



WORSLEY MINE EXPANSION (EP ACT REVISED PROPOSAL / EPBC ACTION)

REFERRAL SUPPORTING DOCUMENT
MAY 2019



Disclaimer

This report has been prepared by South32 specifically for the Worsley Mine Expansion. Neither the report nor its contents may be referred to without the express approval of South32 until the report has been released for referral and assessment.

Document Control

Version	Issue Date	Approved By	Submitted To
Version 1	21 st December 2018	Scott Coleman	DWER (EPA)
Version 2	5 th April 2019	Dennis Lindgren	DWER (EPA) and DoEE
Version 3	16 May 2019	Dennis Lindgren	DWER (EPA) and DoEE

CONTENTS

1. Introduction.....	1
1.1. Background	1
1.2. Purpose of this Document.....	4
1.3. Scope of this Proposal.....	4
1.4. The Proponent.....	6
1.5. Environmental Impact Assessment Process	6
2. General Description of the Proposal	8
2.1. Overview of the Proposal.....	8
2.2. Key Proposal Characteristics	17
2.3. Location of the Proposal	21
2.4. Land Tenure	21
2.5. Native Title.....	22
2.6. Project Delivery Timeframes and ongoing activities	22
2.7. Justification for the Proposal	22
3. Stakeholder Engagement.....	32
3.1. Engagement for the Proposal	32
3.2. Worsley Community Engagement.....	32
4. Assessment of Preliminary Key Environmental Factors	40
4.1. Flora and Vegetation.....	40
4.2. Terrestrial fauna.....	70
4.3. Terrestrial environmental quality	87
4.4. Inland Waters	90
4.5. Air quality.....	97
4.6. Social surroundings	101
4.7. Other Factors.....	113
4.8. Factors not considered relevant.....	113
5. Offsets	114
6. References	116
7. Appendices.....	126
Tables	
Table 1: Proponent and Project Contacts.....	6
Table 2: Summary of Proposed Disturbance (Indicative).....	17
Table 3: Key Characteristics Table for the Proposal.....	17
Table 4: Summary of Stakeholder Engagement associated with the Proposal.....	33
Table 5: Summary of Flora and Vegetation Surveys undertaken for the Project.....	41
Table 6: Extent of Vegetation Complexes within the WMDE.....	47
Table 7: Extent of Vegetation Complexes within the Bauxite Transport Corridor.....	48
Table 8: Extent of Vegetation Complexes within the CBME and Indicative Clearing Requirements.....	50

Table 9: Extent of Site Vegetation Types within the WMDE.....	51
Table 10: Extent of Site Vegetation Types within the Bauxite Transport Corridor.....	55
Table 11: Extent of Site Vegetation Types within the CBME and Indicative Clearing Requirements.....	57
Table 12: Vegetation Condition within the WMDE.....	58
Table 13: Vegetation Condition within the Bauxite Transport Corridor.....	59
Table 14: Vegetation Condition within the CBME.....	59
Table 15: Threatened Flora potential occurrence within the Primary Assessment Area	63
Table 16: Summary of Terrestrial Vertebrate Fauna Surveys undertaken for the Project.....	71
Table 17: Summary of Fauna Habitats identified within the WMDE and Bauxite Transport Corridor.....	75
Table 18: Summary of Fauna Habitats identified within the CBME.....	75
Table 19: Threatened Fauna within the Primary Assessment Area	77
Table 20: Summary of Aquatic Fauna Surveys undertaken for the Project.....	78
Table 21: Summary of SRE Surveys undertaken for the Project.....	81
Table 22: Surface and Groundwater Features within the Primary Assessment Area.....	91
Table 23: Summary of Aboriginal Heritage Surveys undertaken for the Project.....	102
Table 24: Registered Aboriginal Heritage Sites and Other Heritage Places intersecting the Primary Assessment Area.....	102

Figures

Figure 1: Worsley Project Location.....	24
Figure 2: Worsley Mine Expansion Proposal Overview.....	25
Figure 3: Proposed Bauxite Transport Corridor Envelope	26
Figure 4: Proposed Contingency Bauxite Mining Envelope	27
Figure 5: Proposed Clearing for Maintenance Areas within the Refinery Lease Area	28
Figure 6: Indicative Protected Areas within the Worsley Mining Development Envelope.....	29
Figure 7: Worsley Mine Development Envelope Summary of Tenure Arrangements	30
Figure 8: Contingency Bauxite Mining Envelope Summary of Tenure Arrangements.....	31
Figure 9: Overview of Site Vegetation Types within the WMDE and Bauxite Transport Corridor.....	67
Figure 10: Overview of Site Vegetation Types within the CBME	68
Figure 11: Overview of Vegetation Condition within the WMDE and Bauxite Transport Corridor.....	69
Figure 12: Summary of Aboriginal Heritage Surveys within and surrounding the WMDE.....	109
Figure 13: Summary of Aboriginal Heritage Surveys within and surrounding the Refinery Leases.....	110
Figure 14: Existing Section 18 Consent Areas over the WMDE.....	111
Figure 15: Existing Section 18 Consent Areas over the Refinery Lease Area.....	112

Appendices

Appendix A: Flora and Vegetation Report (Mattiske Consulting)
Appendix B: Vertebrate Fauna Report (Biostat)
Appendix C: Short-Range Endemic Invertebrate Fauna Report – Mine (Phoenix Environmental)
Appendix D: Short-Range Endemic Invertebrate Fauna Report – Refinery (Phoenix Environmental)
Appendix E: Subterranean Fauna Report – Mine (Phoenix Environmental)
Appendix F: Subterranean Fauna Report – Refinery (Phoenix Environmental)
Appendix G: Aboriginal Heritage Report – Hotham River (Brad Goode and Associates)
Appendix H: Worsley Biodiversity and Forest Management Plan 2016
Appendix I: Matters of National Environmental Significance

Abbreviations and Acronyms

Acronym	Definition
ABS	Australian Bureau of Statistics
AHA	<i>Aboriginal Heritage Act 1972 (WA)</i>
Alcoa	Alcoa of Australia Limited
ASRIS	Australian Soil Resource Information System
ASS	Acid Sulphate Soils
BAM Act	<i>Biodiversity and Agricultural Management Act 2007 (WA)</i>
BC Act	<i>Biodiversity Conservation Act 2016 (WA)</i>
BB	Blackbutt Habitats
BBM	Boddington Bauxite Mine
BDRA	Bauxite Residue Disposal Areas
BFMP	Biodiversity Forest Management Plan
BGM	Boddington Gold Mine (Newmont)
CBME	Contingency Bauxite Mining Envelope
CEMP	Construction Environmental Management Plan
CEO	Chief Executive Officer
CER	Consultative Environmental Review
CLC	Community Liaison Committee
CO	Carbon Monoxide
Cth	Commonwealth
Cth Policy	The Australian Government Environmental Offsets Policy
DBCA	Department of Biodiversity, Conservation and Attractions
DJTSI	Department of Jobs, Tourism, Science and Innovation
DMIRS	Department of Mines, Industry Regulation and Safety
DoEE	Department of the Environment and Energy
DPAW	Department of Parks and Wildlife
DPLH	Department of Planning, Lands and Heritage
DRF	Declared Rare Flora (declared under the <i>Wildlife Conservation Act 1950 (WA)</i> , which was in force when the majority of flora surveys were complete and under the <i>Biodiversity Conservation Act 2016 (WA)</i>).
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (now DoEE)
DWER	Department of Water and Environment Regulation
EAG	Environmental Assessment Guideline
EC	Electrical Conductivity
EMLG	Worsley Environmental Management Liaison Group
EPA	Environmental Protection Authority
EP Act	<i>Environmental Protection Act 1986 (WA)</i>
EPASU	Environmental Protection Authority Services Unit (part of DWER)
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999 (Cth)</i>
ERMP	Environmental Review and Management Programme

EWR	Ecological Water Requirements
FDA	Flux Density Analysis
FRTBC	Forest Red-tail Black-Cockatoo
FWL	The Worsley Freshwater Lake
GKB	Gnaala Karla Booja WC1998/058 Native Title Claim Group
GL	Gigalitre
ha	Hectares
HME	Hotham Mine Extension
IBRA	Interim Biogeographic Regionalisation for Australia
ILM	Intelligent Land Management
ILUA	Indigenous Land Use Agreement
km²	Square kilometres
mm	Millimetres
MNES	Matters of National Environmental Significance
M258SA	Mining Lease granted to Worsley under the <i>Alumina Refinery (Worsley) Agreement Act 1973 (WA)</i> (Worsley State Agreement)
MS423	Ministerial Statement 423
MS719	Ministerial Statement 719
MS751	Ministerial Statement 751
MS971	Ministerial Statement 971
Mtpa	Million tonnes per annum
MTR	Marradong Timber Reserve
MW	Megawatt
N104197	Crown Lease Agreement
NBG	Newmont Boddington Gold Pty Ltd
NEPC	National Environment Protection Measure for Ambient Air Quality 2003
NGO	Non-governmental Organisations
NO_x	Nitrogen Oxide
Oxalate	Sodium Oxalate
PASS	Potential Acid Sulphate Soils
PBA	Primary Bauxite Area
PEC	Priority Ecological Community
PHT	Potential Habitat Tree
PMST	Protected Matters Search Tool
PM₁₀	Particulate matter which is 10 micrometres or less in diameter
QTR	Quindanning Timber Reserve
RLA	Refinery Lease Area (Crown Lease I150306)
RIWI Act	<i>Rights in Water and Irrigation Act 1914</i>
Settlement	South West Native Title Settlement
Settlement Area	South West Native Title Settlement Area
SO₂	Sulphur Dioxide
SRE	Short-range Endemic

STR	Saddleback Timber Reserve
SWALSC	South West Aboriginal Land and Sea Council
TARP	Trigger Action Response Plan
TDS	Total Dissolved Solids
TEC	Threatened Ecological Community
Tpa	Tonnes Per Annum
VOC	Volatile Organic Compounds
WA	Western Australia
WAH	Western Australian Herbarium
WAM	Western Australian Museum
WA Policy	WA Environmental Offsets Policy (September 2011)
WJV	Worsley Alumina Joint Venture. The WJV includes South32 Aluminium (RAA) Pty Ltd, South32 Aluminium (Worsley) Pty Ltd, Japan Alumina Associates (Australia) Pty Ltd and Sojitz Alumina Pty Ltd.
WMDE	Worsley Mining Development Envelope
WORSLEY	South32 Worsley Alumina Pty Ltd
WORSLEY STATE AGREEMENT	<i>Alumina Refinery (Worsley) Agreement Act 1973 (WA)</i>

Definitions

Term	Definition
Primary Assessment Area	The area subject of the proposed Worsley Mining Development Envelope, the Bauxite Transport Corridor and the Contingency Bauxite Mining Envelope as a whole (where applicable in the document).
Bauxite Transport Corridor	The proposed development envelope where long term truck haulage and conveying routes and associated supporting infrastructure will be developed from Marradong to Hotham North and Extended Mining Areas. A broad corridor for flexibility and optionality for routes, alignments of which have yet to be determined. This overlaps the WMDE for a majority of the corridor.
Contingency Bauxite Mining Envelope	The proposed development envelope of 747 ha within the existing Refinery Lease Area where contingency bauxite mining activities are proposed to occur.
Extended Mining Areas	The Extended Mining Areas the subject of assessment in the 2005 ERMP. The Extended Mining Areas represent a 74,918 ha development envelope in which 8,400 ha has been approved for clearing of native vegetation for mining activities subject to Extended Mining of Ministerial Statement 719 (MS719) and EPBC 2004/1566. Mining has not yet commenced in these areas.
Pre-existing Approval Area	An envelope that reflects the innermost boundary of the 1995, 2004 and 2005 Primary Bauxite Areas (PBAs) proposed for mining activities, within which pre-existing approved mining activities will be confined.
Worsley Mining Development Envelope	The proposed development envelope for mining activities (not including Extended Mining Areas).

