha of this disturbance was planned for Stage 4 but has been cleared as part of Stages 2 and 3.	• Additional clearing and disturbance of no more than 665 ha within a Development Envelope (Figure 2) of 7,142 ha located within the Stage 4 Section, of which no less than 100 ha will be rehabilitated. • Limit permanent clearing of vegetation in Good to Excellent condition within the Development Envelope to 550 ha.	• No more than 1,239 ha will be cleared of which no less than 237 ha will be rehabilitated. • All clearing and disturbance for Stage 4 of the Proposal is to be confined within a Development Envelope (Figure 2) of 7,142 ha. • No more than 650 ha of vegetation in Good to Excellent condition will be cleared within the Stage 4 Development Envelope of which at least 100 ha will be rehabilitated.
Clearing within Millstream-Chichester National Park	145 ha.	No change.	• No more than 145 ha of the Millstream-Chichester National Park will be cleared.
Pre-European Vegetation Associations	No vegetation types would be reduced to below the 'threshold level' of 30% of their pre-clearing extent.	No change.	• No vegetation types will be reduced to below the 'threshold level' of 30% of their pre-clearing extent.
Threatened Ecological Communities	Disturbance of up to 17.5 ha.	• Reduce clearing and disturbance of *Themeda* Grasslands TEC by 2.5 ha.	• No more than 15 ha of the *Themeda* Grasslands TEC will be cleared.

Element	Approved Proposal	Proposed Changes	Revised Proposal
	Impact of change to sheet flow identified as potential risk but not quantified.	• Add - No impacts on TECs will occur outside of the Development Envelope. • Add - No indirect impacts on TECs will occur.	• No impacts on TECs will occur outside of the Development Envelope. • No indirect impacts on TECs will occur.
Priority Ecological Communities	Not identified in CER.	• Addition of up to 12 ha of clearing of the Brockman Iron Cracking Clay Communities of the Hamersley Range PEC. • Add - No impacts on PECs will occur outside of the Development Envelope. • Add - No indirect impacts on PECs will occur.	• No more than 12 ha of the Brockman Iron Cracking Clay Communities of the Hamersley Range PEC will be cleared. • No impacts on PECs will occur outside of the Development Envelope. • No indirect impacts on PECs will occur.
Vegetation of local significance	Not identified in CER.	• Add - for Stage 4, clearing and disturbance of vegetation type C2 will be limited to 15.1 ha of which 8.6 ha is temporary clearing which will be rehabilitated and clearing and vegetation type M1 and M2 (combined) will be limited to 77.5 ha of which 14.3 ha is temporary clearing that will be rehabilitated. • Add - No impacts on vegetation of local significance will occur outside of the Development Envelope. • Add - No indirect impacts on vegetation of local significance will occur.	• For Stage 4, clearing and disturbance of vegetation type C2 will be limited to 15.1 ha of which 8.6 ha is temporary clearing which will be rehabilitated and clearing and vegetation type M1 and M2 (combined) will be limited to 77.5 ha of which 14.3 ha is temporary clearing that will be rehabilitated • No impacts on vegetation of local significance will occur outside of the Development Envelope. • No indirect impacts on vegetation of local significance will occur.
Vegetation associated with drainage lines	Not identified in CER.	• Add - for Stage 4, clearing and disturbance of vegetation associate with drainage lines will be limited to 30 ha. • Add - No impacts on vegetation of local significance will occur	• No more than 30 ha of vegetation associated with drainage lines will be cleared. • No impacts on vegetation associated with drainage lines will occur outside of the Development Envelope.

Element	Approved Proposal	Proposed Changes	Revised Proposal
		outside of the Development Envelope. • Add - No indirect impacts on vegetation of local significance will occur.	• No indirect impacts on vegetation associated with drainage line will occur.
Groundwater dependent vegetation	Not identified in CER.	• Add - No indirect impacts on groundwater dependent vegetation will occur.	• No indirect impacts on groundwater dependent vegetation will occur.
Banded mulga vegetation	Impact of change to sheet flow identified as potential risk but not quantified.	• Add - No indirect impacts on banded mulga vegetation will occur.	• No indirect impacts on banded mulga vegetation will occur.
Fringed Fire-bush	Not identified in CER	• Add - No clearing will occur in the exclusion zone around the single Fringed Fire-bush plant identified within the Stage 4 Development Envelope will occur.	• No clearing will occur in the exclusion zone around the single Fringed Fire-bush plant identified within the Stage 4 Development Envelope will occur.
Priority flora species	Clearing of individuals of two Priority flora species: • *Themeda* sp. Hamersley Station pn (P3); and • *Ishaemum albovilliosum* (sic) (P2).	Additional clearing of individuals of four Priority flora flora species: • *Euphorbia australis* var. glabra (P3); • *Sida* sp. Hamersley Range (K. Newbey 10692) PN(P3); • *Eremophila magnifica* subsp. Magnifica (P4); and • *Goodenia nuda* (P4). Removal of *Ischaemum albovillosum* which is no longer a priority specie[12]	Clearing Priority flora to be limited to individuals of five Priority flora species as follows: • *Euphorbia australis* var. glabra (P3); • *Sida sp.* Hamersley Range (K. Newbey 10692) PN (P3); • *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) (P3); • *Eremophila magnifica* subsp. Magnifica (P4); and • *Goodenia nuda* (P4).
Weeds	Management measures will be sufficient to reduce the risks of weed spread to an acceptable level.	No introduction of weeds into Stage 2 and 3 Project Area or Stage 4 Development Envelope.	No introduction of weeds into Stage 2 and 3 Project Area or Stage 4 Development Envelope.

[12] I*schaemum albovillosum* (P2) is no longer a priority species. This species was identified in the CER as being present in the Abydos Plain in the northern part of the route which is outside of the Stage 4 Development Envelope.

5.1.7.2 Summary of Assessment of Significant Residual Impacts

The following significant residual impacts are predicted to occur as a result of the Revised Proposal. Impacts associated with the completed Stage 2 and 3 have been offset in accordance with the implementation conditions for the Approved Proposal. The significant residual impacts to flora and vegetation resulting from Stage 4 of the Revised Proposal will be offset, as outlined in Section 6.

- permanent clearing of 437 ha of vegetation for Stage 2 and 3 of the Revised Proposal. This clearing has been offset in accordance with the implementation conditions for the Approved Proposal;
- permanent clearing of up to 550 ha of Good to Excellent condition vegetation for Stage 4 of the Revised Proposal;
- temporary clearing of up to 100 ha of Good to Excellent condition vegetation which will be rehabilitated for Stage 4 of the Revised Proposal;
- clearing of 15 ha of the *Themeda* Grasslands TEC (all within Stage 4); and
- clearing of up to 12 ha of the Brockman Iron Cracking Clays PEC (all within Stage 4).

Other potential direct and indirect impacts to flora and vegetation associated with the Revised Proposal will not be significant at the local or regional scale as the vegetation associations are well represented in the region. Given the small extent of the proposed clearing of vegetation identified as being locally significant, this clearing will not result in a significant residual impact. Clearing of Priority flora species are also not considered to be significant at the local or regional scale given the small extent of clearing of these species and the wide distribution and number of known records of these species.

5.1.7.3 Assessment against EPA's Environmental Objective

While there is expected to be a change in the extent/magnitude of impact of the Revised Proposal when compared to the Approved Proposal, the overall significance of the impact is unlikely to be greater than that identified for the Approved Proposal, particularly as significant residual impacts will be offset.

Main Roads will implement the Revised Proposal so as to achieve the environmental outcomes outlined in Table 5-11 and will offset all significant residual impacts. Doing so will ensure that the Revised Proposal avoids and minimises impacts to flora and vegetation as far as reasonably practicable.

This avoidance and minimisation of impacts, together with the offsetting of significant residual impacts will result in the biological diversity and ecological integrity of the study area being preserved, meaning that the Revised Proposal is consistent with the EPA's environmental objective for Flora and Vegetation.

Assurance of achievement of the environmental outcomes is via:

- the proposed implementation conditions for the Revised Proposal detailed in Section 6 which are outcome-based conditions which mandate where an impact must be avoided, where a level of impact must not be exceeded or where a level of environmental protection must be met; or
- regulation by other DMAs approval, permitting and licensing requirements (i.e. 26D and 5C licenses under the RIWI Act).

5.2 Terrestrial Fauna

5.2.1 EPA Objective

The WA EPA defines terrestrial fauna as 'animals living on land or using land (including aquatic systems) for all or part of their lives' (EPA, 2016c).

The WA EPA objective for the terrestrial fauna environmental factor is 'To protect terrestrial fauna so that biological diversity and ecological integrity are maintained'.

5.2.2 Policy and Guidance

The following EPA policies and guidelines have been considered for Stage 4 of the Revised Proposal in order to meet the EPA's objective in relation to this factor:

- Statement of *Environmental Principles, Factors and Objectives* (EPA, 2020a);
- *Environmental Factor Guideline – Terrestrial Fauna* (EPA, 2016c);
- *Technical Guidance – Terrestrial Fauna Surveys* (EPA, 2020b);
- *EPA Strategic Advice for Cumulative Environmental Impacts of Development in the Pilbara Region* (EPA, 2014);
- EPBC Act referral guideline for the endangered northern quoll (DoE, 2016);
- Survey Guidelines for Australia's Threatened Birds (DEWHA, 2010a);
- Survey Guidelines for Australia's Threatened Bats (DEWHA, 2010b); and
- Survey Guidelines for Australia's Threatened Mammals (DSEWPaC, 2011).

The Environmental Factor Guideline has been considered during the identification of fauna values within the Development Envelope and the issues identified in the guideline considered in relation to potential impacts from Stage 4 of the Revised Proposal.

Fauna surveys for Stage 4 of the Revised Proposal have been planned and executed in accordance with the EPA's technical guidance for this factor. Any survey limitations relative to the technical guidance are noted in the fauna survey report.

5.2.3 Receiving Environment

5.2.3.1 Stage 4 Surveys and Studies

The following surveys and investigations in relation to terrestrial fauna were undertaken to inform the ERD:

- A desktop fauna assessment was undertaken for Stage 4 of the Revised Proposal by Biota (2021), which included database searches (PMST and NatureMap) and review of DBCA records and relevant existing survey reports. The Development Envelope and surrounding areas have been well surveyed historically with nine surveys undertaken between 2007 and 2017 in the region, which were reviewed as part of the desktop assessment. These were:
  - Karratha Tom Price Road (K-TP3 and KTP4a to Rio Access) Northern Quoll Reconnaissance Survey (GHD, 2017);

- Red Hill Campground (Biota, 2016);
- West Turner Syncline Section 10 Below Water Table and Satellite Ore Bodies Targeted Terrestrial Fauna Survey (Biota, 2015);
- Solomon Hub Vertebrate Fauna Assessment (Ecologia, 2014a);
- Stingray project Terrestrial Vertebrate Fauna Assessment (Ecologia, 2014b);
- Central Pilbara project - Mine Vertebrate Fauna Assessment (Ecologia, 2012);
- A Two Phase Fauna Survey of the Hamersley Agriculture project (Biota, 2011);
- Tom Price Power Line West Detritals: Two-phase fauna survey (Biota, 2009); and
- Rio Tinto Rail Duplication Fauna Assessment: Bellbird Siding to Juna Downs (Biota, 2008).

- A basic and targeted fauna survey for Stage 4 of the Revised Proposal providing up to date and accurate information on the species of conservation significance and broad characteristics of the fauna assemblages (Biota (2021)). This fauna survey was completed between 17 April and the 31 May 2020. Survey methods included; diurnal and nocturnal foot traverses of potential habitat to search for individuals and secondary evidence; the use of ultrasonic and audible automated recording units to record bird and bat calls, motion cameras; and unmanned aerial vehicles.
- A reconnaissance survey for the Northern Quoll was completed over an area that includes the northern portion of the Development Envelope between 26 and the 31 July 2017. The survey used motion sensor camera trapping and visual habitat assessments (GHD,2017).
- A desktop short range endemic (SRE) fauna assessment was undertaken for Stage 4 of the Revised Proposal by Biota (2022).

The Biota (2021) survey report is provided in Appendix A.2. The Biota (2022) desktop SRE fauna report is provided in Appendix A.3.

5.2.3.2 Fauna Species

The desktop study and fauna surveys have been used to determine the likelihood of occurrence of each species in the Development Envelope and surrounding area. The likelihood of occurrence assessment is based on available desktop and survey information, the known distributions and habitat preferences for each species (Biota, 2021) and the proximity of known records. A likelihood of occurrence assessment for those BC Act listed species identified by NatureMap and/or DBCA records as potentially occurring within the study area, and/or having previously being recorded within the study area, is provided in Appendix A.2.

The desktop assessment (Biota 2021) identified a total of 305 vertebrate fauna species with the potential to occur in the survey area. Thirty-one of these species are listed as conservation significant. As the survey area does not encompass any marine habitats, these taxa were not considered further in the assessment. The consolidated potential species list is provided in the Biota (2021) report (Appendix A.2).

During the Biota (2021) field survey, a total of 110 native vertebrate fauna species were recorded within the survey area. In addition, secondary evidence (long extinct nest relics) of the Lesser Stick-nest Rat (extinct on the mainland) was recorded. The Lesser Stick-nest Rat was not included in the species list and total counts for the field survey due to its extinct status.

Based on the survey findings, previous records from the study area, and an assessment of habitat within the survey area, the following significant species were recorded, are likely to occur in the Development Envelope or may occur in the Development Envelope. These species are:

Recorded:

- Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia* Pilbara form) - Vulnerable;
- Ghost Bat (*Macroderma gigas)* - Vulnerable;
- Grey Falcon (*Falco hypoleucos)* – Vulnerable; and
- Western Pebble-mound Mouse (*Pseudomys chapmani)* – Priority 4.

Likely to Occur:

- Peregrine Falcon (*Falco peregrinus*) – Other Specially Protected Fauna;
- Fork-tailed Swift (Apus pacificus) - Migratory;
- Northern Quoll (*Dasyurus hallucatus*) – Endangered;
- Northern Short-tailed Mouse (*Leggadina lakedownensis*) – Priority 4;
- Pilbara Olive Python (*Liasis olivaceus barroni*) – Vulnerable; and
- Lined Soil-crevice Skink (Dampier) (*Notoscincus butleri*) - Priority 4;

May Occur:

- Night Parrot (*Pezoporus occidentalis*) – Critically Endangered;
- Oriental Pratincole (*Glareola maldivarum*) – Migratory;
- Oriental Plover (*Charadrius veredus*) - Migratory;
- Common Sandpiper (*Actitis hypoleucos*) - Migratory;
- Long-tailed Dunnart (*Sminthopsis longicaudata*) – Priority 4;
- Gane's Blind Snake (*Anilios ganei*) - Priority 1;
- Pilbara Barking Gecko (*Underwoodisaurus seorsus*) - Priority 2; and
- Spotted Ctenotus (northeast) (*Ctenotus uber johnstonei*) - Priority 2.

Several of the migratory bird species listed above are considered likely to occur or may occur within the Development Envelope and/or immediate surrounds due to their migratory nature. These species are primarily expected to occur transitionally through the Development Envelope and would not be dependent upon the habitats present, and therefore are unlikely to be significantly impacted by the Revised Proposal. In addition, the Development Envelope is not located close to any internationally or nationally important sites for these species. Given this, these species (Fork-tailed Swift, Oriental Pratincole, Oriental Plover and Common Sandpiper) are not considered further in this assessment.

5.2.3.3 Fauna Habitats

Biota (2021) mapped twelve fauna habitat types in the Development Envelope. The habitats aligned broadly with the landforms, with some isolated habitats that support specific fauna assemblages. Each of these habitat types are common and widespread in the Pilbara region.

Table 5-12 shows the habitat types found in the Development Envelope, which significant fauna are likely to be associated with each habitat type, and the extent of each habitat type in the Development Envelope and Indicative Disturbance Footprint. Most of the fauna species of significance would be associated with the rocky habitats of the Hamersley Range section (habitat types mesas, caves, cliffs and free faces, rocky hills and slopes with low open spinifex and scattered trees, eucalyptus fringed major drainage lines and associated tributaries, melaleuca forest/major drainage lines and rocky gullies).

The estimated extent of suitable habitat within the Pilbara region for threatened fauna that are known to occur, likely to occur or that may occur in the Development Envelope has been estimated based on land systems within the species distribution. That is, areas where it is considered the species is likely to or may occur based on spatial data from DAWE, that contain habitats similar to those identified by Biota (2021) in the Development Envelope. While this approach may not provide the full extent of suitable habitat for each species (as there are likely to be habitats not present within the Development Envelope that are also suitable), it does provide context with respect to the regionally available habitat. The extent of habitat for each species in the Pilbara region is provided in Table 5-13. Note that areas do not total the same size as the Indicative Disturbance Footprint and Indicative Temporary Clearing Areas due to the presence of existing cleared areas that are not classified as fauna habitat.

Table 5-12 Fauna Habitats in the Development Envelope and BC Act listed Fauna Associations (Biota, 2021)

Habitat	Description	Significant fauna association with habitat	Extent of habitat within the Indicative Disturbance Footprint (ha)	Extent of habitat within the Indicative Temporary Clearing Area (ha)	Extent of habitat within the Development Envelope (ha)
MG - Grove Mulga	Bands of *Acacia aneura* woodland over mixed shrubs over *Triodia melvillei/Triodia epactia* and annual herbs, alternating with bare ground.	Supporting habitat: • Grey Falcon (foraging); and • Peregrine Falcon (foraging).	69.7	14.4	666.2
MWP - Mulga woodland plain	*Acacia aneura* open woodland plains over scattered shrubs over. *Triodia* spp open hummock grassland.	Supporting habitat: • Grey Falcon (foraging); and • Peregrine Falcon (foraging).	16.1	0.5	122.5
ASCC - *Acacia xiphophylla* shrublands over cracking clay.	*Acacia xiphophylla* low woodland over *Triodia epactia* open hummock grassland with cracking clay substrate.	Supporting habitat: • Grey Falcon (foraging); • Peregrine Falcon (foraging); and • Spotted Ctenotus (foraging).	10.4	9.3	328.9
ASM - Mixed Acacia shrublands	*Corymbia* trees with mixed *Acacia* shrublands over *Triodia epactia* and stony substrates.	Supporting habitat: • Grey Falcon (foraging); • Peregrine Falcon (foraging); and • Western Pebble-mound Mouse (foraging, nesting).	157.5	31.7	1,659.2

Habitat	Description	Significant fauna association with habitat	Extent of habitat within the Indicative Disturbance Footprint (ha)	Extent of habitat within the Indicative Temporary Clearing Area (ha)	Extent of habitat within the Development Envelope (ha)
GPCC - Grassland plains with cracking clay	*Themeda* grassland in the south and in the north, *Astrebla* grasslands, both with crackling clay substrates	Supporting habitat: • Grey Falcon (foraging); • Peregrine Falcon (foraging); • Night Parrot (foraging); and • Northern Short-tailed Mouse (foraging, nesting).	29.3	0.0	203.4
CP - Floodplain	*Corymbia hamersleyana*/ *Eucalyptus victrix* low open woodland over mixed *Acacia* shublands over scattered *Triodia* hummock grasses and mixed tussock grasses.	Supporting habitat: • Ghost Bat (foraging); • Pilbara Olive Python (foraging); • Grey Falcon (foraging); and • Peregrine Falcon (foraging).	135.0	43.9	1,778.6
HS - Mesas, caves, cliffs and free faces	*Eucalyptus leucophloia* over mixed acacia scattered-open shrubland over *Triodia wiseana*/ *Triodia epactia* hummock grassland.	Habitat considered to be habitat critical to the survival of the species (Hill and Ward 2010) for: • Northern Quoll (denning). Supporting habitat: • Pilbara Leaf-nosed Bat (potential roosting habitat, foraging); • Ghost Bat (roosting, foraging);	0.14	0.0	8.4

Habitat	Description	Significant fauna association with habitat	Extent of habitat within the Indicative Disturbance Footprint (ha)	Extent of habitat within the Indicative Temporary Clearing Area (ha)	Extent of habitat within the Development Envelope (ha)
		• Pilbara Olive Python (foraging); • Grey Falcon (foraging); • Peregrine Falcon (foraging); • Long-tailed Dunnart (foraging); and • Pilbara Barking Gecko (foraging).			
RHS – Rocky hills and slopes with low open spinifex and scattered trees	*Eucalyptus leucophloia* over mixed acacia scattered-open shrubland over *Triodia wiseana/Triodia epactia* hummock grassland.	Supporting habitat: • Northern Quoll (foraging, dispersal); • Pilbara Leaf-nosed Bat (foraging); • Ghost Bat (foraging); • Pilbara Olive Python (foraging); • Grey Falcon (foraging); • Peregrine Falcon (foraging); • Western Pebble-mound Mouse (foraging, nesting); • Long-tailed Dunnart (foraging); and	88.7	0.0	702.1

Habitat	Description	Significant fauna association with habitat	Extent of habitat within the Indicative Disturbance Footprint (ha)	Extent of habitat within the Indicative Temporary Clearing Area (ha)	Extent of habitat within the Development Envelope (ha)
		• Pilbara Barking Gecko (foraging)			
MDE – Eucalyptus fringed major drainage lines and associated tributaries	*Open Eucalyptus victrix*/*Eucalyptus camaldulensis*	Supporting habitat: • Pilbara Leaf-nosed Bat (foraging); • Pilbara Olive Python (foraging); • Grey Falcon (nesting, foraging); • Peregrine Falcon (foraging); • Northern Quoll (foraging, dispersal); • Ghost Bat (foraging, drinking); and • Lined Soil-crevice Skink (foraging).	75.5	0.0	1,233.1
MDM - Melaleuca forest/major drainage lines	Melaleuca argentea and Mel glomerate over *Acacia bivenosa* and *Cyperus vaginatus*, with ephemeral pools.	Supporting habitat: • Pilbara Leaf-nosed Bat (foraging, flyway, drinking); • Grey Falcon (nesting, foraging); • Peregrine Falcon (foraging);	0.03	0.0	21.2

Habitat	Description	Significant fauna association with habitat	Extent of habitat within the Indicative Disturbance Footprint (ha)	Extent of habitat within the Indicative Temporary Clearing Area (ha)	Extent of habitat within the Development Envelope (ha)
		• Northern Quoll (foraging, dispersal); • Ghost Bat (foraging, flyway, drinking); • Pilbara Olive Python (foraging); and • Lined Soil-crevice Skink (foraging).			
RG - Rocky gullies	*Eucalyptus leucophloia* and *Corymbia ferriticola* over mixed *Acacia spp.* (including A. *bivenosa*) over *Triodia epactia* open hummock grassland.	Habitat considered to be habitat critical to the survival of the species (Hill and Ward 2010): • Northern Quoll (denning). Supporting habitat: • Northern Quoll (foraging, dispersal); • Pilbara Leaf-nosed Bat (foraging); • Ghost Bat (foraging); • Pilbara Olive Python (foraging); • Grey Falcon (foraging); • Peregrine Falcon (foraging);	3.8	0.0	13.7

Habitat	Description	Significant fauna association with habitat	Extent of habitat within the Indicative Disturbance Footprint (ha)	Extent of habitat within the Indicative Temporary Clearing Area (ha)	Extent of habitat within the Development Envelope (ha)
		• Long-tailed Dunnart (foraging); and • Gane's Blind Snake (foraging).			
MMW - Man-made water bodies	*Dams etc*	Supporting habitat: • Ghost Bat (drinking); • Grey Falcon (drinking, foraging); and • Peregrine Falcon (drinking, foraging).	0.14	0.0	2.3

Table 5-13 Threatened Fauna Habitat Extent

Species / habitat type	Habitat extent within Development Envelope (ha)	Estimated habitat extent in Pilbara region (ha)	Percent of estimated Pilbara habitat within Development Envelope
Northern Quoll – habitat critical to the survival of a species	22.1	8,786,246	0.022%
Northern Quoll – supporting habitat	1,956.4		
Pilbara Leaf-Nosed Bat – supporting habitat	1,978.5	8,176,685	0.024%
Ghost Bat – supporting habitat	3,759.4	9,304,536	0.040%
Pilbara Olive Python – supporting habitat	3,757.1	8,741,003	0.043%
Night Parrot – supporting habitat	203.4	669,982	0.030%
Grey Falcon – supporting habitat	6,739.6	17,823,126*	0.038%

*Spatial data not available. Supporting habitat likely extends throughout the entire Pilbara region of 17,823,126 ha

5.2.3.4 Threatened Fauna

Threatened fauna are protected under the BC Act and/or the EPBC Act. These species are in need of conservation and are given a ranking ranging from Critically Endangered to Vulnerable. Threatened fauna recorded during the Biota (2021) survey, are likely to occur or may occur in the Development Envelope are discussed in the following sections. Information about each species including species presence, is discussed in the context of potential habitat extents within the Development Envelope.

5.2.3.4.1 Northern Quoll (*Dasyurus hallucatus*)

Species Background Information

The Northern Quoll is listed as Endangered under the BC Act and occurs in Queensland, the Northern Territory and Western Australia. It has previously occurred across most of the northern third of Australia, but its range has significantly declined over the past century and is now restricted to six areas within Australia, two of which are in WA in the northwest Kimberley and the Pilbara (Braithwaite and Griffiths, 1994). Analyses indicate genetic disjunction between populations across Australia, even between the populations in the Pilbara and Kimberley (Hill and Ward, 2010). Henderson (2015) found during a study into the effects of mining infrastructure on Northern Quoll movement and habitat, that the mean home range was 58 ha for males and 13 ha for females.

In the Pilbara, the distributional boundaries of the Northern Quoll are defined in the north, east and south by the Great Sandy Desert, Gibson Desert and Little Sandy Deserts. The distribution of Northern Quolls in the Pilbara is fragmented, and the species is mostly confined to ironstone formations (such as those found in the Hamersley section of Stage 4 of the Revised Proposal), some river systems and

the Burrup Peninsula and adjacent offshore islands. Records from the Pilbara bioregion are scattered across the four subregions (namely the Hamersley, Fortescue Plains, Chichester and Roebourne Plains subregions), with records extending as far west as the Little Sandy Desert (How et al., 2009) and as far south as Karijini National Park (Figure 25).

Northern Quolls do not have highly specific habitat requirements and occur in a variety of habitats across their range (Hill and Ward, 2010). They are most abundant in rocky terrain, which is shown to support higher population densities and longer-lived individuals (Burnett, 1997; Oakwood, 2000). They use a range of micro-habitats for foraging and denning such as gorges, breakaways and hills, and also occur near creek lines and drainage lines, where adjacent plains and vegetated areas provide habitats for foraging and dispersal of young (van Dyck and Strahan, 2008). Northern Quoll dens are often made in rock crevices, with surrounding vegetated habitats used for foraging and dispersal. Den sites may also include tree holes, logs, termite mounds, and goanna burrows, but these are used less often than rocky habitats (van Dyck and Strahan, 2008). In the Pilbara, Northern Quolls occur in rocky mesa habitats situated near dense vegetation along drainage areas (Biota, 2021) and boulder tors of the Abydos-Woodstock Plain (How et al., 1991). These habitats are common within the Pilbara region, with vast amounts being vested in National Parks in the region including the adjacent Millstream-Chichester National Park.

The abundance of the Northern Quoll has declined since European settlement with the species contracting to a small number of geographic regions across northern Australia. While there are no overall assessments of the Northern Quoll population size available, the 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' identifies a number of important populations for this species, including the populations in the Pilbara region of WA where the Revised Proposal is located (Hill and Ward, 2010).

Species Prescence

Distribution modelling of the Northern Quoll shows Stage 4 of the Revised Proposal is located within an area where the species is known or likely to occur; particularly in the Hamersley Range where approximately 40 km (200 ha) of Stage 4 of the Revised Proposal is located (DAWE, 2021b). No observations or secondary evidence (such as scats or tracks) of the Northern Quoll were recorded during the Biota (2021) survey. Naturemap has 152 records within 18 km of the Development Envelope, the closest being 4.8 km from the Development Envelope and the most recent being from 2018 (Biota, 2021, Figure 25). There is excellent quality habitat for the species both within the Development Envelope and contextual area, particularly along drainage lines and surrounding rocky areas within the Hamersley Ranges.

No observations or secondary evidence of the Northern Quoll were recorded during the Biota (2021) survey. However, the species has been recorded previously within proximity to the Development Envelope and there is suitable habitat that the species may use within the Development Envelope and surrounding areas, particularly along drainage lines and surrounding rocky areas within the Hamersley Ranges. Given this, the Northern Quoll is considered likely to occur in the Development Envelope.

Species Habitat Extent

The extent of potential Northern Quoll habitat types present in the Development Envelope is shown in Table 5-14. The distribution of these habitats is shown in Figure 19. These habitat types are common within the Pilbara region (estimated extent >8.7 million ha) with vast amounts being vested in

National Parks in the region, including the Millstream-Chichester National Park adjacent to Stage 2 and Stage 3 of the Revised Proposal.

Table 5-14 Northern Quoll Habitat Types in the Development Envelope

Habitat type	Extent in Development Envelope (ha)
HS - Mesas, caves, cliffs and free faces	8.4
RHS - Rocky hills and slopes with low open spinifex and scattered trees	702.1
MDE - Eucalyptus fringed major drainage lines and associated tributaries	1,233.1
MDM - Melaleuca forest/major drainage lines	21.2
RG - Rocky gullies	13.7
Total	1,978.5

Species Habitat Importance

The Northern Quoll habitat present in the Development Envelope represents denning, foraging and dispersal habitat for the species. Of the suitable habitats present, the mesas, caves, cliffs and free faces and rocky gullies habitat types are suitable for denning. These represent only a small proportion of the suitable habitat present in the Development Envelope (1.1%). Given this, any Northern Quolls present in the Development Envelope are more likely to be using the area primarily for foraging and dispersal. Any individual Northern Quolls that use the denning habitat in the Development Envelope may have some level of reliance on those habitats, but Northern Quolls are unlikely to be restricted to the habitat present in the Development Envelope.

Habitat critical to the survival of for the Northern Quoll is defined as habitat within the modelled distribution of the species which provides shelter for breeding, refuge from fire / or predation and potential poisoning from Cane Toads (DoE, 2016). Habitat critical to the survival of the species usually occurs in the form of (Hill and Ward, 2010):

- rocky habitats such as ranges, escarpments, mesas, gorges, breakaways, boulder fields, major drainage lines or treed creeklines;
- structurally diverse woodland or forest areas containing large diameter trees, termite mounds or hollow logs; and
- offshore islands where the Northern Quoll is known to exist.

The following habitat types are rocky habitats within the Development Envelope considered to represent habitat critical to the survival of the Northern Quoll (Biota, 2021):

- Mesas, caves, cliffs and free faces; and
- Rocky gullies.

There is a total of 4.0 ha of habitat critical to the survival of the Northern Quoll within the Indicative Disturbance Footprint. There is no habitat critical to the survival of the Northern Quoll within the Indicative Temporary Clearing Areas.

The EPBC Act referral guideline for the Northern Quoll (DoE, 2016) also identifies dispersal and

foraging habitat associated with or connecting populations considered 'important for the long-term survival of the northern quoll' (high density populations within habitat critical to the survival of the species, populations in habitats free of cane toads and populations subject to ongoing conservation or research actions) as habitat critical to the survival of the northern quoll.

The guideline identifies foraging or dispersal habitat to be any land comprising predominantly native vegetation in the immediate area (i.e. within 1 km) of shelter habitat. Given this, Northern Quoll habitat within 1 km of the habitat identified as habitat critical to the survival of the Northern Quoll is considered to be important habitat for the species. There is 42.3 ha of this habitat within the Indicative Disturbance Footprint. This area is not considered to be habitat critical to the survival of the species as it does not meet the criteria of connecting high density populations or populations subject to ongoing conservation or research activities. None of this habitat is within the Indicative Temporary Clearing Areas.

Given the low density of Northern Quolls in the area and the widely available nature of Northern Quoll foraging and dispersal habitat in the region, the foraging and dispersal habitat in the Development Envelope more than 1 km from habitat critical to the survival of the species) is not considered to be of high importance to Northern Quolls.

5.2.3.4.2 Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*)

Species Background Information

The Pilbara Leaf-nosed Bat is listed as Vulnerable under the BC Act. It occurs over an approximate area of 120 million ha in the Pilbara bioregion, extending southwards into the northern half of the Gascoyne bioregion (DAWE, 2021c). It occurs in three sub-populations (eastern Pilbara, Hamersley Range and upper Gascoyne), which are separated by flat areas such as the Fortescue and Ashburton valleys (Armstrong, 2013, 2001). The Pilbara Leaf-nosed Bat is endemic to the Pilbara and Ashburton regions, which are separated from the main tropical populations of the Orange Leaf-nosed Bat by the unsuitable habitat of the Great Sandy Desert (Biota, 2021). The Pilbara Leaf-nosed Bat represents one interbreeding biological population comprising multiple colonies and is considered to be an important population (TSSC, 2016).

The Pilbara Leaf-nosed Bat is a poor thermoregulator, exhibiting evaporative water loss of more than double that of other bats (Churchill, 2008). Therefore, it is reliant on deep caves and underground mines for roosts, especially in the Pilbara (Armstrong, 2001). Its persistence in the Pilbara depends heavily on the presence of physiologically benign, humid and temperature-stable caves and dis-used mines. These sites provide the necessary narrow temperature and humidity conditions for the species, which range from 28ºC to 32ºC and 96 to 100 percent relative humidity (Churchill, 2008). The species forages in *Triodia* hummock grassland, sparse tree and shrub savannah and riparian vegetation along drainage lines. Other foraging habitat used by the species includes gorges with pools, gullies, rocky outcrops, major watercourses and open grassland and woodland (TSSC, 2016).

The Pilbara Leaf-nosed Bat's foraging height of less than three metres makes it vulnerable to collision with cars and many records of the species are from road kills (DAWE, 2021c). The species displays a curiosity for light sources (DAWE, 2021c) and may be attracted to head lights (Armstrong, 2013).

Species Prescence

During the Biota (2021) field survey, Pilbara Leaf-Nosed Bat calls were recorded using ultrasonic acoustic recording units at two locations within the Development Envelope. These records included:

- Call recordings on two occasions (on consecutive evenings) in the eucalyptus fringed major drainage lines and associated tributaries habitat towards the northern end of the Development Envelope; and
- Call recoding on one occasion in mulga grove habitat towards the southern end of the Development Envelope.

These calls were recorded in habitat types suitable for foraging. While no caves suitable for roosting were recorded in the Development Envelope, the call recordings from the Biota (2021) field survey suggest that there is likely one or more unknown roosts in the vicinity of the Development Envelope. This shows that a population of Pilbara Leaf-nosed Bats uses the Development Envelope and surrounding areas for foraging, and there are likely active roost caves within 15-20 km of the Development Envelope.

Species Habitat Extent

The extent of the potential Pilbara Leaf-Nosed Bat habitat present in the Development Envelope is shown in Table 5-15. The distribution of these habitats is shown in Figure 20. These habitat types are common within the Pilbara region (estimated extent >8.1 million ha) with vast amounts being vested in National Parks, including the Millstream-Chichester National Park adjacent to Stage 2 and Stage 3 of the Revised Proposal. Extensive suitable foraging habitat is available within an approximately 20 km radius of the Development Envelope (Biota, 2021).

Table 5-15 Pilbara Leaf-nosed Bat Habitat Types in the Development Envelope

Habitat type	Extent in Development Envelope (ha)
HS - Mesas, caves, cliffs and free faces	8.4
RHS - Rocky hills and slopes with low open spinifex and scattered trees	702.1
MDE - Eucalyptus fringed major drainage lines and associated tributaries	1,233.1
MDM - Melaleuca forest/major drainage lines	21.2
RG - Rocky gullies	13.7
Total	1,978.5

Species Habitat Importance

The conservation advice for the species identifies permanent diurnal roosts, non-permanent breeding roosts and transitory diurnal roosts as habitat critical to the survival of the Pilbara Leaf-nosed Bat. Nocturnal refuges are not considered habitat critical to the survival of the species but are considered important for local persistence in the area (TSSC, 2016). As no suitable roosting caves have been identified within the Development Envelope, no habitat critical to the survival of the species (as defined by the conservation advice) has been identified within the Development Envelope.

Foraging habitat is also important for sustaining populations including gorges with pools, gullies, rocky outcrops, major watercourses, and open grassland and woodlands. Foraging habitat types in the Development Envelope include:[13]

- Mesas, caves, cliffs and free faces (Priority 3 foraging habitat);
- Rocky hills and slopes with low open spinifex and scattered trees (Priority 5 foraging habitat);
- Rocky gullies (Priority 5 foraging habitat);
- Eucalyptus fringed major drainage lines and associated tributaries (Priority 4 foraging habitat); and
- Melaleuca forest/major drainage lines (Priority 4 foraging habitat).

5.2.3.4.3 Ghost Bat (*Macroderma gigas*)

Species Background Information

The Ghost Bat is listed as Vulnerable under the BC Act . They are restricted to the tropical north of Australia and populations of this species display genetic variation as they are isolated from each other, with Pilbara populations being isolated from those in the Kimberley and Northern Territory (Armstrong and Wilmer, 2004; Churchill, 2008). Given this, the Pilbara population is considered to be an important population as it is necessary for maintaining genetic diversity.

Ghost Bats occur over a range of landforms and inhabit areas with caves suitable for roost sites (Churchill, 2008). The roost sites include deep natural caves, rock crevices and disused mine adits that have a stable temperature and moderate to high relative humidity (TSSC, 2016b). In the Hamersley Ranges, preferred roosting habitat appears to be caves beneath bluffs of low rounded hills composed of Marra Mamba geology and larger hills of Brockman Iron Formation (Armstrong and Anstee, 2000). The species may also forage over large areas, depending on the productivity of the landscape (Churchill, 1998).

The occurrence of pools of water is a critical component of the Ghost Bat foraging habitat (Armstrong, 2001). There is no documented information on the importance of surface drinking water for the Ghost Bat; however, anecdotal accounts from field observations suggest that this species requires surface water for drinking, and water sources in proximity to day roost caves are therefore likely to be important (Armstrong, 2013). Data are not available on the maximum distance that Ghost Bats will fly from a day roost cave before it requires a drink of water; however, based on a foraging range of 10 km from a roost, the species is likely to require at least one drinking water source within this range. Water sources closer to the roost may be more critical than water sources further away. Surface water pools that provide drinking and feeding habitat for the Ghost Bat may be derived from surface runoff or spring seepage following rainfall, or may be groundwater-fed.

While there is a lack of data for roadkill rates for the Ghost Bat, the species' tendency to forage close to the ground (Churchill, 2008) makes it vulnerable to collision with cars. The species displays a curiosity for light sources (DAWE, 2021c) and may be attracted to head lights (Armstrong, 2013). Ghost bats often fly at approximately fence height and substantial numbers are known to be killed when colliding with fencing wire.

[13] Priority 3, 4, 5 refers to protection priorities for Pilbara Leaf-nosed habitat as defined in the conservation advice for the species.

Species Prescence

During the Biota (2021) survey, one cave containing Ghost Bat scat and Ghost Bat remains was identified within the Development Envelope (Figure 18). This cave is located in the Hamersley section of Stage 4 of the Revised Proposal, approximately 300 m from the Indicative Disturbance Footprint in the mesas, caves, cliffs and free faces habitat type. In addition, Ghost Bats caves were reported in two caves in the Tom Price section of the Biota (2021) survey (outside of the Development Envelope), with one identified as a potential maternity roost cave located approximately 125 m from the Development Envelope and 250 m from the Indicative Disturbance Footprint (Figure 18). This, together with the extensive suitable foraging habitat and historical records shows that a population of Ghost Bats uses the area.

Species Habitat Extent

The extent of the potential Ghost Bat habitat present in the Development Envelope is shown in Table 5-16. The distribution of these habitats is shown in Figure 18. These habitat types are common within the Pilbara region (estimated extent >9.3 million ha) with vast amounts being vested in National Parks, including the Millstream-Chichester National Park adjacent to Stage 2 and Stage 3 of the Revised Proposal. This habitat includes one cave containing evidence of Ghost Bat usage within the Development Envelope (Figure 18).

Table 5-16 Ghost Bat Habitat Types in the Development Envelope

Habitat type	Extent in Development Envelope (ha)
CP - Floodplains	1,778.6
HS - Mesas, caves, cliffs and free faces	8.4
RHS - Rocky hills and slopes with low open spinifex and scattered trees	702.1
MDE - Eucalyptus fringed major drainage lines and associated tributaries	1,233.1
MDM - Melaleuca forest/major drainage lines	21.2
RG - Rocky gullies	13.7
MMW - Man-made water bodies	2.3
Total	3,759.4

Species Habitat Importance

The conservation advice for the Ghost Bat notes that the species' persistence in the arid Pilbara depends on the physiologically benign day roosts found deep underground in humid, temperature-stable caves. The cave with evidence of Ghost Bat usage identified within the Development Envelope and the two caves located in close proximity to the Development Envelope area represent habitat of high importance to the Ghosts Bats in the area, with the local population likely reliant on the caves. The conservation advice for Ghost Bats suggests that suitable habitat within 5 km of diurnal roost sites provide good foraging opportunities for the species (TSSC, 2016b. Given this, the Ghost Bat habitat within 5 km of the possible maternity roost is likely of higher importance to Ghost Bats. The remaining Ghost Bat habitat in the area is likely used as foraging, flyway and drinking habitat. Given these

habitats are widely represented in the region, it is unlikely that Ghosts Bats would be restricted to or reliant on these habitats.

5.2.3.4.4 Pilbara Olive Python (*Liasis olivaceus barroni*)

Species Background Information

The Pilbara Olive Python is listed as Vulnerable under the BC Act. It is a distinct subspecies of the Olive Python found across northern Australia. The subspecies has a known distribution coinciding roughly within the Pilbara region such as the Hamersley Ranges and Islands of Dampier Archipelago, with 21 important populations known to occur in four areas: Pannawonica, Millstream, Tom Price and the Burrup Peninsula (Pearson, 2006, 1993).

The Pilbara Olive Python prefers escarpments, gorges, rocky outcrops and water holes in the ranges of the Pilbara region (Pearson, 1993; Wilson and Swan, 2003). The snake finds shelter in caves, under boulders, in water and trees overhanging water (Bush and Maryan, 2011). Radio-telemetry has shown that individuals are usually in close proximity to water and rock outcrops that attract suitable sized prey species (TSSC, 2008). It should be noted though that while the species is often associated with ephemeral or permanent water, individuals have large home ranges (between 88 ha and 449 ha) and may be recorded in rocky habitats some distance from these features (Biota, 2021).

Species Prescence

The modelled distribution for the species suggests the Development Envelope is in an area where the Pilbara Olive Python is known or likely to occur with records throughout the Hamersley Ranges (Biota, 2021). Biota (2021) did not record any evidence of Pilbara Olive Pythons. However, the species has been recorded in the area previously with the closest record to the Development Envelope being approximately 4 km west, where the alignment deviates around Hamersley Homestead. Known important populations of the Pilbara Olive Python in the vicinity of the Development Envelope exist in the Tom Price and Millstream areas (DSEWPaC, 2012). The Biota (2021) survey identified excellent quality habitat within the Development Envelope, particularly along major drainage lines and associated rocky area. This suggests that the species is likely to occur in the Development Envelope.

Species Habitat Extent

The extent of the potential Pilbara Olive Python habitat present in the Development Envelope is shown in Table 5-17. The distribution of these habitats is shown in Figure 21. These habitat types are common within the Pilbara region (estimated extent >8.7 million ha) with vast amounts being vested in National Parks, including the Millstream-Chichester National Park adjacent to Stage 2 and Stage 3 of the Revised Proposal.

Table 5-17 Pilbara Olive Python Habitat Types in the Development Envelope

Habitat type	Extent in Development Envelope (ha)
CP - Floodplains	1,778.6
HS - Mesas, caves, cliffs and free faces	8.4
RHS - Rocky hills and slopes with low open spinifex and scattered trees	702.1

MDE - Eucalyptus fringed major drainage lines and associated tributaries	1,233.1
MDM - Melaleuca forest/major drainage lines	21.2
RG - Rocky gullies	13.7
Total	3,757.1

Species Habitat Importance

Given the species habitat preference the habitats present in the Development Envelope area likely to be used for foraging by the Pilbara Olive Python. As these habitats are common and widespread in the region it is unlikely that the species is restricted to the habitat within the Development Envelope. Pilbara Olive Python individuals have large home ranges (between 88 ha and 449 ha), therefore they are unlikely to be dependent on the habitat to be cleared (Biota, 2021).