1. INTRODUCTION

1.1. BACKGROUND

South32 Worsley Alumina Pty Ltd (Worsley) operates the Worsley Bauxite-Alumina Project (the Project) in the southwest of Western Australia (WA). The Project is one of the largest bauxite mining and alumina refining operations in the world, comprising the Boddington Bauxite Mine (BBM), an existing conveyor, the Worsley Refinery (the Refinery) near Collie and port operations at Bunbury Port. Worsley began production in 1984 and has since produced more than 71 million tonnes of alumina.

The BBM is located 5km away from the town of Boddington, approximately 130 km south-east of Perth. Situated primarily on a mining lease granted under the *Alumina Refinery (Worsley) Agreement Act 1973* (Worsley State Agreement), M258SA stretches from the Shire of Brookton in the north to the Shire of Collie in the south. The Refinery is located near (but about 21 km away from) Collie, on Crown Lease I150306. The Refinery is currently licensed under the *Environmental Protection Act 1986* (WA) (EP Act) to produce up to 4.7 Million tonnes per annum (Mtpa) of alumina.

The mining of bauxite by Worsley at BBM is a continuous process of mining and rehabilitation. Bauxite ore mined at BBM is transported to crushing facilities and crushed ore is then transported via conveyors to the Refinery. The process of refining ore into alumina comprises a four stage Bayer Process involving digestion, clarification, precipitation and calcination. Alumina produced at the Refinery is then transported by train to Bunbury Port, where it is shipped to aluminium smelters around the world.

The Project is a long-term operation with a current expected ore reserve life of 17 years as at 30 June 2018 based on a total ore reserve of 298 Mt.¹ The Project has a Mineral Resource of 11,170 Mt from which additional Ore Reserves may be estimated beyond the current Ore Reserves.² Existing primary *Environmental Protection Act 1986* (WA) (EP Act) approvals and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) approvals and exemptions relate to BBM mining activities within Saddleback, Marradong, Hotham North and Extended Mining Areas, although operational mining currently occurs only within the Saddleback and Marradong mining areas. Additional bauxite resources have been confirmed in the region since existing primary approvals were last granted, therefore consolidated EP Act and EPBC Act Project approvals are being sought expand the BBM mining operation to enable access to additional resource areas, inside and adjacent to, current operational mining areas. This expansion of the BBM will increase the existing mining envelope (previously referred to as the Primary Bauxite Area (PBA) from 22,102 ha to 27,796 ha (but will not increase the alumina production rate of 4.7 Mtpa), to an area which will now encompass and expand the PBA and be referred to as the Worsley Mining Development Envelope (WMDE).

¹The information that relates to the Mineral Resource and Ore Reserve estimates of Worsley Alumina was declared as part of South32's Annual Resource and Reserve declaration in the FY18 Annual Report (www.south32.net) issued on 7 September 2018. South32 confirms that it is not aware of any new information or data that materially affects the information included in the original announcement. All material assumptions and technical parameters underpinning the estimates in the relevant market announcement continue to apply and have not materially changed. South 32 confirms that the form and context in which the Competent Person's findings are presented have not been materially modified from the original market announcement.

EP Act and EPBC Act approvals are also being sought for revised/altered bauxite transport activities, with the main revised activity including the establishment of a long-term transport corridor along a revised route from that previously proposed and now including optionality for road haulage and/or conveying between existing mining areas and the Hotham North mining areas (up to the Extended Mining Areas) including crossings of the Hotham River.

Project approvals are also being sought for expansion and revision/alteration of other existing Project activities, including access to bauxite stockpiles at the Boddington Gold Mine (BGM) (stockpiling has already been approved under EPBC No. 2012/6370 and MS971 issued to Newmont Boddington Gold Pty Ltd), the inclusion of some new activities at the Refinery (such as contingency bauxite mining and additional management and maintenance activities), as well as construction activities, temporary support facilities and other activities associated with the Project expansion and revision/alteration as required.

The implementation of expansion and revisions/alterations to the Project will enable Worsley to expand the Project to access valuable ore resources without increasing the currently approved alumina refinery production rate of 4.7 Mtpa allowing long-term development of the Project whilst providing significant economic benefits and stable employment opportunities for the people and businesses in the South West region of Western Australia.

It is expected that this referral will be assessed as a Revised Proposal under the EP Act. This will also enable the issuance of a single whole of operations EP Act approval for the expansion/revision combined with continuation of existing operational activities currently the subject of Ministerial Statement 719 (MS719) (as amended). This will ensure effective and efficient environmental management of the Project as a whole.

It is expected that the referred action will be assessed under the EPBC Act using an accredited assessment approach.

Current Project mining activities are the subject of MS719 and EPBC Act exemption, and will continue to operate within the Pre-existing Approval Area (**Figure 2**) during the referral and assessment processes, up to the extent of existing approval and exemption and subject to the conditions of EP Act approval MS719. Other existing Project activities (such as transport and Refinery operations), which are the subject of MS719, EPBC Act exemption and EPBC Act approval 2004/1566, will also continue during the referral and assessment process.

1.1.1. Previous Assessments and Approvals

The Worsley State Agreement provided the initial basis for the Project to proceed. Clause 5A of the Agreement under the Act required the Worsley Alumina Joint Venturers (WJVs) to submit a detailed Environmental Review and Management Programme (ERMP) for assessment and approval in order for project operations to begin.

This initial ERMP was submitted in July 1978 and released for public comment by the Western Australian (WA) Department of Conservation and Environment and the Commonwealth Department of Environment, Housing and Community Development. The final ERMP for the Project was submitted in October 1979. In 1980, the WJVs received environmental approval to proceed with the Project to a capacity of 2 Mtpa alumina production.

The Project has since been the subject of the following assessment bulletins and received the following primary approvals relating to significant expansions:

- 3.5 Mtpa refinery capacity expansion (from 2.0 Mtpa to 3.5 Mtpa) and associated bauxite mining activities at BBM: This proposal was referred in October 1995 and subject to a Consultative Environment Review (1995 CER). EPA Bulletin 823 was published on 14 June 1996, and Ministerial Statement 423 (MS423) was issued on 2 July 1996. The proposal to date remains subject to the EPBC Act exemption as it was approved prior to the EPBC Act coming into force.
- 4.4 Mtpa refinery capacity increase in production (from 3.5 Mtpa to 4.4 Mtpa): 'Worsley Alumina Efficiency and Growth': This proposal was referred in 2004 and subject to an Environmental Review and Management Programme (2005 ERMP) and assessed under Bilateral Agreement. EPA Bulletin 1209 was published on 28 November 2005 and MS 719 (which consolidated MS 423) was issued on 13 April 2006. MS719 replaced MS423 and, so it continued to provide approval for the proposal originally subject to MS423, as well as provide new approval for the proposal described in the 2005 ERMP.
- EPBC Act approval 2004/1566 was issued for the "Worsley Alumina Efficiency and Growth aspects of the Project on 6 June 2007.
- Part B of MS719 and conditions 1 and 2 of EPBC Act approval 2004/1566 relate to the Extended Mining Areas (**Figure 1**) which were one of the primary subjects of the 2005 ERMP. To date, mining has not commenced in the Extended Mining Areas and the conditions relating to these areas have not yet been applied.

Note: Several non-substantial changes were approved for the proposal the subject of MS423 pursuant to condition 2 of MS423. Changes which did not have a significant impact on the environment were also made to the proposal the subject of MS719 pursuant to section 45C of the EP Act. Some MS719 conditions were also amended by MS751, issued on 24 September 2007.

Other significant existing approvals relevant to the Project include:

- Environmental Licence L5960/1983/11 for the BBM (18.8 Mtpa); and
- Environmental Licence L4504/1981/17 for the Refinery (4.7 Mtpa).

1.1.2. Previous Referral

A referral titled, "Hotham Mining Extension and Refinery Production Increase (Revised Proposal)" was submitted to the EPA for assessment under Section 38 of the EP Act in April 2017 and to the Department of Environment and Energy (DoEE) in June 2017. These referrals outlined Worsley's proposal to extend the mining area into the adjacent Hotham mining area and increase production at the Refinery from 4.7 Mtpa to 5.1 Mtpa. It involved an increase to the mining footprint of 1,200 ha and the clearing of up to 350 ha of native vegetation. In June 2017, the EPA made the decision to assess this proposal as an Environmental Review with a public review period of six weeks. In August 2017, the DoEE made the decision to assess using an accredited assessment approach by an Environmental Review under the EP Act with a public review period of six weeks.

Over the course of the assessment process, Worsley identified significant changes that were required to be made to the contents of the referred proposal and subsequently, South32 requested that the EPA terminate the referral in November 2018 and the DoEE terminate the referral in December 2018. The EPA's termination became effective on 28th November 2018 and the DoEE's termination became effective on 6th December 2018.

The referral (subject of this document) represents a new and significantly modified proposal to the referral titled “Hotham Mining Extension and Refinery Production Increase (Revised Proposal)” for the following main reasons:

- An expansion of mining activities inside current BBM areas is now being proposed in addition to expand into new areas;
- A Bauxite Transport Corridor is now proposed for longer term conveying and/or haulage routes;
- The proposal no longer includes an increase to alumina production at the Refinery; and
- The proposal now includes contingency bauxite mining within the Refinery Lease Area.

1.2. PURPOSE OF THIS DOCUMENT

This document has been prepared to provide detailed supporting information for the referral under the EP Act and EPBC Act.