5.2.3.4.5 Night Parrot (*Pezoporus occidentalis*)

Species Background Information

The Night Parrot is listed as Critically Endangered under the BC Act. The current distribution of the Night Parrot is unknown; however, they have been found in the semi-arid and arid areas of inland Australia (Murphy et al., 2017). Despite numerous unverified sightings, several dedicated searches and public campaigns, there have been only two areas (western Queensland and the Pilbara in Western Australia) where reliable records indicate that populations may persist. Accepted sightings of the Night Parrot have been recorded near Fortescue Marsh (approximately 60 km east of the Development Envelope) in the Pilbara in 2005 (Davis and Metcalf, 2008). The species is nocturnal and is thought to be nomadic with a large home range (TSSC, 2016b).

Historically, the Night Parrot has been known to inhabit a wide variety of habitats, however most records are within *Triodia* (Spinifex) grasslands and/or chenopod shrublands in arid and semi-arid zones. *Astrebla* spp. (Mitchell grass), shrubby samphire and chenopod associations, scattered trees and shrubs, *Acacia aneura* (Mulga) woodland, treeless areas and bare gibber (desert pavement) are also associated with sightings of the species (Garnett et al., 2011; Higgins and Davies, 1996).

Species Prescence

The modelled distribution for the species places the Development Envelope in an area where habitat may be present (TSSC, 2016b). However, there are no DBCA records for this species within 50 km of the Development Envelope. It is noted though, that the Night Parrot is an elusive species and has a large home range, so the absence of records does not mean that the Development Envelope is outside of the home ranges of a population of Night Parrots.

Two nights of survey using auditory acoustic recording units (ARUs) within FP habitat (Coolawanyah section), and five nights within Grassland plains with cracking clay habitat (Tom Price section), were undertaken in April 2020 (Biota, 2021). No Night Parrots were detected during the survey. The Night Parrot was also not recorded in surveys of areas nearby previously undertaken by Biota.

The closest confirmed recording of the Night Parrot is on the edge of the Fortescue Marsh, recorded during surveys for the Cloudbreak Mine development. Assessment in relation to the Cloudbreak Mine

found that the habitats on the edge of the Fortescue March may be disproportionately important to Night Parrots as they offer protection from fire and have increased groundwater availability (Map IT, 2012). No habitats similar to this habitat are present in the Development Envelope. The Grassland plains with cracking clay habitat within the Development Envelope may provide adequate habitat for Night Parrot foraging.

Based on the above, while this species 'may occur' within the Development Envelope due to the presence of suitable habitat, it is highly unlikely that a Night Parrot population is present in the Development Envelope. In addition, given the large home range of the species, it would not be reliant on the areas of habitat to be cleared for Stage 4 of the Revised Proposal.

Species Habitat Extent

The extent of the potential Night Parrot habitat present in the Development Envelope is shown in Table 5-17. The distribution of this habitat is shown in Figure 22. This habitat types is common within the Pilbara region (estimated extent >0.6 million ha).

Table 5-18 Night Parrot habitat types in the Development Envelope

Habitat type	Extent in Development Envelope (ha)
Grassland plains with cracking clay (GPCC)	203.4
Total	203.4

Species Habitat Importance

Given the lack of evidence that Night Parrots exist in the Development Envelope, large home ranges and the extensive (>0.6 million ha) similar suitable Night Parrot habitat available in the Pilbara region, it is highly unlikely that the Night Parrot is reliant on the habitat present in the Development Envelope.

5.2.3.4.6 Grey Falcon (*Falco hypoleucos*)

Species Background Information

The Grey Falcon is listed as Vulnerable under the BC Act. It is the rarest of the falcon species found in Australia and consists of a single population with an estimated number of mature individuals of less than 1,000 (BirdLife International, 2019; Garnett et al., 2011; Schoenjahn, 2018; TSSC, 2020). The Grey Falcon is sparsely distributed across arid and semi-arid inland Australia, including the Murray-Darling Basin, Eyre Basin, central Australia and WA (Marchant and Higgins, 1993).

Grey Falcons typically nest in the tallest trees along watercourses, particularly River Red Gum (*Eucalyptus camaldulensis*), though they have also been known to nest in communications towers (Marchant and Higgins, 1993). It is known to frequent timbered lowland plains, particularly *Acacia* shrublands that are crossed by tree-lined water courses, tussock grassland and open woodland, and has been observed hunting in treeless areas (Garnett et al., 2011; Schoenjahn, 2018).

Species Prescence

During the Biota (2021) survey, the Grey Falcon was observed once and has also been recorded previously in close proximity to the Development Envelope. This observation was within the Rocky hills and slopes with low open spinifex and scattered trees habitat type. The species is likely to use all habitats within the Development Envelope for foraging.

Species Habitat Extent

The extent of the potential Grey Falcon habitat present in the Development Envelope is shown in Table 5-19. The distribution of these habitats is shown in Table 5-19. These habitat types are common within the Pilbara region (estimated extent >17.8 million ha).

Table 5-19 Grey Falcon Habitat Types in the Development Envelope

Habitat type	Extent in Development Envelope (ha)
MG - Grove Mulga	662.2
MWP - Mulga Woodland Plain	122.7
ASCC - Acacia *xiphophylla* shrublands over cracking clay	328.9
ASM - Mixed Acacia shrublands	1,659.2
GPCC - Grassland plains with cracking clay	203.4
CP - Floodplains	1,778.6
HS - Mesas, caves, cliffs and free faces	8.4
RHS - Rocky hills and slopes with low open spinifex and scattered trees	702.1
MDE - Eucalyptus fringed major drainage lines and associated tributaries	1,233.1
MDM - Melaleuca forest/major drainage lines	21.2
RG - Rocky gullies	13.7
MMW - Man-made water bodies	2.3
Total	6,735.8

Species Habitat Importance

The Grey Falcon may use all habitat types present in the Development Envelope although they are primarily associated with the floodplains, eucalyptus fringed major drainage lines and associated tributaries, melaleuca forest/major drainage lines, and man-made water bodies habitat types. Open grassland plains and floodplains, in particular, would present ideal foraging habitat for the Grey Falcon (Biota, 2021). As this species preys on smaller birds (and almost exclusively so during breeding periods) water holes with aggregations of birds may also provide attractive foraging habitat for the Grey Falcon.

Taller trees along major drainage lines also offer potentially suitable breeding habitat for this species, although no nests were recorded during the Biota (2021) survey. The species lays its eggs in the old

nests of other birds (mainly corvids and other raptors), and therefore a tall tree would only provide suitable breeding habitat for the Grey Falcon if it contains an old stick-nest used by another bird (which is large enough to suit the species nesting behaviour (Schoenjahn, 2018).

The potential Grey Falcon habitats within the development area are common and widespread in the region and given the large range and mobile nature of the species, it is unlikely that the species is restricted to the habitat within the Development Envelope or is reliant on it.

5.2.3.5 Other Specially Protected Fauna - Peregrine Falcon (*Falco peregrinus*)

The Peregrine Falcon is listed as Other Specially Protected Fauna under the BC Act. It occurs almost Australia-wide but is absent from most deserts and the Nullarbor Plain (Johnstone and Storr 1998). This species inhabits a wide range of habitats including forest, woodlands, wetlands and open country (Pizzey and Knight 2007). Individuals maintain large home ranges of up to 30 km^2, and nest in recesses of cliff faces, tree hollows and along rivers (Johnstone and Storr 1998). The Peregrine Falcon was not recorded during the Biota (2021) survey but has previously been recorded in close proximity and is therefore likely to occur in the Development Envelope (Biota, 2021). Similarly to the Grey Falcon, all habitats within the survey area are likely to be used for foraging with cliffs and taller trees potentially suitable for breeding. A total of 6,739.6 ha of suitable habitat for the species occurs in the Development Envelope. Given the widespread nature of the suitable habitat for the species in the region, it is unlikely that the species is restricted to, or reliant on the habitat within the Development Envelope.

5.2.3.6 Priority Fauna

DBCA produces a list of Priority species that have not been assigned statutory protection under the BC Act. This system gives a ranking from Priority 1 to Priority 4. Priority fauna that were recorded during the Biota (2021) survey, are likely to occur or may occur in the Development Envelope are discussed in the following sections.

5.2.3.6.1 Western Pebble-mound Mouse (*Pseudomys chapmani*)

The Western Pebble-mound Mouse is listed as Priority 4 by DBCA (DBCA, 2019). It has a scattered distribution with abundant habitat across the entire Pilbara region and into the Gascoyne (van Dyck and Strahan, 2008). The species has been recorded from Karijini National Park, Rudall River National Park, Millstream-Chichester National Park and Collier Range National Park (Lee, 1995).

Generally, the Western Pebble-mound Mouse is restricted to the non-coastal, central and eastern parts of the Pilbara and is typically found on gentle slopes of stony hillsides (Menkhorst and Knight, 2011). Their preferred habitat is vegetated with hummock grasslands with little soil and *Triodia* grasses, *Senna*, *Acacia* and *Ptilotus* species (Ford and Johnson, 2007; Lee, 1995; Menkhorst and Knight, 2011). The species constructs mounds of small stones, which are common on spurs and gentle slopes where suitable stones occur (van Dyck and Strahan, 2008).

The Western Pebble-mound Mouse constructs its mounds over its burrows. The purpose of this behaviour has not been confirmed, but it may be to afford the mouse protection from the heat of the day (Ecologia, 2005). This suggests that these mounds are important to the individuals of the species that use them.

During the Biota (2021) field survey, three mounds constructed by the species were recorded in the southern part of the Hamersley section of the Development Envelope. Two of these were likely to be active, while the other appeared old and inactive. These mounds are located approximately 60-80 m from the Indicative Disturbance Footprint. A fourth inactive mound was recorded in the middle to north of the Hamersley section approximately 440 m from the Indicative Disturbance Footprint (Figure 24). The species has been recorded previously in proximity to Stage 4 of the Revised Proposal, with the closest recording being 9 km from the survey area boundary in 2014 (Biota, 2021).

A total of 2361.3 ha of suitable habitat for the species (Mixed Acacia shrublands and rocky hills and slopes with low open spinifex and scattered trees) occurs in the Development Envelope. The distribution of these habitats is shown in Figure 24. These habitat types are common within the Pilbara region. Given the common and widespread nature of the suitable habitat for the species in the region, the species is unlikely to be restricted to or reliant on the habitat within the Development Envelope.

5.2.3.6.2 Northern Short-tailed Mouse (*Leggadina lakedownensis*)

The Northern Short-tailed Mouse is listed as Priority 4 by the DBCA. In Western Australia, its distribution includes the Pilbara and Kimberley regions (Menkhorst and Knight 2011). This species is known to occur in areas of open tussock and hummock grassland, *Acacia* shrubland and savannah woodland, on sandy soils and cracking clays (Morris et al. 2008). The species has been recorded from cracking clay communities from Cape Preston (60 km west of Dampier) in the west to the northern flanks of the Fortescue Marshes in the east (Halpern Glick Maunsell et al. 2001). It has also been recorded from hilltops and sandy coastal areas near Onslow (Biota, 2021)

While the Northern Short-tailed Mouse was not recorded during the Biota (2021) survey, areas of suitable cracking clay habitat were identified in the Development Envelope by Biota (2021). The species has also frequently been recorded previously in close proximity to the survey area and is therefore likely to occur in the Development Envelope (Biota, 2021).

A total of 203.4 ha of suitable habitat for the species (CPCC) occurs in the Development Envelope. Given the common and widespread nature of the suitable habitat for the species in the region, the species is unlikely to be restricted to or reliant on the habitat within the Development Envelope.

5.2.3.6.3 Lined Soil-crevice Skink (Dampier) (*Notoscincus butleri*)

The Lined Soil-crevice Skink (Dampier) is listed as a Priority 4 species by the DBCA and is endemic to Western Australia. It is restricted to the arid northwest (Storr et al. 1999) of the Pilbara bioregion. It has been associated with Spinifex-dominated areas near creek and river margins (Wilson and Swan 2008). This small skink is diurnal and egg laying (Wilson and Knowles 1988).

While the species was not recorded during the Biota (2021) survey, there have been previous records within 18 km of the Development Envelope and suitable habitat including the Melaleuca forest/major drainage lines and Eucalyptus fringed major drainage lines and associated tributaries habitat types is present throughout the development area. The species is therefore likely to occur in the Development Envelope (Biota, 2021)

A total of 1,254.3 ha of suitable habitat for the species (Melaleuca forest/major drainage lines and Eucalyptus fringed major drainage lines) occurs in the Development Envelope. Given the common and

widespread nature of the suitable habitat for the species in the region, the species is unlikely to be restricted to or reliant on the habitat within the Development Envelope.

5.2.3.6.4 Long-tailed Dunnart (*Sminthopsis longicaudata*)

The Long-tailed Dunnart is listed as Priority 4 by the DBCA. It inhabits rocky, rugged habitat from the Pilbara and adjacent upper Gascoyne region east to the central Northern Territory and South Australia (Menkhorst and Knight 2011). The species was once considered to be rare and possibly threatened, however research has shown that it is relatively common and widespread but is restricted to a specific habitat (Burbidge 2004). Preferred habitat includes rocky plateaux, breakaways and scree slopes with hummock grass and shrubs, and tall open *Acacia* shrubland and woodland (van Dyck and Strahan 2008).

The Long-tailed Dunnart was not recorded during the Biota (2021) survey, but it has been infrequently recorded in close proximity and suitable rocky habitat exists in the survey area. As such, it is considered that the species may occur in the Development Envelope (Biota, 2021).

A total of 724.2 ha of suitable habitat for the species (mesas, caves, cliffs and free faces, rocky hills and slopes with low open spinifex and scattered trees and rocky gullies) occurs in the Development Envelope. Given the common and widespread nature of the suitable habitat for the species in the region, the species is unlikely to be restricted to or reliant on the habitat within the Development Envelope.

5.2.3.6.5 Gane's Blind Snake (*Anilios ganei*)

The Gane's Blind Snake is listed as Priority 1 by the DBCA and is known from scattered locations across the Pilbara, from the Newman area in the east, west to Pannawonica and Millstream (DBCA 2020b). Early records of the species indicated that it may be associated with moist gorges and gullies (Wilson and Swan 2017), but they have since also been recorded from mulga woodland and rocky scree slopes (Biota, 2021), suggesting a wider range of habitat preferences. Habitat preferences of the species are still not well-understood, making accurate assessment of habitat suitability difficult.

The Gane's Blind Snake was not recorded during the Biota (2021) survey, however, as habitats consistent with those of previous records are present within the survey area it is considered the species may occur within the Development Envelope.

A total of 13.7 ha of suitable habitat for the species (rocky gullies) occurs in the development area. Given the common and widespread nature of the suitable habitat for the species in the region, the species is unlikely to be restricted to or reliant on the habitat within the Development Envelope.

5.2.3.6.6 Pilbara Barking Gecko (*Underwoodisaurus seorsus*)

The Pilbara Barking Gecko is listed as a Priority 2 species by the DBCA. The species is a Hamersley Range endemic that was discovered in 2006 but was not described until 2011 (Doughty and Oliver 2011). To date there are very few records of this species, which occurs in a band from north of Tom Price in the western Hamersley to West Angelas mine in the south-east (Doughty and Oliver 2011). The Development Envelope is to the northwest of this area of occurrence. The habitats used by this species vary in their topography and vegetation but are usually associated with rocky ridges, slopes and gullies.

The Pilbara Barking Gecko was not recorded during the Biota (2021) survey, however, a previous record exists within 4.1 km Development Envelope and suitable habitat is present the species may occur in the Development Envelope.

A total of 710.5 ha of suitable habitat for the species (mesas, caves, cliffs and free faces and rocky hills and slopes with low open spinifex and scattered trees) occurs in the Development Envelope. Given the common and widespread nature of the suitable habitat for the species in the region, the species is unlikely to be restricted to or reliant on the habitat within the Development Envelope.

5.2.3.6.7 Spotted Ctenotus (northeast) (*Ctenotus uber johnstonei*)

The Spotted Ctenotus (northeast) is listed as a Priority 2 by the DBCA. The species in only known from the Balgo Hills area of Western Australia. However, Biota (2002) have collected specimens from the western edge of the Fortescue Marshes that have tentatively been identified as Spotted Ctenotus (northeast). Specimens possibly belonging to this taxon collected by Biota (2002) in the Pilbara were recorded from *Acacia xiphophylla* over chenopods south of the Fortescue Marsh and *Acacia xiphophylla* scattered tall shrubs to high open shrubland over *Sclerolaena cuneata* herbland and open chenopods on the western edge of the Fortescue Marsh. One possible record for this species within close proximity to the survey area was recorded in Ecologia (2014b).

While the species was not recorded during the Biota (2021) survey, Suitable habitat containing *Acacia xiphophylla* occurs within the survey area (*Acacia xiphophylla* shrublands over cracking clay) and given this, it is considered that the species may occur in the Development Envelope (Biota, 2021).

A total of 328.9 ha of suitable habitat for the species (*Acacia xiphophylla* shrublands over cracking clay) occurs in the Development Envelope. Given the common and widespread nature of the suitable habitat for the species in the region, the species is unlikely to be restricted to or reliant on the habitat within the Development Envelope.

5.2.3.7 Short Range Endemic Fauna

Biota (2022) undertook a desktop assessment of potential impacts to SRE invertebrate fauna arising from Stage 4 of the Revised Proposal. The assessment involved:

- database searches conducted in order to build a potential SRE species list for the study area; and
- review of publicly available literature, focussing on previous SRE invertebrate fauna surveys conducted within 20 km of Stage 4 of the Revised Proposal within the past 10 years.

Six relevant surveys were identified, conducted from 2012 to 2018. Five of the six survey areas overlap the Development Envelope.

A total of 763 invertebrate specimens that have previously been recorded within the study area were returned from the desktop study. Consolidation of the data identified 43 taxa of interest that have been recorded within the study area and that may represent SRE fauna. This total comprised six land snail taxa, 29 mygalomorph spider taxa, six scorpion taxa and two millipede taxa. Only four of these species have been formally described with the vast majority being undescribed morphospecies represented by very few specimens (24 taxa are known from only one or two records). It is therefore difficult to confidently assess their distributions and their true SRE status. While all taxa currently

qualify as potential SREs, this is mainly due a lack of additional records and that short-range endemism is known to be common in their genera or families.

Four taxa regarded as either confirmed or potential SREs have been recorded within the Development Envelope or within 500 m of its boundary (Figure 5-1 and Figure 5-3 of Appendix A.3):

- *Idiommata* `BMYG173`- Inside the Development Envelope;
- *Idiommata* `MYG247` - Inside the Development Envelope (but also at other locations in the study area);
- *Aname* `MYG367` - 200 m west of the Development Envelope; and
- *Antichiropus* sp. indet. 500 m east of the Development Envelope.

Due to the linear nature of the highway corridor (less than 100 m wide and 112 km long), it is likely that any taxa recorded within the Development Envelope also occurs outside of it. None of the broad habitat types or smaller habitat units are restricted to within the Development Envelope , and all extend as continuous features in the landscape outside of the Development Envelope.

No SRE fauna species listed as Threatened under either the EPBC Act or BC Act were identified from the database searches and literature review.

5.2.3.8 Introduced Fauna

The following introduced fauna species potentially occur or have been previously recorded within the Development Envelope and/or immediate surrounds (Biota, 2021):

- Domestic Pigeon (*Columbia liva*);
- Camel (*Camelus dromedarius*);
- Domestic Dog (*Canis lupus familiaris*);
- Donkey (*Equus asinus*);
- Horse (*Equus caballus*);
- Domestic Cat (*Felis catus*);
- House Mouse (*Mus musculus*);
- Rabbit (*Oryctolagus cuniculus*);
- Black rat (*Rattus rattus*);
- Fox (Vulpes vulpes); and
- European Cattle (*Bos taurus*).

Two of these species (Domestic Cat and European Cattle) were identified during the field survey. One naturalised exotic species Dog/Dingo (*Canis familiaris familiaris and/or C. f. dingo*) was also identified during the survey (Biota, 2021).

5.2.4 Potential Impacts

The following sections provide an overview of the potential direct and indirect impacts to the BC Act listed Critically Endangered, Endangered, Vulnerable species and other Specially Protected Species, as

well as species that are on the DBCA Priority Species list as a result of implementing the Revised Proposal.

Habitat Loss

Clearing for construction of the road will result in the permanent direct loss of fauna habitat. The proposed extent of clearing of habitats for significant fauna that were recorded by Biota (2021), are likely to occur or may occur in the Development Envelope is provided in Table 5-20.

These estimated habitat impact areas include an allowance of approximately 10% more than the habitat area mapped within the Indicative Disturbance Footprint and Indicative Temporary Clearing Areas. This provides flexibility in the location of the road and construction areas for access and laydown.

Table 5-20 Extent of Proposed Significant Fauna Habitat Clearing

Species	Habitat Type	Extent within Indicative Disturbance Footprint (ha)	Extent within Indicative Temporary Clearing Area (ha)
Threatened Species			
Northern Quoll	Denning, foraging and dispersal	178.3	0.0
Pilbara Leaf-nosed Bat	Potential Roosting, foraging, flyway, drinking	178.2	0.0
Ghost Bat	Potential roosting, flyway, foraging, drinking	313.4	48.3
Pilbara Olive Python	Foraging	313.3	48.3
Night Parrot	Foraging	29.3	0.0
Grey Falcon	Nesting, foraging and drinking	596.1	100.0
Other Specially Protected Fauna			
Peregrine Falcon	Foraging and drinking	596.1	100.0
Priority Fauna			
Western Pebble-mound Mouse	Foraging and nesting	246.2	100.0
Northern Short-tailed Mouse	Foraging	29.3	0.0
Lined Soil-crevice Skink	Foraging	85.7	0.0
Long-tailed Dunnart	Foraging	92.7	0.0
Gane's Blind Snake	Foraging	3.8	0.0
Pilbara Barking Gecko	Foraging	89.0	0.0
Spotted Ctenotus	Foraging	10.4	10.3

All habitat type identified as present in the Development Envelope by Biota (2021a) are likely to support SRE invertebrate fauna because it is the microhabitat level that is of importance for SRE

invertebrate fauna and preferred microhabitats may exist across a range of landforms. Preferred microhabitats are typically features which provide shelter from exposure and promote moisture conservation (for example, rock piles or leaf litter accumulations) that are absent from the surrounding landscape. In terms of offering the greatest refugia for potential SRE invertebrate fauna, drainage features (drainage lines, rocky gorges and gullies) represent the highest value for invertebrate fauna. This is due to the presence of leaf litter accumulation, deep rock fractures, elevated topography, and soil accumulation (Biota, 2022). Up to 650 ha of potential SRE fauna habitat will be cleared for Stage 4 of the Revised Proposal with at least 100 ha of that clearing to be rehabilitated. Of the 650 ha of habitat to be cleared, up to 168.1 ha represents the highest value habitat for invertebrate fauna.

Interaction with construction activities

Injury or mortality of fauna individuals may occur during the construction of Stage 4 of the Revised Proposal as a result of interaction with the construction activities including equipment, clearing and blasting, although in most situations fauna will avoid construction activities and associated areas. The highest risk is considered to be during vegetation clearing activities.

Vehicle strike

The Stage 4 of Revised Proposal has the potential to impact individual fauna, causing injury or mortality from vehicle strike during road operations.

Collision with fencing

It is possible that fencing will be installed at select areas along the new road, to protect road users, at the request of landowners or for other health, safety and environment reasons. Fauna individuals (such as bats and birds) may collide with this fencing. Collision with fences may result in injury or mortality of fauna individuals, although given the limited height of proposed fencing this risk is relatively low. Barbed wire will not be used in fencing.

Disturbance from artificial light

While there is no permanent lighting associated with Stage 4 of Revised Proposal, temporary mobile lighting will be used during construction. Temporary lighting will not remain in one place for long periods of time and will be moving along the road route as dictated by scheduled construction activities. Fauna may be attracted to areas where prey such as insects are attracted to the light emissions. Light emissions may also cause other behaviour responses such as changing the timing of bats entering and exiting caves where light sources are close to these.

Disturbance from noise and vibration

Increased noise and vibration will occur temporarily as a result of construction activities (including blasting) but will decrease in the operational phase of the road, though it will remain slightly higher than background levels in close vicinity of the new road. Existing anthropogenic noise and vibration in the area currently comes from the existing Rio Tinto rail line and access road.

Noise is an environmental stressor and can potentially affect fauna in a number of ways including alienation from noisy habitats, hearing loss, or reduction in foraging success due to masking (i.e. interference with the perception of sounds of interest).

Fragmentation of habitat and population isolation

Clearing and the construction of the road can result in the fragmentation of small pockets of suitable fauna habitat. However, the road will not present a barrier to the movement of fauna, except in locations where fencing is required, though the type of fencing installed is expected to allow for movement of the small to medium sized animals discussed in Sections 5.2.3.4 to 5.2.3.6.

Habitat degradation, increased predation and/or increased competition due to the exacerbation of the presence of introduced species

The presence of introduced predators may be exacerbated by Stage 4 of the Revised Proposal as a result of the creation of new pathways for pest animals and potential attraction of animals to waste. The presence of roadkill also has the potential to attract feral fauna into the area, particularly those using roadkill as food sources. However, the presence of the rail and access road means that pathways for pest animals already exist in the local area.

Illegal dumping and littering

Dumping or inappropriate disposal of waste of during construction (e.g. at the construction camp) and operations (such as at rest areas) may attract fauna which can potentially make individuals more susceptible to vehicle strike, predation from feral predators and illness due to inappropriate food intake.

5.2.5 Mitigation

Construction of Stage 2 and 3 of the Revised Proposal is completed. Therefore, mitigation is focussed on Stage 4 of the Revised Proposal.

The following measures have been implemented during the route alignment selection to minimise the extent of significant fauna habitat clearing required for Stage 4 of the Revised Proposal:

- the use of existing cleared areas where practicable (existing tracks and pits);
- to minimise impacts within areas of high value habitat, the selection of areas where temporary clearing will be required for construction activities such as camps, laydown areas, stockpile areas and vehicle turnarounds has been based on the habitat type (within the constraints of factors such as heritage). Existing cleared areas and areas of lower environmental value will be prioritised, and habitat critical to the survival of the Northern Quoll, Northern Quoll habitat within 1 km of critical habitat and Ghost Bat foraging habitat within 5 km of the possible Ghost Bat maternity roost avoided; and
- avoidance of significant fauna habitat as far as practicable.

The following measures will be implemented during the detailed design of Stage 4 of the Revised Proposal to reduce the extent of significant fauna habitat clearing required for Stage 4 of the Revised Proposal:

- the use of spent ballast from RTIO rail, pending confirmation of suitability and no contamination issues;
- sourcing materials that don't require additional vegetation clearing, such as using materials from areas of cut in areas where fill is needed;

- where safe to do so, batters will be steepened to reduce the width of the clearing footprint; and
- safety barriers will be installed where practicable to allow roadside batters to be steepened to reduce the width of the clearing footprint.

Table 5-21 outlines project specific threatened fauna mitigation, management and monitoring measures.

Table 5-21 Terrestrial Fauna Mitigation and Management

EPA factor: Terrestrial Fauna
EPA objective: To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.
Proposal objective: To avoid and minimise impacts to significant fauna species as far as practicable during the implementation of the Stage 4 of the Revised Proposal.
Key environmental values: Significant fauna species and habitat.
Key impacts and risks:

- Clearing of significant fauna habitat;
- Injury or mortality to significant fauna species during construction of Stage 4 of the Revised Proposal; and
- Injury or mortality to significant fauna species during operation of the Revised Proposal.

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
Construction – Fauna Habitat Management								
Prevent unauthorised clearing of significant fauna habitat.	Avoid	The extent of the approved clearing will be clearly communicated in documentation.	• Drawings and shape/CAD files showing approved clearing areas provided to Construction Contractor Representative.	• Prior to commencement of clearing.	• Main Roads to check that drawings and shape/CAD files show correct approved clearing areas; and • Record of provision of drawings and shape/CAD files showing approved clearing areas.	• Drawings do not show correct approved clearing areas; • Shape/CAD files not provided; and • Clearing of no more fauna habitat than that specified in Table 5-20.	• Clearing will not recommence until no-go areas and clearing boundaries have been reviewed and confirmed to be in place correctly, and Main Roads Superintendent provides approval to recommence; • Environmental incident will be recorded, and the cause investigated; • Unauthorised clearing of vegetation containing habitat for significant fauna will be assessed for potential remediation; • Rehabilitation works will commence within 6-12 months of the incident; and • Refresher or updated training will be conducted (if appropriate).	• Construction Contractor Environmental Management Representative; and • Main Roads Superintendent.
	Avoid	All clearing areas will be clearly demarcated and approved by the Main Roads superintendent prior to clearing commencing.	• Monthly site inspections; and • Site inspection prior to and following clearing to confirm no-go areas are appropriately flagged/fenced, and that clearing remains within limits.	• Prior to commencement of clearing.	• Incident reporting (EQSafe); • Monthly site inspections; • Site inspection prior to and following clearing to confirm no-go areas are appropriately flagged / fenced, and that clearing remains within limits; and • Monthly construction reports including clearing amounts.	▪ Clearing of no more fauna habitat than that specified in Table 5-20.		
	Avoid	Vegetation to be retained will be clearly demarcated with flagging on site.		• Prior to commencement of clearing.	• Site inspection prior to and following clearing to confirm no-go areas are appropriately flagged / fenced, and that clearing remains within limits; and • Monthly construction reports including clearing amounts.			

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
	Minimise	Within the constraints of other requirements (construction requirements, avoiding heritage sites), consideration will be given to habitat importance during the selection of additional areas required for construction such as laydown areas, stockpile areas and vehicle turn around. Areas will be prioritised in the following order: 1. Existing cleared areas / areas cleared for permanent works; 2. Areas that do not contain habitat associated with BC Act listed threatened species that are considered likely to or may occur in or near the Development Envelope; and 3. Areas that contain habitat that may be used by BC Act listed threatened species that are considered likely to or may occur in or near the Development Envelope. The following areas will not be used as additional (temporary) areas required for construction such as laydown areas, stockpile areas and vehicle turn around: • Habitat critical to the survival of the Northern Quoll; • Important foraging and dispersal habitat for the Northern Quoll (defined as Northern Quoll habitat within 1 km of habitat critical to the survival of the Northern Quoll); and • Ghost Bat foraging habitat within 5 km of the possible maternity roost identified by Biota (2021a).	• Monthly site inspections; and • Site inspection prior to and following clearing to confirm no-go areas are appropriately flagged/fenced, and that clearing remains within limits.	• During construction.	• Construction site plan; • Monthly site inspections; and • Monthly construction reports including clearing amounts.			
	Avoid	Restrict all personnel to the approved final disturbance footprint including designated access routes and parking areas.	▪ Not applicable	▪ During construction.	▪ Construction site plan showing all approved access areas.	▪ Construction site plans do not show correct approved access areas.	▪ Review and revise construction site plan.	
Construction – General fauna management measures								

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
Avoid injury or mortality to significant fauna species during construction of Stage 4 of the Revised Proposal.	Minimise	In the event of fauna injury, advice shall be sought from local qualified wildlife organisations/persons, such as: ▪ Pilbara Wildlife Carers Association (PWCA): Contact Main Coordinator Mob: 0438 924 842; and ▪ PWCA: Tom Price – Mob: 0438 957 463. Contact details for these organisations will be maintained onsite to facilitate rapid transfer sick or injured wildlife to an appropriate organisation, thereby reducing the holding time and potential stress on the animal.	• Monthly inspection.	• During construction.	• Incident reports.	• A list of local wildlife rescue organisations and carers is not on site; and • Wildlife rescue specialists not contacted immediately on discovery of an injured EPBC Act listed threatened fauna.	• A list of local wildlife rescue organizations and carers is obtained by site immediately; and • Refresher training will be conducted within 1 week of determining that requirement is not be met.	• Construction Contractor Environmental Management Representative. • Main Roads Superintendent.
	Minimise	Where construction of Stage 4 of the Revised Proposal results in fauna fatality, this will be recorded as an environmental incident through Main Roads EQSafe system.	• Monthly inspection.	• During construction.	• Incident reports	• Routine inspections find deceased fauna near the construction activities and the impact is attributable to Stage 4 of the Revised Proposal.	• Refresher training with respect to fauna impacts mitigation will be conducted within 1 week of determining that requirement is not met.	
	Minimise	Speed limits between 40-80 km/hr will be applied throughout the construction site for safety purposes which will consequently reduce the risk of fauna strikes during clearing and construction.	• Not applicable	• During construction.	• Incident reports.	• Any incident of speeding within the construction boundary.	• Refresher training will be conducted within 1 week of determining that requirement is not be met; • Instances of speeding are identified and offenders will be asked to immediately reduce speed; and • Repeat offenders (i.e. Caught speeding more than 2 times) will undergo further refresher training.	
	Minimise	Inductions for all personnel will include appropriate road driving procedures and significant fauna awareness.	• Monthly inspection of induction records.	• During construction.	Staff induction records; and • Site records.	• Required information not including in induction material; and • Monthly inspection finds any personnel working on site not correctly inducted.	• Review and update induction material; and • Persons not correctly inducted are to immediately cease work and not recommence until induction complete.	

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
	Minimise	Night work to be minimised. It is expected that regular work hours will be 6am and 6pm. Night works will not be significant, however, due to the high temperatures in the area, some night work activities may be carried out. If required, lighting will be directed onto active construction areas to minimise light spill. Requirement to be included in site inductions.	• Monthly inspections of lighting.	• During construction.	Staff induction records; and • Site records.	• Required information not including in induction material; • Monthly inspection finds personnel on site not correctly inducted; and • Monthly inspection finds requirement not being complied with.	• Review and update induction material; • Personnel not correctly inducted to immediately cease work and not recommence until induction complete; and • Refresher training will be conducted within 1 week of determining that requirement is not being met.	
	Minimise	Induction for all personnel will include the requirement to report sightings of feral animals, no feeding of native and/or feral animals and no pets allowed on site.	• Monthly inspection of induction records.	• During construction.	• Staff induction records.	• Monthly inspection finds personnel working on site not correctly inducted; and • Instances of personnel not complying with requirement.	• Personnel not correctly inducted to immediately cease work and not recommence until induction complete. • Refresher training will be conducted within 1 week of determining that requirement is not being met.	
	Minimise	Construction camp waste including food waste will not be dumped. Waste will be appropriately segregated and contained, including use of lids that cannot be removed by fauna.	• Monthly inspection.	• During construction.	• Waste disposal records.	• Monthly inspection or review of records find waste not being segregated, stored correctly or disposed of appropriately.	• Review and update waste management procedures and increase frequency of inspections.	
Construction - Northern Quoll management measures								
Avoid injury or mortality to significant species during construction of Stage 4 of the Revised Proposal	Minimise	Clearing of habitat critical to the survival of the Northern Quoll (i.e. denning habitat) will be limited to between 1 April and 30 September to prevent coinciding with Northern Quoll when they have large pouch or denned young.	• Monthly site inspections.	• During construction.	• Monthly construction reports.	• Clearing of habitat critical to the survival of the Northern Quoll occurs between 1 April and 30 September.	• Clearing of habitat critical to the survival of the Northern Quoll will cease immediately if trigger is met. Clearing of habitat critical to the survival of the Northern Quoll will not recommence until after 30 September and Main Roads Superintendent provides approval to recommence; and • Environmental incident will be recorded, and the cause investigated.	• Construction Contractor Environmental Management Representative; and • Main Roads Superintendent.

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
	Minimise	Prior to clearing any Northern Quoll denning habitat, undertake preclearance surveys. If individuals are identified in area to be cleared, clearing in this area not to commence until confirmed the identified fauna is no longer present. Relocation of individuals will be considered where appropriate and in consultation with a wildlife specialist	• Not applicable	• Survey to be undertaken two weeks prior to commencement of clearing.	• Records of pre-clearance surveys.	• Clearing of habitat critical to the survival of Northern Quoll occurs without the survey confirmation that species is not present.	• Clearing will cease immediately if trigger is met. Clearing will not recommence until preclearance survey confirms species is not present and Main Roads Superintendent provides approval to recommence; and • Environmental incident will be recorded, and the cause investigated.	
	Minimise	Construction site inductions will provide detailed information about Northern Quolls.	• Not applicable	• During construction.	• Review of induction material.	• Induction material does not contain required information; and • Monthly inspection finds personnel working on site not correctly inducted.	• Review and revise induction material; and • Personnel that are not correctly inducted to immediately cease work and not recommence until induction complete.	• Construction Contractor Environmental Management Representative • Main Roads Superintendent
Construction - Pilbara Leaf-nosed Bat and Ghost Bat management measures								
Avoid injury or mortality to significant species during construction of Stage 4 of the Revised Proposal.	Avoid	Construction site inductions will provide detailed information about Pilbara Leaf-nosed Bats and Ghost Bats.	• Not applicable.	• During construction.	• Review of contractor induction material.	• Induction material does not contain required information; and • Monthly inspection finds personnel working on site not correctly inducted.	• Review and revise induction material; and • Personnel that are not correctly inducted to immediately cease work and not recommence until induction complete.	• Construction Contractor Environmental Management Representative; and • Main Roads Superintendent.
Avoid impacts to roosting caves utilised by Ghost Bats.	Avoid	An activity buffer of 400 m will be created within which monitoring of caves identified by Biota (2021) as Ghost Bat roosting caves would be required. A 150 m no-go zone will be created between the construction activities and known caves that have been identified	• Monitoring of caves via acoustic and visual method prior to, during and after construction activities occur	• Contract award and prior to commencement of clearing.	• Record of provision of drawings showing no-go zones. • Monitoring records.	• Drawings do not show correct approved clearing areas.	• Clearing/blasting not to commence until drawings are reviewed and revised to show required no-go zone.	• Construction Contractor Environmental Management Representative; and • Main Roads Superintendent.

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
		as having evidence of Ghost Bat use (Figure 18). These no-go zones will be clearly shown on all project drawings and communicated in documentation.	within the activity buffer.			• Monitoring shows signs of disturbance attributable to construction activities during construction.	• Construction activities within the activity buffer will cease. • Construction method will be reviewed to identify any areas that can be improved to reduce disturbance to roosting bats. • Construction will not recommence until Main Roads Superintendent provides approval to recommence.	
	Avoid	Caves that have been identified as having evidence of Ghost Bat use and associated no-go zones will be clearly demarcated on site (Figure 18).	• Monthly site inspections; and • Site inspection by Construction Contractor Environmental Management Representative prior to and following clearing to confirm no-go areas are appropriately flagged / fenced, and that clearing remains within limits.	• Prior to commencement of clearing or blasting; and • During construction.	Incident reporting (EQSafe); Monthly site inspections; and • Site inspection by Construction Contractor Environmental Management Representative prior to and following clearing to confirm no-go areas are appropriately flagged / fenced, and that clearing remains within limits.	• Clearing or blasting activities occurring within 150 m of caves that have been identified as having evidence of Ghost Bat use.	• Clearing and blasting within 150 m of the caves will cease immediately if trigger is met and will not recommence until no-go areas have been reviewed and confirmed to be in place correctly, and Main Roads Superintendent provides approval to recommence; • Environmental incident will be recorded, and the cause investigated; and • Incident will be reported to EPA along with the cause identified from an investigation.	
	Avoid	Ghost Bat roosts will be recorded in a site database and mapped on all construction plans. The database will be accessible to all site personnel.	• Monthly site inspections.	• During construction.	• Site database.	• Bat roosting areas not recorded in site database and mapped on construction plans.	• Clearing and blasting to cease until database and drawing reviewed and revised.	• Construction Contractor Environmental Management Representative; and • Main Roads Superintendent.

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
		Confined blasting techniques (where inert material such as crushed stone is used to seal off blast holes and contain energy released) will be used within 400 m of caves known to be used by Ghost Bats in preference to unconfined methods.	• Review of contractor method statement; and • Monthly inspection.	• During construction.	• Monthly construction reports.	• Unconfined blast technique used within 400 m of caves known to be used by Ghost Bats, unless pre-blasting survey indicates that no bats are present.	• Environmental incident will be recorded, and the cause investigated. • Blasting activities to cease immediately and not recommence until Main Roads Superintendent provides approval to recommence.	• Construction Contractor Environmental Management Representative; and • Main Roads Superintendent.
	Avoid	Main Roads will prepare a Blasting Noise and Vibration Management Plan to address risks to Ghost Bats from construction activities. This plan will be prepared for approval by the CEO prior to any blasting occurring within 400 m of a cave with evidence of Ghost Bat usage. The purpose of this plan will be to meet the stated management objective to “Avoid impacts to roosting caves used by Ghost Bats”. This plan will outline the blasting activities, noise and vibration monitoring (in relation to the caves) and an adaptive management approach. The Blasting Noise and Vibration Management Plan will include a requirement for the blasting contractor to ensure that the predicted peak particle velocity (PPV) values for each blast is included in the blast design. The PPV will be required to be calculated using an industry recognised approach that incorporates predictive mechanisms for ground vibration and is in accordance with AS 2187. Following consultation with a fauna specialist a threshold for the predicted PPV will be agreed between Main	Monitoring of PPV during blasting at caves with evidence of Ghost Bat usage	• During construction.	• Blasting monitoring reports	• PPV as measured during blasting at caves with evidence of Ghost Bat usage exceeds threshold level. Following consultation with a fauna specialist a threshold for the predicted PPV will be agreed between Main Roads and DWER to ensure no impact to any cave being used by Ghost Bats.	• Blasting will cease immediately if trigger is met. Blasting will not recommence until Main Roads Superintendent provides approval to recommence. • Environmental incident will be recorded, and the cause investigated. • Incident will be reported to DWER along with the cause identified from an investigation.	• Construction Contractor Environmental Management Representative; and • Main Roads Superintendent.

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
		Roads and DWER to ensure no impact to any cave being used by Ghost Bats. The plan will also specify procedures for monitoring of the PPV including monitoring of blasts undertaken away from the Ghost Bat caves, to verify that impact thresholds will not be exceeded during blasting activities within 400 m of a cave with evidence of Ghost Bat usage.						
Construction – Western Pebble-mound Mouse management measures								
Avoid injury or mortality to significant species during construction of Stage 4 of the Revised Proposal	Avoid	A 50 m no-go zone will be created between the construction activities and known active Western Pebble-mound Mouse mounds that are located outside of the final disturbance footprint. These no-go zones will be clearly shown on all project drawings communicated in documentation and demarcated on site during construction.	• Not applicable	• Contract award and prior to commencement of clearing.	• Record of provision of drawings showing no-go zones.	• Drawings do not show correct approved clearing areas.	• Clearing/blasting not to commence until drawings are reviewed and revised to show required no-go zone.	• Construction Contractor Environmental Management Representative; and • Main Roads Superintendent.
	Minimise	Where active Western Pebble-mound Mouse mounds are required to be cleared, displacement methods will be used to encourage the individuals using the mounds to relocate within their home range following the methods described in 5.2.6.3.1. This process will not include physical capture and relocation.	• Not applicable	• During construction.	• Reports on displacement process.	• Relocation not successful or not undertaken.	• Clearing of mounds not undertaken until relocation successfully completed.	• Construction Contractor Environmental Management Representative; and • Main Roads Superintendent.
Operations – General EPBC Act listed threatened species management measures								
Minimise injury or mortality to BC Act listed threatened	Minimise	Fauna sensitive road design will consider installing signage in places where motorists may encounter significant fauna.	• Not applicable	• Pre-construction and during construction.	• Pre-construction design reviews.	• Pre-construction review finds requirement not included.	• Pre-construction - review and revise design.	• Design contractor. • Main Roads Superintendent.

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
species during operation.	Minimise	Fencing will use devices such as discs on the top wire to make them more visible to bats and birds. Barbed wire will not be used in fencing.			• Post-construction as built reviews against the design.	• Post-construction as-built review find requirement not implemented.	• Post-construction – rectify no-conformance.	• Construction Contractor Environmental Management Representative; and • Main Roads Superintendent.

5.2.6 Assessment of Impacts

5.2.6.1 Threatened Fauna

5.2.6.1.1 Northern Quoll (*Dasyurus hallucatus*)

Potential direct impacts that may occur to Northern Quoll as a result of Stage 4 of the Revised Proposal are:

- habitat loss;
- interaction with construction activities;
- vehicle strike during operations resulting in increased fauna injury or mortality; and
- disturbance from light, noise and vibration emissions.

Potential indirect impacts that may occur to Northern Quoll as a result of Stage 4 of the Revised Proposal include:

- fragmentation of habitat or due to clearing and the presence of the road;
- introduced species resulting in increased predation or competition for resources;
- habitat degradation resulting from weed invasion; and
- attraction to food waste at construction camp, illegal rubbish dumping and litter.