1.3. SCOPE OF THIS PROPOSAL

This Worsley Mining Expansion referral primarily proposes to expand and revise/amend existing Project mining and transport activities, and other activities associated with the expansion and revisions/amendments

Existing Project activities will continue in the meantime up to the date of any approval for the Worsley Mining Expansion and are not within the scope of this proposal.

Project expansions components

The referral expansion and revision/amendment components primarily comprise expansion of mining activities at BBM within the WMDE. These mining activities will involve accessing additional resource areas and mining activity (inside and adjacent) to current operational and already approved mining areas at BBM). Without this expansion, the existing approval to clear native vegetation in mining areas within the WMDE would be exhausted in approximately 3 years. Mining activities are detailed further in **Section 2** below.

Expansion and revision/amendment components also include construction and operation of revised transport routes and infrastructure, with optionality for conveyor and/or roads, within the Bauxite Transport Corridor for the transport of mined ore. Other components include access to (already approved) bauxite stockpiles at the BGM, the inclusion of contingency bauxite mining and other maintenance activities at the Refinery, construction activities, temporary support facilities and other activities associated with the expansion and revision/amendment as required.

Existing Project components (ongoing use post-date of any approval for the Worsley Mine Expansion only)

Existing Project elements will be used for the Project expansions and revisions/amendments from the date of any approval of the Revised Proposal/Proposed Action. This referral therefore includes the ongoing use of the following existing Project activities but only from the date, if and when, the expansions and revisions/amendments are approved:

- Mining activities in the Pre-existing Approval Area (**Figure 2**), up to the extent of existing approvals and exemptions. This includes the clearing of up to 942 ha of native vegetation and mining activities on already disturbed land (refer to Section 2.1.1.1).

- Alumina refining activities up to 4.7 Mtpa (the current approved license capacity under the EP Act) and ongoing related refinery activities and maintenance;
- Ore transport activities and use of existing transport infrastructure, including operation of the existing conveyor;
- Alumina transport activities to the Port of Bunbury;
- Exploration activities identified in the annual Plan of Bauxite Mining Operations (10 Year Mine Plan); and
- Construction and operation of other minor infrastructure activities, such as fencing, access of tracks, firebreaks, bores and associated water infrastructure, that are required for the Project.

This referral does not make any modifications to the above existing Project activities, which are already primarily subject to MS719, EPBC Act exemption or EPBC Act approval 2004/1566.

However, the referral is required to include ongoing use of existing activities as part of the Revised Proposal/Proposed Action, but from the date of any approval of that Revised Proposal/Proposed Action (only), because:

- If expansion and revision/amendment activities are approved, all existing Project facilities will be utilized, expanded and revised etc. as approved, and it will then no longer be practical or possible to differentiate between existing and expansion activities, impacts, management practices, monitoring results, etc;
- The referral of expansion/revision activities with (post approval only) ongoing use of existing activities will ensure appropriate cumulative impact assessment is carried out of whole of operations impacts;
- It will ensure that, where possible, the overall Project can be subject to a whole of operations environmental approval to ensure effective and efficient environmental management;
- Under the EPBC Act, if the Project expansion and amendment/revision activities are approved, the EPBC Act exemption which many existing Project activities are currently subject to will lapse due to the scope and nature of the changes made by the Worsley Mining Expansion. New EPBC Act referral and decision making for any post approval ongoing use of these existing activities is therefore required; and
- Including post approval ongoing use of existing activities for expansion and amendment activities is necessary for consistency with the EP Act revised proposal mechanism.

Existing Project activities, which are the subject of existing approvals and/or an EPBC Act exemption, will however continue in the meantime up to the date of any approval for the Worsley Mining Expansion and are not within the scope of this referral.

Extended mining areas

Mining and transport corridor activities have not commenced in the Extended Mining Areas (**Figure 1**). These activities are already approved under EPBC Act approval 2004/1566 (subject to conditions 1 and 2 of that approval) and Part B conditions of State Approval MS719. The mining of these areas is not expected for some time. Although mining in these areas forms part of the overall Project, no changes are currently proposed to activities in these areas as part of this proposal.

It is proposed that, if the referral is approved, a single EP Act approval be issued for all operations including the Extended Mining Areas. The Extended Mining Areas will however continue to be subject to conditions in the form of the current Part B conditions (issued under that single new EP

Act approval). Given the length of time since assessment of the Extended Mining Areas however, it is expected that the conditions which relate to them will need to be reviewed before operations can be implemented in these areas.

The Extended Mining Areas will remain regulated by EPBC approval 2004/1566.

1.4. THE PROPONENT

The Proponent for the Worsley Mine Expansion proposal is:

South32 Worsley Alumina Pty Ltd
 PO Box 344
 Collie WA 6225
 Telephone: +61 8 9324 9000
 ACN: 58 008 905 155
 Website: <https://www.south32.net>

South32 Worsley Alumina Pty Ltd is a joint venture (WJV) between South32 Aluminium (RAA) Pty Ltd (56%), South32 Aluminium (Worsley) Pty Ltd (30%), Japan Alumina Associates (Australia) Pty Ltd (10%) and Sojitz Alumina Pty Ltd (4%). Worsley is the management company for the WJVs.

Key contacts for the proposal are outlined in **Table 1**.

Table 1: Proponent and Project Contacts

Name	Company	Role	Contact Details
Noel Pillay	South32 Worsley Alumina Pty Ltd	Vice President of Operations	P: +61 9734 9380 E: Noel.Pillay@South32.net A: PO Box 344, Collie WA 6225
Dennis Lindgren	South32	Environment Lead	P: 0435 635 941 E: Dennis.Lindgren@South32.net A: Level 37, 108 St Georges Terrace, Perth WA 6000

1.5. ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

It is expected that the environmental impact assessment process for this proposal will involve:

- Referral under Section 38(1) of the EP Act with the expectation that the proposal will be set at a Public Environmental Review level of assessment; and
- Referral under the EPBC Act with the expectation that the Action will be determined to be a Controlled Action (and assessed using an as an Accredited Assessment approach).

This proposal has been drafted using a single consolidated development envelope (the WMDE), which includes and expands the existing development envelopes for Worsley's current and proposed mining activities. To ensure a comprehensive environmental impact assessment, it is proposed that the environmental impact assessment will involve the consideration of all areas within the WMDE (Primary Assessment Area³) in the baseline condition that they are in at the point of Referral. Current mining activities will continue to operate within the Pre-existing Approval Area (**Figure 2**) during the referral and assessment processes, up to the extent of existing approvals. If and when this proposal

³ For the purpose of this document, the **Primary Assessment Area** refers to the Worsley Mining Development Envelope, the Bauxite Transport Corridor and the Contingency Bauxite Mining Envelope collectively as a whole (where applicable).

is approved, any continuation of the mining activities within the Pre-existing Approval Area is proposed to be subject to the environmental management conditions associated with the new approval.

Other assessment processes may include:

- Mining Proposal/s, Programmes of Work under the *Mining Act 1978*
- Consideration will be given to any new requirements under the *Biodiversity Conservation Act 2016 (WA)*;
- Part V Approvals under the *Environment Protection Act 1986 (WA)*
- Approvals under the *Rights in Water and Irrigation Act 1914 (WA)*;
- Regulation 4 Lawful Authority to do an act on Department of Biodiversity, Conservation and Attractions (DBCA) managed lands under the *Conservation and Land Management Regulations 2002, and other authorities and requirements under the Conservation and Land Management Act 1984 and Conservation and Land Management Regulations 2002*;
- Western Power decommissioning, design and install consent under the *Occupational Safety and Health Regulations 1996*;
- Building and Development under the *Building Act 2011 (WA)*;
- Development Approvals under the *Planning and Development Act 2005 (WA)* in areas of freehold title where most mineral rights are conveyed to the owner of the land (Minerals to Owner freehold land), local planning schemes and other relevant laws;
- Section 18 Notice under the *Aboriginal Heritage Act 1972* for disturbance to a registered Aboriginal Heritage site;
- Ministerial Consent under the Land Administration Act 1997 (WA);
- Any additional approvals required.

Water usage at the Refinery for contingency bauxite mining will be managed under existing surface water licences issued under the Rights in Water and Irrigation Act 1914 and no changes to licence conditions are required. Currently groundwater abstracted at the BBM is within groundwater areas not proclaimed under Rights in Water and Irrigation Act 1914 and subsequently have not been required to be licenced.

2. GENERAL DESCRIPTION OF THE PROPOSAL

2.1. OVERVIEW OF THE PROPOSAL

This Worsley Mining Expansion referral primarily proposes to expand and revise/amend existing Project mining and transport activities, and other activities associated with the expansion and revisions/amendments. Key activities are:

- Expansion of the existing mining envelope from 22,102 ha to 27,796 ha to incorporate new and expanded mining resource areas within a consolidated area referred to as the WMDE (**Figure 2**). This expansion will involve accessing additional resource areas and mining activities inside and adjacent to current operational and already approved mining areas at BBM;
- Expansion of mining activities at the BBM with a footprint of 8,662 ha within the WMDE including the clearing of up to 5,925 ha of native vegetation for mining activities (not including continuation of existing approved mining in the Pre-existing Approval Area);
- Access to existing (already approved under EPBC No. 2012/6370 and MS971 bauxite stockpiles within the BGM mining area (**Figure 2**);
- The establishment of a Bauxite Transport Corridor (with transport optionality) linking existing mining areas at Saddleback and Marradong to new and future mining areas (**Figure 3**) including up to two crossings of the Hotham River;
- Contingency bauxite mining activities within the Refinery Lease Area (**Figure 4**);
- Construction activities and temporary support facilities associated with the proposal as required; and
- Additional clearing within the Refinery Lease Area for maintenance purposes (**Figure 5**).

Current mining and associated activities at Saddleback and Marradong will continue to operate up to the extent of existing approvals throughout the duration of the referral and assessment process. The transport of ore to the Refinery using existing transport infrastructure will also continue. Operations at the Refinery and the Port will also continue on a business as usual basis throughout the referral and assessment process for this proposal. These activities will continue to be subject to the EPBC Act exemption and EPBC Act approval 2004/1566, regulation under MS719 and Part V EP Act operational licences.

As noted in section 1.3, if and when this referral is approved, continuation of the above activities from that date will be used for the Project expansions and revisions/amendments, so from that time on existing activities are proposed to be considered part of the Revised Proposal/Action. This will also ensure that as far as possible the Project can be subject to a whole of operations, consolidated environmental approval to ensure effective and efficient environmental management of the Project as a whole.

A detailed description of the activities associated with this proposal are outlined in the sections below.