Habitat loss

Habitat degradation and habitat destruction are identified in the National Recovery Plan for the Northern Quoll as key threats to the species. A breakdown on the expected loss of Northern Quoll habitat as a result of clearing for Stage 4 of the Revised Proposal is provided in Table 5-22. No Northern Quoll habitat is present within the Indicative Temporary Clearing Area. Any refinement to the Indicative Temporary Clearing Area will avoid habitat critical to the survival of the Northern Quoll and important foraging and dispersal habitat for the Northern Quoll (defined as Northern Quoll habitat within 1 km of habitat critical to the survival of the Northern Quoll).

While Northern Quoll was not recorded during the Biota (2021) survey, they are likely to occur in the Development Envelope given their habitat presence and historical records. The Northern Quoll habitat loss for Stage 4 of the Revised Proposal represents less than 0.022% of the similar habitat available in the Pilbara region. It is also noted that the Revised Proposal is linear infrastructure which means the habitat loss will not be concentrated in one particular area.

Table 5-22 Extent of Northern Quoll Habitat Clearing for Stage 4 of the Revised Proposal

Habitat type	Habitat importance	Indicative Disturbance Footprint (ha)[1]	Indicative Temporary Clearing Area (ha)[1]	Extent present within Development Envelope (ha)	% of habitat within Development Envelope to be cleared
HS – Mesas, caves, cliffs and free faces	Critical to the survival of the species – denning	Up to 0.14	0.0	8.4	Up to 1.67%
RHS – Rocky hills and slopes with low open spinifex and scattered trees	Supporting habitat – foraging, dispersal	Up to 88.7	0.0	702.1	Up to 12.65%
MDE – Eucalyptus fringed major drainage lines and associated tributaries	Supporting habitat – foraging, dispersal	Up to 85.5	0.0	1,233.1	Up to 6.94%
MDM Melaleuca forest/major drainage lines	Supporting habitat – foraging, dispersal	Up to 0.03	0.0	21.2	Up to 0.14%
RG - Rocky gullies	Critical to the survival of the species – denning	Up to 3.8	0.0	13.7	Up to 27.73%
Total		Up to 178.3	0.0	1978.5	Up to 9.02%

[1]Extent to be cleared based on Indicative Disturbance Footprint and Indicative Temporary Clearing Area.

Up to 4.0 ha of potential Northern Quoll denning habitat (habitat types mesas, caves, cliffs and free faces and rocky gullies) will be cleared for Stage 4 of the Revised Proposal, representing approximately 18% of the suitable denning habitat in the Development Envelope. This habitat is identified in the National Recovery Plan for the Northern Quoll as being habitat critical to the survival of the species.

The reduction in available denning habitat may have a significant residual impact to Northern Quolls in a local context, potentially resulting in individual Northern Quolls needing to relocate to other areas and potentially a temporary reduction in breeding success in Northern Quolls that rely on the denning habitat. Given the low density of Northern Quolls in the area, these impacts would be limited to a small number of individual Northern Quolls. As the loss of Northern Quoll potential denning habitat may result in a significant residual impact in the local context, this loss is proposed to be offset as outlined in Section 6.

The loss of up to 4.0 ha of potential Northern Quoll denning habitat represents loss of a very small component of the locally available habitat for the species. Northern Quolls would not be restricted to the habitat that will be lost and as such the impact to the species is not expected to result in a decline in the population of Northern Quolls. FMG (2018) identified 8,224 ha of potential Northern Quoll denning habitat in the region. Based on this, Stage 4 of the Revised Proposal will result in the removal 0.05% of the total denning habitat in the region as mapped by FMG (2018).

The remaining Northern Quoll habitat that will be cleared as a result of Stage 4 of the Revised Proposal represents 174.3 ha of foraging and dispersal habitat. Of this habitat, 42.3 ha is foraging and dispersal habitat within 1 km of habitat critical to the survival of the Northern Quoll and is important dispersal habitat for the species (DoE, 2016). The loss of this 42.3 ha of important foraging and dispersal habitat is likely to result in a significant residual impact on local Northern Quoll populations. The loss of the 132.2 ha of this habitat type that is more than 1 km from habitat critical to the survival of the Northern Quoll is not likely to represent a significant residual impact. This habitat is common throughout the Pilbara region, totalling an estimated extent of more than 8.7 million ha (Table 5-13). Northern Quoll are not restricted to this foraging and dispersal habitat and are unlikely to be reliant on it or significantly impacted by its loss.

Overall, the loss of a very small proportion of the available denning, foraging and dispersal habitat for Northern Quolls is not expected to result in a loss of ecological integrity such that a decline in the Northern Quoll species occurs.

Interaction with construction activities

Injury or mortality of Northern Quoll individuals may occur during the construction of Stage 4 of the Revised Proposal as a result of interaction with the construction activities including equipment and vehicle movements, clearing and blasting. The risk of such impacts occurring are higher during construction in and near the denning habitat during mating season. This risk will be mitigated by limiting clearing of this habitat to between 1 April and 30 September to prevent interactions with Northern Quoll when they have large pouch or denned young. Further, prior to clearing any Northern Quoll denning habitat, pre-clearance surveys will be undertaken to confirm no Northern Quolls are present in the area.

Given the proposed mitigation measures and the low density of Northern Quolls expected in the Development Envelope, impacts are expected to be minimal and limited to temporary avoidance behaviour in a small number of Northern Quolls. This avoidance behaviour will further reduce the risk of more serious impacts such as injury or mortality occurring.

Vehicle strike (operational traffic)

Once construction is complete and the road opened to traffic, there will be a permanent risk of vehicle strikes involving Northern Quoll leading to injury or mortality of individual quolls. Traffic modelling for the Revised Proposal indicates traffic volumes will be low compared to other roads in the region with a likely maximum of 635 vehicles per day, of which up to around 230 will be heavy vehicles. Lower volumes of traffic are expected at night which reduces the risks to Northern Quoll given it is a nocturnal species. Given this low expected traffic volume and low density of Northern Quolls in the area, impacts to Northern Quolls as a result of vehicle strike are not expected. In the unlikely event that they do occur, they will be limited to a small number of individuals and are not expected to result

in a decline in the Northern Quoll population in the Pilbara. These impacts may occur throughout the operational life of the road.

Disturbance from light, noise and vibration

While there is no permanent lighting associated with the Revised Proposal, temporary mobile lighting will be installed during construction. Temporary lighting will not remain in one place for long and will be moving along the road route as per the construction schedule.

These temporary light emissions have the potential to result in behavioural responses in Northern Quolls, particularly as they forage at night. These impacts are expected to be limited to temporary avoidance of the illuminated areas previously used for foraging or changes to prey item (insects) aggregation resulting in changes to foraging behaviour. Given the temporary and localised nature of the light emissions and resultant minor behavioural changes, these impacts are not expected to be significant in consideration of the low densities of Northern Quoll likely to exist in the Development Envelope.

Increased noise and vibration will occur temporarily as a result of construction activities (including blasting) but will decrease in the operational phase of the road, though noise levels close to the road will be slightly higher than background levels prior to road operations or further from the new road.

Noise is an environmental stressor and can potentially affect wild animals including the Northern Quoll in a number of ways including alienation from noisy habitats, hearing loss or reduction in foraging success due to masking (i.e. interference with the perception of sounds of interest). There is a lack of research into the impact of noise on native fauna in the Pilbara in general, and on the Northern Quoll in particular.

Low level noise emissions and vibration from equipment during construction have the potential to result in behavioural responses in exposed Northern Quolls. Given the low densities of Northern Quoll likely to exist in the Development Envelope. These impacts are expected to be limited to temporary avoidance of the area by a small number of individuals.

Noise and vibration from limited blasting activities have the potential to cause injury (hearing loss) to individuals close to the blast point. This risk of this occurring is low however, as individuals will likely have displayed avoidance behaviour due to construction activities and as such would be unlikely to be in the area.

Operational traffic noise may cause minor avoidance behaviour in a small number of individual Northern Quolls. Given the low number of Northern Quolls expected in these locations, the temporary and localised nature of construction noise emissions, and the low expected operational traffic volumes, there is a high level of confidence that potential impacts to the Northern Quoll as a result of noise and vibration will not be significant.

Fragmentation of habitat and population isolation

Habitat degradation and population isolation are identified in the National Recovery Plan for the Northern Quoll as key threats to the species (Hill and Ward, 2010). Vegetation clearing, especially for

linear infrastructure, has the potential to result in fragmentation of fauna habitat, reducing the connectivity of fauna populations.

The construction of the road may result in the fragmentation of small pockets of suitable Northern Quoll habitat, particularly in areas where isolated pockets of Rocky hills and slopes with low open spinifex and scattered trees and rocky gullies habitat will be created between the Indicative Disturbance Footprint and the existing rail line (Figure 19). However, as the Northern Quoll will be able to cross the road, these habitats will still be available for use as refuge and foraging habitat. This fragmentation will not result in the isolation of habitat or Northern Quoll populations.

Introduced species

Feral species

Predation by introduced species (cats, foxes, dogs), particularly on juveniles, is identified as a major threat in the National Recovery Plan for the Northern Quoll (Hill and Ward, 2010). Feral predators that prey on food sources that the Northern Quoll relies upon are also a threat (Hill and Ward, 2010).

The presence of introduced predators may be exacerbated by Stage 4 of the Revised Proposal as a result of the creation of new pathways for pest animals and potential attraction of animals to waste. The presence of roadkill also has the potential to attract feral fauna into the area, particularly those using roadkill as food sources.

Feral predators are widespread throughout the Pilbara and recorded in the Development Envelope (Biota 2021). Given the proposed mitigation measures (Section 5.2.5), existing disturbance (such as existing rail lines) and multiple existing transport corridors in the region, it considered unlikely that Stage 4 of the Revised Proposal will result in an increase in feral predators such that Northern Quoll populations are likely to decline.

Cane toads are not present within the Pilbara however the Revised Proposal has the potential to increase access to such species if they are introduced in future.

Weeds

The presence of weeds may be exacerbated by Stage 4 of the Revised Proposal as a result of clearing and introduction or spread of weeds. Any exacerbation of weeds as a result of the Revised Proposed is not predicted to be significant however, due to the planned mitigation measures and the existing background level of weeds in the area. It is also noted that weeds of particular concern for the Northern Quoll such as Gamba Grass and Mission Grass (due to their large biomass and rigidity potentially inhibiting movement and foraging) are not found within the Development Envelope. As such, impacts to Northern Quolls as a result of exacerbated of the presence of weed species by Stage 4 of the Revised Proposal are not expected to occur.

Attraction to food waste at construction camp, illegal dumping and littering

Northern Quolls are scavengers and as such may be attracted to waste (particularly meat) that is dumped or inappropriately disposed of during construction (e.g. at the construction camp) and operations (such as at rest areas). This attraction may make Northern Quoll individuals more susceptible to vehicle strike, predation from feral predators and illness due to inappropriate food intake.

Given the mitigation measures that will be in place during construction (food waste will not be dumped), the low traffic volume expected and the low density of Northern Quolls expected to occur in the area, there is a high level of confidence that impacts to Northern Quolls as a result of illegal dumping and littering will be negligible.

5.2.6.1.2 Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*)

Potential direct impacts that may occur to Pilbara Leaf-nosed Bats as a result of Stage 4 of the Revised Proposal are:

- loss of habitat;
- interaction with construction activities;
- vehicle strike during operations;
- collision with fencing;
- disturbance from light emissions; and
- disturbance from noise and vibration emissions.

Potential indirect impacts that may occur to Pilbara Leaf-nosed Bats as a result of Stage 4 of the Revised Proposal are:

- introduced species including increased predation by feral predators.

Loss of habitat

A breakdown on the expected loss of potential Pilbara Leaf-nosed Bat habitat as a result of clearing for Stage 4 of the Revised Proposal is provided in Table 5-23. No Pilbara Leaf-nosed Bat habitat is present within the Indicative Temporary Clearing Area. Up to 178.2 ha of potential Pilbara Leaf-nosed Bat habitat will be cleared for Stage 4 of the Revised Proposal representing less than 0.003% of the overall similar habitat in the Pilbara Region (estimated extent of over 8.1 million ha - Table 5-13). This habitat has been identified as primarily foraging and flyway habitat with a small amount of potential roosting habitat, however it should be noted that no roosts were identified in the Biota (2021) survey.

Table 5-23 Extent of Pilbara Leaf-nosed Bat Habitat Clearing for Stage 4 of the Revised Proposal

Habitat type	Habitat importance	Indicative Disturbance Footprint (ha)[1]	Indicative Temporary Clearing Area (ha)[1]	Extent present within Development Envelope (ha)	% of Development Envelope to be cleared
HS – Mesas, caves, cliffs and free faces	Supporting habitat - potential roosting, foraging	Up to 0.14	0.0	8.4	Up to 1.67%
RHS – Rocky hills and slopes with low open spinifex and scattered trees	Supporting habitat- foraging	Up to 88.7	0.0	702.1	Up to 12.65%

MDE – Eucalyptus fringed major drainage lines and associated tributaries	Supporting habitat - foraging	Up to 85.5	0.0	1,233.1	Up to 6.94%
MDM Melaleuca forest/major drainage lines	Supporting habitat - foraging, flyway, drinking	Up to 0.03	0.0	21.2	Up to 0.14%
RG Rocky gullies	Supporting habitat - foraging	Up to 3.8	0.0	13.7	Up to 27.73%
Total		Up to 178.2	0.0	1978.5	Up to 9.02%

[1]Extent to be cleared based on current Indicative Disturbance Footprint and Indicative Temporary Clearing Area.

The habitat type mesas, caves, cliffs and free faces is the most significant in the Indicative Disturbance Footprint as it has potential for roosting. Up to 0.14 ha of this habitat type will be cleared for Stage 4 of the Revised Proposal. As noted in Section 5.2.3.4.2, no caves suitable for roosting (which are identified as critical to the survival of the species in the conservation advice for the species) were recorded in the Development Envelope.

Biota (2021) recorded (via call recordings) Pilbara Leaf-nosed Bats at two locations during the survey. While no caves suitable for roosting were recorded in the Development Envelope, the call recordings suggest that there is likely one or more unknown roosts in the vicinity of the Development Envelope and that the potential foraging habitat in and around the Development Envelope may be of importance. The species typically has a dry season foraging range of 15 to 20 km from its primary roost caves and does forage at greater distances if suitable water sources are available (Bullen, 2013). This suggests that there are unknown roosts located within 20 km of the Development Envelope.

Given the relatively small amount (less than 0.003%) of Pilbara Leaf-nosed Bat habitat to be cleared compared to the regionally available habitat, the fact that the Revised Proposal is linear infrastructure which means the habitat loss will not be concentrated in one particular area, and that no roosting caves will be impacted, clearing of up to 178.2 ha of Pilbara Leaf-nosed Bat habitat will not result in a significant impact to the species.

Interaction with construction activities

Injury or mortality of Pilbara Leaf-nosed Bat individuals may occur as a result of interaction with the construction activities including construction equipment while they forage at dusk and during the night.

Given that foraging habitat occurs within the Development Envelope, there is the potential for Pilbara Leaf-nosed Bats to interact with construction activities as they forage, particularly where these activities occur at dusk or during the night. The risk of injury or mortality occurring as a result of interaction with construction equipment is low given the clearing will primarily be undertaken during the daytime with limited night works planned. In the event that such impacts do occur, they would be

limited to a small number of individuals and is unlikely to result in a long term decline in the population.

Vehicle strike

Roadkill is identified by DAWE within the species profile as a threat to the species (DAWE, 2021c). While there is a lack of data for roadkill rates for the Pilbara Leaf-nosed Bat, the species is often observed foraging along roads at night (Churchill, 2008). As noted in Section 5.2.3.4.4 the species' curiosity for light sources and foraging height of less than three metres makes it vulnerable to collision with cars.

An increase in the number of roads or a larger volume of traffic may contribute to a local decline in areas near roosting or foraging sites (DAWE, 2021c). However, the majority of the Development Envelope is adjacent to existing railways and the introduction of a new road is likely to have a minor additional impact to existing light sources.

While intermittent incidences of mortality from collision with vehicles may occur, the low expected traffic volume, especially at night, means that impacts will be limited to a small number of individuals and is unlikely to significantly affect the population size of the Pilbara Leaf-nosed Bat. Therefore, there is a high level of confidence that potential impacts to the Pilbara Leaf-nosed Bat as a result of vehicle strike will not be significant.

Collision with fencing

It is possible that fencing will be installed at selected areas along the new road for the protection of road users or for other health, safety and environment reasons. Consultation with landowners is currently ongoing in regard to fencing and will only be installed where an agreement is reached. It is, therefore, possible that individual bats may collide with this fencing. Collision with fences has the potential to result in injury or mortality of Pilbara Leaf-nosed Bat individuals.

Fencing required for Stage 4 of the Revised Proposal will be managed to reduce the potential for impacts to occur to Pilbara Leaf-nosed Bats. This includes minimising fencing as far as practicable and using devices such as discs or tags on the top wire to make them more visible to bats. Barbed wire will not be used in fencing.

If fencing is required for Stage 4 of the Revised Proposal, this may result in injury or mortality to a small number of individual Pilbara Leaf-nosed Bats. The mitigation measures proposed will reduce the risk of fencing to Pilbara Leaf-nosed Bats such that it is not expected to result in a significant reduction in the Pilbara Leaf-nosed Bat population in the area.

Disturbance from artificial light

While there is no permanent lighting associated with the Revised Proposal, temporary mobile lighting will be installed during construction. Temporary lighting will not remain in one place for long periods of time and will be moving along the road route as per the construction schedule. Insectivorous fauna (such as bats) may be attracted to light sources due to the concentration of insects in well-lit areas. Given the temporary and localised nature of the light emissions and resultant minor behaviour impact, these impacts are not expected to be significant.

Studies at roosts have demonstrated that artificially increased light levels can significantly delay the timing of bat emergence (Downs et al., 2003; Duvergé et al., 2000) and disturb their use of commuting routes (Stone et al., 2009), both of which will reduce the time available for foraging. Given the lack of known suitable roosting caves in the Development Envelope, it is unlikely that lighting for Stage 4 of the Revised Proposal would have a significant impact on the Pilbara Leaf-nosed Bat roosting sites.

Disturbance from noise and vibration

Forced exodus of roosting sites and disturbance as a result of blasting are identified as threats to the species by DAWE within the species profile (DAWE, 2021c). The Pilbara Leaf-nosed Bat is known to be sensitive to noise and vibration disturbances within or in close proximity to roost caves and have been known to abandon caves where construction or mining activities occur within 50 m of the roost (Outback Ecology, 2012). Disturbances that occur at least 85 m from the roost, however, may not result in abandonment (Armstrong, 2001). Displaced bats are susceptible to death through dehydration, particularly during the dry season.

The recording of Pilbara Leaf-nosed Bats by Biota (2021) suggests that one or more unknown roosts exist within 20 km of the Development Envelope. Given that no roosts or suitable roost sites were identified within the Development Envelope or surrounding area during the Biota (2021) survey, any roost caves are considered to be sufficiently far away from construction activities (more than 85 m). Therefore, Pilbara Leaf-nosed Bats will not be disturbed during roosting, or forced to permanently abandon roosts.

Impacts to foraging behaviour may occur due to noise and vibration but would be limited to causing individuals to forage elsewhere. Given the large amount of suitable foraging habitat available in the area and the limited night works planned, any impacts to foraging bats from noise and vibration will be negligible.

Introduced species

The conservation advice for the species states that it is unlikely that the introduction of an invasive species will have a significant impact on the Pilbara Leaf-nosed Bat due to the extent of degradation and modification to natural habitats currently caused by invasive species (TSSC, 2016a). Feral predators are widespread throughout the Pilbara and have been recorded in the Development Envelope Biota (2021).

Mitigation measures will be implemented as described in Section 5.2.5, and include waste management measures to minimise attraction of feral predators. Given the proposed mitigation measures (Section 5.2.5), existing disturbance and multiple existing transport corridors in the region, it is unlikely that Stage 4 of the Revised Proposal will result in a significant increase in feral predators.

Further, given introduced predators in the area are ground dwelling and the Pilbara Leaf-nosed Bat is a highly mobile species, the risk of predation by introduced predators is low. Should such an event occur, impacts would be limited to occasional impacts to a small number of individuals.

5.2.6.1.3 Ghost bat (*Macroderma gigas*)

Potential direct impacts that may occur to Ghost Bats as a result of Stage 4 of the Revised Proposal are:

- loss of habitat;
- interaction with construction activities;
- vehicle strike during operations;
- collision with fencing;
- disturbance from light emissions; and
- disturbance from light, noise and vibration emissions.

Potential indirect impacts that may occur to Ghost Bats as a result of Stage 4 of the Revised Proposal are:

- introduced species including increased predation and competition from feral predators.

Loss of habitat

Habitat loss, particularly roost site loss, and degradation is identified as a threat to species in the conservation advice for the Ghost Bat (TSSC, 2016a). A breakdown on the expected loss of potential Ghost Bat habitat as a result of clearing for Stage 4 of the Revised Proposal is provided in Table 5-24. Up to 313.4 ha of potential Ghost Bat habitat will be permanently cleared for Stage 4 of the Revised Proposal representing less than 0.004% of the overall similar habitat in the Pilbara Region (estimated extent of over 9.3 million ha - Table 5-13). In addition, 48.3 ha of Ghost Bat foraging habitat (Floodplains) may be cleared temporarily. This area will be rehabilitated post construction. The Indicative Temporary Clearing Areas have been placed to avoid Ghost Bat foraging habitat within 5 km of the possible Ghost Bat maternity roost. Any refinement to these areas will maintain this avoidance.

This habitat has been identified as primarily foraging and flyway habitat with a small amount of potential roosting habitat.

Table 5-24 Extent of Ghost Bat Habitat Clearing for Stage 4 of the Revised Proposal

Habitat type	Habitat importance	Indicative Disturbance Footprint (ha)[1]	Indicative Temporary Clearing Area (ha)[1]	Extent present within Development Envelope (ha)	% of Development Envelope to be cleared
CP - Floodplains	Supporting habitat – foraging	Up to 135.0	Up to 48.3	1,778.6	Up to 10.3%
HS – Mesas, caves, cliffs and free faces	Supporting habitat – potential roosting, foraging	Up to 0.14	0.0	8.4	Up to 1.67%
RHS – Rocky hills and slopes with low open spinifex and scattered trees	Supporting habitat – foraging	Up to 88.7	0.0	702.1	Up to 12.65%
MDE – Eucalyptus fringed major	Supporting habitat – foraging, drinking	Up to 85.5	0.0	1,233.1	Up to 6.95%

drainage lines and associated tributaries					
MDM - Melaleuca forest/major drainage lines	Supporting habitat – foraging, flyway, drinking	Up to 0.03	0.0	21.2	Up to 0.14%
RG - Rocky gullies	Supporting habitat – foraging	Up to 3.8	0.0	13.7	Up to 27.74%
MMW - Man-made water bodies	Supporting habitat – drinking	Up to 0.14	0.0	2.3	Up to 6.09%
Total		Up to 313.4	Up to 48.3	3759.4	Up to 9.62%

[1]Extent to be cleared based on Indicative Disturbance Footprint and Indicative Temporary Clearing Area.

One cave with evidence of Ghost Bat usage was recorded within the Development Envelope during the Biota (2021) survey. This cave is located in the Hamersley section approximately 300 m outside of the Indicative Disturbance Footprint in the Rocky hills and slopes with low open spinifex and scattered trees habitat type (Figure 18). Ghost Bat scats were also recorded at two caves in the Tom Price section of the biota survey area (but outside of the Development Envelope) in the Rocky hills and slopes with low open spinifex and scattered trees habitat type (Figure 18), with one identified as a potential maternity roost located approximately 125 m from the Development Envelope (Biota, 2021).

Ghost Bats are known to require a number of suitable caves throughout their home ranges. The presence of day roosts and/or maternity roosts in an area is the most important indicator of suitable habitat for Ghost Bats, and these caves are generally the primary focus of conservation and/or monitoring (TSSC, 2016a). As such, the presence of these caves (particularly the potential maternity roosting cave within 125 m of the Development Envelope) suggests a population of ghost bats use the area and that the foraging habitat in the Development Envelope, and particularly in the area near the caves is of high importance. The conservation advice for Ghost Bats suggests that suitable habitat within 5 km of diurnal roost sites provide good foraging opportunities for the species (TSSC, 2016b). Up to 18.7 ha of Ghost Bat foraging habitat within 5 km of the possible maternity roost will be cleared for Stage 4 of the Revised Proposal. In addition, up to 92.7 ha of Ghost Bat foraging habitat within 5 km of the cave with evidence of Ghost Bat usage within the Development Envelope will be required.

Main Roads will avoid direct impacts to these caves (including the potential maternity roost) and mitigation measures will be implemented including creating an activity buffer of 400 m within which monitoring of caves identified by Biota (2021) as Ghost Bat roosting caves would be required, and the creation of a 150 m no-go zone between the Indicative Disturbance Footprint and the caves and demarcating the location of the cave during construction activities. This buffer, in which no clearing will be undertaken, will provide effective protection to the Ghost Bat caves and ensure that they are not lost or damaged.

High quality foraging habitat is present in the Development Envelope and surrounding areas. These habitats are common within the Pilbara region, totalling an estimated extent of over 9.3 million ha (Table 5-13), with vast amounts being vested in National Parks including the adjacent Millstream-Chichester National Park. Ghost Bats have a foraging range of 5 km from their roosts, which means

that the Ghost Bats are not dependent on the foraging habitat within the Development Envelope and are expected to use other foraging resources in the area.

Given the relatively small amount of Ghost habitat to be cleared compared to the regionally available habitat (the habitat to be lost represents less than 0.004% of the overall similar habitat in the Pilbara region), the fact that the Revised Proposal is linear infrastructure which means the habitat loss will not be concentrated in a particular area, the expectation that Ghost Bats will utilise other available foraging habitat, and the proposed mitigation measures, Stage 4 of the Revised Proposal is unlikely to result in impacts to Ghost Bat roosting caves or have a significant impact on Ghost Bats foraging activities (with the exception of the clearing within 5 km of the possible maternity roost which represents a significant residual impact as described above).

Interaction with construction activities

Injury or mortality of Ghost Bat individuals may occur as a result of interaction with the construction activities including construction equipment and clearing. Given that caves with evidence of Ghost Bat usage and high quality foraging habitat occurs within the Development Envelope and surrounding areas, there is the potential for Ghost Bats to interact with construction activities as they forage, where these activities occur at dusk or during the night.

Ghost Bats are a highly mobile species and are expected to display avoidance behaviour and actively avoid the construction equipment. Main Roads has committed to a 150 m no go zone around the cave within the Development Envelope that has evidence of Ghost Bat usage.

The risk of injury or mortality occurring as a result of interaction with construction equipment is low given the clearing will primarily be undertaken during the daytime with limited night works planned. In the event that such impacts do occur, they would be limited to a small number of individuals.

Vehicle strike

While there is a lack of data for roadkill rates for the Ghost Bat, as noted in Section 5.2.3.4.3 Ghost Bats curiosity for light sources and foraging height of less than three metres makes it vulnerable to collision with cars

An increase in the number of roads or a larger volume of traffic may contribute to local decline in areas near roosting or foraging sites (DAWE, 2021c). However, the majority of the Development Envelope is adjacent to existing railways and the introduction of a new road is likely to have a minor additional impact.

While intermittent incidences of mortality from collision with vehicles may occur, the low expected traffic volume, especially at night, means that impacts will be limited to a small number of individuals and is unlikely to significantly affect the population size of the Ghost Bat. Therefore, there is a high level of confidence that potential impacts to the Ghost Bat as a result of vehicle strike will not be significant.

Collision with fencing

It is possible that fencing will be installed at selected areas along the new road for the protection of road users or for other health, safety and environment reasons. Consultation with landowners is

currently ongoing in regard to fencing and will only be installed where an agreement is reached. It is, therefore, possible that individual bats may collide with this fencing.

Collision with fences is identified in the conservation advice for the Ghost Bat as a threat to the species. Ghost bats often fly at approximately fence height and substantial numbers are known to be killed when colliding with fencing wire. The conservation advice for the ghost bat notes that a single fence can effectively remove a population of Ghost Bats over time and that this has been observed to occur in the Pilbara (TSSC, 2016a).

Fencing required for Stage 4 of the Revised Proposal will be managed to reduce the potential for impacts to occur to Pilbara Leaf-nosed Bats. This includes minimising fencing as far as practicable and using devices such as discs or tags on the top wire to make them more visible to bats. Barbed wire will not be used in fencing.

Given the mitigation measures, it is expected that if fencing is required for Stage 4 of the Revised Proposal, this may result in the injury or mortality to a small number of Ghost Bat individuals and is not expected to result in a significant reduction in the Ghost Bat population in the area.

Disturbance from artificial light

While there is no permanent lighting associated with Stage 4 of the Revised Proposal, temporary mobile lighting will be installed during construction. Temporary lighting will not remain in one place for long and will be moving along the road route as per the construction schedule.

Very strong light sources may confuse or temporarily blind Ghost Bats, although there is no information available to the extent that this occurs (Biologic, 2016). Insectivorous fauna (such as bats) may be attracted to light sources due to the concentration of insects in well-lit areas. Given the temporary and localised nature of the light emissions and resultant minor behaviour impact, these impacts are not expected to be significant.

Studies at roosts have demonstrated that artificially increased light levels can significantly delay the timing of bat emergence and disturb their use of commuting routes, both of which will reduce the time available for foraging. Lighting required for construction will be directed away from potential roost caves, thereby reducing light spill in the direction of these caves. To reduce the potential for impacts from artificial lighting, mitigation measures will be implemented including creating an activity buffer of 400 m within which monitoring of caves identified by Biota (2021) as Ghost Bat roosting caves would be required, and the creation of a 150 m no-go zone around the caves that were recorded by Biota (2021) as having evidence of Ghost Bat usage.

Given these planned mitigation measures, impacts to the Ghost Bat from light emissions are unlikely to occur as a result of Stage 4 of the Revised Proposal.

Disturbance from noise and vibration

While there is limited information currently available on the impact of noise and vibration on Ghost Bats, they are known to be sensitive to noise and vibration disturbances within or in close proximity to daytime roosts and they could abandon their roost (Biologic, 2016). Displaced bats are susceptible to death through dehydration, particularly during the dry season.

The available literature suggests that the application of buffer zones between noise and vibration generating activity and Ghost Bat caves can effectively mitigate impacts. A study by Bullen and Creese (2014), in relation to the impacts of a mining operation in the Pilbara on Ghost Bats, found that the maximum sound and vibration levels within a cave caused by ore body drilling operations at a minimum drilling distance of 50 m (60 dB(A) and 0.6 mm/s) will likely not result in the bats abandoning the cave. Armstrong (2010) identified that significant impacts were unlikely for short-term disturbance from drilling further than 25 m from a roost entrance and 85 m from the roost location. Based on the Armstrong (2010) study, TM Gold adopted an 85 m buffer between mining activities (including blasting) and known Ghost Bat roosting caves for their Spring Hill Gold Mine Project (Northern Resource Consultants Pty Ltd, 2018). This buffer zone was subsequently mandated as part of the ministerial approval for the project under the EPBC Act.

To ensure that impacts to caves with evidence of Ghost Bat usage does not occur, Main Roads will implement management and mitigation measures including creating an activity buffer of 400 m within which monitoring of caves identified by Biota (2021) as Ghost Bat roosting caves would be required, and the creation of a 150 m no-go zone between the Indicative Disturbance Footprint and the caves where no blasting activities will occur. These areas will be demarcated during construction activities.

The 150 m no-go zone is based on a study by Biota (2013). While not specifically focussed on Ghost Bats, Biota (2013) completed an empirical study using blasting trials, measured vibration levels and bat behavioural response for Rio Tinto's Koodaideri mine. The roost contained a colony of about 400 Pilbara Leaf-nosed Bats but some Ghost Bat individuals were also present (noting that these two species share roost microclimate requirements to a large degree). The objective of the study was to conduct a quantified field trial using explosive charges of incrementally increasing intensity and proximity to the roost and relate these to measures of vibration at the roost (using a triaxial geophone) and behavioural response in the resident bats (with real-time call detection). The closest blast in the trial was 160 m from the centre of the cavern where the bats roost and the study was carried out during the day, when the bats are resident and usually inactive. Very little evidence of any disturbance behaviour was detected that could be associated with the trial blasts. Only three individual calls were recorded during the trial period that were concurrent with blast timing, demonstrating that the great majority of the colony was not disturbed by even the closest blast. There was no evidence detected that blasting significantly disturbed the colony as a whole.

Main Roads will prepare a Blasting Noise and Vibration Management Plan to address any risks to Ghost Bats. This plan will be prepared for approval by the CEO prior to any blasting occurring within 400 m of a cave with evidence of Ghost Bat usage. The purpose of this plan will be to meet the stated management objective to "Avoid impacts to roosting caves used by Ghost Bats". This plan will outline the blasting activities, noise and vibration monitoring (in relation to the caves) and an adaptive management approach. The Blasting Noise and Vibration Management Plan will include a requirement for the blasting contractor to ensure that the predicted peak particle velocity (PPV) values for each blast is included in the blast design. The PPV will be required to be calculated using an industry recognised approach that incorporates predictive mechanisms for ground vibration and is in accordance with AS 2187. Following consultation with a fauna specialist a threshold for the predicted PPV will be agreed between Main Roads and DWER to ensure no impact to any cave being used by Ghost Bats. The plan will also specify procedures for monitoring of the PPV including monitoring of blasts undertaken away from the Ghost Bat caves to verify that impact thresholds will not be exceeded during blasting activities within 400 m of a cave with evidence of Ghost Bat usage.

It should also be noted that blasting will occur intermittently and will not be concentrated in one place for long and will be moving along the road route as per the construction schedule. Given this and the proposed 150 m buffer (i.e. no blasting will occur within 150 m of any cave recorded by Biota (2021) as having evidence of Ghost Bat usage), no significant impacts, such as roost abandonment, are predicted to occur as a result of noise and vibration from construction activities, include blasting.

Impacts to foraging Ghost Bats from noise and vibration may occur but would be limited to disturbance of foraging bats resulting in them foraging elsewhere. Given the large amount of suitable foraging habitat available in the area and the limited night works planned, any impacts to foraging bats from noise and vibration will be negligible.

Introduced species

The conservation advice for the Ghost Bat identifies competition with introduced predators as a threat to the species (TSSC, 2016a).

Feral predators are already present and have been recorded in Biota (2021). Mitigation measures will be implemented as described in Section 5.2.5, and include waste management measures to minimise attraction of feral predators. Given the proposed mitigation measures, existing disturbance and multiple existing transport corridors in the region, it is unlikely that Stage 4 of the Revised Proposal will result in a significant increase in feral predators or resultant competition for prey with Ghost Bats.

5.2.6.1.4 Pilbara Olive Python (*Liasis olivaceus barroni*)

Potential direct impacts that may occur to Pilbara Olive Python as a result of Stage 4 of the Revised Proposal are:

- loss of habitat;
- interaction with construction activities;
- vehicle strike during operations; and
- disturbance from noise and vibration emissions.

Potential indirect impacts that may occur to Pilbara Olive Python as a result of Stage 4 of the Revised Proposal are:

- fragmentation of habitat due to the presence of the road; and
- introduced species including increased predation by feral predators.

Loss of habitat

The Conservation Advice for the Pilbara Olive Python identifies destruction of habitat as a threat to the species (TSSC, 2008). A breakdown on the expected loss of potential Pilbara Olive Python habitat as a result of clearing for Stage 4 of the Revised Proposal is provided in Table 5-25. Up to 313.3 ha of potential Pilbara Olive Python habitat will be permanently cleared for Stage 4 of the Revised Proposal representing less than 0.004% of the overall similar habitat in the Pilbara Region (estimated extent of over 8.7 million ha - Table 5-13). In addition, 48.3 ha of Pilbara Olive Python foraging habitat (Floodplains) may be cleared temporarily. This area will be rehabilitated post construction.

This habitat has been identified as foraging habitat for the species.

Table 5-25 Extent of Pilbara Olive Python Habitat Clearing for Stage 4 of the Revised Proposal

Habitat type	Habitat importance	Indicative Disturbance Footprint (ha)[1]	Indicative Temporary Clearing Area (ha)[1]	Extent present within Development Envelope (ha)	% of Development Envelope to be cleared
CP - Floodplains	Supporting habitat - foraging	Up to 135.0	Up to 48.3	1,778.6	Up to 10.3%
HS – Mesas, caves, cliffs and free faces	Supporting habitat - foraging	Up to 0.14	0.0	8.4	Up to 1.67%
RHS – Rocky hills and slopes with low open spinifex and scattered trees	Supporting habitat - foraging	Up to 88.7	0.0	702.1	Up to 12.65%
MDE – Eucalyptus fringed major drainage lines and associated tributaries	Supporting habitat - foraging	Up to 85.5	0.0	1,233.1	Up to 6.95%
MDM - Melaleuca forest/major drainage lines	Supporting habitat - foraging	Up to 0.03	0.0	21.2	Up to 0.15%
RG Rocky gullies	Supporting habitat - foraging	Up 3.8	0.0	13.7	Up to 27.74%
Total		Up to 313.3	48.3	3,757.1	Up to 9.62%

[1]Extent to be cleared based on the Indicative Disturbance Footprint and Indicative Temporary Clearing Area.

Pilbara Olive Python individuals have large home ranges (between 88 ha and 449 ha), therefore they are unlikely to be dependent on the habitat to be cleared (Biota, 2021). The habitat to be lost represents less than 0.004% of the overall similar habitat in the Pilbara region. The Revised Proposal is linear infrastructure which means the habitat loss will not be concentrated in a particular area. Given the lack of dependence on the habitat to be cleared and the low density of Pilbara Olive Pythons expected to occur in the area, it is not predicted that the loss of this foraging habitat will significantly impact Pilbara Olive Python foraging.

Interaction with construction activities

Clearing activities may result in the loss of individual animals that are unable to move out of the way of heavy machinery. It is expected that Pilbara Olive Pythons will display avoidance behaviour and move away from the construction area as a result vibration from the construction equipment. Given this and mitigation measures such as reduced speed limits, it is unlikely that clearing activities will result in injury or mortality to Pilbara Olive Pythons.

Vehicle strike

The Conservation Advice the Pilbara Olive Python identifies roadkill as a main threat to the species (TSSC, 2008).

Road networks potentially increase the chance of Pilbara Olive Python mortality through vehicle strike. Vehicle strikes are likely to occur as the Pilbara Olive Python moves across roads, between shelters and forage sites. While there is a lack of road mortality literature specific to the Pilbara Olive Python, it is suspected that they may be particularly vulnerable to vehicle strikes as roads are often preferred basking spots for snakes. Suitable habitat for the Pilbara Olive Python occurs on either side of the proposed road, further increasing the potential for vehicle strike.

Given this, intermittent incidences of mortality from vehicle strike may occur, however the low expected traffic volume means that impacts will be limited to a small number of individual and is unlikely to significantly affect the population size of the Pilbara Olive Python. Therefore, there is a high level of confidence that potential impacts to the Pilbara Olive Python as a result of vehicle strike will not be significant.

Noise and vibration

Vibrations caused by the construction equipment may lead to behavioural (avoidance) impacts to Pilbara Olive Pythons. These impacts are expected to be temporary and limited to a small number of individuals. Due to the linear nature of the construction, this effect is expected to be short lived with individuals recolonising the area once construction activities cease. Therefore, there is a high level of confidence that potential impacts to the Pilbara Olive Python as a result of noise and vibration will be insignificant.

Fragmentation of habitat and population isolation

Clearing along the road alignment has the potential to fragment Pilbara Olive Python habitat. However, as Pilbara Olive Python individuals will be able to cross the road, these habitats will still be available for use as refuge and foraging habitat. As this fragmentation will not result in the isolation of habitat or Pilbara Olive Python populations, it is not expected to result in a significant impact to the species.

Introduced species

The Conservation Advice for the Pilbara Olive Python identifies predation by feral cats and foxes and predation of food sources by foxes as a main threat to the species (TSSC, 2008).

Feral predators may play a role in the decline of the Pilbara Olive Python through predation, particularly of juveniles, as well as predation of the Pilbara Olive Python's food sources (such as Quolls and Rock-Wallabies) (DAWE, 2021c; Ellis, n.d.; Pearson et al., 2013; TSSC, 2008).

Feral predators are already present and have been recorded by Biota (2021). Mitigation measures will be implemented as described in Section 5.2.5, and include waste management measures to minimise attraction of feral predators. Given the proposed mitigation measures (Section 5.2.5), existing disturbance and multiple existing transport corridors in the region, it is unlikely that Stage 4 of the

Revised Proposal will result in an increase in feral predators such that Pilbara Olive Python population is likely to decline.

5.2.6.1.5 Night Parrot (Pezoporus occidentalis)

Potential direct impacts that may occur to Night Parrots as a result of Stage 4 of the Revised Proposal are:

- loss of habitat;
- interaction with construction activities;
- vehicle strike during operations;
- collision with fencing; and
- disturbance from light, noise and vibration emissions.

Potential indirect impacts that may occur to Night Parrots as a result of Stage 4 of the Revised Proposal are:

- introduced species including increased predation and competition from feral predators.

Loss of habitat

The Conservation Advice for the Night Parrot (TSSC, 2016b) lists 'habitat loss, disturbance and modifications' as a threat to this species.

A breakdown on the expected loss of potential Night Parrot habitat as a result of clearing for Stage 4 of the Revised Proposal is provided in Table 5-26. Up to 29.3 ha of potential Night Parrot foraging habitat will be cleared for Stage 4 of the Revised Proposal representing less than 0.005% of the overall similar habitat in the Pilbara Region (estimated extent of over 0.6 million ha - Table 5-13). No Night Parrot habitat is present within the Indicative Temporary Clearing Area.

Table 5-26 Extent of Night Parrot Clearing for Stage 4 of the Revised Proposal

Habitat type	Habitat importance	Indicative Disturbance Footprint (ha)[1]	Indicative Temporary Clearing Area (ha)[1]	Extent present within Development Envelope (ha)	% of Development Envelope to be cleared
Grassland plains with cracking clay (GPCC)	Supporting habitat - foraging	Up to 29.3	0.0	203.4	Up to 14.41%

[1]Extent to be cleared based on the Indicative Disturbance Footprint and Indicative Temporary Clearing Area.

As described in Section 5.2.3.4.5, while this species 'may occur' within the Development Envelope due to the presence of suitable habitat, it is highly unlikely that a Night Parrot population is present in the Development Envelope.

Given the Night Parrot is highly mobile and nomadic, populations in the region will continue to have access to suitable foraging habitat and Stage 4 of the Revised Proposal is unlikely to result in decreases to the abundance of Night Parrots attributable to foraging habitat loss.

Interaction with construction activities

Clearing activities may result in the loss of individual animals that are unable to move out of the way of heavy machinery. It is expected that Night Parrots (if present in the area) will display avoidance behaviour and move away from the construction area as a result of noise from the construction equipment.

Given this and as Night Parrots are highly unlikely to be present in the area, the risk of such impacts is low.

Vehicle strike

While Night Parrots are ground dwelling, they are unlikely to be attracted to the road given their diet which consists mainly of seeds. Given this and as Night Parrots are highly unlikely to be present in the area, the risk posed by vehicle strike is very low.

Collision with fencing

Fences are noted within the conservation advice for Night Parrots as potential threats to the species as they tend to fly low over the ground, thus increasing the risk of collision compared with other birds. It is possible that fencing will be installed at selected areas along the new road for the protection of road users or for other health, safety and environment reasons. Consultation with landowners is currently ongoing in regard to fencing and will only be installed where an agreement is reached.

Fencing required for Stage 4 of the Revised Proposal will be managed to reduce the potential for impacts to occur to Night Parrots. This includes minimising fencing as far as practicable and using devices such as discs or tags on the top wire to make them more visible to birds. Barbed wire will not be used in fencing.

Given these mitigation measures and as Night Parrots are highly unlikely to be present in the area, the risk posed fencing (is installed) to Night Parrots is very low.

Disturbance from light, noise and vibration

As Night Parrots forage at night, light emissions from the construction activities may result in temporary avoidance behaviour in individual Night Parrots (if present). This impact is unlikely to significantly impact foraging behaviour.

Noise emissions from the construction activities may result in temporary avoidance behaviour in individual Night Parrots (if present). Given the temporary nature of this avoidance behaviour, there is a high level of confidence that potential impacts to the Night Parrot as a result of noise and vibration will not be significant.

Introduced species

The Interim Recovery plan for the Night Parrot identifies predation by feral cats and foxes and grazing by stock or rabbits as a threat to this species (Blyth, 1996). Specifically, the historical arrival of cats in Alice Springs coincided with a decline in Night Parrots, whilst there is no direct evidence of predation on the Night Parrot by foxes (TSSC, 2016b).

Feral predators are already present and have been recorded by Biota (2021). Mitigation measures will be implemented as described in Section 5.2.5, and include waste management measures to minimise attraction of feral predators. Given the proposed mitigation measures, existing disturbance and multiple existing transport corridors in the region, it is unlikely that Stage 4 of the Revised Proposal will result in a significant increase in feral predators or subsequent increased predation on Night Parrots.

5.2.6.1.6 Grey Falcon (*Falco hypoleucos*)

Potential direct impacts that may occur to Grey Falcons as a result of Stage 4 of the Revised Proposal are:

- loss of habitat;
- interaction with construction activities;
- vehicle strike during operations;
- collision with fencing; and
- disturbance from light, noise and vibration emissions.

Potential indirect impacts that may occur to Grey Falcons as a result of Stage 4 of the Revised Proposal are:

- introduced species including increased predation and competition from feral predators.

Loss of habitat

A breakdown on the expected loss of potential Grey Falcon habitat as a result of clearing for Stage 4 of the Revised Proposal is provided in Table 5-27. Up to 596.1 ha of potential Grey Falcon habitat will be cleared for Stage 4 of the Revised Proposal representing less than 0.004% of the overall similar habitat in the Pilbara Region (estimated extent of over 17.8 million ha - Table 5-13).

In addition, up to 100.0 ha of Grey Falcon nesting, foraging and drinking habitat may be cleared temporarily. This area will be rehabilitated post construction. Note that large trees suitable for nesting for Grey Falcons will not be cleared for the temporary clearing.

This habitat has been identified as primarily foraging habitat with some potential nesting habitat in the melaleuca forest/major drainage lines and eucalyptus fringed major drainage lines and associated tributaries habitat types.

Table 5-27 Extent of Grey Falcon Clearing for Stage 4 of the Revised Proposal

Habitat type	Habitat importance	Indicative Disturbance Footprint (ha)[1]	Indicative Temporary Clearing Area (ha)[1]	Extent present within Development Envelope (ha)	% of Development Envelope to be cleared
MG - Grove Mulga	Supporting habitat - foraging	69.7	14.4	666.2	Up to 12.63%

MWP - Mulga Woodland Plain	Supporting habitat - foraging	16.1	0.6	122.5	Up to 13.55%
ASCC - Acacia *xiphophylla* shrublands over cracking clay	Supporting habitat - foraging	10.4	9.3	328.9	Up to 5.98%
ASM - Mixed Acacia shrublands	Supporting habitat - foraging	157.5	31.7	1,659.2	Up to 11.40%
GPCC - Grassland plains with cracking clay	Supporting habitat - foraging	29.3	0.0	203.7	Up to 14.29%
CP - Floodplains	Supporting habitat - foraging	135	44	1,778.6	Up to 10.06%
HS - Mesas, caves, cliffs and free faces	Supporting habitat - foraging	0.14	0.0	8.4	Up to 1.67%
RHS - Rocky hills and slopes with low open spinifex and scattered trees	Supporting habitat - foraging	88.7	0.0	702.1	Up to 12.65%
MDE - Eucalyptus fringed major drainage lines and associated tributaries	Supporting habitat – nesting, foraging	85.5	0.0	1,233.1	Up to 6.95%
MDM - Melaleuca forest/major drainage lines	Supporting habitat – foraging, nesting	0.03	0.0	21.2	Up to 0.14%
RG - Rocky gullies	Supporting habitat - foraging	3.8	0.0	13.7	Up to 27.74%
MMW - Man-made water bodies	Supporting habitat – drinking, foraging	0.14	0.0	2.3	Up to 6.09%
Total		596.1	100.0	6739.9	Up to 10.32%

[1]Extent to be cleared based on Indicative Disturbance Footprint

The Conservation Advice for the Grey Falcon (TSSC, 2020) lists the conservation of known nesting trees, and the inclusion of an adequate exclusion buffer, as a conservation and management priority. Both the eucalyptus fringed major drainage lines and associated tributaries and melaleuca forest/major drainage lines habitats cross the Indicative Disturbance Footprint in a number of places. These habitats contain tall trees that may be required to be removed for Stage 4 of the Revised Proposal. No nesting trees were recorded during the Biota (2021) survey, however one Grey Falcon was observed, and the species has been recorded in the area previously. This suggests that the species forages in the area and may use tall trees in the melaleuca forest/major drainage lines and eucalyptus fringed major drainage lines and associated tributaries habitat type for nesting.

As noted in Section 5.2.3.4.6, the Grey Falcon is not reliant on the habitat that will be lost within the Development Envelope. The species is not restricted to nesting in one species of tall tree and the removal of tall trees for Stage 4 of the Revised Proposal is unlikely to impact future nesting. The species is also unlikely to be reliant on the foraging habitat in the Development Envelope given its mobile nature and the extensive availability of similar habitat in the region.

The habitat to be lost represents less than 0.004% of the overall similar habitat in the Pilbara region. Given this, the lack of dependence of the species on the habitat to be cleared, and the fact that the Revised Proposal is linear infrastructure which means the habitat loss will not be concentrated in a particular area, it is predicted that clearing will not result in a significant impact to Grey Falcons.

Interaction with construction activities

Clearing activities may result in the loss of individual animals that are unable to move out of the way of heavy machinery. It is expected that Grey Falcons will display avoidance behaviour and move away from the construction area as a result of noise from the construction equipment. Given this, the low number of individuals likely to be in the area, and as Grey Falcons are a highly mobile, aerial species, the risk of such impacts is low.

Vehicle strike

Like many birds of prey, the Grey Falcon may forage on road-kill animals such as reptiles, mammals and other bird species. The construction of a new road presents a risk to these species as they are vulnerable to vehicle strike when feeding on road-kill. Grey Falcons also often roost on bare ground at night which may include areas within the road reserve. The conservation advice for the Grey Falcon identified collisions with vehicles as a threat to the species and notes that Schoenjahn (2018) documented six cases of Grey Falcons being found injured or dead along roads between 2007 and 2017 (TSSC, 2020). Given this, intermittent incidences of mortality from collision with vehicles may occur. However, the low number of individuals in the area, and the low expected traffic volume means that impacts will be limited to a small number of individuals and is unlikely to significantly affect the population size of the Grey Falcon.

Collision with fencing

Collision with fences is noted within the conservation advice for Grey Falcons as a potential threat to the species (TSSC, 2020). It is possible that fencing will be installed at selected areas along the new road for the protection of road users or for other health, safety and environment reasons. Consultation with landowners is currently ongoing in regard to fencing and will only be installed where an agreement is reached. It is therefore, possible individual Grey Falcons may collide with this

fencing when approaching the ground or taking off, however given the low density of Grey Falcons expected to occur in the area and the small sections of fencing relative to the broader landscape, this is highly unlikely.

Fencing required for Stage 4 of the Revised Proposal will be managed to reduce the potential for impacts to occur to Grey Falcons. This includes minimising fencing as far as practicable and utilising devices such as, discs on the top wire to make them more visible to birds.

Disturbance from light, noise and vibration

Noise emissions from the construction activities may result in avoidance behaviour in individual Grey Falcons (if present). Given the abundant suitable habitat available in the area, avoidance behaviour as a result of noise emissions is not expected to have a discernible impact on Grey Falcons.

Introduced species

The Conservation Advice for the Grey Falcon recognises predation by feral cats as a 'Very High' risk. Whilst the Grey Falcon nests in tall trees they have been shown to roost on bare open ground (Schoenjahn, 2018). This behaviour exposes this species to predation by introduced species such as feral cats.

Feral predators are already present and have been recorded in the Biota (2021) survey. Given the proposed mitigation measures (Section 5.2.5), existing disturbance and multiple existing transport corridors in the region, it considered unlikely that Stage 4 of the Revised Proposal will result in a significant increase in feral predators or subsequent increased predation on, or competition with Grey Falcons.

5.2.6.2 Other Specially Protected Fauna – Peregrine Falcon (*Falco peregrinus*)

The Peregrine Falcon is likely to occur in the area and uses the same habitats as the Grey Falcon (Table 5-27). As with the Grey Falcon, the Peregrine Falcon may use tall trees in the eucalyptus fringed major drainage lines and associated tributaries and melaleuca forest/major drainage lines for nesting, and all habitat types in the Development Envelope for foraging.

Potential impacts of Stage 4 of the Revised Proposal on the Peregrine Falcon are also similar to that for the Grey Falcon. These impacts are not expected to be significant given:

- the potential Peregrine Falcon habitat to be lost represents less than 0.004% of the overall similar habitat in the Pilbara region and the species is not restricted to the habitat within eh Development Envelope or reliant on it;
- the low density of Peregrine Falcons that are expected to occur in the area and their mobile nature means that there is a low likelihood that interactions between the construction activities and individual Peregrine Falcons resulting in injury or mortality will occur;
- while intermittent incidences of mortality from collision with vehicles during the road's operations may occur, the low number of individuals in the area, and the low expected traffic volume means that impacts will be limited to a small number of individual Peregrine Falcons;
- the low density of Peregrine Falcons expected to occur in the area and the proposed mitigation measures (minimising fencing as far as practicable and utilising devices such as, discs on the top

wire to make them more visible to bird) means Peregrine Falcon collisions with fences associated with Stage 4 of the Revised Proposal are highly unlikely to occur;

- impacts from light, noise and vibration are expected to be limited to behavioural impacts (avoidance) given the species highly mobile nature; and
- it is not expected that Stage 4 of the Revised Proposal will result in a significant increase in feral predators or subsequent increased predation on, or competition with Peregrine Falcons.

5.2.6.3 Priority Fauna

5.2.6.3.1 Western Pebble-mound Mouse (*Pseudomys chapmani)*

Up to 246.2 ha of potential Western Pebble Mound Mouse foraging and nesting habitat (habitat types mixed acacia shrublands, and rocky hills and slopes with low open spinifex and scattered trees) will be cleared for Stage 4 of the Revised Proposal. As noted in Section 5.2.3.6.1, two active and two non-active Western Pebble-mound Mouse mounds were identified during the Biota (2021) survey. The two active mounds and one of the non-active mounds are located in close proximity to each other and between 60 m and 80 m from the Indicative Disturbance Footprint. The other non-active mound is located over 400 m from the Indicative Disturbance Footprint (Biota, 2021).

These mounds provide a micro-climate for the Western Pebble-mound mouse and protection from the heat of the day. They are likely to be important for the population that use each mound. Based on the current Indicative Disturbance Footprint and planned mitigation measures which include the establishment on no-go zones around the mounds, these mounds are unlikely to be impacted.

Should the Indicative Disturbance Footprint change and require removal of these mounds, Main Roads will relocate Western Pebble-mound Mouse through displacement methods where the mice using the active burrows are encouraged to vacate the mounds and relocate within their home range. This process will not include physical capture and relocation.

To do this, Main Roads, will endeavour to work around active mounds within the clearing footprint, leaving a corridor for the Western Pebble-mound Mouse to relocate to other areas within their home range, hopefully taking up residence within nearby vacant burrows they are already familiar with, Main Roads will work within 5 m of active mounds, leaving a 6 m wide corridor of vegetation to the nearest clearing boundary for a period of three days. If activity is still detected on the mound after three days, the clearing radius to the mound will be reduced to 2 m for a further two days, then within 1 m for two days again. The mound area will only be cleared after two consecutive nights of inactivity or following the nine days of perimeter disturbance, whichever occurs first. Activity will be determined using motion sensor cameras.

In the event the above method is not successful, an alternative will be to install a light tower on/next to each mound for three days, triggering the mice to relocate to avoid the noise, vibration and light. It is proposed to establish lighting towers on mounds within 15 days of clearing occurring. After the third night, where possible, manual excavation of up to 200 mm of the surface of the mound will take place to ensure the mound is unattractive for mice to relocated back into the mound before the area is cleared, but still providing the opportunity for any remaining resident mice to evacuate the damaged mound.

The proposed displacement method has previously been used by Main Roads Coongan Gorge upgrade. As part of the Coongan Gorge upgrade Main Roads prepared a Vegetation Clearing Permit (VCP) application which resulted in the issuance of Clearing Permit CPS 7549/1. An appeal was lodged in relation to the condition of the clearing permit which appealed against the management conditions relating to Western Pebble Mound Mouse mounds. During the appeals process Main Roads undertook further work to demonstrate how impacts could be further minimised to this species where active mounds could not be avoided. This included consultation with fauna specialists and the DBCA. Main Roads committed to avoiding active mounds where practicable and to relocate mice through displacement methods where clearing of active mounds could not be avoided. DBCA advised that it was satisfied with this approach and confirmed that displacement is the most appropriate relocation method for this species. The proposed approach for Stage 4 of the Revised Proposal reflects the approach approved for the Coongan Gorge upgrade.

The removal of one or two active mounds would not be expected to significantly impact the species at a population level.

The Western Pebble-mound Mouse foraging and nesting habitats present in the Development Envelope are common within the Pilbara region (van Dyck and Strahan, 2008). With the relatively small amount of Western Pebble-mound Mouse habitat to be cleared compared to the regionally available habitat, along with avoidance of active mounds as far as practicable, and the fact that Stage 4 of the Revised Proposal is linear infrastructure which means the habitat loss will not be concentrated in a particular area, it is predicted that permanent clearing of up to 246.2 ha and temporary clearing of up to 100 ha of potential foraging and nesting habitat will not result in a significant impact to the Western Pebble-mound Mouse.

Other potential impacts to Western Pebble-mound Mouse as a result of Stage 4 of the Revised Proposal are not predicted to be significant given:

- being a rodent, the species has a high fecundity which enables populations to recover from individual deaths (Start et al., 2000);
- construction of the road is not expected to result in the isolation of Western Pebble-mound Mouse populations as the species, as the Western Pebble-mound Mouse will be able to cross the road and habitats will still be available for use as foraging and nesting habitat;
- with the exception of the potential removal of the Western Pebble-mound Mouse mounds described above, the mobile nature of the species means that there is a low likelihood that interactions between the construction activities and individual Western Pebble-mound Mouse individuals resulting in injury or mortality will occur;
- the small size of the species, the low expected traffic volume and the fact that Western Pebble-mound Mice are unlikely to be attracted to the operating road means that it is highly unlikely that mortality or injury will occur to the species as a result of vehicle strike;
- the species is adaptable and active mounds are known to occur adjacent to noise generating activities such as mining exploration (Biologic, 2020). As such, it is unlikely that the light, noise or vibrations from the construction activities will significantly disturb the active Western Pebble-mound Mouse mounds; and
- it is expected that Stage 4 of the Revised Proposal will not result in a significant increase in feral predators or subsequent increased predation on Western Pebble-mound mice.

5.2.6.3.2 Other Priority Fauna

Priority fauna that are likely to occur or may occur in the Development Envelope are described in Section 5.2.3.6. The potential impact that is most relevant to these species is habitat loss as a result of clearing for Stage 4 of the Revised Proposal. The Priority fauna identified in Section 5.2.3.6 have a widespread distribution in the Pilbara region and none are restricted to or reliant on the habitats in the Development Envelope. The habitat that will be lost as a result of Stage 4 of the Revised Proposal is common and widespread in the Pilbara area and locally. Impacts to Priority fauna as a result of habitat loss are not expected to be significant.

Other impacts that may occur to these Priority species are consistent with potential impacts to threatened species described in Section 5.2.6.1. With the implementation of the planned mitigation measures described in Table 5-21, impacts to these species are expected to be limited to changes in behavioural patterns such as attraction or avoidance to the light and noise emissions from the construction activities, and potential injury or mortality to a small number of individuals as a result of vehicle strike during operation of the road.

5.2.6.4 Short Range Endemic Species

Due to the width and linear nature of Stage 4 of the Revised Proposal it is likely that any SRE taxa that occurs within the indicative Disturbance Footprint also occurs outside of it. None of the broad habitat types or smaller habitat units are restricted to within the Development Envelope, and all extend as continuous features in the landscape outside of the Development Envelope . Any potential impacts arising from the construction and operation of Stage 4 of the Revised Proposal are unlikely to significantly affect the potential SRE taxa identified in the desktop study (Section 5.2.3.7).

5.2.6.5 Impacts in the Context of Ongoing Project Refinements

The project design is in the alignment definition phase and is being further refined based on planning, stakeholder consultation and investigations. The alignment, Indicative Disturbance Footprint and Indicative Temporary Clearing Areas are therefore subject to change. Main Roads will however manage these refinements in a manner that ensure the environmental outcomes presented in Section 0 are achieved.

To confirm that refinements to the alignment (within the Development Envelope) can be made without resulting in a significantly different environmental outcome, Main Roads has undertaken an analysis of the impact of a series of refinements that are currently under consideration. This analysis includes a comparison of the predicted environmental impacts to threatened, other specially protected and priority fauna and fauna habitat for the Indicative Disturbance Footprint and two alternate alignments that include minor refinements to the Indicative Disturbance Footprint. Figure 26 shows the Indicative Disturbance Footprint and alternate disturbance footprints in the context of the vegetation mapping.

Table 5-28 presents the extent of suitable habitat for each significant fauna that were recorded by Biota (2021), are likely to occur or may occur in the Development Envelope for the Indicative Disturbance Footprint and alternate disturbance footprints. Note that the estimated habitat impact areas presented elsewhere in the document include an allowance of approximately 10% more than the habitat area mapped within the Indicative Disturbance Footprint. This provides flexibility in the location of the road and construction areas for access and laydown. However, for the purpose of this comparison (i.e. to show that habitat clearing can be maintained within the presented limits even with

potential refinements to the Indicative Disturbance Footprint), the 10% allowance has not been included in Table 5-28.

Table 5-28 shows that the refinements currently under consideration would result in a slight increase in the total permanent habitat clearing requirements when compared to the Indicative Disturbance Footprint. However, the total habitat clearing for each significant fauna species remains within the extents assessed in Section 5.2.6 (noting that the extents assessed include a 10% allowance for minor refinements to the Indicative Disturbance Footprint).

With respect to habitat critical to the survival of the Northern Quoll, there is a slight reduction (0.07 ha) in clearing required for alternate disturbance footprints when compared to the Indicative Disturbance Footprint. The required clearing of this habitat remains within the limits presented in this impact assessment (which include the 10% allowance for minor refinements).

Within this ERD, Main Roads has committed to implementing Stage 4 of the Revised Proposal such that direct and indirect impacts to Ghost Bat roosting caves identified in the Biota (2021) survey are avoided. Any refinement of the alignment will be undertaken in a manner that ensures no impact occurs to Ghost Bat Roosting caves.

As noted in Section 5.2.6.3.1, Stage 4 of the Revised Proposal may require the removal of two active Western Pebble-mound Mouse mounds. These are not located in the Indicative Disturbance Footprint and would only be removed if the Indicative Disturbance Footprint is adjusted. As shown on Figure 26 the refinements under consideration would result in the requirement to remove the two active Western Pebble-mound Mouse mounds. The removal of these mounds has been considered within the impact assessment. Displacement methods will be used to relocate Western Pebble-mound mice that utilise the mounds in the event that the mounds require removal.

Overall, the analysis shows that minor refinements can be made to the Indicative Disturbance Footprint without significantly altering the environmental outcomes for the Revised Proposal for the environmental factor Terrestrial Fauna.

Table 5-28 Comparison of Fauna Habitat Clearing Between Base Case and Alignment Refinements Under Consideration

Species	Habitat Type	Indicative Disturbance Footprint (ha)	Refinement Case A Disturbance Footprint (ha)	Refinement Case B Disturbance Footprint (ha)
Threatened Species				
Northern Quoll	Denning, foraging and dispersal	162.0	164.7	164.6
Pilbara Leaf-nosed Bat	Potential Roosting, foraging, flyway, drinking	162.0	164.7	164.6
Ghost Bat	Potential roosting, flyway, foraging, drinking	284.9	287.3	287.3
Pilbara Olive Python	Foraging	284.7	287.2	287.2
Night Parrot	Foraging	26.6	26.5	26.5

Grey Falcon	Nesting, foraging and drinking	541.6	548.8	547.8
Other Specially Protected Fauna				
Peregrine Falcon	Foraging and drinking	541.6	548.8	547.8
Priority Fauna				
Western Pebble-mound Mouse	Foraging and nesting	223.8	224.1	223.1
Northern Short-tailed Mouse	Foraging	26.6	26.5	26.5
Lined Soil-crevice Skink	Foraging	77.9	82.3	82.3
Long-tailed Dunnart	Foraging	84.2	82.4	82.4
Gane's Blind Snake	Foraging	3.4	3.4	3.4
Pilbara Barking Gecko	Foraging	80.9	79.0	79.0
Spotted Ctenotus	Foraging	9.5	6.7	6.7

Refinements to the location, extent and orientation of the Indicative Temporary Clearing Areas may also be required. These refinements will be made such that the environmental outcomes for the Revised Proposal remains within the limits described in Table 5-29.

5.2.7 Predicted Outcome

5.2.7.1 Environmental Outcomes

Table 5-29 details of the predicted environmental outcomes of the current Approved Proposal and Revised Proposal for Terrestrial Fauna.

It should be noted that the CER for the Approved Proposal was prepared in 2003 and the EPA finalised its decision report in 2005. Requirements in environmental impact assessment has progressed significantly in the early 2000's and the EPA has released a series of technical guidance with respect to the preparation of ERDs, the undertaking of biological surveys and the assessment of technical factors. Given this, direct comparison between the Approved Proposal and Revised Proposal is not possible in all cases.

Table 5-29 Environmental Outcomes for Revised Proposal – Terrestrial Fauna

Element	Approved Proposal	Proposed Changes	Revised Proposal
Impacts to Northern Quoll habitat	Not identified in CER.	• Addition of - No more than 178.3 ha of potential Northern Quoll denning, foraging and dispersal habitat within the Stage 4 Development Envelope will occur. Of this clearing, no more than 4.0 ha is of habitat identified as being critical to the survival of	• No more than 178.3 ha of potential Northern Quoll denning, foraging and dispersal habitat within the Stage 4 Development Envelope will occur. Of this clearing, no more than 4.0 ha is of habitat identified as being critical to the survival of the Northern Quoll and 42.3 ha of important

Element	Approved Proposal	Proposed Changes	Revised Proposal
		the Northern Quoll and 42.3 ha of important foraging and dispersal habitat within 1 ha of habitat critical to the survival of the Northern Quoll will be cleared.	foraging and dispersal habitat within 1 ha of habitat critical to the survival of the Northern Quoll will be cleared.
Impacts to Pilbara Leaf-nosed Bat habitat	Noted as potentially present but no assessment of impacts to habitat made.	• Addition of - No more than 178.2 ha of potential Pilbara Leaf-nosed Bat foraging, flyway and drinking habitat within the Stage 4 Development Envelope will be cleared.	• No more than 178.2 ha of potential Pilbara Leaf-nosed Bat foraging, flyway and drinking habitat within the Stage 4 Development Envelope will be cleared.
Impacts to Ghost Bat habitat	Noted as potentially present but no assessment of impacts to habitat made.	• Addition of - No more than 313.4 ha of potential Ghost Bat potential roosting, foraging, flyway and drinking habitat within the Stage 4 Development Envelope will be permanently cleared. Of this clearing no more than 18.7 ha of Ghost Bat foraging habitat within 5 km of the possible maternity roost and 92.7 ha of Ghost Bat foraging habitat within 5 km of the cave with evidence of Ghost Bat usage within the Development Envelope will be cleared. • Addition of - No direct or indirect impacts to Ghost Bat caves will occur • Additional of - No clearing activities will occur in the exclusion zone around caves with evidence of Ghost Bat usage. • Additon of - No more than 48.3 ha of Ghost Bat foraging habitat (Floodplains) will be cleared temporarily. This area will be rehabilitated post construction. The Indicative Temporary Clearing Areas have been placed to avoid Ghost Bat foraging habitat within 5 km of the possible Ghost Bat maternity roost. Any	• No more than 313.4 ha of potential Ghost Bat potential roosting, foraging, flyway and drinking habitat within the Stage 4 Development Envelope will be permanently cleared. Of this clearing no more than 18.7 ha of Ghost Bat foraging habitat within 5 km of the possible maternity roost and 92.7 ha of Ghost Bat foraging habitat within 5 km of the cave with evidence of Ghost Bat usage within the Development Envelope will be cleared. • No more than 48.3 ha of Ghost Bat foraging habitat (Floodplains) will be cleared temporarily. This area will be rehabilitated post construction. The Indicative Temporary Clearing Areas have been placed to avoid Ghost Bat foraging habitat within 5 km of the possible Ghost Bat maternity roost. Any refinement to these areas will maintain this avoidance. • No direct or indirect impacts to Ghost Bat caves will occur. • No clearing activities will occur in the exclusion zone around caves with evidence of Ghost Bat usage.

Element	Approved Proposal	Proposed Changes	Revised Proposal
		refinement to these areas will maintain this avoidance.	
Impacts to Pilbara Olive Python habitat	Presence of species noted in CER but assessment of impacts to habitat made.	• Addition of - No more than 313.3 ha of potential Pilbara Olive Python foraging habitat in the Stage 4 Development Envelope will be permanently cleared • Addition of - No more than 48.3 ha of Pilbara Olive Python foraging habitat (Floodplains) may be cleared temporarily. This area will be rehabilitated post construction.	• No more than 313.3 ha of potential Pilbara Olive Python foraging habitat in the Stage 4 Development Envelope will be permanently cleared. • No more than 48.3 ha of Pilbara Olive Python foraging habitat (Floodplains) may be cleared temporarily. This area will be rehabilitated post construction.
Impacts to Night Parrot	Not identified in CER	• Addition of - No more than 29.3 ha of potential Night Parrot foraging habitat within the Stage 4 Development Envelope will be cleared.	• No more than 29.3 ha of potential Night Parrot foraging habitat within the Stage 4 Development Envelope will be cleared.
Impacts to Grey Falcon habitat	Not identified in CER	• Addition of - No more than 596.1 ha of potential Grey Falcon foraging and drinking habitat in the Stage 4 Development Envelope will be permanently cleared. • Addition of - No more than 100.0 ha of Grey Falcon nesting, foraging and drinking habitat will be cleared temporarily cleared. This area will be rehabilitated post construction. Large trees suitable for nesting for Grey Falcons will not be cleared for the temporary clearing.	• No more than 596.1 ha of potential Grey Falcon foraging and drinking habitat in the Stage 4 Development Envelope will be permanently cleared. • No more than 100.0 ha of Grey Falcon nesting, foraging and drinking habitat will be cleared temporarily cleared. This area will be rehabilitated post construction. Large trees suitable for nesting for Grey Falcons will not be cleared for the temporary clearing.
Other Specially Protected Fauna and Priority Fauna habitat	Peregrine Falcon noted as potentially present but no assessment of impacts to habitat made. Fortescue Grunter, Lined Soil-crevice Skink (Dampier), Long-tailed Dunnart,	• Change to – Clearing of Other Specially Protected Fauna and Priority Fauna habitat will be avoided where possible and otherwise minimised.	• Clearing of Other Specially Protected Fauna and Priority Fauna habitat will be avoided where possible and otherwise minimised. • Removal of active Pebble Mound Mouse Mounds will be avoided where possible and otherwise minimised.

Element	Approved Proposal	Proposed Changes	Revised Proposal
	Spectacled Hare-Wallaby, Ghost Bat, Pebble-mound Mouse noted as potentially present but no assessment of impacts to habitat made		
SRE fauna	Not identified in CER	• Addition of – Clearing of SRE habitat will be avoided where possible and otherwise minimised.	• Clearing of SRE habitat will be avoided where possible and otherwise minimised.
Other impacts to fauna.	• Increased numbers of road kills, particularly significant for species such as the Pilbara Olive Python; • Changes in fire frequency, increases in abundance of introduced predators and increased • Levels of disturbance associated with increased human activity in the area.	Change to - Direct and indirect impacts to terrestrial fauna will be avoided where possible and otherwise minimised.	Direct and indirect impacts to terrestrial fauna will be avoided where possible and otherwise minimised.

5.2.7.2 Summary of Assessment of Significant Residual Impacts

No significant residual impacts to threatened fauna were identified in the Approval Proposal. The assessment of the significance of impacts to threatened fauna has been reviewed in this ERD. The following significant residual impacts are predicted to occur as a result of the Revised Proposal including the Proposed Changes:

- clearing of up to 4.0 ha of potential Northern Quoll denning and dispersal habitat that is identified as habitat critical to the survival of the Northern Quoll.
- clearing of up to 42.3 ha of important foraging and dispersal habitat for the Northern Quoll (defined as Northern Quoll habitat within 1 km of habitat critical to the survival of the Northern Quoll); and

- clearing of up to 18.7 ha of Ghost Bat foraging habitat within 5 km of the possible maternity roost identified by Biota (2021).

The significant residual impacts to terrestrial fauna resulting from Stage 4 of the Revised Proposal will be offset, as outlined in Section 6.

Other potential impacts to fauna and fauna habitat associated with Stage 4 of the Revised Proposal will not be significant at the local or regional scale. Given the small extent of the proposed clearing of fauna habitat, this clearing will not result in a significant residual impact (with the exception of habitat critical to the survival and important habitat of the Northern Quoll and Ghost Bat).

Clearing of Ghost Bat foraging habitat around the cave with evidence of Ghost Bat use that is located in the Development Envelope is not considered significant given the extensive suitable habitat that is available within the foraging range of Ghost Bats.

Clearing of two active Pebble Mound Mouse mounds is not considered to be significant at a population level given the proposed mitigation (avoidance where practicable and the use of displacement methods to relocate individuals using active mounds).

5.2.7.3 Assessment against EPA's Environmental Objective

While there is expected to be a change in the extent/magnitude of impact of the Revised Proposal when compared to the Approved Proposal, the overall significance of the impact is unlikely to be greater than that identified for the Approved Proposal, particularly as significant residual impacts will be offset.

Main Roads will implement the Revised Proposal so as to achieve the environmental outcomes outlined in Table 5-29 and will offset all significant residual impacts. Doing so will ensure that the Revised Proposal avoids and minimises impacts to terrestrial fauna as far as reasonably practicable.

This avoidance and minimisation of impacts, together with the offsetting of significant residual impacts will result in the biological diversity and ecological integrity of the study area being preserved, meaning that the Revised Proposal is consistent with the EPA's environmental objective for Terrestrial Fauna.

Assurance of achievement of the environmental outcomes is via:

- the proposed implementation conditions for the Revised Proposal detailed in Section 6 which are outcome-based conditions which mandate where an impact must be avoided, where a level of impact must not be exceeded or where a level of environmental protection must be met; or
- development or revision of outcome-based management plans required by the proposed implementation conditions.

5.3 Inland Waters

5.3.1 EPA Objective

Inland waters are defined as 'The occurrence, distribution, connectivity, movement, and quantity (hydrological regimes) of inland water including its chemical, physical, biological and aesthetic

characteristics (quality)' (EPA, 2018). Inland waters include groundwater, such as superficial and confined aquifers, and surface water, such as waterways, wetlands and estuaries (EPA, 2018).

The WA EPA objective for the inland waters environmental factor is 'To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected' (EPA, 2018).

5.3.2 Policy and Guidance

The following EPA policies and guidelines have been considered for Stage 4 of the Revised Proposal in order to meet the EPA's objective in relation to this factor:

- *Statement of Environmental Principles, Factors and Objectives* (EPA, 2020a);
- *Environmental Factor Guideline – Inland Waters* (EPA, 2018);
- *Water Quality Protection Note no.25. Land use compatibility tables for public drinking water source areas* (DoW 2016a);
- *Water Quality Protection Note no.44. Roads near sensitive water resources (DoW 2006);*
- *Water Quality Protection Note no.65. Toxic and hazardous substances (DoW 2015);*
- *Water Quality Protection Note no.83. Infrastructure corridors near sensitive water Resources (DoW 2007);*
- *Water Quality Protection Note no.84. Rehabilitation of disturbed land in public drinking water source areas (DoW 2009);*
- *Millstream Water Reserve. Drinking water source protection plan* (DoW, 2010); and
- *Contaminated Sites Guidelines* (DWER, 2020).

The Environmental Factor Guideline – Inland Waters has been considered during the identification of values within the Development Envelope and the issues identified in the guideline considered in relation to potential impacts from Stage 4 of the Revised Proposal. Specifically, the guidance requires a focus on the following aspects to ensure the objective of this Environmental Factor is met:

- the significant impacts the alteration of the hydrological regime will have on water dependent ecosystems and other environmental values;
- how the discharge of waste [to inland waters] is minimised; and
- how any discharge of waste, or use of land or water, will significantly impact on water quality, the local hydrological regime, and the environmental values inland waters support (EPA, 2018).

5.3.3 Receiving Environment

5.3.3.1 Stage 4 Surveys and Studies

A hydrological assessment of the alignment options was undertaken, which has informed the understanding of surface water hydrology for this ERD and informed the environmental impact assessment. The hydrological assessment focussed on:

- identifying the catchment zones;
- recording the existing condition of the waterways, floodways and associated vegetation; and

- examining any impacts from the existing culverts and embankments of the Dampier to Paraburdoo railway.

The following additional studies specific to Stage 4 were undertaken by Cardno once the alignment was established:

- Fortescue River, Weelamurra Creek and Caves Creek Flood Study which presents the hydrology and modelling processes undertaken for these major waterways within the project area for the 'pre-development' scenario (Cardno, 2021a);
- Fortescue River, Weelamurra Creek and Caves Creek Waterways Risks Report which considers the risks and opportunities identified from the modelling and waterways investigations, develops and defines the concept of 'Pilbara Proof' for design (Cardno, 2021b), and
- MRDH Stage 4 Alignment Definition Hydrological Summary Report (Appendix A.4), which summarises the above two detailed studies and presents a clear way forward for design development (Cardno, 2021c).

5.3.3.2 Groundwater

Groundwater aquifers within the Pilbara region are primarily recharged through large rainfall events via infiltration through streambeds (CSIRO, 2015). Significant groundwater supplies can be found with relative ease in the alluvium and colluvium found in the low-lying areas of the coastal plain, Fortescue River valley and the upper reaches of Weelumurra Creek to the south of Hamersley Station. Information from the then Water and Rivers Commission (now DWER) indicates that depths to water in these bores range from around four to 37 m below ground level.

The Millstream area is a complex system of permanent pools and wetlands, which is predominantly fed by groundwater discharge from the Millstream Dolomite, along with seasonal flows in the Fortescue River. Groundwater flow is generally towards the north in this aquifer (SKM, 2009).

The Water Corporation's Millstream wellfield feeds into the West Pilbara Water Supply Scheme, supplying water to Karratha, Dampier, Roebourne, Wickham, Point Samson, Cape Lambert and the Burrup Peninsula (DWER, 2018). The bores of the Millstream wellfield are situated in the Millstream Dolomite, which is an unconfined and highly transmissive aquifer, making the wellfield vulnerable to contamination from inappropriate land uses (DWER, 2018). Surrounding the wellfield is the Millstream Water Reserve (West Pilbara) Public Drinking Water Resource Area (Millstream Water Reserve) and associated Priority 1 and Priority 2 Groundwater Protection Areas. Priority 1 areas are afforded the highest level of protection to avoid contamination risks. The Development Envelope intersects both of these priority drinking water areas (Figure 27).

5.3.3.3 Surface Water Hydrology

Major watercourses that cross the Development Envelope include (Figure 27):

- Fortescue River and associated tributaries – intersects the northern part of the Development Envelope;
- Weelumurra Creek (an ephemeral creek) – intersects the northern to central part of the Development Envelope; and
- Caves Creek - intersects the southern part of the Development Envelope (no crossing required).

In addition, minor creek crossings include Cowcumba Creek / Tunkawanna Creek, Ballyeerina Creek (crosses twice, north and south) and Barnett Creek.

Surface water flows of Weelumurra Creek and Fortescue River are provided in Table 5-30.

Table 5-30 Peak flows

Location	20% Annual Exceedance Interval (m^3/s)	5% Annual Exceedance Interval (m^3/s)	2% Annual Exceedance Interval (m^3/s)	1% Annual Exceedance Interval (m^3/s)
Weelumurra Creek Crossing	N/A	700	1,200	-
Fortescue River Crossing - Coolawanyah	656	1,525	2,070	2,371

There are also a large number of ephemeral drainage lines throughout the Development Envelope, which are generally tributaries of one of the above watercourses.

Surface water flow across the Development Envelope is influenced by the presence of the Rio Tinto rail line to the east. This has been accounted for in the modelling Cardno (2021a, b, c).

As described in Section 5.4, the waterways within the area are of special cultural importance to the Traditional Owners of the land and have an intrinsic connection to cultural heritage places in country.

No wetlands of international importance (declared Ramsar Wetlands) or Nationally Important Wetlands are located within or downstream of the Development Envelope.

5.3.3.3.1 Coolawanyah Section

The Fortescue River catchment significantly influences surface water flow and therefore design approach in the Coolawanyah Section. Between the Chichester and Hamersley Ranges, all surface drainage is directed to the Fortescue River across a wide plain. Flows tend westwards across the Development Envelope. In this section, Rio Tinto has protected the rail line with levee banks, which has modified the natural surface water flow paths (Cardno, 2021).

The braided channels of Weelumurra Creek run parallel to the road before joining the Fortescue River. Although the Weelamurra Creek (and most of its catchment) lies in the Hamersley Section, it converges with the Fortescue River in the Coolawanyah Section, and influences design approach at the southern edge of the section.

5.3.3.3.2 Hamersley Section

Through the Hamersley Ranges, the rugged topography leads to small catchments drained by numerous, small incised gullies. All drainage feeds into Weelumurra Creek, which runs along the

Development Envelope in a northerly direction before exiting the ranges through the mouth of the Hamersley Gorge.

South of the Hamersley Ranges, the country is flat to undulating, and surface flow disperses in a fan pattern on the Fortescue River floodplain after exiting the gorge mouth. Drainage may be in the form of sheet flow in places, with much of the sheet flow aligned parallel to the Development Envelope.

5.3.3.3.3 Tom Price Section

The Tom Price section includes an extensive floodplain with clay soils, and includes the Ashburton River floodplain, as well as Caves Creek and Barnett Creek and their confluence. It is dominated by the Northern Ashburton catchment which is a floodplain with poorly-defined streams.

Surface water flow is generally north-westerly, however water from the eastern part of the catchment diverts to the Fortescue River catchment and to Caves Creek. In the steepest parts of the Tom Price Section, rail embankments lead to some areas of water storage (Cardno, 2021).

5.3.4 Potential Impacts

Activities associated with the construction of the road (e.g. cut and fill and compaction activities) and associated infrastructure (e.g. culverts) have the potential to influence and/or alter existing hydrological processes and water quality within the Development Envelope and surrounding area. Impacts to hydrological processes may occur due to:

- changes to surface water flows due to the physical presence of the road, including shadowing (where water level and/or flow is reduced as a result of infrastructure interrupting flow), flooding and waterlogging;
- changes to infiltration from the creation of new hardstand areas (i.e. the road surface);
- temporary drawdown of groundwater, should dewatering be required to construct watercourse crossings; and
- temporary drawdown of groundwater in the vicinity of bores supplying construction water.

Altered or impacted hydrological processes may in turn lead to flooding and/or erosion (e.g. of the banks of watercourses) and subsequent indirect impacts to vegetation and flora lining embankments and waterways. Additionally, changes to surface water levels may lead to ponding, backwater accumulation, or shadowing. Where vegetation is reliant on surface water flows, shadowing may lead to impacts to vegetation including changes in vegetation structure or composition. This may also occur where the depth of surface water flows in an area is significantly increased. Grove-intergrove Mulga communities are reliant on overland flows, and are particularly vulnerable to changes in surface hydrology.

Significant changes to surface flows may impact Aboriginal heritage and are a key item of interest for stakeholders for Stage 4 of the Revised Proposal. Indirect impacts may occur to other water users as a result of impacts to groundwater quality and/or groundwater levels, noting that the Development Envelope intersects Priority 1 and Priority 2 Groundwater Protection Areas and lies in an area proclaimed as a surface water area (DWER, 2018).

Significant changes to surface flows have the potential to affect other infrastructure in the area as a result of backwater accumulation. The key infrastructure of relevant to Stage 4 of the Revise Proposal with respect to surface flow changes is the existing RTIO rail line.

Changes to groundwater and surface water quality may occur due to:

- clearing and earthworks during construction and/or maintenance activities potentially resulting in a temporary increase to sediment loads entering watercourses (noting that sedimentation was not identified as a problem in channels and culverts over the surveyed alignment during the Hydrological Assessment undertaken for the CER [GHD, 2003]);
- contamination of surface and/or groundwater sources from:
  - accidental spills during construction and/or maintenance activities;
  - increased contamination loads in stormwater runoff due to traffic using the road once completed; and
  - spills from vehicle accidents (including hydrocarbons and other potentially hazardous materials from transport vehicles) during construction, maintenance and operations
- discharge of groundwater from dewatering (if required) potentially temporarily impacting surface water quality.

5.3.5 Mitigation

Construction of Stage 2 and 3 of the Revised Proposal is completed. Therefore, mitigation is focussed on Stage 4 of the Revised Proposal.

Table 5-31 details the measures that are proposed to manage and mitigate the potential environmental impacts from Stage 4 of the Revised Proposal on Inland Waters. It is noted that discussions regarding waterways management with the Traditional Owner's is continuing and may result in additional design considerations.

Table 5-31 Inland Waters Management

EPA factor: Inland Waters

EPA objective: To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected

Proposal objective: To minimise as far as practicable the direct and indirect impacts to inland waters from Stage 4 of the Revised Proposal.

Key environmental values: Surface water flows and drinking water quality

Key impacts and risks: Disruption of surface water flows and degradation of surface water and groundwater quality

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
Road and drainage designed to maintain surface water flows and velocities	Minimise	The road and drainage design will be developed to maintain the existing hydrological regime of the area. This will include: • design of major surface water crossing points to ensure that flooding is not exacerbated; and • preventing water shadow effects where sheetflow occurs following rains by minimising the dam effect of the road formation.	*Not applicable*					
	Minimise	Best practice in culvert and floodway design as identified in the AustRoads (2020) Guide to Road Design – Part 5 will be implemented.	*Not applicable*					
	Minimise	Development of surface water management measures to maintain existing drainage patterns and prevent soil erosion and sedimentation caused by construction activity or new waterways structures. These will include: • protection of embankments and waterway banks and beds; • protection of riparian vegetation; • the use of vegetation to promote filtering and slow run-off; • reinstatement or protection of creek banks as required to reduce the risk or erosion; • installation of silt curtains into watercourses when working over or in waterways to limit sedimentation impacts; • details for monitoring of waterway integrity and erosion risks during and following construction; • management and remediation of any impacts found during monitoring; and	Site inspections to confirm surface water management measures in place.	• During construction	• Site inspection reports	• Site inspection identifies that surface water management measures not in place or not effective.	• Environmental incident will be recorded, and the cause investigated; and • Correct or additional surface water management measures to be implemented within 48 hours.	• Construction Contractor Environmental Management Representative; and • Main Roads Superintendent.