2.1.1. Mining Activities in the WMDE

Mining activities will occur within the WMDE; an area covering 27,796 ha of land comprising approximately 11,890 ha of native vegetation and 15,905 ha of agricultural pasture, plantation and cleared areas (based on current mapped extent). Of this 27,796 ha, a total of 4,321 ha of native vegetation has previously been cleared for mining activities under existing approvals with a

remaining 942 ha as described in **Section 2.1.1.1**. The proposed mining activities are expected to result in an additional 8,662 ha⁴ of disturbance in the WMDE, up to 5,925 ha (based on current mapped extents) of which represents remnant native vegetation. The WMDE is shown in **Figure 2**.

Mining will continue at an already approved rate of 18.8 Mtpa. No changes to the ore mining rate are proposed.

Mining disturbance will occur concurrently with rehabilitation, which will keep the amount of cleared area open at any one time to a minimum. Mining areas will not be left uncleared in perpetuity, instead, rehabilitation is undertaken progressively at an ongoing basis.

Mining activities involve the salvaging of forest products, clearing of vegetation, stripping of topsoil and removal of overburden, preparation of blasting areas, blasting, excavation, the establishment of mine haul and trunk roads including to access ore and transport ore to a crushing facility, ore stockpiling, ore crushing, mine haul and trunk roads to transport of crushed ore to a conveyor point, roads for material movement and related activities. Expansion of the mine roads in the southern expansion area of the WMDE to facilitate the long-term transport of bauxite ore reserves will include at least one river crossing. All mining activities will occur within the WMDE.

Where required, mine haul and trunk roads may cross public roads, waterways and rivers (including the Hotham River) to access bauxite resource areas, through the construction and/or establishment of bridges, level crossings or similar. A mine haul road is primarily for access to and transport from bauxite resource areas, and a trunk road is a primary arterial road serving mine haul road(s).

The north western part of the WMDE is overlapped by the BGM development envelope as approved under MS971 and EPBC Act No. 2012/6370. These provide approval for Newmont Boddington Gold Pty Ltd (NBG) to carry out its proposal for gold mining operations including allowing NBG to remove, delineate, preserve and stockpile bauxite (overburden in their mining activities) for third parties (such as Worsley) to access for bauxite recovery purposes. The BGM proposal assessed the impacts of this activity on native vegetation and surface water, including rehabilitation and closure, and environmental measures including the placement of stockpiles on disturbed land where possible. It also provided offsets for the associated disturbance of native vegetation. Consistent with NBG's proposal, Worsley is proposing to access the stockpiled and already cleared in situ bauxite resources located at the BGM area for transport by Worsley to a crushing facility and further on to the Refinery.

Mining activities shown as Extended Mining Areas in **Figure 1** refer to areas already approved and subject to conditions under Part B of MS719 and EPBC Act approval 2004/1566 conditions 1 and 2. Although mining in these areas forms part of the overall Project, no changes are currently proposed to activities in these areas as part of this proposal and mining in these areas has not commenced.

Where practicable, mining activities will not occur within the areas of high biodiversity value as shown in **Figure 6** (protected areas in this figure are indicative only and will be ground-truthed in Environmental Review Document technical studies) in accordance with the Protected Areas Procedure in the Biodiversity and Forest Management Plan (**Appendix H**). This procedure is incorporated into Worsley's mine planning process and the indicative mining calculations have been assessed based on avoidance of the areas as shown in **Figure 6**. These areas include Threatened or Priority flora, Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs), poorly represented (less than 30% of pre-European extent) vegetation complexes, Aboriginal heritage sites, high value areas such as caves and breakaways, river protection buffers

⁴ This figure does not include continuation of mining activities in the Pre-existing Approval Area to the existing approved extent (refer to Section 2.1.1.1).

and other areas as determined with relevant stakeholders. Preliminary analysis of recent changes under the BC Act identify that the species protected under the BC Act are considered in this procedure, however, further updates may be required to ensure protection under the BC Act.

All mine planning for mining activities is, and will continue to be, presented in the 10 Year Mine Plan; an established process that is facilitated and endorsed by the Worsley Environmental Management Liaison Group (EMLG).

2.1.1.1. Continuation of Mining Activities in the Pre-existing Approval Area to Existing Approved Extent

The 1995 CER described the clearing of up to 35% of native vegetation within the area then referred as the PBA. This represents 5,263 ha of native vegetation that has already been approved/subject to exemption to be cleared for existing mining activities at BBM. To date, approximately 29% (4,321 ha) of native vegetation has been cleared within the PBA, with approximately 6% (942 ha) remaining of the 35% described.

Over time there has been several versions of the PBA boundary produced and referred to for various regulatory purposes, most relevantly including the 1995 PBA, the 2004 PBA and the 2005 PBA. If approved, the WMDE boundary will make the PBA redundant as a concept for regulating and defining the proposal, and therefore remove any ongoing impact of potential ambiguity associated with the differing PBA boundaries over time.

However, for the purpose of defining the area where mining activities are already approved and will continue during the referral and assessment process for this proposal, an amalgamated PBA area to be referred to as the Pre-existing Approval Area (defined in **Figure 2**). Worsley proposes this Pre-existing Approval Area be defined as an envelope that reflects the innermost boundary of the 1995, 2004 and 2005 PBAs within which existing exempt and approved mining activities will be confined (subject to MS719 regulatory conditions). This results in the Pre-existing Approval Area confining existing approved mining activities to the smallest possible area and represents a reduction of 4,090 ha from the 2005 PBA (the largest of the three versions of the PBA).

The mining activities that involve the clearing of the remaining 942 ha of native vegetation, and mining activities on already disturbed land, will continue during the referral and assessment process of this proposal, up to the extent of the existing EPBC Act exemption and EP Act approvals and subject to the conditions of MS719. If and when this proposal is approved, any continuation and expansion of mining activities within the now defined Pre-existing Approval Area is, from that time on only, proposed to be subject to any new environmental management conditions associated with any new approval. It is expected that these conditions will represent modern and holistic environmental management conditions and that as far as possible, and to ensure efficient and effective environmental management, these will apply to all mining activities associated with the Project (apart from the Extended Mining Areas which are already subject to separate approvals conditions), which are expected to be separately revised before mining in those areas commences).

Mining disturbance will occur concurrently with rehabilitation, which will keep the amount of cleared area open at any one time to a minimum. Mining areas will not be left uncleared in perpetuity, instead, rehabilitation is undertaken progressively at an ongoing basis.

As part of this proposal, Worsley is also proposing to release the isolated portion to the northeast of the PBA (referred to as the Release Area) to counterbalance minor historical clearing of native vegetation (less than 40 ha of good to excellent quality) which has already occurred inside one or more of the historical PBA boundaries (and was subject to MS719), but which is outside the now amalgamated, confined Pre-existing Approval Area. The Release Area comprises 101 ha of good to

excellent quality native vegetation. Mining activities in this area have been approved, however, no disturbance has occurred in this area to date, and the area will now be released as part of this proposal. The Release Area is shown in **Figure 2**.

Transport of bauxite mined in the Pre-existing Approval Area to existing crushing facilities and/or the Refinery will continue using existing transport and conveying infrastructure. The bauxite will be refined at the Refinery on a business as usual basis. All activities associated with the continuation of mining in the Pre-existing Approval Area (up to the extent of existing approvals) will continue during the referral and assessment process for this proposal. If and when the proposal is approved, however, any continuation of these existing activities from that time on only is proposed as far as possible to be subject to whole of operations approval conditions to ensure the efficient and effective environmental management of the Project as a whole.

2.1.2. Bauxite Transport Corridor

Long term transport of bauxite ore reserves from Hotham North, Hotham North Extension, Central and Brookton mining areas (as defined in Ministerial Statement 719 Figure 1) to and from crushing facilities and the conveyor will be carried out within the Bauxite Transport Corridor (**Figure 3**). Transport methods within the Bauxite Transport Corridor will potentially include truck haulage and/or the use of a conveyor system (potentially a combination of both) within the Bauxite Transport Corridor. Whilst mining activities already include mine haul roads and trunk roads, the bauxite transport activities within the Bauxite Transport Corridor in most cases reflect longer term and more permanent transport infrastructure with the optionality for conveyor or road transport.

Both truck haulage and conveyor routes in the Bauxite Transport Corridor are still being defined. Two routes for truck haulage are currently being investigated for the transport of ore to the existing Marradong crushing facility across the Hotham River from the Nullaga and Hotham North mining areas. It is proposed that the truck haulage routes will be constructed to a maximum road pavement width of 50 m and length of approximately 25 km, requiring a maximum construction width of up to 200 m to allow for infrastructure associated with construction methods including, access, cutbacks and stockpiling. Construction of the haulage route will require the clearing of up to 500 ha of native vegetation, however it is expected that a significant portion of the route will be located on already disturbed land (pastoral areas) so the actual disturbance figure is expected to be much lower. Design options are still being evaluated and disturbed area requirements may change once final design is completed. The proposed route will cross the Hotham River at up to two locations, requiring the construction of a bridge across the river.

An extension of the existing bauxite conveying systems may be required as part of the future mine plan, however a final route for the extension is yet to be determined. It is proposed that the conveyor route will be constructed to a maximum width of 50 m and length of approximately 22 km, requiring a maximum construction width of up to 200 m. Construction of the conveyor will require the clearing of up to 440 ha of native vegetation, however it is expected that a significant portion of the route will be located on already disturbed land, so the actual disturbance figure is expected to be much lower. It is also expected that impacts will be significantly reduced when the conveyor route is further defined in the future. The proposed conveyor will cross the Hotham River at up to two locations, requiring the construction of a bridge across the river at these locations.

The truck haulage route and bauxite conveyor routes within the Bauxite Transport Corridor will be designed to avoid the areas as shown in **Figure 6** (protected areas in this figure are indicative only and will be ground-truthed in Environmental Review Document technical studies), where practicable, applying the principles in Worsley's Biodiversity and Forest Management Plan (**Appendix H**). Design

options are still being evaluated and disturbed area requirements may change once final design is completed.

The Bauxite Transport Corridor from the Marradong mining area to the Hotham North mining area is also required for the transport of bauxite ore via truck haulage or a future conveyor to the Marradong crushing facility. The existing indicative bauxite conveyor corridor as shown in Figure 1.3 of the 2005 ERMP is no longer the planned route for this conveyor.

Worsley's operation of the existing conveyor and other transport infrastructure to the Refinery will continue subject to MS719, the EPBC Act exemption and the Worsley State Agreement throughout the duration of the referral and assessment process. If and when the proposal is approved, any continuation of these activities from that date will be used for the Project expansions and revisions/amendments, so is proposed to be part of the Project. This will ensure that as far as possible the Project can be subject to a whole of operations approval to ensure efficient and effective environmental management of the Project as a whole.