		• measurement and evaluation of environmental performance.						
Minimise impacts to grove – intergrove mulga from overland flow disruption	Minimise	The road alignment has been selected to generally match the direction of the natural flow in the area where Mulga communities are present, thus minimising flow disruption.	*Not applicable*					
Prevent impacts to third party infrastructure	Minimise	Investigation will be undertaken during detailed design at relevant locations to determine and assess any increase in backwater, with consultation with third party infrastructure owners to be undertaken to confirm acceptability and changes made to the design if required.	*Not applicable*					
Prevent impacts to water quality during construction	Minimise	During construction: • only substances such as fuel, oil and bitumen will be used and works will adhere to Main Roads standard management actions and Safety Data Sheets; • spill kits will be readily available during all works and stocked as appropriate to the risk; and • bulk storage of chemicals and hydrocarbons will only occur at the construction compound, where secondary containment measures will be implemented. Temporary storage of minor quantities of chemicals required during construction activities will not occur within 100 m of a watercourse or within the 100-year Average Recurrence Interval (ARI) flood high water mark.	Site inspections	During construction	Site inspection reports	Site inspection identifies non-compliance with requirements.	• Environmental incident will be recorded, and the cause investigated; and • Remedial action will be undertaken within 48 hours.	• Construction Contractor Environmental Management Representative; and • Main Roads Superintendent.
Prevent impacts to groundwater availability	Minimise	Water required for construction and dust management will be sourced from existing bores and potentially from new sources for the southern section. Should new bores be required, a 26D licence to construct or alter a well will be submitted along with a 5C licence to extract water.	Audits against requirements of licences.	During construction.	Audit reports	Audit identifies non-compliance with licence requirements.	▪ Environmental incident will be recorded, and the cause investigated; and ▪ Remedial action will be undertaken in accordance with licence requirements.	▪ Construction Contractor Environmental Management Representative; and ▪ Main Roads Superintendent.
		Results of further studies on sustainable construction water abstraction will be implemented to reduce project water use as far as practicable.	*Not applicable*					

Prevent impacts to the Millstream Water Reserve Drinking Water Source	Minimise	The Millstream Water Reserve Drinking Water Source Protection Plan (DoW, 2010) specifically considered management of contamination associated with the Manuwarra Red Dog Highway and recommended protection strategies which will be implemented including: • that road drainage be designed to prevent the spread of contaminants from spills of chemicals; and • that sumps and drains are utilised. In addition, Main Roads will undertake consultation with DWER to develop a spill response strategy. These management and mitigation measures will be in place to prevent contamination of surface and groundwater sources.	Site inspections	During construction	Site inspection reports	Site inspection identifies non-compliance with requirements.	• Environmental incident will be recorded, and the cause investigated • Remedial action will be undertaken within 48 hours.	• Construction Contractor Environmental Management Representative. • Main Roads Superintendent.
		Adherence to the relevant recommendations included in: • Water Quality Protection Note no.25. Land use compatibility tables for public drinking water source areas (DoW 2016a); • Water Quality Protection Note no.44. Roads near sensitive water resources (DoW 2006); • Water Quality Protection Note no.65. Toxic and hazardous substances (DoW 2015); • Water Quality Protection Note no.83. Infrastructure corridors near sensitive water Resources (DoW 2007); and • Water Quality Protection Note no.84. Rehabilitation of disturbed land in public drinking water source areas (DoW 2009). This includes: • minimising the impact of crossings on surface water flows; • the application of water sensitive design to the design of the new road; • minimising vegetation clearing and revegetation of cleared areas not required for permanent infrastructure; • undertaking consultation with DWER and the community; • implementation of erosion and sediment control during construction; • use of vehicle wash down bays; • siting of construction camps, storage areas ect away from waterways; • appropriate waste management;	Site inspections	During construction	Site inspection reports	Site inspection identifies non-compliance with requirements.	• Environmental incident will be recorded, and the cause investigated; and • Remedial action will be undertaken within 48 hours.	• Construction Contractor Environmental Management Representative; and • Main Roads Superintendent.

		• appropriate chemical use and management (e.g. storage, bunding); and • ensuring workforce awareness.						
Minimise impacts to cultural heritage values	Minimise	Impacts on cultural heritage receptors for high probability events will be assessed during detailed design, with consultation with stakeholders undertaken to confirm acceptability and change made to the design if required.	*Not applicable*					

5.3.6 Assessment of Impacts

5.3.6.1 Groundwater Abstraction and Dewatering

Water required for construction will be sourced from new or existing bores. It is estimated that between 148,000 and 412,000 KL will be required. Water required for construction and dust management will be sourced from existing bores or from new sources. Should new bores be required, a 26D licence to construct or alter a well will be submitted along with a 5C licence to extract water. These licenses will set out the permissible well locations and quantities of water that can be abstracted which will provide assurance with respect to minimising impacts to groundwater levels in the area.

Groundwater abstraction for water supply or dewatering during construction of water crossings will be temporary and of a short duration. Abstraction will be managed to minimise groundwater drawdown in accordance with the applicable license.

The DOW (2016b) undertook a groundwater assessment of the north-west Hamersley Ranges including in the Weelumurra Creek area. Much of the Development Envelope lies within this area. DOW (2016b) estimated the groundwater storage in the area as 95 GL, with an average recharge rate of 7.8 GL/year. Based on this recharge rate, once abstraction activities have ceased, groundwater is expected to recover to pre-impact level with no long-term effects on the environment.

Groundwater abstraction would be undertaken at a number of well locations (depending on the specific location of the construction activities at the time). It is likely that the majority of water will be sourced from existing bores within the existing allowance under the 5C license for the well in accordance with the RIWI Act. Should new bores be required or where extraction greater than allowed in an existing licence be required, Main Roads will seek the required licenses in accordance with the RIWI Act. Main Roads anticipates that the need to gain new licences or extend existing licenses, if required, would be for a small number of bores (probably not more than three).

Before issuing a 5C license, DWER undertakes an assessment of the potential impacts of taking the groundwater. As such the potential impacts, including potential impacts to groundwater dependent vegetation, have already been determined to be acceptable by DWER for the majority of the proposed groundwater abstraction. The same assessment would be undertaken for any new bores with abstraction only to occur is approved by DWER via a 5C license.

5.3.6.2 Changes to Infiltration Rates

Construction of the road will result in the establishment of new hardstand areas that may result in a minor localised reduction in infiltration rates. The impact of this on groundwater levels is expected to be negligible given that groundwater aquifers within the Pilbara region are primarily recharged through large rainfall events via infiltration through streambeds (CSIRO, 2015). In addition, the proposed road is narrow and unlikely to block an entire recharge zone.

5.3.6.3 Groundwater Quality

As the Development Envelope is located within the Millstream Water Reserve, there is a risk of contamination of this resource due to accidental spills of hazardous materials during construction, run-off from the road, and accidental release of hazardous martials due to unforeseen emergencies such as a truck roll over. The management measures outlined in Table 5-31, including those

implemented during construction of Stage 3 and the recommendations of the Millstream Water Reserve Drinking Water Source Protection Plan and relevant Water Quality Protection Notes, will reduce the risk to the drinking water resource as a result of Stage 4 of the Revised Proposal. As such, it is unlikely that contamination of the drinking water aquifer will occur due to Stage 4 of the Revised Proposal.

5.3.6.4 Surface Water Quality

Clearing of vegetation, construction earthworks and altered surface water regimes associated with the Stage 4 of Revised Proposal have the potential, if unmanaged, to result in erosion and sedimentation of surrounding drainage infrastructure, vegetation, wetlands and waterways. Construction in the vicinity of watercourses will require clearing of riparian vegetation and works in proximity of the riverbanks, which could lead to erosion of the bed and banks. Erosion in these areas may increase surface water turbidity and decrease water quality within the watercourses. The potential impacts from Stage 4 of the Revised Proposal will be effectively managed through mitigation measures outlined above and are therefore considered unlikely to be significant.

5.3.6.5 Surface Water Flows

Changes to surface water flows due to the physical presence of the road may result in shadowing (where water level is reduced or surf ace water absent as a result of infrastructure interrupting flow), flooding and waterlogging. The extent of impact in an area will generally depend on terrain slopes in the area and the angle of the road compared to the terrain. In gently sloping areas the impact of the road could potentially be substantial as it has the potential to obstruct considerable flow if it is perpendicular to the natural flow direction.

Changes to surface flow may result in impacts to flora and vegetation as well as backwater impacts on existing infrastructure (such as the Rio Tinto rail line, the proposed FMG rail line and access roads), and the serviceability and resilience of the new road itself. Significant changes to surface flows may also impact Aboriginal heritage and are a key item of interest for stakeholders for Stage 4 of the Revised Proposal.

A preliminary hydrological assessment has been undertaken with the objective of identifying waterways issues and constraints which will influence the road and corridor alignment. The assessment determined key design criteria for the future detailed design. The relevant design criteria in relation to the environmental impact assessment are:

- allowance for climate change and future changes in rainfall regimes;
- all impacts to third party infrastructure are to be avoided and detailed investigation must be conducted at relevant locations to determine if an increase in backwater is acceptable to the asset owner; and
- impacts on sensitive environmental and heritage receptors is to be evaluated for high probability events together with key stakeholders in all locations.

Adoption of these design criteria will ensure that Stage 4 of the Revised Proposal is designed and constructed in a manner that results in surface water flow paths and velocities being maintained. As such it is not expected that surface water flows will be altered such that significant impacts to sensitive environmental and cultural heritage receptors occur.

5.3.7 Predicted Outcome

5.3.7.1 Environmental Outcomes

Table 5-32 details of the predicted environmental outcomes of the Approved Proposal and Revised Proposal for Inland Waters.

It should be noted that the CER for the Approved Proposal was prepared in 2003 and the EPA finalised its decision report in 2005. Requirements in environmental impact assessment has progressed significantly in the early 2000's and the EPA has released a series of technical guidance with respect to the preparation of ERDs and the assessment of technical factors. Given this, direct comparison between the Approved Proposal and Revised Proposal is not possible in all cases.

Table 5-32 Environmental Outcomes for Revised Proposal – Inland Waters

Element	Approved Proposal	Proposed Changes	Revised Proposal
Surface flows	Risk to surface flow can be adequately dealt with through thorough flow investigations, modelling and subsequent bridge and culvert design and management. The construction of a new road over the Fortescue plain is unlikely to exacerbate any broadscale flood risk.	• Change to - No change to surface flows resulting in significant impacts to environmental values, Aboriginal heritage values or existing infrastructure will occur.	• No change to surface flows resulting in significant impacts to environmental values, Aboriginal heritage values or existing infrastructure will occur.
Surface water quality	Low likelihood of impacts to identified surface water features such as Harding Dam, Western Creek and Harding River.	• Change to - No significant change to surface water quality will occur.	• No significant change to surface water quality will occur.
Groundwater levels	Not assessed in CER.	• Addition of - No change to groundwater levels resulting in significant impacts to groundwater dependent vegetation will occur.	• No change to groundwater levels resulting in significant impacts to groundwater dependent vegetation will occur.
Groundwater quality	No significant threat to ground water resources including Millstream Water Reserve Priority 1 and Priority 2 protection areas.	• Change to -Implementation of the Revised Proposal will not negatively affect the likelihood that the objectives of the Millstream Water Reserve Priority 1 and Priority 2 protection areas will be met.	• Implementation of the Revised Proposal will not negatively affect the likelihood that the objectives of the

Element	Approved Proposal	Proposed Changes	Revised Proposal
			Millstream Water Reserve Priority 1 and Priority 2 protection areas will be met.
Impacts to vegetation from changes to water flow	Although there are some areas of mulga woodland in the southern part of the route alignment the road will mostly run parallel to the surface drainage which does not pose a threat to the communities. Further, detailed assessment of the risk to mulga communities will be carried out at the final design stage to ensure that drainage shadows are not created.	Change to - Significant impacts to vegetation, including the grove – intergrove mulga communities, as a result in changes to surface water flows or quality due to implementation of the Revised Proposal will be avoided.	No significant impacts to vegetation, including the grove – intergrove mulga communities, as a result in changes to surface water flows or quality due to implementation of Stage 4 of the Revised Proposal will occur.
Cultural heritage values of waterways	Not assessed in CER.	• Addition of - Changes to the cultural heritage values of waterways as a result of the Revised Proposal will not occur.	• Changes to the cultural heritage values of waterways as a result of the Revised Proposal will not occur.

5.3.7.2 Summary of Assessment of Significant Residual Impacts

No significant residual impacts to Inland Waters were identified in the Approved Proposal. The Proposed Changes do not introduce any new significant residual impacts to inland waters and as such significant residual impacts are not expected to occur to inland waters as a result of the Revised Proposal.

Groundwater abstraction and dewatering for Stage 4 of the Revised Proposal may result in a temporary minor impact to groundwater levels. The impact of the new road on infiltration rates and subsequent impacts to groundwater levels is expected to be negligible. Given recharge rates that expected in the area, these changes are not expected to result in significant impacts to groundwater levels or resultant impacts to vegetation or flora.

While minor leaks and spills may occur during construction, with the proposed mitigation measures (e.g. storage, bunding), it is highly unlikely that unplanned events such as spillage of hazardous materials will result in impacts to groundwater or surface water quality. Leaks and spills may also occur during the operation of the road (for example, as a result of a vehicle accident), although given the expected magnitude of such an event, this is unlikely to result in significant contamination. As such, contamination of groundwater or surface water quality as a result of Stage 4 of the Revised Proposal is not predicted to occur.

Changes to surface water quality may occur during construction as a result of erosions and runoff after vegetation clearing. This will be managed via standard mitigation measures such as the use of erosion controls and revegetation. Any changes would be minor and temporary, and are not expected to result in a significant impacts to vegetation or flora, or to cultural heritage values of the waterways in the area.

Changes to surface water flows will occur as a result of the physical presence of the road, however Main Roads will design and construct the road such that the existing hydrological regime of the area is maintained. In particular, changes to surface waters flows resulting in significant impacts to third party infrastructure, sensitive environmental receptors, and cultural heritage values will be avoided.

5.3.7.3 Assessment against EPA's Environmental Objective

There is not expected to be a change in the extent/magnitude of impact of the Revised Proposal when compared to the Approved Proposal, and the overall significance of the impact is unlikely to be greater than that identified for the Approved Proposal. No significant residual impacts to Inland Waters have been identified.

Main Roads will implement the Revised Proposal so as to achieve the environmental outcomes outlined in Table 5-32. Doing so will ensure that the Revised Proposal avoids and minimises impacts to Inland Waters as far as reasonably practicable.

This avoidance and minimisation of impacts will ensure that the Revised Proposal does not significantly impact the hydrological regimes, groundwater quality or surface water quality, and ensure that the environmental values of the area are preserved. As such the Revised Proposal is consistent with the EPA's environmental objective for inland waters.

Assurance of achievement of the environmental outcomes is via:

- the proposed implementation conditions for the Revised Proposal detailed in Section 6 which are outcome-based conditions which mandate where an impact must be avoided, where a level of impact must not be exceeded or where a level of environmental protection must be met; or
- regulation by other DMAs permitting and licensing requirements (i.e. 26D and 5C licenses and Permits to Interfere with Bed and Banks under the RIWI Act).

5.4 Social Surroundings

5.4.1 EPA Objective

The WA EPA states that 'social surroundings is a part of the environment that may require consideration' where there is 'clear link between a proposal or scheme's impact on the physical or biological surroundings and the subsequent impact on a person's aesthetic, cultural, economic or social surroundings' (EPA, 2016d).

The WA EPA objective for social surroundings is 'to protect social surroundings from significant harm'.

5.4.2 Policy and Guidance

The following EPA policies and guidelines have been considered for Stage 4 of the Revised Proposal in order to meet the EPA's objective in relation to this factor:

- *Statement of Environmental Principles, Factors and Objectives* (EPA, 2020a);
- *Environmental Factor Guideline – Social Surroundings* (EPA, 2016d);
- Environmental Protection (Noise) Regulations 1997 (Noise Regulations);
- State Planning Policy 5.4 Road and Rail Noise;
- *Aboriginal Heritage Act 1972* (AH Act); and
- *Aboriginal Cultural Heritage Act* (2021) (ACH Act).

5.4.3 Receiving Environment

The receiving environment in relation to social surroundings is made of many elements including land tenure, historic and cultural features, tourism and recreational features, and amenity.

5.4.3.1 Surveys and Studies

The studies relating to the social surroundings undertaken for the Revised Program are described in Table 5-33.

Table 5-33 Social Surroundings Studies Undertaken for Stage 4 of the Revised Proposal

Report title	Consultant	Scope
Preliminary advice of a site avoidance archaeological heritage survey for the Karratha Tom Price Road Stage 4 Alignment Tom Price Railway Rd trip 1, SLK0-51, Eastern Guruma Country (November 2020).	Yulur Heritage	Aboriginal Archaeological site avoidance survey of a single polygon (7.9 km^2) identified as Tom Price Railway Rd (the SLK0-51 project area – Trip 1) which runs adjacent to the existing Tom Price Railway Road for approximately 51 km (with consistent width of 150 m). All survey work was conducted with the participation of Eastern Guruma Tradition Owners as nominated by their representative, the Wintawari Guruma Aboriginal Corporation.
Report on a site avoidance archaeological heritage survey for the Karratha Tom Price Road	Yulur Heritage	Aboriginal Archaeological site avoidance survey of a single polygon (7.9 km^2) identified as Tom Price Railway Rd (the SLK0-51 project area – Trip 1) which runs

Stage 4 Alignment Tom Price Railway Rd trip 1,SLK0-51, Eastern Guruma Country (November 2020).		adjacent to the existing Tom Price Railway Road for approximately 51 km (with consistent width of 150 m). All survey work was conducted with the participation of Eastern Guruma Tradition Owners as nominated by their representative, the Wintawari Guruma Aboriginal Corporation.
Preliminary advice of the trip 2 site avoidance archaeological heritage survey of the Manuwarra Red Dog Highway Karratha Tom Price Road Stage 4 Alignment Tom Price Railway Rd SLK0-50 undertaken in Eastern Guruma Country by the Wintawari Guruma representatives and Yulur Heritage (April 2021).	Yulur Heritage	Further Aboriginal Archaeological site avoidance heritage survey of a single polygon identified as Tom Price Railway Rd (the SLK0-50 project area) comprising two polygons that run adjacent to the existing Tom Price Railway Road for approximately 14 and 17 km. The survey area measured approximately 4.9 km^2 comprised of Hamersley Section (2.77 km^2) and Tom Price Section (2.11 km^2). All survey work was conducted with the participation of Eastern Guruma Tradition Owners as nominated by their representative, the Wintawari Guruma Aboriginal Corporation.
Report on the trip 2 site avoidance archaeological heritage survey of the Manuwarra Red Dog Highway Karratha Tom Price Road Stage 4 Alignment Tom Price Railway Rd SLK0-50 undertaken in Eastern Guruma Country by the Wintawari Guruma representatives and Yulur Heritage (May 2021).	Yulur Heritage	Further Aboriginal Archaeological site avoidance heritage survey of a single polygon identified as Tom Price Railway Rd (the SLK0-50 project area) comprising two polygons that run adjacent to the existing Tom Price Railway Road for approximately 14 and 17 km. The survey area measured approximately 4.9 km^2 comprised of Hamersley Section (2.77 km^2) and Tom Price Section (2.11 km^2). All survey work was conducted with the participation of Eastern Guruma Tradition Owners as nominated by their representative, the Wintawari Guruma Aboriginal Corporation.
Final Report of an Ethnographic Survey Karratha to Tom Price Road Alignment in Eastern Guruma Country (3 August – 8 August 2020).	Yulur Heritage	Main Roads specified two priority sections be investigated within the Survey Area. The proposed new road alignment is to the west of the Rio Tinto Railway. The northern section (Priority 1) runs parallel with the Weelumurra Wuntu site ID 38183 and the southern section (Priority 2) intersects with Narraminju (Caves Creek) ID 36670. The survey area was originally 51 km but was revised by Main Roads prior to the survey commencing to exclude the area south of the Nanutarra Munjina Road (towards Tom Price). The survey area is approximately 45 km in length and between 400 m and 1 km at its widest point in the northern section (Priority 1).
Preliminary advice of an Aboriginal archaeological Site Avoidance survey of works associated with the Karratha to Tom Price Road Stage 4 Alignment Corridor (Roebourne Wittenoom Rd SLK68-74 & Tom Price Railway Rd SLK51-108), Pilbara, Western Australia	Gavin Jackson Cultural Resource Management	The Heritage Project Area comprises six polygons (Priority Area 1 – Priority Area 6) and four additional polygons located adjacent to these priority areas. These polygons are situated within or adjacent to the Main Roads Karratha Tom Price Stage 4 Heritage Survey Corridor. The Heritage Project Area is located to the west of the Tom Price Railway Road and to the south of the Manuwarra Red Dog Highway. and is approximately 26

Trip 4 (March 2021).		km in length with a combined area of approximately 3.97 km^2.
Report of an Aboriginal archaeological Site Avoidance survey of works associated with the Karratha to Tom Price Road Stage 4 Alignment Corridor (Roebourne Wittenoom Rd SLK68-74 & Tom Price Railway Rd SLK51-108), Pilbara, Western Australia Trip 4 (March 2021).	Gavin Jackson Cultural Resource Management	The Heritage Project Area comprises six polygons (Priority Area 1 – Priority Area 6) and four additional polygons located adjacent to these priority areas. These polygons are situated within or adjacent to the Main Roads Karratha Tom Price Stage 4 Heritage Survey Corridor. The Heritage Project Area is located to the west of the Tom Price Railway Road and to the south of the Manuwarra Red Dog Highway. and is approximately 26 km in length with a combined area of approximately 3.97 km^2.
Preliminary advice of an Aboriginal archaeological Site Avoidance survey of works associated with the Karratha to Tom Price Road Stage 4 Alignment Corridor (Roebourne Wittenoom Rd SLK68-74 & Tom Price Railway Rd SLK51-108), Pilbara, Western Australia Trip 3 (January 2021).	Gavin Jackson Cultural Resource Management	The Heritage Project Area comprises six polygons (Priority Area 1 – Priority Area 6) located adjacent to the Manuwarra Red Dog Highway and the Tom Price Railway Road and is approximately 50 km in length with a combined area of approximately 7.20 km^2.
Report of an Aboriginal archaeological Site Avoidance survey of works associated with the Karratha to Tom Price Road Stage 4 Alignment Corridor (Roebourne Wittenoom Rd SLK68-74 & Tom Price Railway Rd SLK51-108), Pilbara, Western Australia Trip 3 (January 2021).	Gavin Jackson Cultural Resource Management	The Heritage Project Area comprises six polygons (Priority Area 1 – Priority Area 6) located adjacent to the Manuwarra Red Dog Highway and the Tom Price Railway Road and is approximately 50 km in length with a combined area of approximately 7.20 km^2.
Preliminary advice of an Aboriginal archaeological Site Avoidance survey of works associated with the Karratha to Tom Price Road Stage 4 Alignment Corridor (Roebourne Wittenoom Rd SLK68-74 & Tom Price Railway Rd SLK51-108), Pilbara, Western Australia Trip 2 (October 2020).	Gavin Jackson Cultural Resource Management	The Heritage Project Area comprises four polygons located adjacent to the Roebourne Wittenoom Road and the Tom Price Railway Road and is approximately 60 km in length and has a combined area of approximately 18.8 km^2. The Heritage Project Area features three Priority Areas (Priority Area 1 – Priority Area 3) that cover a combined total area of 8.93 km^2 of the entire Heritage Project Area.
Report of an Aboriginal archaeological Site Avoidance survey of works associated with the Karratha to Tom Price Road Stage 4 Alignment Corridor (Roebourne Wittenoom Rd SLK68-74 & Tom Price Railway Rd SLK51-108), Pilbara, Western Australia Trip 2 (October 2020).	Gavin Jackson Cultural Resource Management	The Heritage Project Area comprises a single polygon, approximately 60 km in length, located adjacent to the Roebourne Wittenoom Road and the Tom Price Railway Road. There are three Priority Areas (Priority Area 1 – Priority Area 3) within the Heritage Project Area covering a combined total area of 18.8km^2.

Preliminary advice of an Aboriginal archaeological survey of works associated with the Karratha to Tom Price Road Stage 4 Alignment Corridor (Roebourne Wittenoom Rd SLK58-74 & Tom Price Railway Rd SLK51-106), Pilbara, Western Australia Trip 1 (July 2020).	Gavin Jackson Cultural Resource Management	The Heritage Project Area comprises a single polygon located adjacent to the Roebourne Wittenoom Road and the Tom Price Railway Road that measures approximately 51.8 km^2. The Heritage Project Area includes five Survey Priority Areas (Survey Priority Area 1 – Survey Priority Area 5) that cover a combined total 21.5 km^2 of the entire Heritage Project Area.
Report of an Aboriginal archaeological survey of works associated with the Karratha to Tom Price Road Stage 4 Alignment Corridor (Roebourne Wittenoom Rd SLK58-74 & Tom Price Railway Rd SLK51-106), Pilbara, Western Australia Trip 1 (August 2020).	Gavin Jackson Cultural Resource Management	The Heritage Project Area comprises a single polygon located adjacent to the Roebourne Wittenoom Road and the Tom Price Railway Road that measures approximately 51.8 km^2. The Heritage Project Area includes five Survey Priority Areas (Survey Priority Area 1 – Survey Priority Area 5) that cover a combined total 21.5 km^2 of the entire Heritage Project Area.
Preliminary Advice following an Yindjibarndi Ethnographic Site Identification Heritage Survey of the Karratha Tom Price Road Stage 4 Alignment Corridor; Roebourne Wittenoom Rd SLK58-74 and Tom Price Railway Rd SLK51-106 in the West Pilbara Trip 1 (June-July 2020).	Stevens Heritage Services	The ethnographic component of the heritage survey intended to concentrate on site assessments and values within five priority areas, as well as provide an overview of any areas throughout the entire corridor that may be of major cultural concern to Yindjibarndi, such as impact to waterways. An overview of the entire survey route was undertaken, and detailed assessments of areas and sites was undertaken in the whole of Priority areas 1 and 2 and most of Priority area 3
Report of a Yindjibarndi Ethnographic Site Identification Heritage Survey of the Karratha Tom Price Road Stage 4 Alignment Corridor; Roebourne Wittenoom Rd SLK58-74 and Tom Price Railway Rd SLK51-106 in the West Pilbara Trip 1 (June – July 2020).	Stevens Heritage Services	The ethnographic component of the heritage survey intended to concentrate on site assessments and values within five priority areas, as well as provide an overview of any areas throughout the entire corridor that may be of major cultural concern to Yindjibarndi, such as impact to waterways. An overview of the entire survey route was undertaken, and detailed assessments of areas and sites was undertaken in the whole of Priority areas 1 and 2 and most of Priority area 3.

5.4.3.2 Native Title, Aboriginal Heritage and Culture

The Development Envelope is located within two Native Title areas. The northern portion of the Development Envelope sits within Yindjibarndi Country while the southern portion is within Wintawari Guruma country (Figure 7). The Federal Court assessed the Native Title claims submitted by each group under the *Native Title Act 1993* and determined that Native Title does exist in the claim areas. These determinations were made in 2005 and 2007 respectively.

A search of the Department of Planning Lands and Heritage's Aboriginal Heritage Inquiry System (AHIS) database (DPLH, 2020) identified 32 registered sites within 2.5 km of the Development Envelope (Figure 8). The following sites overlap the Development Envelope:

- Site ID 17332: Horseshoe Bore 02 – Artefacts/Scatter;
- Site ID 17335: Mt Margaret 96-1 (Hamersley Plateau) – Modified Tree;
- Site ID 18173: Weelamurra Creek Ceremonial Ground - Artefacts / Scatter, Ceremonial and Historical site;
- Site ID 37670: Narraminju (Caves Creek) – Mythological site associated with Caves Creek and its tributaries; and
- Site ID 38183: Weelamurra Wuntu (Willamarranha, Wilumarra and Wirlumarra) – a complex of Ceremonial, Mythological, and Water Sources associated with Weelamurra Creek.

Over 50 Aboriginal heritage surveys have been undertaken across the general area of Stage 4 of the Revised Proposal since the 1970's. These have been undertaken for a range of proposed developments, including for the original Manuwarra Red Dog Highway proposal.

Main Roads has undertaken additional Archaeological and Ethnographic Surveys within the Development Envelope to adequately understand the cultural heritage of the area, to confirm the values present for the existing registered sites and identify any additional sites that may not have been found during previous surveys (Table 5-33). The information gathered from these surveys will be used to inform ongoing consultation with the Yindjibarndi and Wintawari Guruma Traditional Owners.

5.4.3.2.1 Wintawari (Eastern) Guruma Native Title Determination Area

A desktop assessment for the Wintawari (Eastern) Guruma native title determination area (WC2007/001) located in the southern portion of the Development Envelope identified a total of 33 relevant heritage survey reports.

As indicated in Table 5-33 two archaeological surveys were undertaken on Eastern Guruma Country.

Assessments of this portion of the Development Envelope and surrounding areas emphasise Wintawari Guruma peoples' strong and unceasing connection to their culture and country. These heritage assessments found:

- the waterways within this area are of special cultural importance and have an intrinsic connection to cultural heritage places both within and beyond Wintawari Guruma country. Wintawari Guruma representatives stated that it is vital to ensure the health of the waterways and the flow of water is not negatively impacted;
- the Wintawari Guruma peoples' wish to protect and preserve their cultural heritage places and particularly requested that the Weelamurra Creek Ceremonial Ground (DPLH RS ID 18173), Kartaynha Law Ground (DPLH ID 20473), and Nguan Munda (DPLH ID 12070), Jurkanunha Marnta (DPLH OHP ID 37886), Partririnha, Nhuwarnmunha (Four Mile Bore / EAS-ETH-016), and Martangngartana (Barnett Creek) not be disturbed;
- Weelamurra Creek Ceremonial Ground (DPLH RS ID 18173) intersects both the Development Envelope and Indicative Disturbance Footprint, Martangngartana (Barnett Creek) is within the Development Envelope but is not within the Indicative Disturbance Footprint, whilst Kartaynha Law Ground (DPLH ID 20473), and Nguan Munda (DPLH ID 12070), Partririnha, Nhuwarnmunha (Four Mile Bore / EAS-ETH-016) are not in either the Development Envelope or Indicative Disturbance Footprint;

- fourteen newly identified sites were recorded to a Site Avoidance standard[14]:
  - WG Site 1- a modified pantalpa (*Grevillea striata*), ethnobotanical resource, and an associated artefact scatter which includes both panilpa (a flat basal stone on which materials are ground) and karnju grinding material (stone pestle used to grind materials). The modified pantalpa is approximately 7 m in height with a 12 m canopy diameter;
  - WG Site 2- modified kartapirangu (*Eucalyptus leucophloia*) tree's canopy;
  - WG Site 3–a series of three tharra (rockshelters) situated within a steep valley in a low ironstone range. The Wintawari Guruma representatives noted that MR_EAS_20_007 and the sites surrounding it are located along an ancestral travel route following major tributaries of the Narraminju (DPLH ID RS 37670) and Weelumurra Wuntu (DPLH RS ID 38183) between the Yulurngulurngkamu (Dreaming) site Jawunpa (DPLH ID RS 38488) and the highly culturally significant Weelumurra Creek Ceremonial Ground (DPLH ID RS 18173) where Lore Business has been conducted for many generations. They commented that people using the site and area were likely travelling along the ancestral route during lore time to conduct Lore and Culture Business at the Weelumurra Creek Ceremonial Ground (DPLH ID RS 18173) (pers comm. Michael Hughes 20/11/2020);
  - WG Site 4 - a culturally modified kartapirangu tree (*Eucalyptus leucophloia*) with an exceptionally large scar. Wintawari Guruma representatives informed the survey team that their Ancestors removed the bark from the kartapirangu tree for sacred and ceremonial purposes relating to Men's Business;
  - WG Site 5 - an artefact scatter with panilpa (flat basal stone on which materials are ground) grinding material and two separate reduction areas distributed throughout the boundary in moderately dense concentrations, on either side of the bisecting access track that runs northwest-southeast through the site;
  - WG Site 6 - an artefact scatter with panilpa (flat basal stone on which materials are ground) grinding material and two separate reduction areas distributed throughout the boundary in moderately dense concentrations, on either side of the bisecting access track that runs northwest-southeast through the site;
  - WG Site 7- a tharra with a potential cultural deposit and panilpa and karnju grinding material on the surface. The Wintawari Guruma representatives consider the site to be an ethnobotanical resource area due to two mature bushfood plants winyarrpa (*Ficus platypoda*), and a water source due to the site's location in a well-watered riverine gully which pools water in front of the tharra after seasonal rainfall;
  - WG Site 8 - a wintertime ngurra (campsite) with stone cultural material and ethnobotanical resources that was used by Ancestral Guruma people. The artefactual assemblage consists of modified ironstone, dolerite, chert, chalcedony, and pitan (white quartz) raw material types. These raw material types are not available in the area surrounding MR_EAS_20_012 and were carried into the site by Ancestral Guruma people;

[14] Site Avoidance surveys are designed to identify the location and extent of Aboriginal heritage, generally archaeological sites and provide basic details of the type and contents of any sites that are identified. The Site Avoidance methodology identifies the location and extent of Aboriginal archaeological sites and records minimal information on these places. Site Avoidance surveys can be used in circumstances where it is highly likely that the proposed activity can be modified to avoid impacting any Aboriginal heritage sites identified by the survey.

  - WG Site 9 - a large and significant ngurra (campsite) used recurrently by Wintawari Guruma people for their cultural practice. The heritage place comprises of highly diverse stone cultural material, a water source, yurrama (soak), and ethnobotanical resources used by Ancestral Guruma people;
  - WG Site 10 - a ngurra (campsite), likely occupied on multiple occasions, which contains a moderate artefact assemblage including multiple panilpa (basal grindstone) fragments, a water source, and ethnobotanical resources;
  - WG Site 11- a ngurra (campsite) that was likely occupied on multiple occasions by Ancestral Guruma groups travelling through the floodplains. The ngurra (campsite) contains an artefact scatter with at least one panilpa (basal grindstone) fragment, two complete karnju (stone pestle), two karnju (stone pestle) fragments, complete flakes, transversely broken flakes, longitudinally broken flakes, two utilised pieces, and one single platform core;
  - WG Site 12 - a ngurra (campsite), associated artefact scatter, and resource hub that was likely occupied and utilised on numerous occasions by Ancestral Guruma making use of the waterway-based travel route connecting lore places in the north and south of Guruma country;
  - WG Site 13 – a small panilpa (basal grindstone) within an ethnobotanical resource area. The panilpa (basal grindstone) measures 13 cm wide, 11 cm long, and 2 cm high with the ground surface occupying 9.5 cm x 8 cm of this space; and
  - WG Site 14 – a culturally modified kartapirangu (*Eucalytpus leucophloia*) with ceremonial affiliations located within an ethnobotanical resource area situated along a known Ancestral pathway through Guruma Country;.
- eight previously identified heritage places were reassessed to a site avoidance standard;
- the Wintawari Guruma representatives identified an expansive and significant cultural area known as Nhuwarnmunha (Four Mile) and established a preliminary HRZ boundary known as the Four Mile HRZ to encompass the associated heritage values;
- the Wintawari Guruma representatives identified the preliminary boundary for this Four Mile HRZ site known as Nhuwarnmunha (Four Mile) and indicated the site must extend further southwards to encapsulate additional heritage values and should have further site-specific assessment on a subsequent Main Roads heritage survey.; and
- the Wintawari Guruma representatives confirmed that the health and wellbeing of the waterways associated with the Narraminju (Caves Creek) and Weelamurra Wuntu, is of vital importance to them, as both waterways have deep significance to Wintawari Guruma traditions and beliefs, and are intrinsically connected to the surrounding cultural landscape within Wintawari Guruma country. They requested that Main Roads ensure that the water flow is not impeded and ensure that the quality of the water is not compromised during the Main Roads land use, including the construction, and maintenance of the project.

The Wintawari Guruma representatives recommended that the proposed works are clear to proceed subject to the following:

- where possible, heritage places be avoided and protected from damage;
- Main Roads employees and contractors are advised of the contents of this report and their obligations under the ACH Act;

- if newly identified heritage values are identified, Main Roads must stop work immediately in vicinity of the area and contact the Wintawari Guruma traditional owners through Wintawari Guruma Aboriginal Corporation as soon as possible to enable culturally appropriate management of any heritage values;
- if human remains, skeletal material that may be human, or material that potentially belongs to a human burial are identified, Main Roads must stop work immediately in vicinity of the area and follow the DPLH procedures. The materials and surrounding area must be left undisturbed and the Western Australian Police informed immediately, as required by law. Main Roads must contact the Wintawari Guruma traditional owners through Wintawari Guruma Aboriginal Corporation as soon as possible to enable culturally appropriate management of any human remains;
- Main Roads continue discussion with Wintawari Guruma traditional owners regarding any future matters relating to the Wintawari Guruma heritage places and surveyed project areas, including any further ground disturbing activities;
- Main Roads ensure that the water flow is not impeded and ensure that the quality of the waterways including Narraminju (Caves Creek) and Weelumurra Wuntu is not compromised during the Main Roads land use, including the construction, and maintenance of the project;
- a large nesting tree directly adjacent to a waterhole is used by a hawk family group. At the time of the heritage survey, three adult hawks were using the location as a nesting site. The Wintawari Guruma representatives instructed Yulur Heritage to create a restriction zone around the extent of the nesting tree and waterhole. They further stated the restriction zone is to be avoided by Main Roads to conserve the nesting site;
- Main Roads integrate a high portion of culverts in the road design to ensure the movement of water through their country is not blocked by the new road alignment. The representatives indicated that it is especially important that culverts are used abundantly in the floodplain areas and area around Hamersley Station to allow water to flow unimpeded through the country and ensure the health of the vegetation;
- windrows should not be utilised in the new road alignment design due to environmental concerns. They explained that windrows block the water flow and facilitate concentrated growth of vegetation along the roadside. They expressed concern that animals native to their country may be drawn to such build ups of vegetation and be killed by traffic;
- accordingly, Main Roads are requested to consult with WGAC regarding the design and location of the culverts and the utilisation of windrows in the Stage 4 Karratha Tom Price Road design; and
- Main Roads discuss Mt Brockman Road access with WGAC to ensure their access to the Mt Brockman Road and cultural heritage is not impeded.

An ethnographic survey of the Main Roads Karratha to Tom Price Road Project Alignment in Guruma Country recommended Main Roads:

- notes that the proposed road alignment through the Eastern Guruma native title determination area is supported by Wintawari Guruma Aboriginal Corporation (WGAC);
- notes that four new Eastern Guruma ethnographic sites were recorded during the field work between 3 – 8 August 2020;
- aligns the road to avoid these four sites;

- notes that a section 18 consent under the AH Act[15] will be required for impacts to Weelumurra Wuntu ID 38183 and Narraminju 37670;
- consults with WGAC regarding the design of the culverts before they are installed in the creeks; and
- consults with WGAC regarding facilitating unrestricted access to the Eastern Guruma people for Mount Brockman Road and for important cultural sites.

5.4.3.2.2 Yinjibarndi Heritage Survey Area

The northern portion of the Development Envelope lies within the traditional lands of the Yindjibarndi people, located within the northern half of the Ngarluma Yindjibarndi native title determination (WCD2005/001; WAD6017/1996) and within the Yindjibarndi #1 determination area (WCD2017/010; WAD6005/2003).

As indicated in Table 5-33 four archaeological surveys were undertaken on Yindjibarndi Country:

Sixteen newly identified sites were recorded to a Site Avoidance standard:

- Yin site 1 - an artefact scatter located in a flat open area, adjacent the southern slopes of a small hill, to its north, and a small vegetated creek (a fan of Wirlamarra Wuntu).
- Yin site 2, a modified snappy gum (*Eucalyptus leucophloia*) tree with a single northwest facing oval shaped scar
- Yin site 3 - a large sized, medium density artefact scatter located on a gibber plain.
- Yin site 4 - a large sized artefact scatter located on a flat gravel terrace on an interbank between two branches of Weelumurra Creek.
- Yin site 5 - a large sized artefact scatter located on a flat gravel terrace on an interbank between two branches of Weelumurra Creek.
- Yin site 6 - a large sized artefact scatter located in a snakewood (*Acacia xiphophylla*) grove on an alluvial plain.
- Yin site 7- a medium sized artefact scatter located on a flat ironstone gravel terrace located on the southeast side of a large northeast/southwest oriented tributary of the Fortescue River.
- Yin site 8 - a large sized, medium density artefact scatter located on a gently undulating gravel terrace on the southeast bank of a creek.
- Yin site 9 - a medium sized, medium density artefact scatter flat ironstone gravel terrace.
- Yin site 10 - a large sized, low to medium density artefact scatter and three modified trees located on a banded iron formation and ironstone gravel floodplain.
- Yin site 11 - a medium sized, low to medium density artefact scatter located in a snakewood grove within a flat gilgai clay pan.
- Yin site 12 - a modified tree located on the southeast bank of creek. The tree stands on a partially eroded sand terrace on the banks of Cowcumba Creek, which is a major tributary of the Fortescue River and held some water at the time of recording.

[15] Approval will be via an Aboriginal Cultural Heritage Management Plan in accordance with Division 6 of the ACH Act post 22/12/2022.

- Yin site 13 - a large sized, low to medium density artefact scatter located on an open gravel clearing within a snakewood grove.
- Yin site 14 - a very large sized, low to medium density artefact scatter located on an open gravel clearing. The gravel clearing is directly south of a sand wash, and north of a gilgai clay pan and snakewood grove.
- Yin site 15 - a very large sized, low density artefact scatter located on a flat plain, approximately 20 m to the south of the Roebourne-Wittenooom Road. The site is located in an area of wash associated with Cowcumba Creek, located approximately 1.6 km to the southeast.
- Yin site 16 - a medium sized, low density artefact scatter located on a flat gravel terrace within a gibber plain.

These newly identified Aboriginal archaeological sites are likely to constitute Aboriginal heritage sites to which the AH Act applies and should, therefore, be avoided. Several hundred isolated artefacts and finds recorded are not considered likely to constitute Aboriginal sites as defined under the AH Act.

Yindjibarndi representatives recommended all Aboriginal heritage sites remain in situ and be avoided by Main Roads. Should Main Roads and the Yindjibarndi representatives agree that it is necessary to disturb the above sites, it is recommended that an application, seeking consent to do so, be made to the Minister for Aboriginal Affairs under Section. 18 of the AH Act[16] under condition that:

- such an application is acceptable to the Yindjibarndi People;
- all Yindjibarndi sites MR_YIN_20_001 through to MR_YIN_21_001, are recorded to a Site Identification standard with the involvement and collaboration of the Yindjibarndi People; and
- the Yindjibarndi People are afforded the opportunity to salvage any Aboriginal heritage sites that will be impacted by the proposed works.

An ethnographic site identification heritage survey undertaken on portions of the Ngarluma Yindjibarndi and Yindjibarndi #1 determination areas within the Karratha - Tom Price Road Stage 4 Alignment Corridor recommended Main Roads:

- avoid impacting the following identified sites: Yin Site 1, Yin Site 2 and Yin Site 3;
- avoid impacting the identified (Gurdi) pebble mound mouse mounds 1 and 2;
- avoid impacting the Weelamurra Creek;
- avoid impacts to the (Wirlamarra Birdirra) Law Ground;
- avoid impeding the natural flow of water along west-east oriented creeks and tributaries; and should seek to minimise impact upon all other waterways to the best of their ability;
- aim to select a route that will have the least impact upon water flow;
- minimise impact upon the natural environment, such as avoiding impact upon large trees wherever possible, and removing any debris which is a result of the works;
- design a route that has the least negative impact upon their landscape in this order:
  - avoid impacting creeks;

[16] Consent will be via an Aboriginal Cultural Heritage Management Plan in accordance with Division 6 of the ACH Act post 22/12/2022

  - avoid impacting sites;
  - avoid impacting the pebble mound mouse mounds, and
  - avoid large trees.
- discuss with the Yindjibarndi Community (via Yindjibarndi Ngurra Aboriginal Corporation (YNAC)) the possibility of organising an elders 'Respect' ritual at Manggurdu (Fortescue River) prior to any works beginning that will impact or cross or intersect in some manner with any of the waterways (river, creeks, major drainage channels);
- meet with Yindjibarndi to discuss the final route and determine final feedback and recommendations from the Yindjibarndi community;
- discuss with Yindjibarndi (YNAC) incorporating dual English – Yindjibarndi names and signage for any named bridges, parking areas and so forth;
- If Main Roads personnel or any of its contractors become aware of any cultural materials or of places believed to be of Indigenous cultural significance, including possible human remains or goods belonging to a human grave, they are to cease work immediately and contact the YNAC (or JAC) for further advice and in the instance of suspected human remains they must also inform the police and the DPLH; and
- seek to extend their activities in the area or undertake other associated works they should maintain communications with YNAC (or JAC) regarding these requirements, and in undertaking any associated consultations.

The ethnographic site identification heritage survey report recommended that Main Roads WA may proceed with their proposed work subject to the report's recommendations.

5.4.3.3 Historic Heritage

There are no known historic heritage places listed on either the State Heritage List, National Heritage lists, or local Municipal heritage lists associated with Stage 4 of the Revised Proposal.

5.4.3.4 Amenity

The Development Envelope is located in a remote area and is not close to any towns or population centres. Hamersley Homestead is the closest residence to the Development Envelope at approximately 2 km to the east. The nearest recreational or tourism areas are Millstream-Chichester National Park and Karijini National Park, 14 km and 18 km from the Development Envelope, respectively.

5.4.4 Potential Impacts

Potential direct and indirect impacts to the Social Surrounds of the Development Envelope may result from the following project activities:

- permanent clearing of vegetation and topsoil removal including all clearing for construction of the road and ongoing maintenance activities;
- temporary clearing for associated access and facilities including site offices, camps, stockpile and laydown areas, turnarounds and access tracks;

- constructing watercourse crossings (bridges, culverts and other drainage) including any associated dewatering;
- constructing off formation drainage;
- constructing the road formation, including applying asphalt and bitumen;
- earthworks and materials haulage;
- blasting (required in areas of cut which cannot be excavated by standard earthmoving machinery);
- movement of construction vehicles and machinery around the site;
- abstraction of water for construction purposes;
- completing landscaping and revegetation; and
- undertaking ongoing maintenance activities.