2.1.3. Exploration

Exploration is needed as part of the Project for the definition of bauxite resources and for grade control and is conducted in accordance with tenement conditions. Exploration is not restricted to the WMDE, but rather occurs at various locations across current (and future) tenure held by Worsley. Necessary tenure would be secured prior to conducting any drilling. Proposed drilling areas are submitted annually in the 10 Year Mine Plan.

For its production drilling Worsley currently employs a low impact technology for bauxite exploration in the form of rubber tyred drill rigs that do not require the clearing of native vegetation for drilling. Only minor disturbance of vegetation is required for drill rig access, which may include the occasional removal of bushes or small trees. These rigs do not use any drilling fluids and do not need any cleared access except in areas of very dense vegetation or in very specific areas for safety (i.e. steep areas). Any clearing required for drilling is managed and accepted in the same way as clearing required for mining activities, which is through utilisation of the 10 Year Mine Plan notification. Drilling activity in forested areas is usually restricted to drier months to minimise the potential for spread of forest disease.

Drilling creates a 60 – 70 mm hole typically approximately 10 m in length. Following drilling, the cleared drill hole is plugged by a wooden peg that is forced down the hole or capped by a rock that is forced down the hole and backfilled to prevent erosion, collapse of the hole or fauna entry.

Worsley also employs other low impact drilling methods such as aircore, aircore/vacuum or modified reverse cycle or diamond drilling methods in restricted circumstances. In restricted circumstances alternate drilling methods that are not considered low impact, such as diamond drilling, may be required but only in areas where disturbance information has already been provided and areas are approved for clearing.

Exploration activities within forested areas are undertaken in accordance with Working Arrangements with the DBCA, which determine appropriate management procedures to cover matters, such as forest clearing (where required), occasional clearing of rehabilitated areas, weed control, forest disease, vegetation and flora, fire control, erosion control and site rehabilitation. Prior to commencement of exploration in any catchments declared Public Drinking Water Supply Areas, Worsley is required to develop working arrangements in consultation with the DWER. On private land, exploration is undertaken by agreement with the land holder.

All exploration activities at Worsley are, and will continue to be, carried out in accordance with any relevant tenement and/or mining agreement conditions including rehabilitation standards and procedures.

Planned and undertaken exploration is included in the 10 Year Mine Plan, which is presented to the EMLG on an annual basis.

2.1.4. Contingency Bauxite Mining and Stockpiling at the Refinery

Contingency bauxite mining may be required at the Refinery in the event that bauxite supply to the Refinery is disrupted from events, such as catastrophic failure (bushfire or mechanical faults of the conveyor, reclaimers or other related infrastructure) or other impacts that result in low bauxite stockpile inventory at the Refinery. An existing bauxite resource is located at the Refinery Lease Area within the proposed Contingency Bauxite Mining Envelope (CBME) (**Figure 4**). The proposed CBME covers an area of 747 ha and is located entirely on M258SA. If required, contingency bauxite mining activities will involve salvaging of forest products, clearing of native vegetation, topsoil stripping and overburden removal, caprock blasting or surface mining and excavation of bauxite. Bauxite will also be crushed, screened and stockpiled on site with potential to also include, bauxite sourced from resources external to the CBME such as bauxite transported from BBM, future adjoining mining leases or third party sources. Stockpiled bauxite may also be stored within disturbed areas within the Refinery Lease Area. After mining, areas would be progressively rehabilitated to a forest ecosystem compatible with the surrounding jarrah forest. Water usage requirements for dust suppression requirements will be from existing water sources and within existing surface water limits.

The Refinery Lease Area is accessed via existing public roads. Access to the CBME will be via existing private roads and tracks within the Refinery Lease Area. Mine Haul and trunk roads will need to be established within the CBME to access the ore reserves. Contingency bauxite mining activities may require eventual disturbance of up to 255⁵ ha of native vegetation, within the larger proposed CBME or locations within the refinery footprint. These activities will not be carried out within or on the boundary of the existing freshwater lake (**Figure 4**).

It is expected that any contingency mining campaign would require similar mining activities to those at the BBM with the addition of mobile crushing. In the event that contingency bauxite is required, it is expected that the resource will be mined and crushed at short notice by contractors using mobile mining equipment, mobile crushing and screening plant. It is proposed that an initial mining area of (30 ha) would be fully developed and stockpiled within the CBME or Refinery Lease Area so that hauling of a contingency bauxite supply to feed the Refinery could be instigated at very short notice. The intent is to maintain a small inventory of prepared bauxite (approximately 500,000t) in the event that the initial supply is called upon in an emergency. Detailed plans will be included in the Worsley Project Plan of Bauxite Mining Operations (10 Year Plan) provided annually to the state.

It is possible that an emergency supply will never be required and therefore mining (outside of development of the initial bauxite inventory) at the Refinery may never eventuate.

If required, bauxite may also be trucked under emergency requirements to the Refinery from the BBM or other sources and on alternative routes.

⁵ 250 ha clearing of native vegetation for the Contingency Bauxite Mining Envelope and 4.5 ha clearing of native vegetation for Maintenance within the Refinery Lease Area. The 4.5 ha value has been rounded up to 5 ha.

As part of the need to provide alternative supply to the Refinery during repair events, additional opportunistic ore stockpiling from other areas may also be required and may be located within the CBME or other already cleared areas within the Refinery area.

2.1.5. Refinery

Ore mined and crushed at BBM is transported on the existing conveyor to the Refinery. The Refinery is located at the Refinery Lease Area near Collie. Alumina is currently approved to be produced at a rate of 4.7 Mtpa under the EP Act subject to Environmental Licence L4504/1981/17 and is proposed to continue on a business as usual basis. No changes to production rates at the Refinery are proposed as part of the Revised Proposal/Action.

2.1.6. Maintenance within the Refinery Lease Area

Additional clearing of native vegetation within the Refinery Lease Area is required for maintenance purposes. A turkey nest (water containment dam) is required for site water management to minimise silt and erosion within the Freshwater Lake catchment area. Some minor maintenance to the water quality management system for the Freshwater Lake is also required, including an access track. Altogether these activities will require the clearing of approximately 4.5 ha of native vegetation, as well as use of already cleared areas within the Refinery Lease Area. The new areas required for clearing are shown in **Figure 5**.

2.1.7. Oxalate Management

Sodium oxalate (or oxalate) is a by-product of the alumina refining process. It is formed when sodium hydroxide bonds with organic material contained within the bauxite ore and is relatively insoluble. Investigation into oxalate management at the Refinery will be undertaken by Worsley to determine the most appropriate long-term solution, which may involve the use of technology. This may include additional oxalate storage or an oxalate destruction area, details of which will be determined in the near future. It is proposed that, should additional storage or associated works be required at the Refinery involving oxalate, the management of this activity is regulated under Part V of the EP Act.

2.1.8. Port

Alumina produced at the Refinery is transported by rail to the Bunbury Port. This referral proposes to continue this on a business as usual basis. Worsley manages its shipping operations at the Bunbury Port under an EP Act Certificate of Registration (Registration No. 1859). No changes to activities at the Bunbury Port are required as part of this Revised Proposal/Action.

2.1.9. Regulation of Air Emissions and Crushing Facilities

Air emissions associated with the Refinery and crushing facilities associated with mining activities at BBM are currently regulated under both Part IV and Part V of the EP Act. Air emissions associated with alumina refining activities at the Refinery are regulated under MS719 and under Worsley's existing Environmental Licence L4504/1981/17. It is proposed that the following five air emissions elements, and any changes to them in the future, still be considered part of the Project which continues, but that they be assessed and regulated solely under Part V of the EP Act only, through L4504/1981/17 (and its replacement and amendments from time to time):

- Sulphur dioxide (SO₂) from coal fired facilities;
- Nitrogen oxides (NO_x) from combustion, liquor burner and calciner sources;

- Particulates (PM) from combustion, liquor burner and calciner sources;
- Carbon monoxide (CO) from combustion, liquor burner and calciner sources; and
- Total volatile organic compounds (VOCs) from all sources.

Crushing facilities at BBM are also regulated under MS719 and under Worsley's existing Environmental Licence L5960/1983/11 for BBM. It is also proposed that crushing facilities, and any changes to them in the future, still be considered part of the Project which continues but be assessed and regulated solely under Part V of the EP Act through L5960/1983/11 (and its replacement and amendments from time to time).

2.1.10. Water Supply and Consumption

Water supply for mining activities will be extracted from new and existing groundwater and surface water sources, including rainwater collection in the vicinity of the WMDE, or other regional sources where available. Water usage requirements and demands for mining activities in the WMDE are associated with haul distances. Water usage to support CBME mining operations will be minor and sourced from existing freshwater sources at the Refinery and will be within existing surface water licence limits. It is expected that a maximum of 900 ML of water will be required for continuation of all mining activities in the WMDE on an annual basis, with the primary use for dust suppression. Water is also used for the cleaning of equipment, in crushing facilities and for potable supplies. No dewatering is required for this proposal.

2.1.11. Construction and Support Facilities

Proposal activities will require temporary construction and support facilities during construction periods, including mobile offices and ablutions, lay down areas and field maintenance facilities for minor servicing and essential repairs. These will be located in already cleared areas or areas where clearing is planned to take place for mining/transport activities anyway within the Bauxite Transport Corridor and the WMDE as far as reasonably practicable, however up to 20 ha⁶ of native vegetation will be required to be cleared where this is not practicable. Major servicing and scheduled maintenance will likely involve demobilisation of equipment to local workshops in the region. Trucks and equipment will be refuelled on-site using mobile refuelling contractors. A Construction Environmental Management Plan (CEMP) will be prepared to manage impacts during construction.

Activities associated with the construction of Project roads (in the WMDE, Bauxite Transport Corridor, CBME and otherwise) will require typical construction activities including blasting, mining and mobile crushing and screening plant. Licensing for these activities will be sought under Part V of the EP Act as required.

Workers will be accommodated in existing accommodation facilities in or around the town of Boddington (as deemed acceptable for fatigue management purposes) and/or will commute to work on a drive in-drive out basis. During construction, work will occur over 12-hour shifts.

Water will be required for construction activities including road and bridge construction, and dust suppression. It is expected that up to 580 ML per annum of water will be required during the construction period, in addition to water requirements for the ongoing operation of the mine. It is proposed that this be sourced from new and/or existing water sources including bores.

⁶ This 20 ha maximum has been included within the 940 ha of native vegetation clearing for bauxite transport activities within the Bauxite Transport Corridor.

It is expected that the duration of construction will be two to three years.