Potential impacts to the social surrounds of the Development Envelope include:

- physical damage to Aboriginal heritage sites (physical artefacts including artistic creations, built heritage such as buildings and monuments, and other physical or tangible products of human creativity); and
- impacts to anthropological values of heritage sites (Country – spiritual, physical, emotional values inherent to the identity of the Traditional Owners).

Impacts to amenity during construction or operation of Stage 4 of the Revised Proposal are expected to be insignificant given the nearest residence is approximately 2 km from the Development Envelope and the nearest recreational or tourism areas are over 10 km away. Blasting and dust generation will by managed to avoid impacting any local resident or community members.

5.4.5 Mitigation

Construction of Stage 2 and 3 of the Revised Proposal is completed. Therefore, mitigation is focussed on Stage 4 of the Revised Proposal.

The alignment of the road near the Hamersley Homestead has been modified in order to avoid potential amenity impacts to the homestead. This realignment also reduces potential security risks from increased traffic passing by the homestead's driveway, within sight of the Homestead and associated station buildings and equipment. Consultation was undertaken with the residents of Hamersley Homestead to determine an appropriate alignment.

The following measures have been proposed to manage and mitigate the potential impacts to social surroundings from Stage 4 of the Revised Proposal:

- construction noise will be managed in accordance with the Environmental Protection (Noise) Regulations 1997;
- consultation with Traditional Owners will continue to be undertaken to understand the significance of the area and specific sites to the relevant Traditional Owners;
- in consultation with Traditional Owners, where practicable avoid impacting natural features including waterways, large trees and identified (Gurdi) pebble mound mouse mounds;

- the selection of areas where temporary clearing will be required for construction activities such as camps, laydown areas, stockpile areas and vehicle turnarounds will avoid registered heritage places;
- where practicable heritage sites identified during surveys will be protected from disturbance during construction;
- where disturbance to Aboriginal heritage sites is unavoidable, approval under the ACH Act will be sought to disturb these sites;
- a buffer of 1.2 km will be implemented around the Hamersley Homestead to minimise amenity impacts;
- All personnel and contractors engaged on the Project will undergo an induction which includes:
  - the cultural importance of Aboriginal sites (including social sites of significance);
  - requirements to report any Aboriginal material that may be discovered during pre-construction or construction works;
  - responsibilities with regards to the ACH Act; and
  - Main Roads internal requirements relating to the management of ground disturbance activities on the Project.
- the use of dual language signs for locations such as bridges and parking areas will be considered;
- all personnel and contractors engaged on the Project will complete cultural awareness training with the local Traditional Owners; and
- Aboriginal Cultural Heritage Monitors will be engaged to to observe ground disturbance as it is occurring in order to prevent or mitigate possible harm to Aboriginal cultural heritage.

Table 5-33 details the measures that are proposed to manage and mitigate the potential environmental impacts from Stage 4 of the Revised Proposal on Social Surrounds.

Table 5-34 Social Surroundings Management

EPA factor: Social Surroundings EPA objective: to protect social surroundings from significant harm Proposal objective: To minimise as far as practicable the direct and indirect impacts to social surroundings from Stage 4 of the Proposal Key environmental values: Aboriginal heritage and amenity Key impacts and risks: Loss of Aboriginal heritage sites and degradation of amenity

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
Prevent unauthorised impacts to Aboriginal heritage sites during design / pre-construction.	Avoid	Detailed design and construction planning to avoid direct impacts to identified Aboriginal heritage sites of significance where practicable. Specifically avoid impacts to Hamersley Homestead by implementing a 1.2 km buffer to avoid amenity impacts.	• Written records of avoidance during planning / design phase.	• Pre-construction.	• Pre-construction environmental audit.	• Detailed design does not contain measures to avoid direct impacts to Aboriginal heritage sites of significance or a buffer to Hamersley Homestead.	• Amend designs to avoid direct impacts to Aboriginal heritage (archaeological or ethnographic) sites of significance where practicable.	• Project Manager
Prevent unauthorised or undesired impacts to Aboriginal heritage sites or values during construction..	Avoid	Site induction and cultural awareness training will include recognition of aboriginal heritage sites, artifacts or possible remains and include individuals' responsibilities under the ACH Act and the Coroners Act.	• Environmental audit.	• Prior to staff/ contractors commencing on site.	• Environmental audit report; and • Induction material.	• Induction material does not contain information on site survey findings, management requirements and/or procedures.	• Incident will be recorded, and the cause investigated; and • Induction material revised.	• Construction Contractor Environmental Management Representative; and • Main Roads Superintendent.
	Avoid	All site personnel will complete site induction and cultural awareness training including obligations under the ACH Act.	• Written records; and • Training records.	• Prior to staff/ contractors commencing on site.	• Review of training records; and • Environmental audit report.	• Site personnel identified as not having completed site induction.	• Training administered.	
	Avoid	Conduct ongoing consultation with Traditional Owner representatives of Yindjibarndi or Wintawari Guruma about cultural heritage matters including access to Mt Brockman Road and nearby cultural sites, and water flow issues associated with the use of windrows and sufficient culverts.	• Records of consultation.	• Prior to ground disturbance.	• Consultation records.	• No consultation conducted following issue of site reports.	• Consult with Traditional Owner representatives of Yindjibarndi or Wintawari Guruma to rectify any issues of concern.	

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
	Avoid	• Heritage areas to be avoided within the DE must be clearly demarcated on all project drawings and no-go zones established on site prior to construction activities. • In consultation with Traditional Owners, where practicable avoid impacting natural features including waterways, large trees and identified (Gurdi) pebble mound mouse mounds. • The selection of areas where temporary clearing will be required for construction activities such as camps, laydown areas, stockpile areas and vehicle turnarounds will avoid registered heritage places; • The large nesting tree directly adjacent to a waterhole used by a hawk family group identified by Wintawari Guruma representatives during a heritage survey, will be avoided if possible, by the creation of a restriction zone around the nesting tree and nearby waterhole. If construction activities must disturb the tree measures will be taken to ensure the hawks are not harmed, including employment of Aboriginal Heritage Monitors in the vicinity of the nesting tree during construction activities.	• Site inspection prior to ground disturbance to confirm heritage areas are appropriately flagged.	• Prior to ground disturbance; and • During construction.	• Site inspection report/confirmation.	• If flagging is not undertaken around heritage sites; • If heritage sites are accidentally impacted; • Drawings do not show correct approved clearing areas; and • Measures not in place to protect hawk family group using identified nesting tree.	• Construction in the direct vicinity will cease immediately if trigger is met; • Works will not recommence until no go areas have been reviewed and confirmed to be in place correctly, and Main Roads Superintendent provides approval to recommence; • Consultation with DPLH will be undertaken as required; • Incidents will be recorded and the cause investigated; • Inspect and amend pegging and outlines on maps; • Remedial actions as instructed by DPLH; • Refresher or updated training will be conducted (if appropriate); and • Review management actions (and revise if required).	

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
	Minimise	If newly identified heritage values are discovered during construction, such as Aboriginal heritage objects or remains, including human remains, skeletal material that may be human or material that potentially belongs to a human burial, an unexpected finds protocol will be implemented including: ▪ Stop works immediately within 20 m of the find ▪ Notify construction manager. ▪ Contact Traditional Owner representatives of either Yindjibarndi or Wintawari as soon as possible to ensure culturally appropriate heritage management measures are implemented. ▪ Implement a chance finds process incorporating notifications to relevant authorities and DPLH procedures.	• Visual monitoring during clearing and excavation works.	• During ground disturbance; and • When an unexpected find occurs.	• Find reported to DPLH.	• Unknown heritage values, artifacts or remains are uncovered during ground disturbance.	• Notification to DPLH; • Where appropriate, a qualified heritage specialist will be engaged to survey and manage Aboriginal heritage sites/materials; and • Where appropriate, approvals sought to disturb the new site.	
Prevent unauthorised impacts to Aboriginal heritage sites through implementation of Division 6 of the *Aboriginal Cultural Heritage Act* 2021.	Minimise	If impacts to any registered Aboriginal heritage site or any site associated with the Stage 4 of the Revised Proposal likely to be protected by the ACH Act are unavoidable, undertake an archaeological investigation with the ACH Act and provide the results of the excavation to the Registrar of Aboriginal Sites prior to commencing ground disturbing works.	• Archaeological investigation undertaken by suitably qualified person.	• Prior to commencing ground disturbing works.	• Archaeological investigation; and • Record of provision of results of the excavation to the Registrar of Aboriginal Sites.	• Impact to registered Aboriginal site or site associated with Stage 4 of the Revised Proposal likely to be protected by the ACH Act undertaken without archaeological investigation.	• Notification to DPLH; and • Incident will be recorded, and the cause investigated.	• Construction Contractor Environmental Management Representative; and • Main Roads Superintendent.

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
	Minimise	Invite in writing two Traditional Owner representatives of either Yindjibarndi or Wintawari to be present for ground disturbing works on Land intersecting with a registered Aboriginal heritage site or any site likely to be protected by the ACH Act.	• Written records; and • Relevant Traditional Owner representatives present for ground disturbing activities.	• Prior to commencing ground disturbing works on the Land intersecting with a registered Aboriginal heritage site or any site associated likely to be protected by the ACH Act.	• Written record inviting either two Yindjibarndi or two Wintawari Traditional Owner representatives; and • Record of appropriate Traditional Owner representatives present daily.	• No record/evidence of written invitation to Traditional Owner representatives; and • Ground disturbing works on the Land intersecting with a registered Aboriginal heritage site or any site likely to be protected by the ACH Act prior to appropriate Traditional Owner representatives being present on site.		
Minimise construction or operational impacts to water flow or water quality of waterways identified as significant in Heritage site survey findings or recommendations,	Minimise	As identified in Table 5-31 management targets or indicators: • Road drainage designed to maintain surface water flows; and velocities; and • Prevent impacts to water quality during construction	• Site inspections.	• During design, construction and operations.	• Site inspection reports.	• Impacts to water flow or water quality of waterways identified as significant in Heritage site survey findings or recommendations.	• As identified in Table 5-31 management targets or indicators: Road drainage designed to maintain surface water flows and velocities; and prevent impacts to water quality during construction.	• Construction Contractor Environmental Management Representative; and • Main Roads Superintendent.

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
Minimise nuisance and health impacts from dust	Minimise	• Cleared and exposed areas will be rehabilitated or otherwise stabilised as early as practicable to minimise the potential for wind erosion; • Dust emissions will be controlled through appropriate measures where practicable including hydro mulch, water application through water carts and chemical dust suppressants. This applies to the entire construction site and includes, but is not limited to haul roads, cleared areas, batters and stockpiles; • All vehicles carrying dusty loads will be covered by tarpaulins etc. if travelling outside of the DE, where practicable; • If required and practicable, construction material shall be dampened by sprinkling water prior to transportation, especially during dry and windy weather conditions; and • The construction site will be kept clean to minimise dust accumulation within and surrounding the site.	• Visual inspection, pedestrian walkthrough; • Site inspection of dust controls; and • Opportunistic monitoring with emphasis on windy periods.	• During construction; and • Weekly.	• Weekly site inspection records.	• Excessive dust recorded; and • Complaint from receivers.	• Investigation of complaint. All complaints responded to within 24 hours or 48 hours if occurring over weekend; • Incident report if required; and • Implementation of contingency actions including watering, applying covers to dusty loads and moving stockpiles.	• Construction Contractor Environmental Management Representative.

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
Minimise nuisance and health impacts to local community from noise during construction	Minimise	Construction works will be undertaken in accordance with Regulation 13 (Construction) in the *Environmental Protection (Noise) Regulations 1997 (Noise Regulations).* Construction activities (including materials transport) will be limited between 0700 and 1900 Monday to Saturday, excluding public holidays (standard work hours) where possible. Where construction activities are required outside of approved operating hours: • Prepare a Noise and Vibration Management Plan (NVMP); • Obtain approval for the NVMP from the Shire of Ashburton; • Ensure all nearby residents are notified prior to works, with details of time period of activity and summary of why the activity is required outside of usual hours; • Reduce noise emissions as much as practicable, e.g. croakers in place of reverse beepers; • Generators, compressors and other semi-fixed equipment that generate noise will be located as far as practicable from nearby residences; and • Maintenance schedules will be followed to ensure that all equipment is in good condition.	• Visual inspection, pedestrian walkthrough; • Site inspection of noise controls; and • Weekly check of machinery and equipment condition.	• During construction; and • Weekly.	• Weekly site inspection records.	• Excessive noise recorded; and • Complaint from receivers.	• Investigation of complaint. All complaints responded to within 24 hours or 48 hours if occurring over weekend; • Incident report if required; and • Implementation of contingency actions including locating noise or vibratory equipment further from receptors, amending working hours or swapping for less noisy equipment.	• Construction Contractor Environmental Management Representative.

5.4.6 Assessment of Impacts

Wherever practicable, impacts to Aboriginal heritage will be avoided, however some impacts to Aboriginal heritage sites due to Stage 4 of the Revised Proposal may be unavoidable. Consultation with Traditional Owners has been and will continue to be undertaken during the design of Stage 4 of the Revised Proposal in order to understand the values present and to minimise impacts where practicable. Where possible concerns raised during heritage site surveys, including potential impacts from reduced access to cultural heritage and loss of heritage values due to changes in surface water flow or quality will be address during design, construction or operational phases.

Should complete avoidance of Aboriginal sites not be achievable, consent to impact an Aboriginal site will be sought from the Minister via the preparation of a Aboriginal Cultural Heritage Management Plan in accordance with Division 6 of the ACH Act. Consent under the ACH Act will outline the extent of approved impact. Initial consultation has resulted in changes to the alignment to avoid areas of particular significance to the Traditional Owners.

Given the remote location of the Development Envelope, no significant impacts to amenity are anticipated. Stage 4 of the Revised Proposal has been developed to take into account requests from the owners of Hamersley Station to have the road deviate from the Rio Tinto Railway alignment in order to reduce impacts such as unwanted visitation once the road is opened to traffic. This will also reduce the risk of temporary impacts to amenity at the homestead through noise and dust during construction.

5.4.7 Predicted Outcome

5.4.7.1 Environmental Outcomes

Table 5-35 details of the predicted environmental outcomes of the current Approved Proposal and Revised Proposal for Social Surroundings.

It should be noted that the CER for the Approved Proposal was prepared in 2003 and the EPA finalised its decision report in 2005. Requirements in environmental impact assessment has progressed significantly in the early 2000's and the EPA has released a series of technical guidance with respect to the preparation of ERDs and the assessment of technical factors. Given this, direct comparison between the Approved Proposal and Revised Proposal is not possible in all cases.

Table 5-35 Environmental Outcomes for Revised Proposal – Social Surroundings

Element	Approved Proposal	Proposed Changes	Revised Proposal
Impacts to Millstream-Chichester National Park.	The construction of a sealed road will increase visitor pressures on the National Park and may result in DCLM providing camping or picnic areas at particular locations. Given the size and inaccessibility of most of the Park the opportunities for providing better access and viewing points along the existing railway/road	Change to – no change to the social values of the Millstream-Chichester National Park will occur.	No change to the social values of the Millstream-Chichester National Park will occur.

Element	Approved Proposal	Proposed Changes	Revised Proposal
	corridor are likely to outweigh the risks of increased visitor numbers.		
Amenity	There will be little potential visual impact to existing users of the area. Plant and equipment used on the works will comply with standard noise level requirements and negotiations regarding working out of standard hours will be undertaken when work is near the station homestead. Due to the low traffic levels predicted for the southern part of the Karratha to Tom Price road (60 vehicles per day) traffic noise levels are not considered an issue.	No material change given impacts to amenity during construction or operation of Stage 4 of the Revised Proposal are expected to be insignificant given the nearest residence is approximately 2 km from the Development Envelope and the nearest recreational or tourism areas are over 10 km away. Blasting and dust generation will be managed to avoid impacting any local resident or community members.	No significant impacts to amenity will occur.
Aboriginal heritage	Where avoidance of Aboriginal heritage sites is not possible Main Roads will seek a Section 18 clearance under the AH Act.	Change to - No unapproved disturbance in an Aboriginal heritage site will occur.	No unapproved disturbance in an Aboriginal heritage site will occur.
Historic heritage	No impacts identified in CER.	No impact predicted as There are no known historic heritage places listed on either the State Heritage List, National Heritage lists, or local Municipal heritage lists associated with Stage 4 of the Revised Proposal.	No impacts to historic heritage will occur.

5.4.7.2 Summary of Assessment of Significant Residual Impacts

While it is possible that the final Disturbance Footprint may impact on some Aboriginal heritage sites (subject to approval under the ACH Act and consultation with traditional owners), the Revised Proposal has been designed, will continue to be designed, and will be managed throughout the project lifecycle to avoid and minimise impacts on these sites.

Impact to amenity from the Revised Proposal is predicted to be low given the extent of baseline surveys and studies, management measures proposed, ongoing consultation with traditional owners, remoteness of the area, distance to tourism and recreational areas, presence of other infrastructure (such as the Rio Tinto Railway) and the short duration of construction activities.

Stage 4 of the Revised Proposal will bring local community benefits including improved road safety and reduced travel times for local residents, and improved access to tourism and recreations sites.

5.4.7.3 Assessment against EPA's Environmental Objective

The Proposed Changes are not expected to significantly alter the extent of magnitude of impacts currently considered in the Approved Proposal. No significant residual impacts to Social Surrounds have been identified.

Main Roads will implement the Revised Proposal so as to achieve the environmental outcomes outlined in Table 5-35. Doing so will ensure that the Revised Proposal avoids and minimises impacts to Social Surrounds as far as reasonably practicable. Approvals with respect to impacts to Aboriginal heritage sites from Stage 4 will be managed via an Aboriginal Cultural Heritage Management Plan in accordance with Division 6 of the ACH Act. This avoidance and minimisation of impacts will ensure that the Revised Proposal does not cause significant harm to social surroundings. As such the Revised Proposal is consistent with the EPA's environmental objective for Social Surroundings.

Assurance of achievement of the environmental outcomes is via:

- the proposed implementation conditions for the Revised Proposal detailed in Section 6 which are outcome-based conditions which mandate where an impact must be avoided, where a level of impact must not be exceeded or where a level of environmental protection must be met; or
- regulation by other DMAs permitting and licensing requirements (i.e. Division 6 approvals under the ACH Act).

5.5 Air Quality

5.5.1 EPA Objective

The WA EPA states that air quality is 'the chemical, physical, biological, and aesthetic characteristics of air' (EPA, 2019).

The WA EPA objective for air quality is to 'maintain air quality and minimise emissions so that environmental values are protected'.

For this assessment, air quality is only considered in relation to the EPA request for information that includes 'an assessment of potential impacts from degradation of Air Quality due to potential historical and naturally occurring asbestos that may be present in construction dust" (EPA, 2020).

5.5.2 Policy and Guidance

The Environmental Factor Guideline: Air Quality (EPA, 2016) is relevant to this factor. This guideline provides an outline of how air quality is considered by the EPA in the EIA process. Relevant matters discussed in the guideline include the following:

- application of the mitigation hierarchy to avoid and minimise emissions, where possible;
- characterisation of potentially harmful emissions and the pathways by which they may be released to air;
- the application of technology appropriate to the potential environmental impacts and risks; and
- the significance of the likely change to air quality as well as the environmental values affected by those changes, in the context of existing and predicted cumulative impacts.

Main Roads will implement this guidance by:

- identifying emissions from Stage 4 of the Revised Proposal with the potential to impact air quality;
- providing a description of proposed management.

The following guidance documents were also relevant in the consideration of impacts to air quality:

- *National Environment Protection Council Act* 1994 (Cth) and National Environment Protection Measure for Ambient Air Quality (Air NEPM); and
- National Environment Protection (National Pollutant Inventory) Measure (NPI).

5.5.3 Receiving Environment

5.5.3.1 Dust

The Pilbara region experiences significant ambient dust levels due to the semi-arid landscape. Naturally occurring dust in this area can exceed the National Environment Protection Measure for Ambient Air Quality (Air NEPM) criteria (FMG 2018). Stage 4 of the Revised Proposal is remote and there a no nearby receptors other than the Hamersley Homestead and Coolawanyah Station. The alignment has been rerouted to be at least 1.2 km from Hamersley Homestead and is over 20 km from Coolawanyah Station.

5.5.3.2 Historic Asbestos

The Stage 4 alignment runs near the Rio Tinto rail line, which has been in use since 1964. Historic use of the rail line prior to the hazards of asbestos being known means that there is a risk of asbestos contamination along the rail line. The road alignment avoids known areas of historic asbestos contamination including the Roebourne to Wittenoom road. The only access in the vicinity of the Stage 4 alignment is the Rio Railway Access Road known as the Tom Price – Hammersley Road. Access to this rail access road has been controlled by Rio and is not suspected as being historically contaminated with asbestos material.

5.5.3.3 Naturally Occurring Asbestos

Asbestos and asbestiform minerals may form in a wide range of rock types, large accumulations of such minerals are associated with ultramafic rocks. Ultramafic rocks are typically dark rocks rich in magnesium and iron with relatively low silica and potassium and composed mostly of minerals such as olivine and pyroxene. Ultramafic rock is prevalent within the Hamersley group. Sub surface asbestos deposits may occur in the vicinity of the MRDH Stage 4 alignment, and these could potentially be activated by road construction activities.

A desktop assessment of the risk of asbestos disturbance based upon the geological units in the Development Envelope has been undertaken for Stage 4 of the Revised Proposal (Appendix A.5). Table 5-36 summarises the risk of construction activities interacting with naturally occurring asbestos (NOA).

Table 5-36 Risk of Intersection NOA

Project Section and Chainage	Likelihood of disturbance	Likelihood of NOA	Overall Risk	Comments
Coolawanyah 0 - 34000	Medium	Low	Low	NOA may be present within surficial deposits transported to the site, however, the potential for fibrous NOA within these deposits is assessed to be low. Some cuts are anticipated however published mapping indicates that these will mainly be through the natural superficial deposits and the Marra Mamba Iron Formation for which no known occurrences of crocidolite have been recorded within the 1:250,000 Pyramid geological sheet based on the explanatory notes.
Coolawanyah 34000 – Hamersley 400	Low	Medium	Low	NOA may be present within surficial deposits transported to site. Asbestos is identified within the 1:250,000 scale Pyramid geological map, with Asbestos Creek running north to south and Asbestos Gorge located over 16 km to the west of the Site. However, the potential presence within the creek is likely to be associated with the transport of minerals and washout of old tailings with the gorge extending to the Brockman Formation.

Hamerlsey 400 - 12700	Low	Low	Very Low	NOA may be present within surficial deposits transported to site. Risk is elevated due to higher potential to disturb bedrock but the probability of NOA has still been considered low based upon anticipated geology.
Hamersley 12700 – Tom Price 12000	High	High	High	Significant cuts are likely through the Hamersley Range and within the Brockman Iron Formation which may require blasting due to the strength of the rocks. There is a known presence of blue asbestos within the Brockman Iron Formation. Crocidolite deposits in the Wittenoon and Dales Gorge areas have been identified close to the contact with the underlying Mount McRae Shale. These lie over 70 km from the Development Envelope.

Of the four sections assessed, three sections were considered Low to Very Low Risk, and one section, Hamersley to Tom Price (12700-12000), was considered High Risk. This section is defined by the Brockman Iron Formation, Mount McRae / Mount Sylvia Formations and Wittenoom Formation, of which the Brockman Iron Formation is considered to pose the highest risk (Appendix A.5). This is based on the both the mineral formation of the unit and the known presence of blue asbestos from previous mining.

Significant cuts are likely through the Hamersley Range and within the Brockman Iron Formation which may require blasting because of the strength of the rocks and would exacerbate risks associated with airborne fibres.

5.5.4 Potential Impacts

Air emissions can affect both environmental receptors and human health if not managed correctly. Stage 4 of the Revised Proposal has the potential to produce air emissions in the form of dust (including asbestos). Activities which have the potential to impact air quality include:

- road construction activities including excavation, blasting, earthmoving, handling and stockpiling of excavated material (including potentially fibrous mineral materials);
- wheel generated dust from the movement of vehicles and equipment on unsealed roads; and
- windblown dust from disturbed areas and material stockpiles.

This may result in:

- reduction in air quality due to dust generated during construction;
- exposure of the community and construction work force to historical asbestos; and

exposure of the community and construction work force to naturally occurring asbestos.

5.5.5 Mitigation

Construction of Stage 2 and 3 of the Revised Proposal is completed. Therefore, mitigation is focussed on Stage 4 of the Revised Proposal.

Main Roads will implement controls to prevent harm to Main Roads employees and contractors, as well as users of Hamersley Homestead, traditional owners, the rail access road, and the rail line. Road construction workers will be protected from dust impacts by OH&S management systems and measures required by agreements between Main Roads and contractors.

Main Roads standard dust mitigation measures which will be implemented as part of Stage 4 of the Revised Proposal, including:

- Use of dust suppression to manage dust generation from construction activities, access roads and cleared areas
- Use of water sprays to manage dust generation from material transport and stockpiling
- Limit the number and height of stockpiles
- Vehicles confined to designated routes with speed limits strictly enforce

Prior to construction in areas indicated to have a high risk in relation to NOA, Main Roads will undertake targeted soil and rock sampling to define areas where road construction will intersect NOA. Further risk assessment may be undertaken prior to sampling to confirm the high risk areas for sampling. An Asbestiform Materials Management Plan will be required within the Main Roads contract requirements for construction in the areas where sampling determines NOA is present. This plan will describe the processes to be undertaken for the management of fibrous material relating to works undertaken in the High Risk areas. It will outline the requirements to prevent workers and the publics exposure to hazardous levels of naturally occurring fibrous material associated with Stage 4 of the Revised Proposal.

Table 5-37 details the measures that are proposed to manage and mitigate the potential environmental impacts from the Revised Proposal on Air Quality.

Table 5-37 Air Quality Management

EPA factor: Air Quality EPA objective: To maintain air quality and minimise emissions so that environmental values are protected Proposal objective: To minimise as far as practicable the direct and indirect impacts to native vegetation and flora from Stage 4 of the Revised Proposal. Key environmental values: Air quality Key impacts and risks: Historical and naturally occurring asbestiform materials

Management targets or indicators	Hierarchy	Management or response actions	Monitoring	Timing/Frequency	Reporting	Corrective action trigger	Corrective actions	Corrective action responsibility
No significant impacts to air quality as a result of asbestiform materials in dust emissions	Minimise	• Dust generating activities will be suspended at the direction of the construction contractor's environmental representative if deemed too dusty and will not recommence without approval. • Main Roads standard dust mitigation measures which will be implemented throughout construction of Stage 4 of the Revised Proposal, including: - Use of dust suppression to manage dust generation from construction activities, access roads and cleared areas. - Use of water sprays to manage dust generation from material transport and stockpiling. - Limit the number and height of stockpiles. - Vehicles confined to designated routes with speed limits strictly enforced.	• Visual inspection, pedestrian walkthrough (monthly); and • Photographic record, GPS of non-conformance.	• During construction.	• All suspended works to be reported to the Main Roads Superintendent.	• Dust mitigation measures not implemented or not affective.	• Review mitigation measures and implementation procedure and revise if required.	• Construction Contractor Environmental Management Representative.
	Minimise	Prior to construction in areas indicated to have a high risk in relation to NOA, Main Roads will undertake targeted soil and rock sampling to define areas where road construction will intersect NOA. Further risk assessment may be undertaken prior to sampling to confirm the high risk areas for sampling. An Asbestiform Materials Management Plan will be implemented by the construction contractor where sampling determines NOA is present. This Plan will include any requirements with respect to disposal of cut material that contains NOA and any stabilisation required to avoid erosion and mobilisation of NOA in cut areas.	• In accordance with Asbestiform Materials Management Plan.	• In accordance with Asbestiform Materials Management Plan.	• In accordance with Asbestiform Materials Management Plan.	• In accordance with Asbestiform Materials Management Plan.	• In accordance with Asbestiform Materials Management Plan.	• In accordance with Asbestiform Materials Management Plan.

5.5.6 Assessment of Impacts

Stage 4 of the Revised Proposal's dust and fibrous mineral impacts have been assessed by Main Roads.

Although nuisance dust could affect the amenity of dust-sensitive receptors, Stage 4 of the Revised Proposal is remote from communities and other dust-sensitive receptors and impacts from nuisance dust are not expected to occur.

It is possible that Stage 4 of the Revised Proposal's road construction activities could intersect geologies containing fibrous material, including NOA. Fibrous materials intersected in the vicinity of Stage 4 of the Revised Proposal have been identified as riebecktite, griqualardite and tigers eye (FMG 2018). Fibrous minerals present a human health and environmental contamination risk but given the distance to sensitive receptors and potential impacts will be limited to the construction workers.

5.5.7 Predicted Outcome

5.5.7.1 Environmental Outcomes

Table 5-38 details of the predicted environmental outcomes of the current Approved Proposal and Revised Proposal for Air Quality

It should be noted that the CER for the Approved Proposal was prepared in 2003 and the EPA finalised its decision report in 2005. Requirements in environmental impact assessment has progressed significantly in the early 2000's and the EPA has released a series of technical guidance with respect to the preparation of ERDs and the assessment of technical factors. Given this, direct comparison between the Approved Proposal and Revised Proposal is not possible in all cases.

Table 5-38 Environmental Outcomes for Revised Proposal – Air Quality

Element	Approved Proposal	Proposed Changes	Revised Proposal
Impact on air quality – construction dust	No identified in CER	Addition of - Impacts to remote communities and other dust sensitive receptors will be avoided.	No impacts to remote communities and other dust sensitive receptors as a result of construction dust will occur.
Impact on air quality - operations	The potential increase of traffic on the route as a result of the new road will make a negligible difference to the air quality of the area and to nearby land users due to the very low numbers of vehicles and lack of sensitive receptors.	Change to – no significance change to air quality will occur.	No significance change to air quality will occur as a result of operation of the Revised Proposal.

Element	Approved Proposal	Proposed Changes	Revised Proposal
Impact on human health - Naturally occurring asbestos	No identified in CER	Addition of - impacts to human health as a result of air emissions will be avoided.	No impacts to human health will occur as a result of air emissions.

5.5.7.2 Summary of Assessment of Significant Residual Impacts

Main Roads manages potential construction workers exposure to mineral fibres through the implementation of its OHS Management Systems and Procedures. This includes air quality monitoring to ensure workers are not exposed to health risks. The OHS Management Systems and Procedures will be implemented during the Revised Proposal's construction phase activities.

5.5.7.3 Assessment against EPA's Environmental Objective

Given the remote location of the Revised Proposal and the lack of sensitive receptors, which is limited to the construction site work force and given appropriate management, Main Roads considers that dust emissions and impacts associated with fibrous minerals can be controlled using existing environmental and OHS Management Procedures and that the EPA's objective for Air Quality (dust) will be met.

6 Implementation Conditions and Environmental Management Commitments Review

6.1 Approved Proposal Implementation Status

Stage 2 – completed in August 2008

Stage 2 was delivered as follows:

- pre-construction and construction – 2006 to 2008 via the Millstream Alliance
- monitoring and maintenance – undertaken by the Millstream Alliance for a period of 7 years following completion (from August 2008)
- environmental offsets were included in the Ministerial requirements. One of the offsets involved contributing $25,000 per year to the then Department of Environment and Conservation (DEC), for five years, towards a weed control program for areas within Millstream-Chichester National Park. These payments have been completed.

Environmental Management Plans (EMPs) for Stage 2 of the overall Road from Karratha to Tom Price Project were submitted to, and accepted by, the then Department of the Environment (DoE) in May 2006. The following six EMPs addressed the requirements of commitments 2, 4, 10, 12 and 14 of Ministerial Statement 677. Each of these plans was endorsed by the regulator and the requirements of the plans were successfully implemented.

1. Environmental Management Plan Preconstruction
2. Environmental Management Plan Construction
3. Aboriginal Heritage Management Plan
4. National Park Management Plan
5. Vegetation Protection and Rehabilitation Management Plan
6. Surface Drainage Management Plan.

Stage 3a & Stage 3b

Construction commenced in October 2019 after asbestos remediation works along the unsealed Roebourne- Wittenoom Road, were completed. Stage 3 construction was completed on 30 August 2020.

Environmental Management Plans (EMPs) for Stage 3a & Stage 3b of the overall Road from Karratha to Tom Price Project were submitted to, and accepted by, the EPA in 2018. The following six EMPs addressed the requirements of commitments 2, 4, 10, 12 and 14 of Ministerial Statement 677. Each of these plans was endorsed by the regulator and the requirements of the plans were successfully implemented.

1. Environmental Management Plan Construction
2. Cultural Heritage Management Plan
3. National Park Management Plan
4. Vegetation Protection and Rehabilitation Management Plan
5. Weed control and management plan

6. Surface Drainage Management Plan.

Discussions have continued with DBCA about the design of appropriate interpretive signage and rest bays as per commitment 10.2.

Stage 4

Currently in Planning Phase.

6.2 Proposed Revision of Implementation Conditions and Environmental Management Commitments

Main Roads has reviewed the Approved Proposal's implementation conditions and environmental management commitments to assess whether they are relevant and appropriate for the Revised Proposal. As a result of this review, Main Roads proposes that where existing conditions and environmental management commitments are relevant to the Revised Proposal, new conditions capture the intent and requirements of existing conditions and commitments. Given MS 677 was issued in 2005, in a different format to contemporary Ministerial Statements, and that Stage 2 and 3 is completed, Main Roads proposes that MS 677 be revised so that existing implementation conditions and environmental management commitments apply only to Stages 2 and 3 of the Revised Proposal, and that a new set of outcomes based implementation conditions be created for Stage 4 of the Revised Proposal, either within MS 677, or in a new Ministerial Statement.

Table 6-1 indicates the Approved Proposal's compliance against MS 677 conditions, and the relevance of these conditions to Stage 4 of the Revised Proposal. Table 6-2. indicates the Approved Proposal's compliance against MS 677 environmental management commitments and the relevance of these commitments to Stage 4 of the Revised Proposal.

The proposed new set of implementation conditions that Main Roads proposes be adopted for Stage 4 of the Revised Proposal are detailed in Table 6-3.

Table 6-1 Status of Current Implementation Conditions and Relevance to Stage 4 of the Revised Proposal

No.	Current Implementation Conditions	Status	Relevance to Stage 4 of Revised Proposal
1 Implementation			
1-1	The proponent shall implement the proposal as documented in Schedule 1 of Statement 677 subject to the conditions of this statement.	Compliant The area to be disturbed as specified in Statement 677, Condition 7-2 was amended under Section 46C of the EP Act from 110 ha to 145 ha on the 13 July 2007. Stages 2 and 3 of the Approved Proposal have been constructed within the authorised extent of Table 2 of Schedule 1 (as amended via Section 45C on 21 June 2018).	Relevant Note that no Schedule 1 is proposed as part of Proposed Changes. The relevant information is now presented in a Proposal Content Document (PCD) for the Revised Proposal. The PCD outlines the current authorised extent, the Proposed Changes, and the extent of the Revised Proposal.
2 Proponent Commitments			
2-1	The proponent shall implement the environmental management commitments documented in Schedule 2 of Statement 677, to the requirements of the Minister for the Environment on advice of the EPA.	Compliant EMPs were submitted and accepted for Stage 2 and 3. These EMPs addressed the requirements of commitments 2, 4, 10, 12 and 14 of Ministerial Statement 677.	Relevant Note that no Schedule 2 is proposed for Stage 4 of the Revised Proposal. The substantive content of Schedule 2 including the Topics, Actions and Objectives has been incorporated into proposed outcome-based Implementation Conditions for Stage 4 of the Revised Proposal (Table 6-3).
3 Proponent Nomination and Contact Details			
3-1	The proponent for the time being nominated by the Minister for the Environment, under S38(6) or (7) of the EP Act is responsible for the	Compliant	Not Relevant

No.	Current Implementation Conditions	Status	Relevance to Stage 4 of Revised Proposal
	implementation of the proposal until the Minister has revoked this nomination and nominated another person in respect of the proposal under S38(7) of the EP Act.	Proponent – Main Roads Western Australia	Contemporary ministerial statements issued under the EP Act 1986 do not include this implementation condition.
3-2	If the proponent wishes to relinquish the nomination, the proponent shall apply for the transfer of proponent and provide a letter with a copy of this Statement endorsed by the proponent's replacement that the proposal will be carried out in accordance with the conditions of this statement. Contact details and appropriate documentation on the capability of the proposed replacement proponent to carry out the proposal shall also be provided.	Compliant No change to the proponent.	Not Relevant Contemporary ministerial statements issued under the EP Act 1986 do not include this implementation condition. Main Roads are not proposing a change in Proponent.
3-3	Notify the Department of Environment of any change of proponent contact name and address within 60 days of such a change.	Compliant No change – as above.	Relevant This condition is prescribed by proposed implementation conditions for Stage 4 of the Revised Proposal (Condition 6-1) (Table 6-3).
4 Commencement and Time Limit of Approval			
4-1	The proponent shall substantially commence the proposal within five years of the date of this statement or the approval granted in this statement shall lapse and be void. Note: The Minister for the Environment will determine any dispute as to whether the proposal has substantially commenced.	Complete See above	Relevant This condition is prescribed by proposed implementation conditions for Stage 4 of the Revised Proposal (Condition 7-1) (Table 6-3).
4-2	The proponent shall make application for any extension of approval for the substantial commencement of the proposal beyond five years horn the date of this statement to the Minister for the Environment, prior to the expiration of the five-year period referred to in condition 4-1. The application shall demonstrate that: 1 . the environmental factor s of the proposal have not changed significantly;	Compliant No change – as above.	Relevant This condition is prescribed by proposed implementation conditions for Stage 4 of the Revised Proposal (Condition 7-2) (Table 6-3), using contemporary wording similar to recent Ministerial Statements.

No.	Current Implementation Conditions	Status	Relevance to Stage 4 of Revised Proposal
	2. new, significant, environmental issues have not arisen; and 3. all relevant government authorities have been consulted. Note: The Minister for the Environment may consider the gr ant of an extension of the time limit of appr oval not exceeding five years for the substantial commencement of the proposal.		
5 Compliance Audit and Performance Review			
5-1	The proponent shall prepare an audit program and submit compliance reports to the Department of Environment which address: 1. the status of implementation of the proposal as defined in schedule 1 of this statement; 2. evidence of compliance with the conditions and commitments; and 3. the performance of the environmental management plans and programs. Note: Under sections 48(1) and 47(2) of the Environmental Protection Act 1986, the Chief Executive Officer of the Department of Environment is empowered to monitor the compliance of the proponent with the statement and should directly receive the compliance documentation, including environmental management plans, related to the conditions, procedures and commitments contained in this statement.	Compliant Compliance Assessment Reports have been submitted on an annual basis.	Relevant The intent of this condition (i.e., prepare and implement and audit program) is prescribed by proposed implementation conditions for Stage 4 of the Revised Proposal (Conditions 8-1 to 8-6) (Table 6-3), using contemporary wording similar to recent Ministerial Statements.
6 Weed Control			
6-1	In addition to commitment 4 (Vegetation Protection and Rehabilitation Management Plan) in schedule 2, to manage and control the spread of weeds, the proponent shall ensure that 1. earthmoving vehicles and construction equipment are free of soil and vegetative material prior to entering the construction area;	Compliant - Stage 3 Compliance in accordance with the Vegetation Protection and Rehabilitation Management Plan has been ongoing throughout the construction phase.	Relevant The intent of this condition (i.e. manage and control the spread of weeds) is prescribed by proposed outcome based implementation conditions for Stage 4 of the Revised Proposal (Condition 2-1) (Table 6-3) in line with EPA guidance.

No.	Current Implementation Conditions	Status	Relevance to Stage 4 of Revised Proposal
	2. quarries and borrow pits are surveyed for Ruby Dock (*Acetosa vesicaria*) prior to utilising the material from these pits for road construction; 3. borrow pits and areas containing Ruby Dock (*Acetosa vesicaria*) are delineated in the field (by roping or a system of markers) to prevent access for construction crews and machinery; 4. soil and construction materials brought into the construction area from other areas are weed free; and 5. a Weed Control and Monitoring Program is prepared and implemented in collaboration with the neighbouring railway operator (s) with the objective of controlling and eradicating existing weeds and future outbreaks of weeds along the road, particularly Ruby Dock (*Acetosa vesicaria*), both during and following construction, To the requirements of the Minister for' the Environment on advice of the Environmental Protection Authority, the Department of Conservation and Land Management and the Department of Agriculture.		
7 Vegetation Protection and Rehabilitation			
7-1	During road construction, the proponent shall limit the disturbance width of the road where it traverses the *Themeda* grassland threatened ecological community, near Hamersley Station, as shown in Figure 2 in schedule 1, to not more than 20 metres.	Compliant Not applicable to Stage 2 and Stage 3 as they do not intersect the *Themeda* grassland.	Relevant The intent of this condition (i.e. establish a maximum extent of disturbance to the *Themeda* grassland TEC) is prescribed by proposed implementation conditions for Stage 4 of the Revised Proposal (Condition 1-1 and 2-2) (Table 6-3), using contemporary wording similar to recent Ministerial Statements.

No.	Current Implementation Conditions	Status	Relevance to Stage 4 of Revised Proposal
7-2	During road construction, the proponent shall limit the area of vegetation to be cleared within the Millstream- Chichester National Park to not more than 145 hectares.	Compliant	Not Relevant Stage 4 of the Revised Proposal will not result in clearing within the Millstream- Chichester National Park.
7-3	During and following construction, the proponent shall rehabilitate: 1. approximately 137 hectares of land disturbed for the construction of the road; and *either* 2(a) approximately 205 hectares of redundant access tracks, including those tracks associated with the railway, and redundant material pits as an environmental offset activity, or 2(b) alternative offsets of equivalent cost/value, developed in liaison with the Department of Conservation and Land Management, and which deliver greater biodiversity outcomes, to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority and the Department of Conservation and Land Management. For the purpose of this condition, the specific locations, and methods and procedures for rehabilitation shall be included in the Vegetation Protection and Rehabilitation Management Plan (see commitment 4)..	Compliant Rehabilitation in relation to the current authorised extent of clearing has been completed via rehabilitation of 137 ha disturbed by the construction of the road, and the provision of an offset amount in relation to redundant access tracks.	Not Relevant The current authorised extent of clearing has been rehabilitated. Rehabilitation related to clearing proposed for Stage 4 of the Revised Proposal is prescribed by proposed implementation conditions for Stage 4 of the Revised Proposal (Condition 1-1) (Table 6-3) and the PCD.
7-4	Develop rehabilitation completion criteria to apply to the rehabilitation required by condition 7 -3. The rehabilitation completion criteria shall have timeframes and shall be included in the Vegetation Protection and Rehabilitation Management Plan (see commitment 4 in schedule 2).	Compliant Vegetation Protection and Rehabilitation Management Plans were prepared and implemented for both Stage 2 and Stage 3.	Not Relevant In line with the EPA's guidance, outcome based conditions have been proposed. Rehabilitation related to clearing proposed for Stage 4 of the Revised Proposal is prescribed by proposed implementation conditions for Stage 4 of the Revised Proposal (Condition 1-1) (Table 6-3) and the PCD.
7-5	Monitor the progress of rehabilitation against the rehabilitation completion criteria referred to in condition 7 -4 and implement	Compliant	Not Relevant

No.	Current Implementation Conditions	Status	Relevance to Stage 4 of Revised Proposal
	contingency measures and supplementary rehabilitation works where the criteria are not being met.	Rehabilitation has been completed (rip and monitor) as per the management plan.	In line with the EPA's guidance, outcome based conditions have been proposed for Stage 4 of the Revise Proposal. Rehabilitation related to clearing proposed as part of Stage 4 of the Revised Proposal is prescribed by proposed implementation conditions (Condition 1-1) (Table 6-3) and the PCD.

Table 6-2 Status of Environmental Management Commitments and Relevance to Stage 4 of the Revised Proposal

No	Commitment	Objective	Status	Relevance to MRDH Stage 4
1	Employ a dedicated environmental co-ordinator	(1) To ensure that environmental co-ordination is effective. (2) To provide environmental advice and to supervise clearing and rehabilitation activities, particularly in the Millstream-Chichester National Park and the section of the road which traverses the threatened ecological community.	Compliant Main Roads has engaged a dedicated Environmental Co-ordinator for construction planning, and implementation of Stage 2 and Stage 3.	Not Relevant Employment of a dedicated environmental coordinator is an action rather than an outcome. Outcome based conditions have been proposed for Stage 4 of the Revise Proposal as prescribed in Table 6-3, in line with EPA's guidance on outcome based conditions.
2	Prepare a Surface Drainage Management Plan	To maintain existing drainage patterns and to prevent soil erosion and sedimentation caused by construction activity or new waterways structures.	Compliant Surface Drainage Management Plans were prepared and implemented for both Stage 2 and Stage 3.	Relevant The intent of this commitment (i.e. maintain existing drainage patterns and minimise soil erosion and sedimentation) is prescribed in proposed implementation conditions for Stage 4 of the Revised Proposal (Condition 4-1) (Table 6-3) in line with the EPA's guidance on outcome based conditions.
3	Implement Surface Drainage Management Plan	To maintain existing drainage patterns and to prevent soil erosion and sedimentation caused by construction activity or new waterways structures.		

No	Commitment	Objective	Status	Relevance to MRDH Stage 4
4	Prepare a Vegetation Protection and Rehabilitation Management Plan.	To prevent loss of vegetation beyond the 'footprint' of the works and minimise potential indirect effects on vegetation. To rehabilitate areas disturbed by construction of the road.	Compliant Vegetation Protection and Rehabilitation Management Plans were prepared and implemented for both Stage 2 and Stage 3.	Relevant The intent of this commitment (i.e. avoid direct impacts outside of the Disturbance Footprint, minimise indirect impacts and rehabilitate disturbed areas outside the road footprint) is prescribed in proposed implementation conditions for Stage 4 of the Revised Proposal (Condition 1-1, 2-2, 2-3 and 2-4) (Table 6-3) in line with the EPA's guidance on outcome based conditions.
5	Implement the Vegetation Protection and Rehabilitation Management Plan.	To prevent loss of vegetation beyond the 'footprint' of the works and minimise potential indirect effects on vegetation. To rehabilitate areas disturbed by construction of the road.		
6	Prepare a TEC Protection and Management Plan.	To ensure that construction management in the TEC is of a similar standard to that employed in the National Park, and that this is to the satisfaction of CALM	N/A Not applicable to Stage 2 or 3.	Relevant The intent of this condition (i.e. establish a maximum extent of disturbance to the *Themeda* grassland TEC) is prescribed in proposed implementation conditions for Stage 4 of the Revised Proposal (Condition 1-1 and 2-2) (Table 6-3) in line with the EPA's guidance on outcome based conditions.
7	Implement the TEC Protection and Management Plan.	To ensure that construction management in the TEC is of a similar standard to that employed in the National Park, and that this is to the satisfaction of CALM		
8	Prepare a scientifically based rehabilitation trial for the treatment of redundant roads and tracks. Monitor and report outcomes of rehabilitation trials for	To rehabilitate redundant tracks and to provide information on best practice methodology for use by Main Roads and others in the Pilbara in the future.	Compliant Rehabilitation trial was completed during Stage 2 works.	Not Relevant Commitment complete – no further trials to be undertaken.

No	Commitment	Objective	Status	Relevance to MRDH Stage 4
	the treatment of redundant roads and tracks.			
9	Rehabilitate redundant roads and tracks using results of the trials referred to in commitment 8.	To rehabilitate redundant tracks and to provide information on best practice methodology for use by Main Roads and others in the Pilbara in the future.	Compliant The majority of initially identified redundant tracks were not rehabilitated due to changed requirements from DEC Karratha Branch. A number of meetings were held between DEC and Millstream Link representatives, where a cash payment was agreed for DEC to undertake rehabilitation of redundant tracks and erect necessary fencing on behalf of Millstream Link. DEC requested amendments to Commitment 16 and Condition 7-3. During Stage 2 construction available small redundant areas were treated by ripping and where available cleared vegetation and topsoil was re-spread.	Not Relevant Commitment complete – no further rehabilitation of redundant roads and tracks to be undertaken.
10	Prepare a National Park Plan which addresses impacts in the Millstream-Chichester National Park.	To minimise the impacts of the road through the Millstream-Chichester National Park. Design of appropriate interpretive signage and rest bays to promote understanding of Park values and protection of flora and fauna.	Complete National Park Management Plans were prepared and implemented for both Stage 2 and Stage 3.	Not Relevant Stage 4 of the Revised Proposal will not result in clearing within the Millstream- Chichester National Park.
11	Implement the National Park Plan.	To minimise the impacts of the road through the Millstream-Chichester National Park		

No	Commitment	Objective	Status	Relevance to MRDH Stage 4
12	Prepare an Aboriginal Heritage Management Plan (in compliance with the Aboriginal Heritage Act 1972).	To protect and preserve Aboriginal cultural heritage within the area influenced by the roadworks.	Compliant Aboriginal Heritage Management Plans were prepared and implemented for both Stage 2 and Stage 3.	Relevant No related implementation condition is proposed as requirements are regulated under separate legislation. Where Aboriginal heritage sites cannot be avoided, Main Roads will seek any necessary approvals under the relevant legislation (AH Act or ACH Act) and comply with conditions of that approval.
13	Implement the Aboriginal Heritage Management Plan (in compliance with the Aboriginal Heritage Act 1972).	To protect and preserve Aboriginal cultural heritage within the area influenced by the roadworks.		
14	Prepare a Construction Management Plan.	To ensure that environmentally and socially acceptable standards are established and maintained during construction works.	Compliant Construction Management Plans were prepared and implemented for both Stage 2 and Stage 3.	Not Relevant Preparation of a Construction Management Plan is a tactic rather than an outcome. Outcome based conditions have been proposed for Stage 4 of the Revise Proposal as prescribed in Table 6-3 in line with the EPA's guidance on outcome based conditions.
15	Implement the Construction Management Plan.	To ensure that environmentally and socially acceptable standards are established and maintained during construction works.		
16	Construct approximately 30 kilometres of fencing along the northern boundary of the Millstream-Chichester National Park where it is adjacent to Pyramid Station.	To prevent stock access to the National Park.	Compliant Fencing not constructed by Millstream Link. DEC Karratha negotiated other offsets with Main Roads A number of meetings were held between Main Roads, DEC and Millstream Link representatives, where a cash payment from Main Roads was agreed for DEC to undertake rehabilitation of	Not Relevant Commitment complete – no further fencing along the northern boundary of the Millstream-Chichester National Park to be undertaken.

No	Commitment	Objective	Status	Relevance to MRDH Stage 4
			redundant tracks and erect necessary fencing on behalf of Millstream Link.	
17	Contribute $25,000 per year, for five years, towards a weed control program for the Millstream-Chichester National Park	To contribute to the overall weed control and management of the National Park, in particular the control of date and cotton palm, morning glory, khaki weed, Galland's curse, Indian water fern and Parkinsonia.	Complete Main Roads WA have completed payment to the former DEC.	Not Relevant Commitment complete.

Table 6-3 Proposed Implementation Conditions for Stage 4 of the Revised Proposal

<table>
<tr><th>No.</th><th>Proposed Implementation Conditions (Stage 4)</th></tr>
<tr><td colspan="2">1 Limitations and Extent of Proposal</td></tr>
<tr><td>1-1</td><td>When implementing Stage 4 of the Revised Proposal, the proponent shall ensure Stage 4 of the Revised Proposal does not exceed the following extents:
<table>
<tr><th>Element</th><th>Location</th><th>Limitation or Maximum Extent</th></tr>
<tr><td>Development Envelope</td><td>Figure 1 of this statement</td><td>7,142 ha</td></tr>
<tr><td>Indicative Disturbance Footprint</td><td>Figure 1 of this statement</td><td>565 ha</td></tr>
<tr><td>Indicative Temporary Clearing Area</td><td>Figure 2 of this Statement</td><td>100 ha</td></tr>
<tr><td rowspan="2">Direct disturbance of native vegetation</td><td rowspan="2">Within Development Envelope</td><td>Permanent clearing of 550 ha of vegetation in Good to Excellent condition</td></tr>
<tr><td>Temporary clearing (to be rehabilitated) of 100 ha of vegetation in Good to Excellent condition</td></tr>
<tr><td>Themeda Grasslands TEC</td><td>Within Development Envelope</td><td>Permanent clearing of 15 ha</td></tr>
<tr><td>Brockman Iron Cracking Clay Communities of the Hamersley Range PEC</td><td>Within Development Envelope</td><td>Permanent clearing of 12 ha</td></tr>
<tr><td rowspan="2">Vegetation of local significance</td><td rowspan="2">Within Development Envelope</td><td>Permanent clearing of 69.7 ha</td></tr>
<tr><td>Temporary clearing (to be rehabilitated) of 22.9 ha</td></tr>
<tr><td>Vegetation associated with drainage lines</td><td>Within Development Envelope</td><td>Permanent clearing of 30 ha</td></tr>
<tr><td>Northern Quoll denning, foraging and dispersal habitat</td><td>Within Development Envelope</td><td>178.3 ha, of which 4.0 ha is of habitat identified as being critical to the survival of the Northern Quoll and 42.3 ha is identified as important foraging and dispersal habitat.</td></tr>
<tr><td>Pilbara Leaf-nosed Bat foraging, flyway and drinking habitat</td><td>Within Development Envelope</td><td>Permanent clearing of 178.2 ha</td></tr>
<tr><td rowspan="2">Ghost Bat potential roosting, foraging, flyway and drinking habitat</td><td rowspan="2">Within Development Envelope</td><td>Permanent clearing of 313.4 ha of which includes 18.7 ha of Ghost Bat foraging habitat within 5 km of the possible maternity roost.</td></tr>
<tr><td>Temporary clearing (to be rehabilitated) of 48.3 ha (0 ha within 5 km of the possible maternity roost).</td></tr>
</table></td></tr>
</table>

	Pilbara Olive Python foraging habitat	Within Development Envelope	Permanent clearing of 313.3 ha
			Temporary clearing (to be rehabilitated) of 48.3 ha
	Night Parrot foraging habitat	Within Development Envelope	Permanent clearing of 29.3 ha
	Grey Falcon foraging and drinking habitat	Within Development Envelope	Permanent clearing of 596.1 ha
			Temporary clearing (to be rehabilitated) of 100.0 ha
	Pebble Mound Mouse Mounds	Within Development Envelope	2 active and 2 non active mounds.
2 Flora and Vegetation			
2-1	The proponent shall undertake measures while implementing Stage 4 of the Revised Proposal to avoid the introduction of weeds into the Stage 4 Development Envelope.		
2-2	The proponent shall undertake measures while implementing Stage 4 of the Revised Proposal to avoid where possible, otherwise minimise, direct and indirect impacts to: (a) Threatened Ecological Communities (b) Priority Ecological Communities (c) Vegetation of local significance (d) Vegetation associated with drainage lines (e) Groundwater dependent vegetation (f) Sheet flow dependent vegetation (g) Priority flora.		
2-3	The proponent shall undertake measures while implementing Stage 4 of the Revised Proposal to avoid clearing of the single Fringed Fire-bush plant identified within the Stage 4 Development Envelope.		
2-4	The proponent shall undertake measures while implementing Stage 4 of the Revised Proposal to avoid where possible, otherwise minimise, direct and indirect impacts to the following priority flora species: *(a) Euphorbia australis* var. glabra *(b) Sida sp. Hamersley Range* (K. Newbey 10692) PN *(c) Themeda sp*. Hamersley Station (M.E. Trudgen 11431) *(d) Eremophila magnifica* subsp. Magnifica *(e) Goodenia nuda* (P4).		
3 Terrestrial Fauna			
3-1	The proponent shall undertake measures while implementing Stage 4 of the Revised Proposal to avoid where possible, otherwise minimise, direct and indirect impacts to terrestrial fauna.		
3-2	The proponent shall undertake measures while implementing Stage 4 of the Revised Proposal to avoid direct or indirect impacts to caves with demonstrated evidence of Ghost Bat use.		
3-3	The proponent shall undertake measures while undertaking blasting activities to avoid direct or indirect impacts to caves with demonstrated evidence of Ghost Bat use.		
3-4	To achieve the objective of condition 3-2, and 3-3 the proponent will prepare and submit a Blasting Noise and Vibration Management Plan.		

3-5	The proponent shall not undertake blasting within 400 m of caves with demonstrated evidence of Ghost Bat use until the CEO has approved by notice in writing the Blasting Noise and Vibration Management Plan required by condition 3-4. The proponent shall implement the version of the Blasting Noise and Vibration Management Plan approved by the CEO.
3-6	Where active Western Pebble-mound Mouse mounds are required to be cleared, the proponent shall apply displacement methods to ensure the individuals using the mounds to relocate within their home range.
4 Inland Waters	
4-1	The proponent shall construct Stage 4 of the Revised Proposal to ensure no significant change to the existing hydrological regime by avoiding where possible, otherwise minimise direct and indirect impacts to: (1) Surface water quality (2) Groundwater levels (3) Groundwater quality.
5 Offsets	
5-1	The proponent shall implement offset measures for Stage 4 of the Revised Proposal to achieve the objective of counterbalancing residual impacts to the following environmental values: (1) Permanent loss of 550 ha of vegetation in 'Good to Excellent' condition (2) Temporary clearing of 100 ha of vegetation in 'Good to Excellent' condition. (3) 15 ha of the *Themeda* grasslands TEC. (4) 12 ha of the Brockman Iron cracking clay communities of the Hamersley Range PEC. (5) 4.0 ha of potential Northern Quoll denning and dispersal habitat that is identified as habitat critical to the survival of the Northern Quoll. (6) 42.3 ha of important foraging and dispersal habitat for the Northern Quoll (defined as Northern Quoll habitat within 1 km of habitat critical to the survival of the Northern Quoll).
5-2	To achieve the requirements of condition 5-1, the proponent shall contribute funds to the Pilbara Environmental Offsets Fund calculated in accordance with conditions 5-3 to 16-7, subject to any reduction approved by the CEO under condition 5-8.
5-3	The proponent's contribution to the Pilbara Environmental Offsets Fund must be paid biennially, with the amount to be contributed calculated based on the clearing undertaken in each year of the biennial reporting period in accordance with the rates in condition 5-4. The first biennial reporting period must commence from ground disturbing activities of the environmental values identified in condition 5-1.
5-4	Calculated on the 2020-2021 financial year, the contribution rates are (all excluding GST): (1) $1,679 per hectare of *Themeda* grasslands TEC. (2) $1,679 per hectare of Brockman Iron PEC. (3) $1,679 per hectare of habitat critical to the survival of the Northern Quoll. (4) $1,679 per hectare of important foraging and dispersal habitat for Northern Quolls and/or Ghost Bats. (5) $1,679 per hectare of native vegetation in 'Good to Excellent' condition in the Fortescue IBRA subregion. (6) $840 per hectare of native vegetation in 'Good to Excellent' condition in the Hamersley IBRA subregion. (7) $794 per hectare of native vegetation in 'Good to Excellent' condition in the Chichester IBRA subregion.

5-5	From the commencement of the 2020-2021 financial year, the rates in condition 5-4 will be adjusted annually each subsequent financial year in accordance with the percentage change in the CPI applicable to that financial year.
5-6	Prior to ground disturbing activities within the Development Envelope, the proponent shall prepare and submit an Impact Reconciliation Procedure to the CEO.
5-7	The proponent shall submit an Impact Reconciliation Report in accordance with the Impact Reconciliation Procedure approved pursuant to condition 5-6.
5-8	The proponent may apply in writing and seek the written approval of the CEO to reduce all or part of the contribution payable under condition 5-2 where: (1) A payment has been made to satisfy a condition of an approval under the *Environment Protection and Biodiversity Conservation* Act 1999 in relation to the proposal (2) The payment counterbalances impact of the proposal on matters of national environmental significance; and (3) The payment counterbalances the significant residual impacts to the environmental values identified in condition 5-1.
6 Contact Details	
6-1	The proponent shall notify the CEO of any change of its name, physical address, or postal address for the serving of notices or other correspondence within twenty-eight (28) days of such change. Where the proponent is a corporation or an association of persons, whether incorporated or not, the postal address is that of the principal place of business or of the principal office in the State.
7 Time Limit for Proposal Implementation	
7-1	The proponent shall not commence implementation of the proposal after five (5) years from the date of this Statement, and any commencement, prior to this date, must be substantial.
7-2	Any commencement of implementation of the proposal, on or before five (5) years from the date of this Statement, must be demonstrated as substantial by providing the CEO with written evidence, on or before the expiration of five (5) years from the date of this Statement.
8 Compliance Reporting	
8-1	The proponent shall prepare and maintain a Compliance Assessment Plan which is submitted to the CEO at least six (6) months prior to the first Compliance Assessment Report required by condition 8-6, or prior to implementation of the proposal, whichever is sooner.
8-2	The Compliance Assessment Plan shall indicate: (1) the frequency of compliance reporting; (2) the approach and timing of compliance assessments; (3) the retention of compliance assessments; (4) the method of reporting of potential non-compliances and corrective actions taken; (5) the table of contents of Compliance Assessment Reports; and (6) public availability of Compliance Assessment Reports.
8-3	After receiving notice in writing from the CEO that the Compliance Assessment Plan satisfies the requirements of condition 8-2 the proponent shall assess compliance with conditions in accordance with the Compliance Assessment Plan required by condition 8-1.
8-4	The proponent shall retain reports of all compliance assessments described in the Compliance Assessment Plan required by condition 8-1 and shall make those reports available when requested by the CEO.

8-5	The proponent shall advise the CEO of any potential non-compliance within seven (7) days of that non-compliance being known.
8-6	The proponent shall submit to the CEO the first Compliance Assessment Report fifteen (15) months from the date of issue of this Statement addressing the twelve (12) month period from the date of issue of this Statement and then annually from the date of submission of the first Compliance Assessment Report, or as otherwise agreed in writing by the CEO. The Compliance Assessment Report shall: (1) be endorsed by the proponent's Chief Executive Officer or a person delegated to sign on the Chief Executive Officer's behalf; (2) include a statement as to whether the proponent has complied with the conditions; (3) identify all potential non-compliances and describe corrective and preventative actions taken; (4) be made publicly available in accordance with the approved Compliance Assessment Plan; and (5) indicate any proposed changes to the Compliance Assessment Plan required by condition 8-1.
9 Public Availability of Data	
9-1	Subject to condition 9-2, within a reasonable time period approved by the CEO of the issue of this Statement and for the remainder of the life of the proposal, the proponent shall make publicly available, in a manner approved by the CEO, all validated environmental data (including sampling design, sampling methodologies, empirical data and derived information products (e.g. maps)), management plans and reports relevant to the assessment of this proposal and implementation of this Statement.
9-2	If any data referred to in condition 9-1 contains particulars of: (1) a secret formula or process; or (2) confidential commercially sensitive information, the proponent may submit a request for approval from the CEO to not make these data publicly available. In making such a request the proponent shall provide the CEO with an explanation and reasons why the data should not be made publicly available.

7 Offsets Strategy – Stage 4

7.1 Background

The WA Government's Environmental Offset Policy (GoWA, 2011) define offsets as "*an offsite action or actions to address significant residual environmental impacts of a development or activity*". The guidelines state that "*Environmental offsets are actions that provide environmental benefits which counterbalance the significant residual environmental impacts or risks of a project or activity. Unlike mitigation actions which occur on-site as part of the project and reduce the direct impact of that project, offsets are undertaken outside of the project area and counterbalance significant residual impacts*".

As detailed in Section 5, Stage 4 of the Revised Proposal is predicted to have a significant residual impact to the PKEFs of flora and vegetation and terrestrial fauna. Given these potential significant residual impacts, and consistent with the approach implemented for the previous stages of the Proposal, Main Roads intend to implement of an environmental offset strategy. This offset strategy will be proportionate to the level of impact and significance of the residual environmental impact.

It is noted that Stage 4 of the Revised Proposal also requires assessment under the EPBC Act and is subject to the Australian Government's EPBC Act Environmental Offset Policy (DSWEPaC, 2012) as well as the WA Environmental Offset Policy (GoWA, 2011).

7.2 WA Environmental Offset Policy (GoWA, 2011)

The WA Environmental Offsets Policy (GoWA, 2011) requires the following Principles to be considered when developing an offset proposal:

- environmental offsets will only be considered after avoidance and mitigation options have been pursued;
- environmental offsets are not appropriate for all projects;
- environmental offsets will be cost-effective, as well as relevant and proportionate to the significance of the environmental value being impacted;
- environmental offsets will be based on sound environmental information and knowledge;
- environmental offsets will be applied within a framework of adaptive management; and
- environmental offsets will be focussed on longer term strategic outcomes.

An assessment of the residual impacts of Stage 4 of the Revised Proposal as outlined in the Environmental Offset Policy has been undertaken below in Table 7-1.

Table 7-1 Residual Impact Significance Model – Stage 4

Part IV Environmental Factors	Vegetation and flora					Terrestrial fauna	
Part V Clearing Principles	(c) Rare flora	(d) TECs	(e) Remnant vegetation	(f) wetlands and waterways	(h) Conservation areas	(a) High biological diversity	(b) Habitat for fauna
Residual impact that is environmentally unacceptable and cannot be offset	None	None	None	None	None	None	None
Significant residual impacts that will require an offset – All significant residual impacts to species and ecosystems are protected by statute or where the cumulative impact is already at a critical level	None	Clearing of up to 15 ha *Themeda* grassland TEC.	• Permanent clearing of up to 550 ha of Good to Excellent condition native vegetation in the Pilbara Bioregion.	None	None	Clearing of up to 12 ha of Brockman Iron PEC.	• Clearing of up to 4.0 ha of potential Northern Quoll denning and dispersal habitat that is identified as habitat critical to the survival of the Northern Quoll. • Clearing of up to 42.3 ha of important foraging and dispersal habitat for the Northern Quoll (defined as Northern Quoll habitat within 1 km of habitat critical to the survival of the Northern Quoll). • Clearing of up to 18.7 ha of potential Ghost Bat foraging habitat within 5 km of the possible maternity roost identified by Biota (2021).
Significant residual impacts that may require an offset	None	None	Temporary clearing of up to 100 ha of Good to Excellent condition native vegetation in the Pilbara Bioregion.	None	None	None	None
Residual impacts that are not significant	None	None	None	Clearing of up to 30 ha of vegetation associated with drainage lines.	None	Clearing of individuals of up to five Priority flora species, comprising *Euphorbia australis* var. glabra, *Sida* sp. Hamersley Range (K. Newbey 10692) PN, *Themeda* sp. Hamersley Station (M.E. Trudgen 11431), *Eremophila magnifica* subsp. *Magnifica* and *Goodenia nuda*	• Potential removal of two active Western Pebble-mound Mouse Mounds (noting that these are not located in the Indicative Disturbance Footprint and will only be removed if the Indicative Disturbance Footprint is adjusted within the Development Envelope). Displacement methods will be used to relocate the Western Pebble-mound Mice that are using the mounds. • Clearing of up to: o 132.2 ha of suitable Northern Quoll foraging and dispersal habitat (not habitat critical to the survival of species or important dispersal habitat);

							o 178.2 ha of suitable Pilbara Leaf-nosed Bat foraging, flyway and drinking habitat; o 343 ha of suitable Ghost Bat potential roosting, flyway, foraging and drinking habitat (294.7 ha permanent and 48.3 ha temporary); o 361.6 ha of suitable Pilbara Olive Python foraging habitat (313 ha permanent and 48.3 ha temporary) o 29.3 ha of suitable Night Parrot foraging habitat; o 696.1 ha of suitable Gray Falcon foraging and drinking habitat (596.1 ha permanent and 100.0 ha temporary o 696.1 ha of suitable Peregrine Falcon foraging and drinking habitat (596.1 ha permanent and 100.0 ha temporary o 246.2 ha of suitable Western Pebble-mound Mouse foraging and nesting habitat; o 29.3 ha of suitable Northern Short-tailed Mouse foraging habitat; o 85.7 ha of suitable Lined Soil-crevice Skink foraging habitat; o 92.7 ha of suitable Long-tailed Dunnart foraging habitat; o 3.8 ha of suitable Gane's Blind Snake foraging habitat; o 89.0 ha of suitable Pilbara Barking Gecko foraging habitat; and o 20.7 ha of suitable Spotted Ctenotus foraging habitat (10.4 ha permanent and 10.3 ha temporary

7.3 Pilbara Environmental Offsets Fund

The Western Australian Government has released the Pilbara Conservation Strategy which outlines a landscape-scale approach to biodiversity conservation across the Pilbara region and provides strategic direction for conservation actions that may be funded from a variety of sources including through offsets to counterbalance the residual impacts of infrastructure projects (DPAW, 2017). The top four outcomes that will be delivered through the Pilbara Conservation Strategy are (DPAW, 2017):

1) landscape-scale conservation through improved management of key threats;
2) improved condition of threatened and other important species and communities;
3) evidence-based conservation management; and
4) conservation through partnerships.

The outcomes "*Landscape-scape conservation through improved management of key threats*" and "*Evidence-based conservation management*" are relevant to the significant residual impacts of Stage 4 of the Revised Proposal to terrestrial flora and vegetation, and terrestrial fauna.

Of these outcomes, "*Improved condition of threatened and other important species and communities*" is of particular relevance to Stage 4 of the Revised Proposal and the predicted significant residual impacts resulting from clearing of up to 4.0 ha of habitat critical to the survival of the Northern Quoll. The Pilbara Conservation Strategy specifically notes the Northern Quoll as one of the species that is the focus of this objective (DPAW, 2017).

The Pilbara Conservation Strategy also outlines a number of priority areas that will be the focus of the project implemented to meet the objectives of the Strategy. One of these priorities is referred to as "Karijini restoration" which includes actions to that will help restore the central Hamersley Range and enhance biodiversity and ecosystem resilience. These actions include (DPAW, 2017):

- eradicating or controlling feral herbivores;
- controlling feral cats;
- removing priority weeds from high value assets;
- managing fire through prescribed burning;
- undertaking research to address key knowledge gaps; and
- establishing a wildlife sanctuary within Karijini National Park.

The central Hamersley Range, encompassing Karijini National Park, adjacent pastoral leases and unallocated Crown land, comprises a variety of ecosystems that support threatened species, including the Northern Quoll. A portion of Stage 4 of the Revised Proposal lies within the Hamersley Range.

In July 2016, the Western Australian Government approved the establishment of the Pilbara Strategic Conservation Initiative, now known as the Pilbara Environmental Offsets Fund (the 'fund'), to maximise the value of environmental offsets from projects in the Pilbara (DPAW, 2017). The fund facilitates the coordinated delivery of environmental offset projects within the Pilbara bioregion of WA. The fund was established to invest in strategic conservation projects in the Pilbara bioregion to improve vegetation and species habitat impacted by development. The fund combines money from individual offset payments required under the WA EP Act and the EPBC Act into a special purpose account. This

enables the delivery of larger and more strategic landscape-scale projects than would occur if individual offset projects were delivered independently, leading to better biodiversity conservation outcomes (DWER, 2019). Projects funded by the fund address the priorities of the Pilbara Conservation Strategy described above (DPAW, 2017).

Main Roads recognises that the effective implementation of offsets in the Pilbara is hampered by the region's unique land tenure (being all Crown land with overlapping mining, native title and pastoral interests). This makes traditional land acquisition and access for on-ground offset activities difficult. The fund was established to overcome these barriers and as such, Main Roads proposes to use the fund to facilitate offsets for the Revised Proposal. Table 7-2 outlines how the use of fund is consistent with the Principles of the WA Environmental Offsets Policy (GoWA, 2011)

Table 7-2 Principles of the WA Environmental Offsets Policy

Principle	How addressed by proposed offset strategy
Environmental offsets will only be considered after avoidance and mitigation options have been pursued	As detailed in Sections 5.1.5, 5.2.5, 5.3.5, 5.4.5 and 5.5.5 avoidance and mitigation measures have been implemented wherever practicable.
Environmental offsets are not appropriate for all projects	The Revised Proposal is appropriate for environmental offsets, particularly in light of the availability of the Pilbara Environmental Offset Fund. Main Roads recognises that the effective implementation of offsets in the Pilbara is hampered by the region's unique land tenure (being all crown land with overlapping mining, native title and pastoral interests). This makes traditional land acquisition and access for on-ground offset activities difficult. The fund was established to overcome these barriers and as such, Main Roads proposes to use the fund to facilitate offsets for the Revised Proposal.
Environmental offsets will be cost-effective, as well as relevant and proportionate to the significance of the environmental value being impacted	The offset rates paid to the fund are established by DWER and are '*based on the level of biodiversity protection in the region, and cumulative impacts to environmental values, including high quality vegetation and the conservation of significant-species habitat* (DWER 2019)'. These rates include base rates for Good to Excellent quality vegetation and 'higher rates' for specialised environmental values such as specialised fauna habitat, TECs and PECs. It is anticipated that the higher rate will apply to offset clearing of habitat critical to the survival of the Northern Quoll, the Brockman Iron PEC, and the *Themeda* grasslands TEC. It is further anticipated that the base rate will apply to offset clearing of vegetation in Good to Excellent condition (where not already offset as part of the other environmental values). As such, it is considered that the proposed offsets are proportionate to the level of statutory protection that applies to the environmental values being impacted.
Environmental offsets will be based on sound environmental information and knowledge	The fund has an Implementation Plan which outlines the criteria that are used to select projects that are supported through the fund. These criteria include (DWER, 2019): "Be designed to align with the offset principles of the Western Australian and Australian governments and the implementation principles in Chapter 2 (of the Implementation Plan) so that the outcomes of projects:

	• tangibly and measurably improve environmental matters; • are value for money and have a high chance of success; • are strategic and have landscape-scale outcomes where achievable; • are long term and enduring (ideally outcomes will endure for at least 20 years); and • are additional to activities that are already required as a condition of approval or lease or a legislative requirement. “
Environmental offsets will be applied within a framework of adaptive management	The fund Implementation Plan states that “The fund will be adaptively managed to plan, implement, monitor, evaluate and adjust its delivery over time” (DWER, 2019). The Governance Framework for the fund states that “Evaluation of the strategic objectives, outcomes and priorities of the Implementation Plan will be completed every three years to inform adaptive management of the Fund, consistent with Principle 5 of the WA Offset Policy which is that ‘environmental offsets will be applied within a framework of adaptive management’” (DWER, 2019).
Environmental offsets will be focussed on longer term strategic outcomes	Strategic focus items of the fund relevant to longer term strategic outcomes include: • projects will maintain a strategic, landscape-scale focus; and • projects will balance significant impacts identified in state and Commonwealth approvals, reducing duplication and allowing strategic project delivery. The funds approach of combining money from offsets under the EP Act and EPBC Act to deliver larger and more strategic landscape-scale projects than would occur if individual offset projects were delivered independently, effectively manages the risk of offsets not succeeding when compared to smaller individual offset projects implemented by Proponents. The benefit of contributing to strategic landscape-scale projects also includes the opportunity to achieve net ecological gain due to a coordinated approach and the ability to achieve positive biodiversity outcomes on a large scale outside of the project’s disturbance footprint.

7.4 Significant Residual Impacts

The significant residual impacts of Stage 4 of the Revised Proposal, with reference to the Pilbara Environmental Offsets Fund, include:

- Permanent clearing of up to 550 ha of vegetation in ‘Good to Excellent’ condition within the Development Envelope;
- temporary clearing of up to 100 ha of Good to Excellent condition vegetation which will be rehabilitated for Stage 4 of the Revised Proposal;
- clearing of no more than 15 ha of the *Themeda* grasslands TEC;
- clearing of no more than 12 ha of the Brockman Iron cracking clay communities of the Hamersley Range PEC;
- clearing of up to 4.0 ha of potential Northern Quoll denning and dispersal habitat that is identified as habitat critical to the survival of the Northern Quoll;

- clearing of up to 42.3 ha of important foraging and dispersal habitat for the Northern Quoll (defined as Northern Quoll habitat within 1 km of habitat critical to the survival of the Northern Quoll); and
- clearing of up to 18.7 ha of Ghost Bat foraging habitat within 5 km of the possible maternity roost identified by Biota (2021).

7.5 Implementation

It is envisaged that the conditions of any approval of the Revised Proposal under the EP Act will specify the requirement for Main Roads to contribute to the fund. An Impact Reconciliation Procedure will be developed for approval by the DWER CEO.

Impact Reconciliation Reports (IRR) will then be submitted biennially (from the time of approval of the Revised Proposal). The IRR will advise DWER on the amount of clearing that has been undertaken within each year of the biennial reporting period. This clearing is then used to define the amount to be contributed to the fund for areas cleared during the reporting period, with the rate/ha determined in accordance with the fund's implementation plan. The calculations for the fund include a base rate for vegetation in Good to Excellent condition, and a higher rate for areas of specialised environmental values.

7.6 Offsets Fund Contribution

Based on the Pilbara Environmental Offsets Fund Implementation plan (DWER, 2019), it is expected that Main Roads will be required to pay a rate per hectare of impact to native vegetation in Good to Excellent condition, TEC, PEC and Northern Quoll critical habitat.

The base rate will apply for "*impacts to native vegetation in Good to Excellent condition*[17]*, which may include impacts to fauna habitat (including threatened fauna)".* It is noted that different rates will apply dependent on the IBRA subregion (Hamersley, Fortescue or Chichester), all of which intersect Stage 4 of the Revised Proposal (DWER, 2019). The Indicative Disturbance Footprint and Indicative Temporary Clearing Area comprises:

- Fortescue IBRA subregion – 108 ha;
- Hamersley IBRA subregion – 388 ha; and
- Chichester IBRA subregion – 158 ha.

However, in addition to this, it is expected that the higher rate will apply for the Revised Proposal's impact on 15 ha of the *Themeda* grasslands TEC, 12 ha of the Brockman Iron PEC, 4 ha of Northern Quoll critical habitat, 48.4 ha of habitat comprising important foraging and dispersal habitat for Northern Quolls and/or Ghost Bats, noting that a portion of the Northern Quoll foraging and dispersal habitat and Ghost Bat foraging habitat overlap and will only be offset once(DWER, 2019). The important foraging and dispersal habitat for Northern Quolls and/or Ghost Bats comprises:

- 12.6 ha of habitat that represents supporting habitat for both Northern Quoll (foraging and dispersal) and Ghost Bat (foraging).

[17] Good to Excellent condition – as defined in Environmental Protection Authority 2016, Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment.

- 29.7 ha of habitat that represents supporting habitat for Northern Quoll (foraging and dispersal) only.
- 6.1 ha of habitat that represents supporting habitat for Ghost Bat (foraging) only.

All areas to be cleared which are part of the *Themeda* grasslands TEC, the Brockman Iron PEC, the Northern Quoll critical habitat and important foraging and dispersal habitat and Ghost Bat foraging habitat are in Good to Excellent condition; to avoid offsetting these twice, the areas will be removed from the base rate calculation of Good to Excellent condition vegetation and only offset at the higher rate.

The areas to be cleared of *Themeda* grasslands TEC, the Brockman Iron PEC, the Northern Quoll critical habitat and the important foraging and dispersal habitat for Northern Quolls and/or Ghost Bats are all within the Hamersley region. As none of these environmental values overlap, a total of 79.4 ha is to be offset at the higher offset calculation rate.

The total area of Good to Excellent condition vegetation to be cleared in the Hamersley region is 388 ha. Removing the 79.4 ha which is already calculated at a higher rate from this leaves a total of 308.6 ha to be offset at the base rate. This is summarised in Table 7-3.

The estimated financial contribution is based on the 2020/2021 rates, and anticipated hectares to be directly impacted (i.e. cleared) for each IBRA sub-region. However, the financial contribution will be based on actual clearing, and this can only be calculated after clearing has been conducted.

It is anticipated that the value of expenditure per hectare of clearing that is expected to have a significant residual impact will be annually adjusted in accordance with the Perth Consumer Price Index (CPI) fluctuations from 1 July 2022. The Australian Bureau of Statistics (ABS) publish the annual CPI for Australian cities in September of each year and will be referenced when calculating the annual adjustments.

Table 7-3 Significant Residual Impacts Requiring an Offset – Stage 4

Environmental Feature	Clearing	Contribution	IBRA Subregion	Offset rate	Area (ha)	Total
Themeda grasslands TEC	Up to 15 ha	Based on DWER (2019), it is expected that a higher rate per hectare of clearing should be contributed to the fund for the 15 ha of TEC.	Hamersley	$1,679/ha	15	$25,185
Brockman Iron PEC	Up to 12 ha	Based on DWER (2019), it is expected that a higher rate per hectare of clearing should be contributed to the fund for the 12 ha of PEC.	Hamersley	$1,679/ha	12	$20,148

Habitat critical to the survival of the Northern Quoll	Up to 4 ha	Based on DWER (2019), it is expected that a higher rate per hectare of clearing should be contributed to the fund for the up to 4 ha of Northern Quoll critical habitat.	Hamersley	$1,679/ha	4	$6,716
Important foraging and dispersal habitat for Northern Quolls and/or Ghost Bats	Up to 48.4 ha	Based on DWER (2019), it is expected that a higher rate per hectare of clearing should be contributed to the fund for the up to 48.4 ha Important foraging and dispersal habitat for Northern Quolls and/or Ghost Bats.	Hamersley	$1,679/ha	48.4	$81,264
Native vegetation in Good to Excellent condition	Up to 574.6 ha	Based on DWER (2019), a rate per hectare of clearing should be contributed to the fund for the 511 ha of native vegetation in Good to Excellent condition. This rate is expected to be the base rate.	Fortescue	$1,679/ha	108	$181,332
			Hamersley	$840/ha	308.6	$259,224
			Chichester	$794/ha	158	$125,452
					TOTAL	$699,321

8 Matters of National Environmental Significance

Information in this section is informed by ongoing work relative to Commonwealth assessment EPBC 2020/8725, under the purview of DAWE. The Commonwealth assessment has run concurrent but ahead of the assessment being undertaken by the WA EPA. As such, while this section summarises Commonwealth matters to inform the work of the EPA, information released by DAWE under EPBC 2020/8725 is considered to have primacy over this summary.

8.1 Controlled Action Provisions

The Stage 4 of MRDH (referred to as the Proposed Action for the purpose of the Commonwealth Assessment of EPBC 2020/8725) was formally referred to DAWE in July 2020 under the EPBC Act due to potential impacts on MNES. On 3 September 2020, a delegate of the Commonwealth Minister for the Environment determined the Proposed Action (EPBC 2020/8725) was a Controlled Action to be assessed by Preliminary Documentation.

The Preliminary Documentation containing additional information requested by DAWE to support the assessment of the Proposed Action was provided to DAWE in October 2021.

8.2 Policy and Guidelines

The following legislation and guidelines are relevant to the listing and protection of MNES and the assessment of potential impacts to MNES arising from a Proposed Action:

- EPBC Act;
- Environment Protection and Biodiversity Conservation Regulations 2000;
- Significant Impact Guidelines (No. 1.1): Matters of National Environmental Significance (DoE, 2013).; and
- species specific referral guidelines such as the EPBC Act Referral guideline for the endangered northern quoll.

8.3 Protected Matters Relevant to the Proposed Action

A number of desktop and targeted field surveys have been undertaken for the Proposed Action in order to assess the presence of MNES within the Development Envelope. The identified MNES and potential impacts are detailed in Table 8-1 The identified have been summarised in (Table 8-1).

Table 8-1 MNES within the Development Envelope

MNES	Impact of Proposed Action
Listed Threatened Flora	One individual of the Critically Endangered Fringed Fire-bush (*Seringia exastia*) was recorded on the foothills in the south-central section of the survey area. No significant impacts are expected to occur to the single plant.
Listed Threatened Fauna	Clearing for construction of the road will result in the permanent direct loss of EPBC Act listed threated fauna habitat, including no more than

	• 178.3 ha of potential Northern Quoll foraging, dispersal and denning habitat. This includes up to 4.0 ha of rocky areas; a habitat type identified in the 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' as habitat critical to the survival of the Northern Quoll as it may be used for denning with reduced risk of exposure to threats (Hill and Ward 2010) and up to 42.3 ha of important foraging and dispersal habitat for the Northern Quoll (defined as Northern Quoll habitat within 1 km of habitat critical to the survival of the Northern Quoll); • 178.2 ha of potential Pilbara Leaf-nosed Bat roosting, foraging, flyway and drinking habitat, none of which is considered habitat critical to the survival of the species; • 313.4 ha of potential Ghost Bat roosting, foraging, flyway and drinking habitat, none of which is considered habitat critical to the survival of the species but does include of up to 18.7 ha of Ghost Bat foraging habitat within 5 km of the possible maternity roost identified by Biota (20201); • 313.3 ha of potential Pilbara Olive Python foraging habitat, none of which is considered habitat critical to the survival of the species; • 29.3 ha of potential Night Parrot foraging habitat, none of which is considered habitat critical to the survival of the species; • 596.1 ha of potential Grey Falcon nesting, foraging and drinking habitat, none of which is considered habitat critical to the survival of the species; and • within the total disturbance, 100 ha of temporary clearing associated with construction activities (such as site offices, laydown and side-tracks) and ongoing maintenance activities has been included. This temporary clearing will be rehabilitated as part of the Proposed Action. The Proposed Action has potential to cause indirect impacts to EPBC Act listed threated fauna resulting from: • fauna interaction with construction activities; • increased risk of vehicle strike; • Collision with fencing; • Disturbance from artificial light; • Disturbance from noise and vibration; • Fragmentation of habitat and population isolation; and • The introduction of invasive weeds or feral predator species.

8.4 Mitigation Measures

The DAWE request for additional information included the development of an Action Management Plan (AMP). An AMP for the management of impacts to EPBC Act listed threatened fauna was prepared as part of Preliminary Documentation to support assessment of EPBC 2020/8725 under the EPBC Act. The structure and content of this AMP has been prepared in accordance with DAWE's request for additional information.

The AMP has been prepared with the objective that impacts of the Proposed Action to MNES are acceptable, minimised and managed. It is a 'management-based' AMP to document management

actions required during construction and operation of the Revised Proposal. Management measures within the AMP are specific to the Proposed Action. The following management targets have been identified:

1. Prevent unauthorised clearing of EPBC Act listed threatened fauna habitat including permanent clearing of no more than:
    a) 178.3 ha of Northern Quoll foraging, dispersal and denning habitat including no more than 4.0 ha of habitat critical to the survival of the Northern Quoll species;
    b) 178.2 ha of Pilbara Leaf-nosed Bat roosting, foraging, flyway and drinking habitat;
    c) 313.4 ha of Ghost Bat roosting, foraging, flyway and drinking habitat;
    d) 313.3 ha of Pilbara Olive Python foraging habitat;
    e) 26.6 ha of potential Night Parrot foraging habitat; and
    f) 596.1 ha of Grey Falcon nesting, foraging and drinking habitat.
2. Prevent unauthorised impacts to groundwater levels and groundwater quality.
3. Avoid injury or mortality to EPBC Act listed threatened species during construction of the Proposed Action.
4. No introduction or spread of declared weeds, WONS or serious environmental weed species into surrounding native vegetation adjacent to the Development Envelope during and attributable to construction.
5. Avoid impacts to roosting caves used by Ghost Bats.
6. Minimise injury or mortality to EPBC listed threatened species during operation.

In addition, the Preliminary Documentation proposed the following management target for EPBC Act listed threatened flora:

1. Prevent the unauthorised clearing of the single Fringed Fire-bush *(Seringia exastia)* plant identified during the Biota (2021) survey.

The mitigation measures proposed in the Preliminary Documentation and the AMP to address potential impacts on MNES have been included in the relevant sections ('mitigation') for each PKEF in this document.

8.5 Summary of Assessment of Level of Significance of Impact on MNES

The Proposed Action will result in the following significant residual impacts

- clearing of up to 4.0 ha of habitat critical to the survival of the Northern Quoll
- clearing of up to 42.3 ha of important foraging and dispersal habitat for the Northern Quoll (defined as Northern Quoll habitat within 1 km of habitat critical to the survival of the Northern Quoll); and
- clearing of up to 18.7 ha of Ghost Bat foraging habitat within 5 km of the possible maternity roost identified by Biota (2021).

Main Roads propose to offset significant residual impacts to MNES resulting from the Proposed Action via the Pilbara Environmental Offsets Fund.

The Proposed Action is not expected to result in significant impacts (direct or indirect) to Pilbara Leaf-nosed Bats, Olive Pythons, Night Parrots or Grey Falcons which were identified by DAWE as potentially impacted by the Proposed Action.

Implementation of the Proposed Action:

- provides substantial social and economic benefits;
- has been developed with consideration to appropriate stakeholder consultation;
- incorporates substantial impact avoidance and mitigation, and established, effective construction management measures;
- is not inconsistent with the Objects of the EPBC Act and principles of economically sustainable development including the precautionary principles;
- is not inconsistent with relevant Commonwealth Conservation Advice, Recovery Plans and Threat Abatement Plans; and
- includes an offset to counterbalance significant residual impacts to MNES.