2.1.12. Other Infrastructure

Other minor infrastructure activities, such as fencing, access of tracks, firebreaks, bores and associated water infrastructure, are required for the Project. Such infrastructure requirements will be located within the WMDE, BTC or CBME where possible, but may also need to be located outside these areas, such as where required for the following reasons:

- Requirements to clear firebreaks to comply with requirements under the *Bush Fires Act 1954* and associated *Bush Fires Regulations 1954*;
- Prevention of inadvertent access to a mine site by members of the public (through management measures such as fencing and signage) under the *Mines Safety and Inspection Act 1994* and associated *Mines Safety and Inspection Regulations 1995*;
- As an offset requirement under the *Biodiversity Conservation Act 2016 (WA)*; or
- As a landowner requirement.

2.1.13. Proposed Disturbance

The WMDE covers a land area of 27,796 ha including the Pre-existing Approval Area and is overlapped by the Bauxite Transport Corridor. This overlap represents 3,332 ha. The Primary Assessment Area (incorporating the WMDE, BTC and CBME) represents a total of 29,362 ha. Impact estimates within the WMDE relate to mining and related activities, and impact estimates within the Bauxite Transport Corridor relate to long-term transport activities. It is expected that, once routes are determined, the haulage and conveyor routes will result in significantly less clearing of native vegetation than estimated below due to the presence of pastoral and pre-disturbed areas in the Bauxite Transport Corridor (**Figure 2**). Indicative disturbance is outlined in **Table 2**.

: Summary of Proposed Disturbance (Indicative)

Element	Total Area (ha)	Total known native vegetation (ha)	Total previously disturbed ⁷ area (ha)	Clearing of native vegetation (ha)	Clearing of previously disturbed areas (ha)
Worsley Mining Development Envelope	27,796	11,890	15,905	5,925	2,730
Bauxite Transport Corridor	4,146	2,939	1,207	940 ⁸	Not yet determined
Contingency Bauxite Mining Envelope	747	507	240	250	5
Maintenance within the Refinery Lease Area	5	4.5	.5	4.5	.5
TOTAL	29,362 ⁹	15,340.5	17,352.5	7,119.5	2,735.5
Existing elements of the Project (approved under MS719 and EPBC Act 2004/1566)					
Extended Mining Areas	74,918	N/A	N/A	8,400	N/A
Pre-Existing Approval Area	18,012 ¹⁰	8,392	9,621	942 ¹¹	N/A
TOTAL	92,930	N/A	N/A	9,342	N/A

2.2. KEY PROPOSAL CHARACTERISTICS

The key characteristics for the proposal have been defined in accordance with the *Instructions on how to define key characteristics of a proposal* (EPA, 2018b). A summary of the key proposal characteristics for this proposal are provided in **Table 3** using Schedule 1 of MS719 as a basis for definition.

Table 3: Key Characteristics Table for the Proposal

Summary of the Proposal			
Proposal Title	Worsley Mine Expansion		
Proponent Name	South32 Worsley Alumina Pty Ltd		
Short Description	The proposal is for the expansion of existing mining activities at the BBM and Refinery.		
Element	Existing Approval (MS423, MS719, MS751)	Proposed Change	Proposed Extent
Bauxite Alumina Project			
Alumina Production	4.7 Mtpa	No change	4.7 Mtpa

⁷ Previously disturbed areas include pasture, plantation, rehabilitated areas and other areas including dams.

⁸ Up to 940 ha. This is likely to be significantly less once a final route has been determined. It also includes 20 ha of potential clearing for construction laydown areas where these cannot be located within existing cleared areas or previously disturbed areas.

⁹ The WMDE and the Bauxite Transport Corridor have a 3,332 ha overlap area. This overlap area has been deducted from 32,694 ha to arrive at the 29,362 ha value.

¹⁰ The Pre-existing Approval Area lies completely within the WMDE, except for the Release Area.

¹¹ Mining up to the existing approved extent in the Pre-existing Approval Area.

Greenhouse Gases	3.75 Mtpa of CO _{2-e}	No change	3.75 Mtpa of CO _{2-e}
Bauxite Mining			
Mining Development Envelopes	Refer to Figures 1 & 2	<ol style="list-style-type: none"> 1. Worsley Mining Development Envelope (27,796 ha) (Figure 2) (including the Pre-existing Approval Area) 2. Extended Mining Areas (no change) (74,918 ha) (Figure 1) 3. Pre-existing Approval Area (18,012 ha) (Figure 2) 	<ol style="list-style-type: none"> 1. Worsley Mining Development Envelope (27,796 ha) (Figure 2) (including the Pre-existing Approval Area) 2. Extended Mining Areas (74,918 ha) (Figure 1) 3. Pre-existing Approval Area (18,012 ha) (Figure 2)
Mining rate	Up to 18.8 Mtpa	No change	Up to 18.8 Mtpa
Areas of clearing of native vegetation for mining activities: <ol style="list-style-type: none"> 1. Within Worsley Mining Development Envelope 2. Within Extended Mining Areas 3. Within Pre-existing Approval Areas 	<ol style="list-style-type: none"> 1. Areas of bauxite reserves (unchanged) as specified in CER (1995) (Figure 2) 2. Up to 8,400 ha 	<ol style="list-style-type: none"> 1. Up to 5,925 ha of clearing of native vegetation within the Worsley Mining Development Envelope (27,796 ha) (Figure 2) 2. Up to 8,400 ha of clearing of native vegetation within Extended Mining Areas (Figure 1) 3. Up to 942 ha of clearing of native vegetation within the Pre-existing Approval Area (18,012 ha) (Figure 2) (as per 1995 CER) of which 942 ha is remaining to be cleared 	<ol style="list-style-type: none"> 1. Up to 5,925 ha of clearing of native vegetation within the Worsley Mining Development Envelope (27,796 ha) (Figure 2) 2. Up to 8,400 ha of clearing of native vegetation within Extended Mining Areas (Figure 1) 3. Up to 942 ha of clearing of native vegetation within the Pre-existing Approval Area (18,012 ha) (Figure 2) (as per 1995 CER) of which 942 ha is remaining to be cleared
Water supply sources	Groundwater and surface water in the vicinity of mining areas	No change	Groundwater and surface water in the vicinity of mining areas
Water usage (average)	500ML/a	900 ML/a	900 ML/a
Crushing facilities	4 primary crushers, 2 secondary crushers	Current and future facilities proposed to remain part of the proposal but be solely regulated under Part V of the EP Act.	No longer regulated under MS719.
Bauxite transport			
Bauxite Transport Corridor to service mining in Extended Mining Areas	Conventional idler-type conveyors and/or truck transport	No change	Conventional idler-type conveyors and/or truck transport (Figure 1)
Bauxite Transport Corridor to service mining in the Worsley Mining Development Envelope	N/A	Transport of bauxite via truck haulage and/or conveyor to service mining in the Worsley Mining Development Envelope and its connection to	Transport of bauxite via truck haulage and/or conveyor to service mining in the Worsley Mining Development Envelope and its connection to

		Extended Mining Areas (Figure 3) Clearing of up to 940 ha of native vegetation within the Bauxite Transport Corridor Continued use of existing conveyor and transport infrastructure	Extended Mining Areas (Figure 3) Clearing of up to 940 ha of native vegetation within the Bauxite Transport Corridor Continued use of existing conveyor and transport infrastructure
Refinery			
Refinery Lease Area (RLA)	2,500 ha	No change	2,500 ha
Clearing within Wellington National Park	Clearing of up to 8 ha for Wellington Dam Pipeline	No change	Clearing of up to 8 ha for Wellington Dam Pipeline
Clearing within Refinery Lease Area (Attachments 3 and 4)	66.6 ha	4.5 ha	71.1 ha (Figure 5)
Digestion process area emissions control	Regenerative thermal oxidiser	No change	Regenerative thermal oxidiser
Calciners – fuel	Natural gas	No change	Natural gas
Particulate emissions control	Electrostatic precipitators on five calciners, baghouse system on one calciner		Electrostatic precipitators on five calciners, baghouse system on one calciner
Liquor burner Emission control	Baghouse, regenerative thermal oxidiser and wet scrubber	No change	Baghouse, regenerative thermal oxidiser and wet scrubber
Bauxite stockpiles	1.92 Mt approximately	No change	1.92 Mt approximately
Contingency bauxite mining	N/A	Up to 250 ha of clearing of native vegetation for the purpose of contingency bauxite mining within the Contingency Bauxite Mining Envelope (747 ha) (Figure 4)	Up to 250 ha of clearing of native vegetation for the purpose of contingency bauxite mining within the Contingency Bauxite Mining Envelope (747 ha) (Figure 4)
Power and steam raising facilities			
Gas fired cogeneration – capacity	120 MW	No change	120 MW
Gas fired cogeneration (alternative) – capacity	120 MW	No change	120 MW
Coal fired facility – capacity	110 MW (electrical)	No change	110 MW (electrical)
Particulate emission control	Electrostatic precipitators on three boilers		Electrostatic precipitators on three boilers
Coal fired boiler – normal capacity Emission control	Two circulating fluidized bed multi-fuel co-generation boilers	No change	Two circulating fluidized bed multi-fuel co-generation boilers 100 MW (electrical)

	100 MW (electrical) 400 MW (thermal) Limestone injection and baghouse filters		400 MW (thermal) Limestone injection and baghouse filters
Bauxite Residue Disposal Areas (BRDA)			
Deposition rate Footprint and location	18.5 Mtpa (wet) (no change to footprint of BRDA)	No change	18.5 Mtpa (wet) (no change to footprint of BRDA)
Raw Water Supply			
Sources usage (average)	Freshwater lake (Augustus River) and offsite purchase from water provider as required 2.6 GL (from Freshwater lake).	No change	Freshwater lake (Augustus River) and offsite purchase from water provider as required 2.6 GL (from Freshwater lake)
Air emissions			
Sulphur dioxide (SO₂) from coal fired facilities	Up to 13,370 tpa from combustion, liquor burner and calciner sources	<i>Proposed to remain part of the proposal but be solely regulated under Part V of the EP Act</i>	No longer regulated under MS719
Nitrogen oxides (NO_x) from combustion, liquor burner and calciner sources	Up to 6,890 tpa	<i>Proposed to remain part of the proposal but be solely regulated under Part V of the EP Act</i>	No longer regulated under MS719
Particulates (PM₁₀) from combustion, liquor burner and calciner sources	Up to 520 tpa	<i>Proposed to remain part of the proposal but be solely regulated under Part V of the EP Act</i>	No longer regulated under MS719
Carbon monoxide (CO) from combustion, liquor burner and calciner sources	Up to 1,350 tpa	<i>Proposed to remain part of the proposal but be solely regulated under Part V of the EP Act</i>	No longer regulated under MS719
Total volatile organic compounds (VOCs) from all sources	Up to 300 tpa	<i>Proposed to remain part of the proposal but be solely regulated under Part V of the EP Act</i>	No longer regulated under MS719
Construction and Support Facilities			
Temporary construction facilities including mobile offices and ablutions, laydown areas and field maintenance facilities	N/A	Clearing of up to 20 ha of native vegetation (included within the indicative mining footprint of 8,662 ha within the WMDE) for temporary construction and support facilities located within the WMDE (Figure 2). Facilities will be located on pre-disturbed areas where possible	Clearing of up to 20 ha of native vegetation (included within the indicative mining footprint of 8,662 ha within the WMDE) for temporary construction and support facilities located within the WMDE (Figure 2). Facilities will be located on pre-disturbed areas where possible
Water supply	N/A	Temporary water supply of approximately 580 ML/annum from local water sources for the duration of the construction period	Temporary water supply of approximately 580 ML/annum from local water sources for the duration of the construction period

Various activities associated with the Project are regulated under both Part IV of the EP Act and other legislation including the *Rights in Water and Irrigation Act 1914* (RIWI Act) and the *Mining Act 1978*. It is understood that where an activity is not considered to be environmentally significant, that the EPA may recommend that these activities be removed from Schedule 1 of any Ministerial Statement issued in the future for this Revised Proposal. For any of these activities, it is proposed that they and any changes to them in the future, still be considered as part of the proposal, which may be implemented but be assessed and regulated under any other legislation that may apply to them.