8.6 Predicted Outcome

The predicted outcomes for MNES impacted by the Proposal are:

- clearing of no more than 4.0 ha of a habitat identified in the 'National Recovery Plan for the Northern Quoll (*Dasyurus hallucatus*)' as habitat critical to the survival of the Northern Quoll as it may be used for denning with reduced risk of exposure to threats (Hill and Ward 2010);
- clearing of no more than 42.3 ha of important foraging and dispersal habitat for the Northern Quoll (defined as Northern Quoll habitat within 1 km of habitat critical to the survival of the Northern Quoll); and
- clearing of no more than 18.7 ha of Ghost Bat foraging habitat within 5 km of the possible maternity roost identified by Biota (2021).

9 Cumulative Impact Assessment

9.1 Land Systems

Table 9-1 indicates the impact of Stage 4 on the land systems of the Pilbara Bioregion, as well as impacts from nearby projects (Fortescue Metals Group, 2018):

- Eliwana Rail;
- Eliwana Iron Ore Mine; and
- Solomon Iron Ore Mine.

These disturbance areas represent a small percentage of the land system areas present with the three subregions relevant to Stage 4 (Hamersley, Fortescue and Chichester), with more than 97% of each land system being retained. The Revised Proposal's cumulative disturbance to these land systems is therefore not considered significant.

Table 9-1 Land System Impacts

Land System	Stage 4 Area (ha)	Eliwana Mine Area (ha)	Eliwana Rail Area (ha)	Solomon Mine Area (ha)	Total cumulative area to be disturbed (ha)	Total Area in Hamersley, Fortescue and Chichester sub-regions (ha)	Area outside Development Envelopes (ha)	Remaining undisturbed (%)
Boolgeeda	766	3,060	12,850	2,873	19,549	934,744	915,196	97.91%
Hooley	63				63	58,475	58,412	99.89%
Jurrawarrina	110				110	38,427	38,317	99.71%
McKay	6				6	425,967	425,967	100.00%
Newman	100	17,579	4,549	8,987	31,215	1,989,463	1,958,248	98.43%
Nooingnin	234				234	28,748	28,514	99.19%
Pindering	28				28	38,738	38,710	99.93%
Platform	181	1,549	73	4,417	6,220	236,390	230,170	97.37%
River	263				263	356,464	356,201	99.93%
Urandy	186				186	128,854	128,668	99.86%

9.2 Vegetation Associations

Table 9-2 indicates the predicted clearing for the Revised Proposal of each vegetation association in the context of previous clearing. These clearing areas comprise a very small percentage of the remaining pre-European extent within the Pilbara Bioregion for each Vegetation Association (<0.2% in all cases), as well as at the regional and Statewide scales. The extent remaining is well above the EPA target of 30% for each association, and in all cases the extent remaining exceeds 99%. The Revised Proposal's cumulative local and regional clearing impacts to these vegetation associations are, therefore not considered significant.

Table 9-2 Estimated Clearing Area of Beard (1975) Vegetation Associations, TECs and PECs

Vegetation Association	Pre-European Extent Remaining in the Pilbara (%)	Extent in Pilbara Bioregion (ha)	Indicative Disturbance Footprint (ha)	Percentage of Bioregional Extent Proposed to be Cleared	Pre-European Extent Remaining in the Pilbara after Project Clearing (%)
Beard (1975) Vegetation Associations					
Hamersley 565	99.99%	108,874	168	0.2%	99.97%
Chichester Plateau 607	99.84%	119,009	127	0.1%	99.83%
Hamersley 175	99.66%	95,187	102	0.1%	99.65%
Hamersley 644	99.52%	27,180	53	0.2%	99.50%
Hamersley 82	99.44%	2,168,072	77	0.004%	99.44%
Chichester Plateau 646	100%	18,033	6	0.03%	99.97%
Hamersley 645	99.99%	84,608	11	0.01%	99.98%
Hamersley 29	99.13%	151,142	7	0.005%	99.13%
Hamersley 18	99.19%	580,483	7	0.001%	99.19%
TEC					
Themeda Grasslands (within Vegetation Associations 82 and 175)	N/A	34,600[2]	Up to 15[1]	0.04%	N/A
PEC					
Brockman Iron cracking clay communities of the Hamersley Range (within Vegetation Associations 82 and 175 and overlaps the TEC)	N/A	Not known (31,805 ha[2] within 50 km of the Development Envelope)	Up to 12[1]	0.04% (of known occurrence within 50 km)	N/A

Notes: 1 - The TEC and PEC occur within the Beard (1975) Vegetation Associations. As such, the area of PEC and TEC clearing is a subset of the clearing stated for the corresponding Beard (1975) Vegetation Associations, and is not additional clearing on top of the Beard totals, that is, the estimated clearing for the TEC and PEC are not cumulative.

2 – extent remaining has been estimated from DBCA mapping.

9.3 Fauna

The Stage 4 of the Revised Proposal may result in an increase in existing threats and pressures on significant fauna species in the region that already exist as result of the completed stages of the MRDH, the Rio Tinto railway line and access roads, existing local roads, land uses (such as pastoral leases) and developments, particularly existing mines in the Hamersley Ranges. Cumulative impacts may occur as a result of cumulative loss and degradation of habitat, the exacerbation of feral species, and additional injury, mortality or disturbance to significant species as a result of anthropogenic reasons such as construction activities, vehicle strike and fencing.

Habitat loss

Stage 4 of the Revised Proposal will result in the direct loss of significant fauna habitat as detailed in Table 5-20. This habitat loss will add to the cumulative loss of similar habitat that has occurred in the Pilbara region. As described in the impact assessment for each of the significant fauna species, the extent of habitat that will be lost represented a very small component of the overall similar habitat that exists in the Pilbara regions. Based on the cumulative loss in regard to land systems and vegetation associations (Section 9.1 and Section 9.2) it can be seen that over 99% of the pre-European extents remain and Stage 4 of the Revised Proposal will result in the removal of <0.2% of this extent.

Of the habitat to be lost as a result of Stage 4 of the Revised Proposal, 4.0 ha represents habitat critical to the survival of the Northern Quoll as it represents potential denning and dispersal habitat. As described in Section 5.2.6.1.1 there is extensive similar habitat available throughout the Hamersley Ranges, including in close proximity to Stage 4 of the Revised Proposal. FMG (2018) identified 8,224 ha of potential Northern Quoll denning habitat in the region of which 299.3 ha (3.63%) was planned to be removed for the Solomon and Eliana mines and associated rail line. Based on this, Stage 4 of the Revised Proposal will result in the removal of a further 0.05% of the total denning habitat in the region as mapped by FMG (2018). This means that over 96% of the suitable denning habitat mapped by FMG (2018) would remain. Given this, the cumulative impacts to Northern Quoll as a result of habitat loss is not considered significant.

As described in Section 6, the clearing of vegetation and removal of 4.0 ha of Northern Quoll denning and dispersal habitat identified as habitat crucial to the survival of the species will be compensated via offsets.

As described in Section 5.2.6, the loss of roosting caves for Pilbara Leaf-nosed Bats and Ghost Bats is a key threat to these species. Historically, the loss of these caves has occurred as a result of mining operations and the collapse of historic mining shafts. The mitigation measures proposed for Stage 4 of the Revised Proposal will result in no direct impacts occurring to caves used for Pilbara Leaf-nosed Bat and Ghost Bat roosting, and as such Stage 4 of the Revised Proposal will not increase the threat posed to these species from the loss of roosting caves.

Given the above, it is not expected that habitat loss as a result of Stage 4 of the Revised Proposal will contribute cumulatively to similar threats in the region such that significant impacts occur to significant fauna species.

Introduced species

Feral predators are widespread throughout the Pilbara and recorded in the Development Envelope (Biota 2021). With the proposed mitigation measures (Section 5.2.5), Stage 4 of the Revised Proposal is not expected to result in an increased risk to significant fauna species from what already exists.

While the presence of weeds may be exacerbated by Stage 4 of the Revised Proposal as a result of clearing and translocation of seeds, this is not expected to result in a significant impact to fauna habitat given the existing background level of weeds in the area.

Construction activities

As described in Section 5.2.6, with the implementation of the planned mitigation measures, the risk of injury or mortality occurring to significant fauna species as a result of the construction activities is low. Should such an event occur, this would be limited to a small number of individuals which is unlikely to significantly contribute to the cumulative threats to these species.

Likewise, the light, noise and vibration emissions from the construction of Stage 4 of the Revised Proposal may result in minor behavioural disturbance to significant species. These emissions will add to the existing similar emissions that result from the Rio Tinto railway and access road, and other roads in the area. Minor behavioural impacts are not expected to add significantly to the cumulative threat that currently exist for these species.

As described above, mining operations including blasting have presented a historical threat to Pilbara Leaf-nosed Bat and Ghost Bat roosting caves. The mitigation measures proposed for Stage 4 of the Revised Proposal will avoid such impacts occurring to caves used for Pilbara Leaf-nosed Bat and Ghost Bat roosting. As such Stage 4 of the Revised Proposal will not increase the threat posed to these species from the disturbance of roosting caves.

Vehicle strike (operational traffic)

As described in Section 5.2.6, once construction is complete and the road opened to traffic, there will be a permanent risk of vehicle strike to fauna leading to injury or mortality of individual. This will increase the overall risk to fauna of vehicle and rail strike in the local area, particularly given the location of the Rio Tinto Dampier to Paraburdoo rail line which is located approximately 100 m from Revised Proposal for much of the Stage 4 alignment.

Traffic modelling for the Revised Proposal indicates traffic volumes will be low with a likely maximum of 635 vehicles per day, of which up to around 230 will be heavy vehicles. Given this low expected traffic volume and low density of fauna most at risk to vehicle strike (e.g. Pilbara Olive Python), significant impacts to fauna as a result of vehicle strike are not expected. There are up to seven rail movements per day along the Dampier to Paraburdoo rail line. Given these low volumes of vehicle and rail traffic, cumulative impacts to fauna as a result of interaction with vehicles on the MRDH and the rail line are not expected to be significant.

10 Holistic Impact Assessment and Conclusion

Assessment of impacts to the PKEFs for Stage 4 of the Revised Proposal has identified that there are significant residual impacts in relation to:

- Permanent clearing of up to 550 ha of vegetation in 'Good to Excellent' condition within the Development Envelope;
- temporary clearing of up to 100 ha of Good to Excellent condition vegetation which will be rehabilitated for Stage 4 of the Revised Proposal;
- clearing of no more than 15 ha of the *Themeda* grasslands TEC;
- clearing of no more than 12 ha of the Brockman Iron cracking clay communities of the Hamersley Range PEC;
- clearing of up to 4.0 ha of potential Northern Quoll denning and dispersal habitat that is identified as habitat critical to the survival of the Northern Quoll;
- clearing of up to 42.3 ha of important foraging and dispersal habitat for the Northern Quoll (defined as Northern Quoll habitat within 1 km of habitat critical to the survival of the Northern Quoll); and
- clearing of up to 18.7 ha of Ghost Bat foraging habitat within 5 km of the possible maternity roost identified by Biota (2021).

Offsets have been proposed and calculated for these significant residual impacts (Section 6).

Throughout the concept design and environmental assessment phases of Stage 4 of the Revised Proposal, the principles of environmental protection defined in the EP Act have been considered. These are:

- the precautionary principle;
- the principle of intergenerational equity;
- the principle of the conservation of biological diversity and ecological integrity;
- principles relating to improved valuation, pricing and incentive mechanisms; and
- the principle of waste minimisation.

A route options analysis has been undertaken (Section 2.2) and the current route for Stage 4 of the Revised Proposal has been selected based on a range of factors including relative environmental and social impacts (precautionary principle, and the principle of the conservation of biological diversity and ecological integrity), as well as constructability and cost including items such as the likely cut/fill balance of each route (principle of waste minimisation).

A detailed assessment of Stage 4 of the Revised Proposal against the PKEFs is presented in Section 5. The EPA objectives for the PKEFs can be met through a combination of impact avoidance and minimisation, engineering solutions to mitigate impacts, environmental management controls implemented during construction and maintenance works, and provision of offsets for significant residual impacts.

Table 10-1 presents the EPA objectives for each PKEF, together with the outcome expected from the Revised Proposal, to demonstrate that the objective can be met.

There are a number of connections and interactions between the PKEFs considered in this ERD Diagram 9-1). The interactions relevant to Stage 4 of the Revised Proposal are:

- Surface water – vegetation interactions:
  - vegetation clearing can lead to increased sediment loads in surface runoff and ultimately in waterways. Potential impacts to surface water quality due to vegetation clearing and disturbance have been assessed in Section 5.3.6.4. Management measures put in place during construction, including protection and stabilisation of waterway bed and banks, reducing clearing of riparian vegetation, use of silt curtains, along with appropriate design of roadside drainage to avoid pollutants entering waterways will effectively minimise the potential for impacts such that any impacts that do occur will not be significant.
  - vegetation clearing can lead to changes in overland (surface water runoff) flow paths and quantities of runoff entering waterways. The potential for changes to overland flows as a result of vegetation clearing for Stage 4 of the Revised Proposal is considered to be low. Vegetation clearing will be limited to the immediate vicinity of the road footprint and will be narrow and linear in nature, thereby reducing the extent of unimpeded overland flows adjacent to water ways. Areas that are not required to be permanently cleared, such as for the road and to meet clear zone requirements, will be revegetated. Road infrastructure shall be designed to maintain surface water flows. No long-term impacts to surface water flows as a result of vegetation clearing for implementation of Stage 4 of the Revised Proposal are anticipated.
  - changes to surface water flow paths, quantity and quality can adversely impact the health of riparian vegetation and grove – intergrove mulga. Impacts to this vegetation though changes to surface water quality and flows have been assessed in Section 5.1.6.2.1. Impacts were determined to not be significant, particularly after implementation of management measures to be put in place to maintain the hydrological regime in areas of grove – intergrove mulga.
- Vegetation – terrestrial fauna interactions:
  - clearing of native vegetation reduces the area of fauna habitat and specific components such as habitat trees available for use by terrestrial fauna. The impacts related to clearing of vegetation representing habitat for fauna have been assessed in Section 5.2.6. Clearing of vegetation representative of potential foraging and dispersal habitat critical to the survival of the Northern Quoll was identified as a significant residual impact.
- Inland Waters – terrestrial fauna Interactions:
  - Changes to the volume or quality of surface and/or ground waters may impact the health of fauna habitat, particularly that habitat associated with riparian vegetation or pools. The potential for changes in surface water flow or quality to impact vegetation and therefore fauna habitat has been assessed in Section 5.1.6.2.1. Main Roads has committed to maintaining the hydrological regime of the Development Envelope and surrounds and implementing the recommendations of the Millstream Water Reserve Drinking Water Source Protection Plan and relevant Water Quality Protection Notes. It is unlikely that implementation of Stage 4 of the Revised Proposal will significantly impact the volume or quality of surface and/or groundwater and the health and quality of fauna habitat that interacts with these waters will be maintained.
- Vegetation – social surrounds interactions:
  - clearing of vegetation associated with waterways may impact Aboriginal ethnographic values.

- Surface water – social surrounds interactions:
  - impact to waterways may have flow-on impacts to Aboriginal ethnographic values.

Main Roads will continue to liaise with Traditional Owners to understand the cultural heritage values of the area and develop appropriate avoidance and mitigation measures to be implemented during construction of Stage 4, such that impacts to cultural heritage from its interactions with native vegetation or surface water are avoided or minimised. Measures to minimise or avoid impacts to cultural heritage sites include:

- representatives of the Traditional Owners will be invited to observe vegetation clearing and topsoil removal activities in the vicinity of known heritage sites;
- road drainage will be designed to maintain surface water flows and velocities and prevent impacts to water quality;
- protection and stabilisation of waterway bed and banks;
- use of silt curtains for construction activities that may result in increased sediment loads in waterways;
- minimise clearing of riparian vegetation; and
- protect known heritage sites close to but outside of the area to be cleared through the establishment of No Go exclusion zones.

With these measures in place, together with ongoing consultation, no significant impacts to cultural heritage through its interactions with vegetation and surface water are expected.

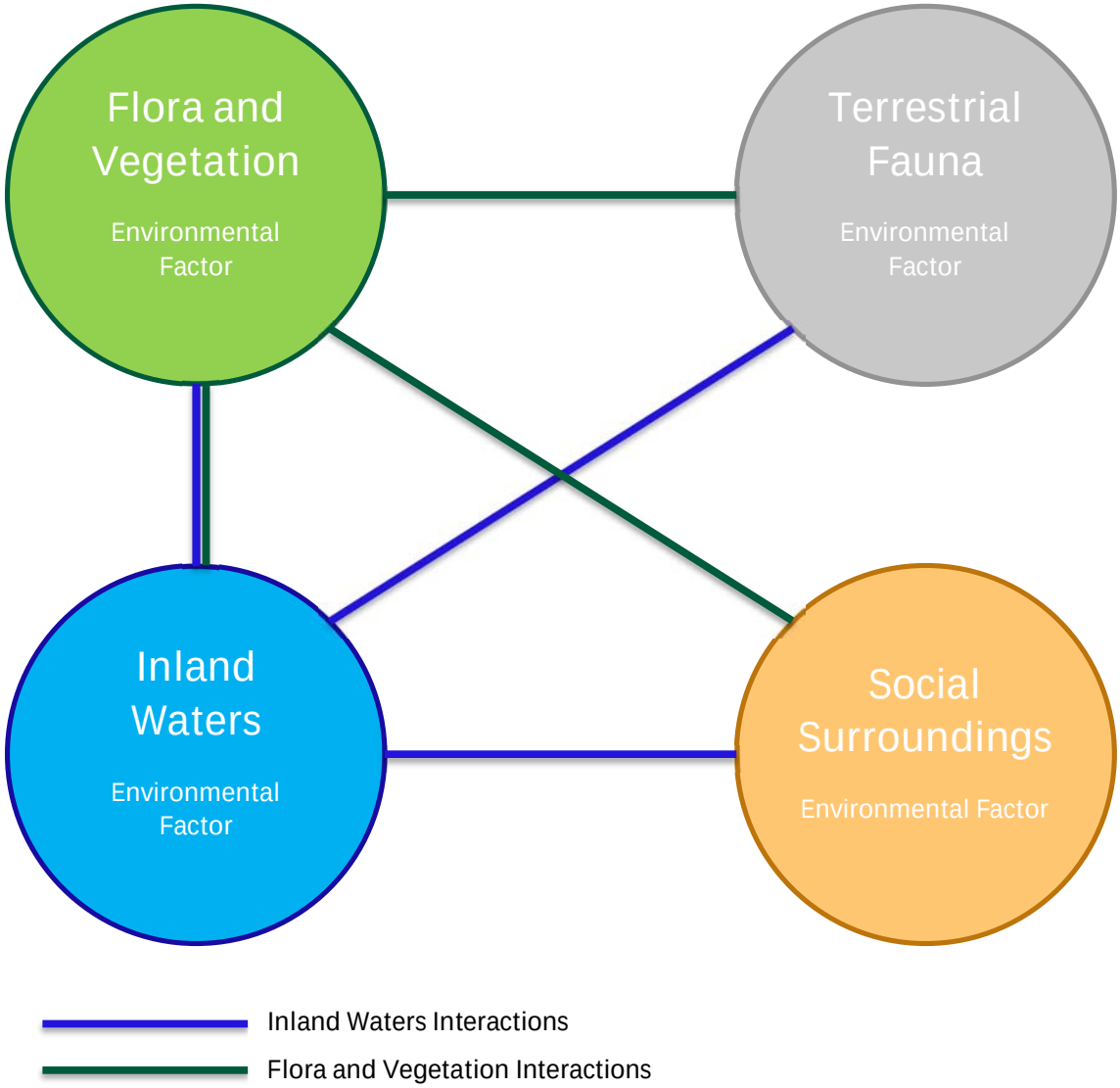


Diagram 10-1 Intrinsic interactions between environmental factors

The management measures and controls proposed for each of the PKEFs will minimise the impacts resulting from these interactions. For example, engineering design of culverts and bridge structures will maintain surface water flow paths, quantity and velocity, which in turn will minimise or avoid impacts to vegetation. Interactions between PKEFs will not reduce the ability of Stage 4 of the Revised Proposal to meet the EPA's objectives in relation to the PKEFs, or protection of the environment as a whole.

Table 10-1 Environmental Factors, Objectives and Outcomes

Preliminary Key Environmental Factor	EPA Objective	Outcome
Flora and vegetation	To protect flora and vegetation so that biological	Objective can be met

	diversity and ecological integrity are maintained'	The majority of impacts are not significant after implementation of management controls and further avoidance during detailed design. Significant residual impacts to native vegetation in Good to Excellent condition, *Themeda* grasslands TEC, and Brockman Iron PEC will be offset.
Terrestrial Fauna	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained	Objective can be met The majority of impacts are not significant after implementation of management controls and further avoidance during detailed design. Significant residual impacts to habitat critical to the survival of the Northern Quoll and important foraging and dispersal habitat for Northern Quoll and Ghost Bats will be offset.
Inland Waters	To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected'	Objective can be met The majority of impacts to surface water flow can be managed due to the orientation of the road to the surface flow (perpendicular) and the engineering approach to minimise water shadow, pool, and backflow.
Social Surroundings	To protect social surroundings from significant harm	Objective can be met It is unlikely that changes to surface water flows will significantly impact Aboriginal heritage. While it is possible that there may be some impacts on Aboriginal heritage sites (subject to approvals under the ACH Act and consultation with traditional owners), Stage 4 of the Revised Proposal has been designed, will continue to be designed, and will be managed throughout the project lifecycle to avoid and minimise impacts on these sites.
Air Quality	To maintain air quality and minimise emissions so that environmental values are protected	Objective can be met Impacts can be managed through existing environmental and OHS Management Procedures (including a targeted NOA assessment prior to works and implementation of the contractor's Asbestiform Materials Management Plan).

11 Environmental Record of the Person Proposing to Take the Action

Main Roads is a State agency with an assured record of responsible environmental management and a certified environmental management system. Main Roads is not subject to any past or present proceedings under Commonwealth or State law for protection of the environment or conservation and sustainable use of natural resources.

All work undertaken by Main Roads is completed in accordance with their Environmental Policy and Environmental Management System (EMS), which is certified with the requirements of ISO 14001:2015 environmental management systems comprising 'Activities, products and services associated with delivering Road Management (planning, building and maintaining) on WA's State Road Network' (Certificate #MRWQ51-CCE04).

Main Roads' environmental policy can be found at https://www.mainroads.wa.gov.au/OurRoads/Environment/Pages/environmentalmanagement.aspx#policy

Main Roads' EMS is independently certified and covers the processes and activities that have the potential to impact the environment, including mitigation and management measures proposed as part of the action. The EMS ensures compliance with Main Roads' environment and heritage compliance obligations, providing the framework for driving environmental requirements through leadership, planning, support, operation, performance evaluation and improvement actions. The action, therefore, will be undertaken, monitored and measured in accordance with the Main Roads EMS.

Main Roads EMS covers processes and activities that have the potential to impact on the environment and ensures compliance with environment and heritage compliance obligations. The EMS responsibilities includes appropriate resource allocation to ensure compliance costs are appropriately budgeted and assessed as part of the overall business case for the project. This ensures that the costs of proposed management measures and offsets is considered in the budget approvals and ensures compliance is appropriately funded and resourced.

12 References

Armstrong, K. N. (2001). The distribution and roost habitat of the orange leaf-nosed bat, *Rhinonicteris aurantius*, in the Pilbara region of Western Australia. Wildlife Research 28: 95-104.

Armstrong, K.N., 2013. Pilbara Leaf-nosed Bat *Rhinonicteris aurantia* (unnamed Pilbara form) in Van Dyck, S, ed Field companion to the Mammals of Australia. New Holland, London.

Armstrong, K.N. and Anstee, S.D. (2000). The Ghost Bat in the Pilbara; 100 years on. Australian Mammalogy 22: 93 – 101. Churchill, S. (2008) Australian Bats. Allen & Unwin, Crows Nest NSW.

Armstrong, K.M., Wilmer, W.J., 2004. The importance of determining genetic population structure for the management of Ghost Bats, Macroderma gigas, in the Pilbara region of Western Australia.

AustRoads (2020) Guide to Road Design, Austroads, Sydney

Beard, J.S. (1975) Vegetation Survey of Western Australia. 1:1 000 000 Vegetation Series sheet 5 - Pilbara. Map and explanatory notes. University of Western Australia Press: Nedlands, Western Australia.

Biota (2002). Proposed Hope Downs Rail Corridor from Weeli Wolli Siding to Port Hedland - Vertebrate Fauna Survey. Unpublished report prepared for Hope Downs Management Services, Biota Environmental Sciences, Western Australia.

Biota (2008). A Vegetation and Flora Survey of the Rio Tinto Rail Duplication - Bellbird Siding to Juna Downs. Unpublished report prepared for Rio Tinto Iron Ore, August 2008, Biota Environmental Sciences, Western Australia.

Biota (2009). Tom Price Power Line West Detritals: Two-Phase Fauna Survey. Unpublished report prepared for Pilbara Iron Pty Ltd, September 2009, Biota Environmental Sciences, Western Australia

Biota (2011). A Two Phase Fauna Survey of the Hamersley Agriculture Project. Unpublished report prepared for Rio Tinto Iron Ore Pty Ltd, November 2011, Biota Environmental Sciences, Western Australia.

Biota (2015). Western Turner Syncline Section 10 Below Water Table and Satellite Ore Bodies Targeted Terrestrial Fauna Survey. Unpublished report prepared for Rio Tinto, February 2015,

Biota Environmental Sciences, Western Australia. Biota (2016). Red Hill Campgrounds Rare Flora and Level 1 Fauna Survey. Unpublished report prepared for Tourism Western Australia, July 2016, Biota Environmental Sciences, Western Australia.

Biota Environmental Sciences Pty Ltd (Biota), 2018. Eliwana Consolidated Detailed Fora and Vegetation Phase 2. Prepared for Fortescue Metals Group.

Biota, 2021. Manuwarra Red Dog Highway Stage 4 Biological Survey. Biota Environmental Sciences Pty Ltd. Report prepared for Main Roads Western Australia

Biota Environmental Sciences Pty Ltd (Biota), 2022. Manuwarra Red Dog Highway SRE Fauna Desktop Study. Prepared for Main Roads Western Australia.

Biologic, 2016. Mining Area C- Southern Flank Environmental Impact Assessment for the Ghost Bat (*Macroderma gigas*).

Biologic, 2020. Miralga Creek Project: Conservation Significant Vertebrate Fauna Impact Assessment Biologic Environmental Survey Report to Atlas Iron Ltd February 2020

BirdLife International, 2019. Species factsheet: Falco hypoleucos.

Bureau of Meteorology (BoM), 2020. Climate Data Online. Available from: http://www.bom.gov.au/climate/data/?ref=ftr (accessed: 26/06/2020)

Braithwaite, R.W., Griffiths, A.D., 1994. Demographic variation and range contraction in the northern quoll, *Dasyurus hallucatus* (*Marsupialia: Dasyuridae*). Wildl. Res. 21, 203–217.

Burnett, S., 1997. Colonizing Cane Toads cause population declines in native predators: reliable anecdotal information and management implications. Pac. Conserv. Biol. 3, 65–72.

Bush, B., Maryan, B., 2011. Field Guide to the Snakes of the Pilbara, Western Australia. Western Australian Museum, Perth.

Cardno, 2020. Rapid Options Assessment - Karratha Tom Price Road Stage 4. Prepared for Main Roads Western Australia

Cardno, 2021a. Fortescue River, Weelamurra Creek and Caves Creek Flood Study – Manuwarra Red Dog Highway Stage 4. Prepared for Main Roads Western Australia

Cardno, 2021b. Fortescue River, Fortescue River, Weelamurra Creek and Caves Creek Waterways Risks Report – Manuwarra Red Dog Highway Stage 4. Prepared for Main Roads Western Australia

Cardno, 2021c. Fortescue River, Alignment Definition Hydrological Summary Report – Manuwarra Red Dog Highway Stage 4. Prepared for Main Roads Western Australia

Churchill, S., 2008. Australian Bats. Allen & Unwin, Crows Nest NSW.

Churchill, S., 1998. Australian Bats. New Holland, Sydney.

Bush, B., Maryan, B., 2011. Field Guide to the Snakes of the Pilbara, Western Australia. Western Australian Museum, Perth.CSIRO, 2015. Pilbara Water Resource Assessment: Upper Fortescue region. An overview report to the Government of Western Australia and industry partners from the CSIRO Pilbara Water Resource Assessment. CSIRO Land and Water, Australia. Available from: https://publications.csiro.au/rpr/download?pid=csiro:EP157485&dsid=DS1 (accessed: 29/06/2020)

Davis, R. A., & Metcalf, B. M., 2008. The Night Parrot (Pezoporus occidentalis) in northern Western Australia: a recent sighting from the Pilbara region. Emu - Austral Ornithology, 108(3), 233- 236. doi:http://dx.doi.org/10.1071/MU07058.

Department of Agriculture, Water and the Environment (DAWE), 2020b. Species Profile and Threats Database. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl (accessed: 25/06/2020)

Department of Agriculture, Water and the Environment (DAWE), 2020a. Australia's bioregions (IBRA). Available from: https://www.environment.gov.au/land/nrs/science/ibra (accessed: 20/06/2020)

Department of Biodiversity, Conservation and Attractions (DBCAa), 2020. Priority Ecological Communities for Western Australia. Version 30. Available from: https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/Priority%20Ecological%20Communities%20list.pdf

Department of Biodiversity, Conservation and Attractions (DBCA) (2020b). NatureMap: Mapping Western Australia's biodiversity [WWW Document]. Retrieved from https://naturemap.dbca.wa.gov.au/.

Department of Biodiversity, Conservation and Attractions (DBCA). (2020c). Recovery plans and interim recovery plans https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/wa-s-threatenedecological-communities

Department of Biodiversity, Conservation and Attractions. (DBCA) (2020d). Themeda grasslands on cracking clays (Hamersley Station, Pilbara) Threatened Ecological Community Fact Sheet. https://www.dpaw.wa.gov.au/images/documents/plants-animals/tecs/Themeda-grasslands.pdf

Department of the Environment (DoE), 2016. EPBC Act referral guideline for the endangered northern quoll, Commonwealth of Australia 2016. Available at: http://environment.gov.au/system/files/resources/d7e011a7-bf59-40ed-9387-9afcb8d590f8/files/referral-guideline-northern-quoll.pdf

Department of the Environment and Energy. (2019). Protected Matters Search Tool Report. Available online from: http://www.environment.gov.au/epbc/pmst/index.html / Accessed 10/10/19.

Department of the Environment, Water, Heritage and the Arts (DEWHA), 2008. Approved Conservation Advice for Liasis olivaceus barroni (Olive Python - Pilbara subspecies). Canberra: DEWHA. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/66699-conservation-advice.pdf (accessed: 25/06/2020).

Department of the Environment, Water, Heritage and the Arts (DEWHA), 2010a. Survey Guidelines for Australia's Threatened Birds. Department of Sustainability, Environment, Water, Population and Communities.

Department of the Environment, Water, Heritage and the Arts (DEWHA), 2010b. Survey Guidelines for Australia's Threatened Bats. Department of Sustainability, Environment, Water, Population and Communities.

Department of Planning, Lands and Heritage (DPLH), 2020. Aboriginal Heritage Inquiry System (AHIS). Accessible at https://espatial.dplh.wa.gov.au/AHIS/index.html?viewer=AHIS

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC), 2013. Approved Conservation Advice for Rostratula australis (Australian painted snipe). Canberra: DSEWPaC. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/77037-conservation-advice.pdf (accessed: 25/06/2020)

Department of Water (DoW), 2006. Water Quality Protection Note no.44. Roads near sensitive water resources. Available from https://www.water.wa.gov.au/__data/assets/pdf_file/0012/4116/81912.pdf

Department of Water (DoW), 2007. Water Quality Protection Note no.83. Infrastructure corridors near sensitive water Resource. Available from https://www.water.wa.gov.au/__data/assets/pdf_file/0010/4042/82127.pdf

Department of Water (DoW). Water Quality Protection Note no.84. Rehabilitation of disturbed land in public drinking water source areas. Available from https://www.water.wa.gov.au/__data/assets/pdf_file/0008/4112/86605.pdf

Department of Water (DoW), 2010. Millstream Water Reserve drinking water source protection plan. West Pilbara Water Supply. Available from: https://www.water.wa.gov.au/__data/assets/pdf_file/0014/4541/93957.pdf (accessed: 29/06/2020)

Department of Water (DoW), 2015. Water Quality Protection Note no.65. Toxic and hazardous substances. Available from https://www.water.wa.gov.au/__data/assets/pdf_file/0010/5959/82270.pdf

Department of Water (DoW), 2016a. Water quality protection note no. 25: Land use compatibility tables for public drinking water source areas. Available from https://www.water.wa.gov.au/__data/assets/pdf_file/0014/1733/12441.pdf

Department of Water (DoW), 2016b. Groundwater assessment of the north-west Hamersley Range. Available from https://www.water.wa.gov.au/__data/assets/pdf_file/0006/8718/HG62_Aug_2016.pdf

Department of Water and Environmental Regulation (DWER). 2018. Millstream Water Reserve drinking water source protection review. Available from: https://www.water.wa.gov.au/__data/assets/pdf_file/0017/9620/114520.pdf (accessed: 29/06/2020)

Doughty, P., and P. M. Oliver (2011). A new species of Underwoodisaurus (Squamata: Gekkota: Carphodactylidae) from the Pilbara region of Western Australia. Zootaxa 3010:20–30

DWER, 2020. Contaminated Sites Guidelines. Available from: https://www.der.wa.gov.au/your-environment/contaminated-sites/61-contaminated-sites-guidelines (accessed: 29/06/2020)

Ecologia environment, 2005, Orebody 25 Biological Review and Environmental Impact Assessment. Report prepared for BHPBilliton, October 2005. https://www.epa.wa.gov.au/sites/default/files/PER_documentation/Appendix%20D.pdf

Ecologia (2012). Central Pilbara Project - Mine Vertebrate Fauna Assessment. Unpublished report for Fortescue Metals Group, Ecologia Environment, West Perth, WA.

Ecologia (2014a). Solomon Hub Vertebrate Fauna Assessment. Unpublished report for Fortescue Metals Group, Ecologia Environment, Perth, WA.

Ecologia (2014b). Stingray Project Terrestrial Vertebrate Fauna Assessment. Unpublished report for Fortescue Metals Group, Ecologia Environment, Perth, Western Australia.

Ecologia Environment, 2018. Karratha-Tom Price Road and Pannawonica-Millstream Road Weed Survey. Perth, Western Australia.

Environment Australia, 2000. Revision of the Interim Biogeographic Regionalisation for Australia (IBRA) and Development of Version 5.1. Available from: https://www.environment.gov.au/system/files/resources/401ff882-fc13-49cd-81fe-bc127d16ced1/files/revision-ibra-development-5-1-summary-report.pdf (accessed: 22/06/2020)

Environmental Protection Authority (EPA), 2016a. Environmental Factor Guideline. Flora and Vegetation. Available from: http://epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Guideline-Flora-Vegetation-131216_4.pdf (accessed: 20/06/2020)

EPA, 2016b. Technical Guidance Flora and Vegetation Surveys for Environmental Impact Assessment. Available from: http://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/EPA%20Technical%20Guidance%20-%20Flora%20and%20Vegetation%20survey_Dec13.pdf (accessed:)

EPA, 2016c. Environmental Factor Guideline. Terrestrial Fauna. Available from: https://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Guideline-Terrestrial-Fauna-131216_3.pdf (accessed:)

EPA, 2016f. Environmental Factor Guideline. Social Surroundings. Available from: https://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Guideline-Social-Surroundings-131216_2.pdf

EPA, 2018. Environmental Factor Guideline. Inland Waters. Available from: https://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Guideline-Inland-Waters-29062018.pdf

EPA, 2020a. Statement of Environmental Principles, Factors and Objectives. EPA, Western Australia.

EPA, 2020b. Environmental Factor Guideline. Greenhous Gas Emissions. Available from: https://epa.wa.gov.au/sites/default/files/Policies_and_Guidance/EFG%20-%20GHG%20Emissions%20-%2016.04.2020.pdf

EPA, 2020c. Technical Guidance Terrestrial Fauna Surveys. Available from: https://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Tech%20guidance-%20Terrestrial%20Fauna%20Surveys-Dec-2016.pdf

EPA, 2020d. *Instructions on how to prepare an Environmental Review Document*. EPA, Western Australia. Available at: https://www.epa.wa.gov.au/sites/default/files/Forms_and_Templates/Instructions%20and%20template%20-%20ERD.pdf

Fortescue Metals Group, 2018. Eliwana Iron Ore Mine Project [WWW Document] URL Eliwana Iron Ore Mine (epa.wa.gov.au)

Garnett, S, Szabo, J, and Dutson, G., 2011. The Action Plan for Australian Birds 2010. CSIRO Publishing, Clayton. https://doi.org/10.1071/9780643103696.

Government of Western Australia (GoWA), 2014. WA Environmental Offsets Guidelines [WWW Document]. URL

http://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/WA%20Environmental%20Offsets%20Guideline%20August%202014.pdf

Government of Western Australia, 2018. 2017 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Current as of December 2017. - SUPERSEDED. Department of Biodiversity, Conservation and Attractions, Government of Western Australia, Perth, Western Australia.

Government of Western Australia, 2019. 2018 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Current as of March 2019. WA Department of Biodiversity, Conservation and Attractions, Perth, https://catalogue.data.wa.gov.au/dataset/dbca-statewide-vegetation-statistics

GHD, 2017. Karratha Tom Price Road (K-TP3 and K-TP4a to Ro Access) Northern Quoll Survey. Perth, Western Australia.

Halpern Glick Maunsell, Biota, and M.E. Trudgen & Associates (2001). Austeel Biological Survey, Phase I. Unpublished report ES974691A100 prepared for Austeel Pty Ltd, February 2001, Halpern Glick Maunsell with Biota Environmental Sciences and M.E. Trudgen & Associates, Western Australia.

Henderson, M., 2015. The Effects of Mining Infrastructure on Northern Quoll Movement and Habitat. Available at: https://library.dbca.wa.gov.au/static/FullTextFiles/925413.pdf (accessed 15 January 2021)

Higgins, PJ (Ed.), 1999. Handbook of Australian, New Zealand and Antarctic Birds. Volume 4: Parrots to Dollarbird. Oxford University Press, Melbourne

Higgins, P.J., Davies, S.J.J.F., 1996. Handbook of Australian, New Zealand and Antarctic Birds. Volume 3, Snipe to Pigeons. Oxford University Press, Melbourne, Victoria.

Hill, B.M. & S.J. Ward, 2010. National Recovery Plan For the Northern Quoll *Dasyurus hallucatus*. Department of Natural Resources, Environment, The Arts and Sport, Darwin.

How, R.A., P.B.S. Spencer & L.H. Schmitt, 2009. Island populations have high conservation value for northern Australia's top marsupial predator ahead of a threatening process. 1-12. Journal of Zoology. Page(s) 1-12.

Johnstone, R. E., and G. M. Storr (1998). Handbook of Western Australian Birds Volume I - NonPasserines (Emu to Dollarbird). Western Australian Museum, Perth.

Main Roads Western Australia, 1997. Roads 2020: Western Australian regional road development strategies. East Perth, W.A

Main Roads Western Australia, 2003. Karratha – Tom Price Road, Karratha to Nanutarra-Munjina Rd Section. Consultative Environmental Review (Assessment No. 1244). Volume 1

Main Roads Western Australia, 2005. Environment Guideline. Revegetation Planning and Techniques.

Marchant, S. and Higgins, P. J. (Eds) (1993). Handbook of Australian, New Zealand & Antarctic Birds, Vol. 2: Raptors to Lapwings. Oxford University Press, Melbourne

Maslin, BR., van Leeuwen, S. and Reid, J. (2010) Factsheet - Acacia aneura. Wattles of the Pilbara. Department of Environment and Conservation, Perth. Available from http://worldwidewattle.com/speciesgallery/descriptions/pilbara/html/aneura.htm

Map IT (2012) Independent expert advice on the likely impacts of the proposed Cloudbreak Iron Ore Expansion Project (EPBC 2010/5696) on the EPBC Act listed endangered and migratory Night Parrot (*Pezoporus occidentalis*) Report prepared by Dr Stephen Murphy Map IT for Department of Sustainability, Environment, Water, Population and Communities 26 March 2012.

Menkhorst, P., and F. Knight (2011). A Field Guide to the Mammals of Australia, 3rd edition. Oxford University Press, Australia.

Morris, K., J. Woinarski, and K. Aplin (2008). Leggadina lakedownensis [WWW Document]. Retrieved June 13, 2012, from http://www.iucnredlist.org/apps/redlist/details/11384/0.

Oakwood, M., 2000. Reproduction and demography of the northern quoll, *Dasyurus hallucatus,* in the lowland savanna of northern Australia. Aust. J. Zool. 48, 519–539.

Pearson D (2003). Giant pythons of the Pilbara. Landscope 19(1), pp. 32–39

Pearson, DJ 1993, 'Distribution, status and conservation of pythons in Western Australia', In: Lunney, D & Ayers, D (Eds) Herpetology in Australia: a Diverse Discipline, pp. 383-395, Royal Zoological Society of NSW, Sydney.

Pearson, D. J., 2006. Giant pythons of the Pilbara. Landscope 19, 32-39.

Pizzey, G., and F. Knight (2007). The Field Guide to the Birds of Australia. Page (P. Menkhorst, Ed.),8th edition. Harper Collins Publishers, Sydney

Schoenjahn, J. (2018). Adaptations of the rare endemic Grey Falcon Falco hypoleucos that enable its permanent residence in the arid zone of Australia. PhD Thesis. University of Queensland

Shepherd, D.P., Beeston, G.R. and Hopkins, A.J.M., 2002. Native vegetation in Western Australia: extent, type and status. Technical Report 249, Department of Agriculture and Food, Western Australia, Perth.

Shire of Ashburton (2019) Economic and Tourism Development Strategy, 2019. Shire of Ashburton, Tom Price

Sinclair Knight Merz (SKM), 2009. Millstream Model Recalibration. Report prepared for the Department of Water.

Storr, G. M., L. A. Smith, and R. E. Johnstone (1999). Lizards of Western Australia. 1: Skinks. Western Australian Museum, Perth.

Sudmeyer, R., 2016. Climate in the Pilbara. Bulletin 4873. Department of Agriculture and Food, Western Australia, Perth.

Sullivan, L, Ward, N, Toppler, N and Lancaster, G 2018, National Acid Sulfate Soils guidance: National acid sulfate soils sampling and identification methods manual, Department of Agriculture and Water Resources, Canberra ACT. CC BY 4.0.

Start, A. N., Anstee, S. D., & Endersby, M. (2000). A review of the biology and conservation status of the Ngadji, *Pseudomys chapmani* Kitchener, 1980 (Rodentia: Muridae). CALMScience, 3(2), 125-147.

Threatened Species Scientific Community (TSSC), 2005. Conservation Advice for Northern Quoll (*Dasyurus hallucatus*). Available from: http://www.environment.gov.au/node/16356 (accessed: 25/06/2020)

TSSC, 2016a. Conservation Advice *Macroderma gigas* Ghost Bat. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/174-conservation-advice-05052016.pdf (accessed: 25/06/2020)

TSSC, 2016b. Conservation Advice *Pezoporus occidentalis* Night Parrot. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/59350-conservation-advice-15072016.pdf (accessed: 25/06/2020)

TSSC, 2016c. Conservation Advice *Rhinonicteris aurantia* (Pilbara form) Pilbara Leaf-nosed Bat. Canberra: Department of the Environment. Available from http://www.environment.gov.au/biodiversity/threatened/species/pubs/82790-conservation-advice-10032016.pdf (accessed 25/06/2020)

van Dyck, S., Strahan, R. (Eds.), 2008. The Mammals of Australia, 3rd edition. Reed New Holland, Sydney, NSW.

van Vreeswyk, A M, Leighton, K A, Payne, A L, and Hennig, P. (2004), An inventory and condition survey of the Pilbara region, Western Australia. Department of Agriculture and Food, Western Australia, Perth. Technical Bulletin 92.

Wilson, S. & G. Swan (2003). A Complete Guide to Reptiles of Australia. Page(s) 480. Sydney: Reed New Holland

Wilson, S., and G. Swan (2017). A Complete Guide to Reptiles of Australia, 5th edition. New Holland.

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Appendices

A.1 Additional Information Request

A.2 Manuwarra Red Dog Highway Stage 4 Biological Survey (Biota, 2021)

A.3 Manuwarra Red Dog Highway SRE Fauna Desktop Study (Biota, 2022)

A.4 MRDH Stage 4 Alignment Definition Hydrological Summary Report

A.5 Preliminary Site Investigation

A.6 Manuwarra Red Dog Highway Stage 4 Greenhouse Gas Estimate