2.3. LOCATION OF THE PROJECT

The Project is located in the southwest of Western Australia on the Darling Plateau. The BBM is located 5 km from the town of Boddington in the Hotham River catchment. Crushed bauxite is transported by a conveyor system approximately 60 km in length from the BBM to the Refinery at Worsley, 21 km northwest of Collie.

The Refinery is located on the western edge of the Darling Plateau approximately 21 km northwest of Collie and 20 km southeast of Harvey within the Augustus River catchment. The Refinery is situated within a Refinery Lease Area covering 2,500 ha, which is surrounded by State Forest on three sides and forested private land owned by the WJVs on the western side. Natural drainage from the forested areas within the Refinery Lease Areas runs towards the Augustus-Brunswick river system. There are no areas reserved for public purposes within proximity to the Refinery. Raw materials and alumina products are transported via train or road to the Port of Bunbury, 45 km to the south-west of the Refinery. Alumina products can include unrefined/calcined alumina products.

Activities associated with the Project are primarily located at the BBM, Refinery and existing conveyors (**Figure 1**). The WMDE extends approximately 45 km from the north of the BGM to the south towards the Quindanning area, covering an area of approximately 27,796 ha (**Figure 1**). The Bauxite Transport Corridor extends from the BGM area south and east towards the Marradong mining area and overlaps the WMDE (**Figure 2** and **Figure 3**). Contingency bauxite mining and other minor maintenance activities are located within the Refinery Lease Area (**Figure 4**).

The Primary Assessment Area supports land uses including mining, agriculture, native vegetation, plantation vegetation, water bodies such as dams and the Hotham and Williams Rivers, and extensively cleared pasture land.

2.4. LAND TENURE

Worsley operates its mining activities on tenements granted under the Worsley State Agreement and the *Mining Act 1978*, as well as Crown Leases granted under the Worsley State Agreement.

Mining Lease M258SA is granted to Worsley under the Worsley State Agreement. In addition, Worsley holds a number of mining leases granted under the *Mining Act 1978* and sub-leases excised from ML1SA held by Alcoa of Australia Limited (Alcoa). Sublease arrangements with Alcoa give the WJVs the right to access and mine within those areas of ML1SA granted pursuant to the *Alumina Refinery Agreement Act 1961* and approved by the Minister for State Development, Jobs and Trade.

Worsley manages the mining tenure held by the WJVs, and the WJVs hold mining tenure over the majority of land (94.21%) within the WMDE. The WJVs also own freehold land however some of these titles are not covered by mining tenure.

The Refinery is located within Crown Lease I150306 and the existing BRDAs are situated on three other parcels of Crown Land governed by a single Crown Lease I154246. The CBME is located within a portion of M258SA which overlaps Crown Lease I150306.

The existing conveyors run from BBM to the Refinery and crosses various parcels of land including WJV held freehold land and Crown Land collectively governed by an overarching Crown Lease agreement (N104197).

Multiple parcels of Freehold Land (Private Property) are owned by WJVs. Some portions of this land are not currently covered by mining tenure/right to mine.

In other areas covered by the Proposal where the WJVs do not have current access, the WJVs will secure tenure or access arrangements before commencing works in those areas. Worsley will not undertake any mining or mining-related development within any area of the WMDE without securing mining tenure, land access, landholder agreements or relevant legislative approvals.

A summary of tenure arrangements for the proposal are provided in **Figure 7** and **Figure 8**.

2.5. NATIVE TITLE

The Project is located within the South West Native Title Settlement Area (Settlement Area). The Settlement Area is the area subject to the South West Native Title Settlement (Settlement), a comprehensive native title agreement negotiated between six Noongar Agreement Groups represented by the South West Aboriginal Land and Sea Council (SWALSC) and the Government of Western Australia. The Project is specifically located within the Gnaala Karla Booja Agreement area (DPC 2018).

In October 2018, all six Indigenous Land Use Agreements (ILUAs) were formally registered. Once complete, the Settlement will provide significant opportunity for sustainable social, economic and cultural outcomes for the Noongar people, the WA Government and stakeholders (DPC, 2018). Until such time, the provisions of the *Native Title Act 1993* will continue to apply to Worsley's operations.

2.6. PROJECT DELIVERY TIMEFRAMES AND ONGOING ACTIVITIES

It is expected that following the grant of all necessary approvals, construction activities for the expansion elements of the Revised Proposal/Action will commence in the second half of 2020. Current mining activities will continue within the Pre-existing Approval Area up to the existing approved extent and subject to MS719 unless and until such time as the proposal is approved for these activities to expand and operate in the WMDE and holistic approval conditions are established (where possible). Associated transport, refining and Port activities will continue throughout the referral and assessment process subject to MS719, and exploration will also continue for the purpose of the Project.

2.7. JUSTIFICATION FOR THE PROPOSAL

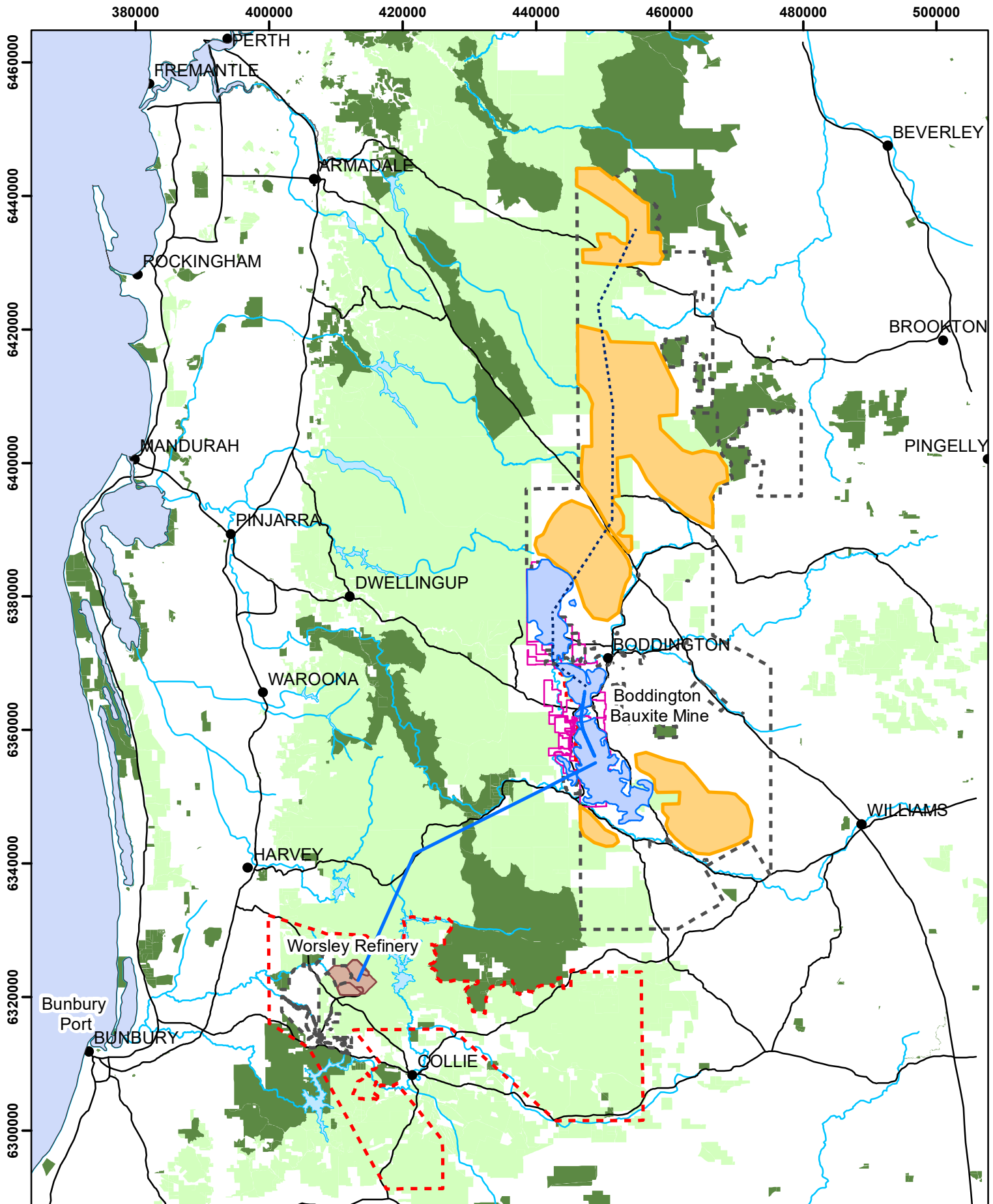
Worsley has considered a number of alternative designs and approaches throughout the planning and development of this proposal. All options consider environmental, social and financial aspects together with operational efficiencies and the 10 Year Mine Plan. Some of the key considerations still being evaluated include the routes for truck haulage and the long-term conveyor within the Bauxite Transport Corridor. Environmental and social factors comprise critical components of the consideration of these routes and are incorporated into internal mine and asset planning processes at Worsley.

Worsley has considered a 'no development alternative' for the proposal. The impacts to environmental values, described in **Section 4**, under 'no development alternative' would be lower within the proposed mine expansion areas, as the Worsley's Pre-existing Approval Area would not be expanded.

The social and economic values under 'no development alternative' would result in a loss of taxation and mining royalties for both the State and Commonwealth Governments, as Worsley is a long-term operation. Under this alternative, there would be fewer employment opportunities and reduced economic growth within both the local and broader region including the Shires of Boddington, Dardanup, Harvey and Collie, and the City of Bunbury.

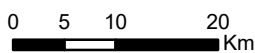
Although this proposal will have a greater environmental impact than current operations, it will also allow mining to proceed in and adjacent to already disturbed areas (including farmland), and be progressively rehabilitated in a way that has the potential to reduce overall impact from having many areas open at one time.

This proposal will allow for the expansion and the continuation of existing activities at the already approved refinery production capacity of 4.7 Mtpa, while allowing impacts to be more holistically assessed and increasing the efficiency and effectiveness of environmental management.



Legend

- - - Historical Indicative Transport alignments (MS719 and EPBC Act Approval 2004/1566)
- Existing Conveyors
- Pre-existing Approval Area (PBA)
- Extended Mining Areas (Part B MS719 and EPBC Act approval 2004/1566)
- M1SA Sub-lease
- M70 Mining Leases
- M258SA
- Refinery Lease Area
- Roads
- Rivers

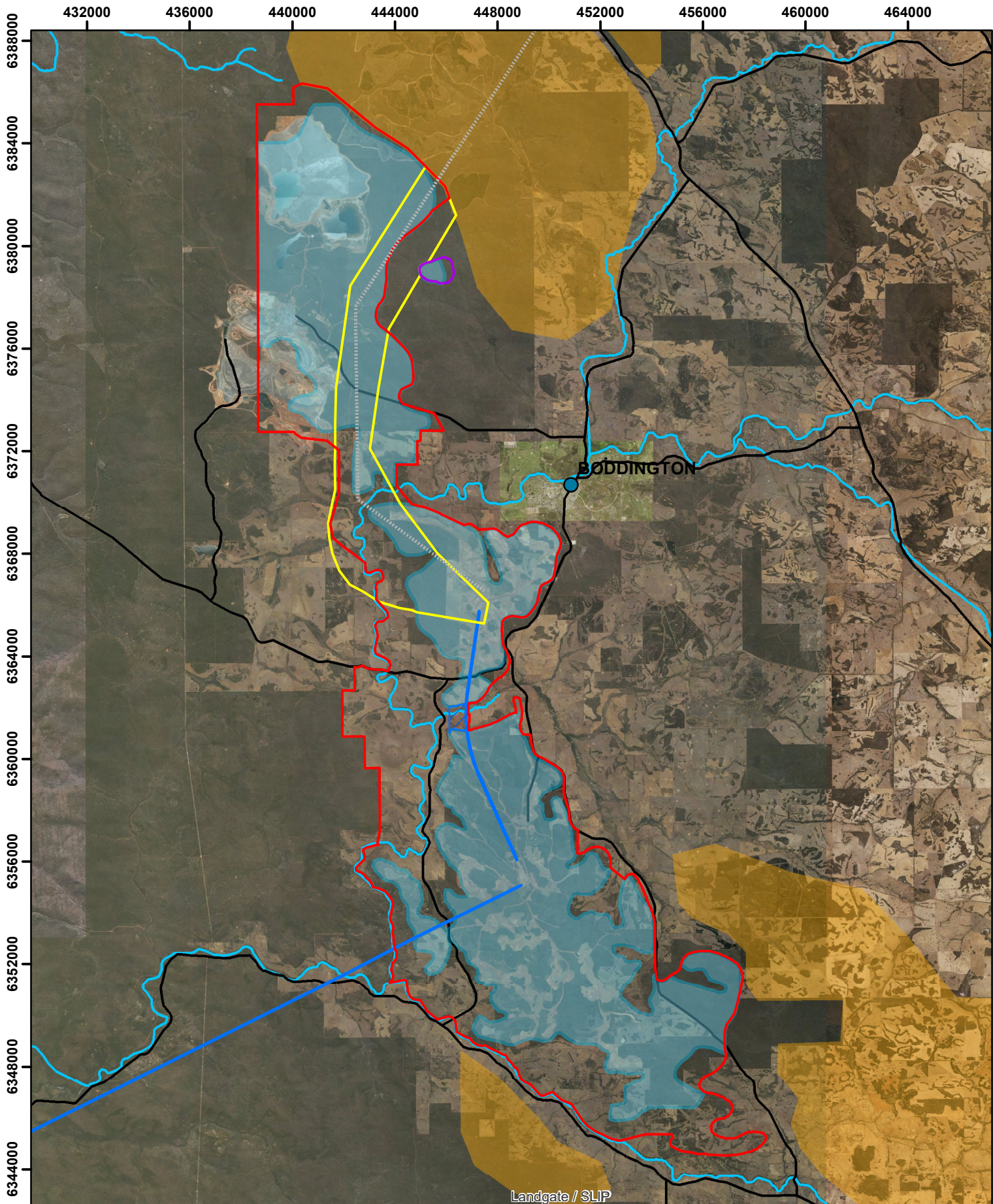


South32 Worsley Alumina Pty Ltd

Worsley Project Location

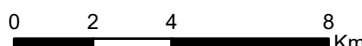
Created by: KNN
 Created: March 2019
 Co-ordinate System: GDA 1994 z50
 Ref: WME Referral - Project Location.mxd

Figure 1



Legend

- Indicative Bauxite Transport Corridor (MS719 and EPBC Act Approval 2004/1566)
- Extended Mining Areas (Part B MS719 and EPBC Act approval 2004/1566)
- Release Area
- Proposed Worsley Mining Development Envelope
- Proposed Bauxite Transport Corridor
- Pre-existing Approval Area (PBA)
- Existing Conveyors
- Roads
- Rivers

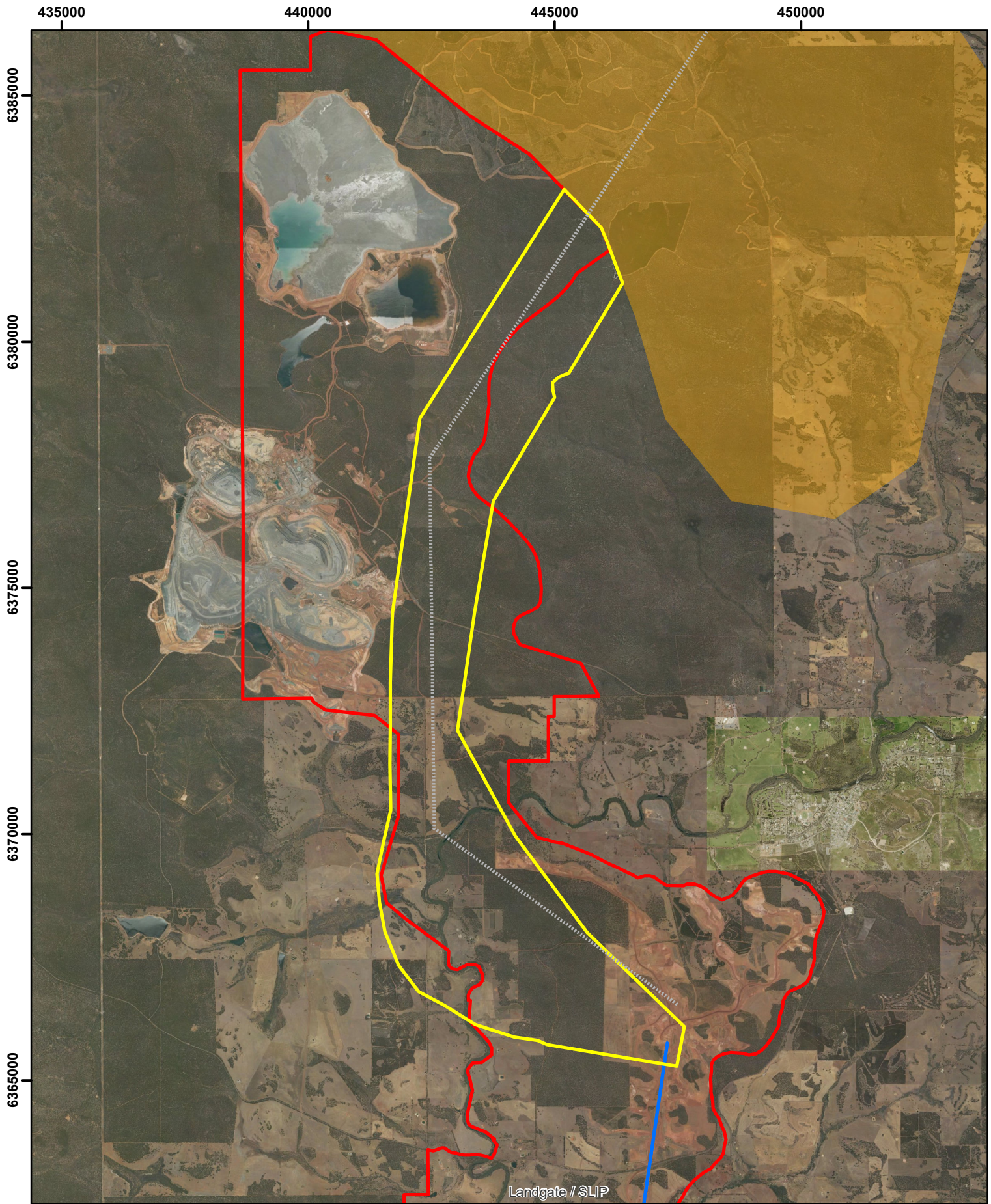


South32 Worsley Alumina Pty Ltd

Worsley Mine Expansion Proposal Overview

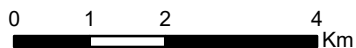
Created by: KNN
 Created: March 2019
 Co-ordinate System: GDA 1994 z50
 Ref: WME Referral - Proposal Overview.mxd

Figure 2



Legend

- Indicative Bauxite Transport Corridor (MS719 and EPBC Act Approval 2004/1566)
- ▭ Proposed Bauxite Transport Corridor
- ▭ Proposed Worsley Mining Development Envelope
- ▭ Extended Mining Areas (Part B MS719 and EPBC Act approval 2004/1566)
- ▭ Existing Conveyors



South32 Worsley Alumina Pty Ltd

Proposed Bauxite Transport Corridor Envelope

Created by: KNN
 Created: March 2019
 Co-ordinate System: GDA 1994 z50
 Ref: WME Referral - BTCE.mxd

Figure 3

410000

412000

414000

416000

6326000

6324000

6322000

6320000

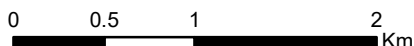
6318000



Landgate / SLIP

Legend

- Proposed Contingency Bauxite Mining Envelope
- M258SA
- Refinery Lease Area
- Freshwater Lake



South32 Worsley Alumina Pty Ltd

Proposed Contingency Bauxite Mining Envelope

Created by: KNN
 Created: March 2019
 Co-ordinate System: GDA 1994 z50
 Ref: WME EPBC Referral - CBME.mxd

Figure 4

410000

412000

414000

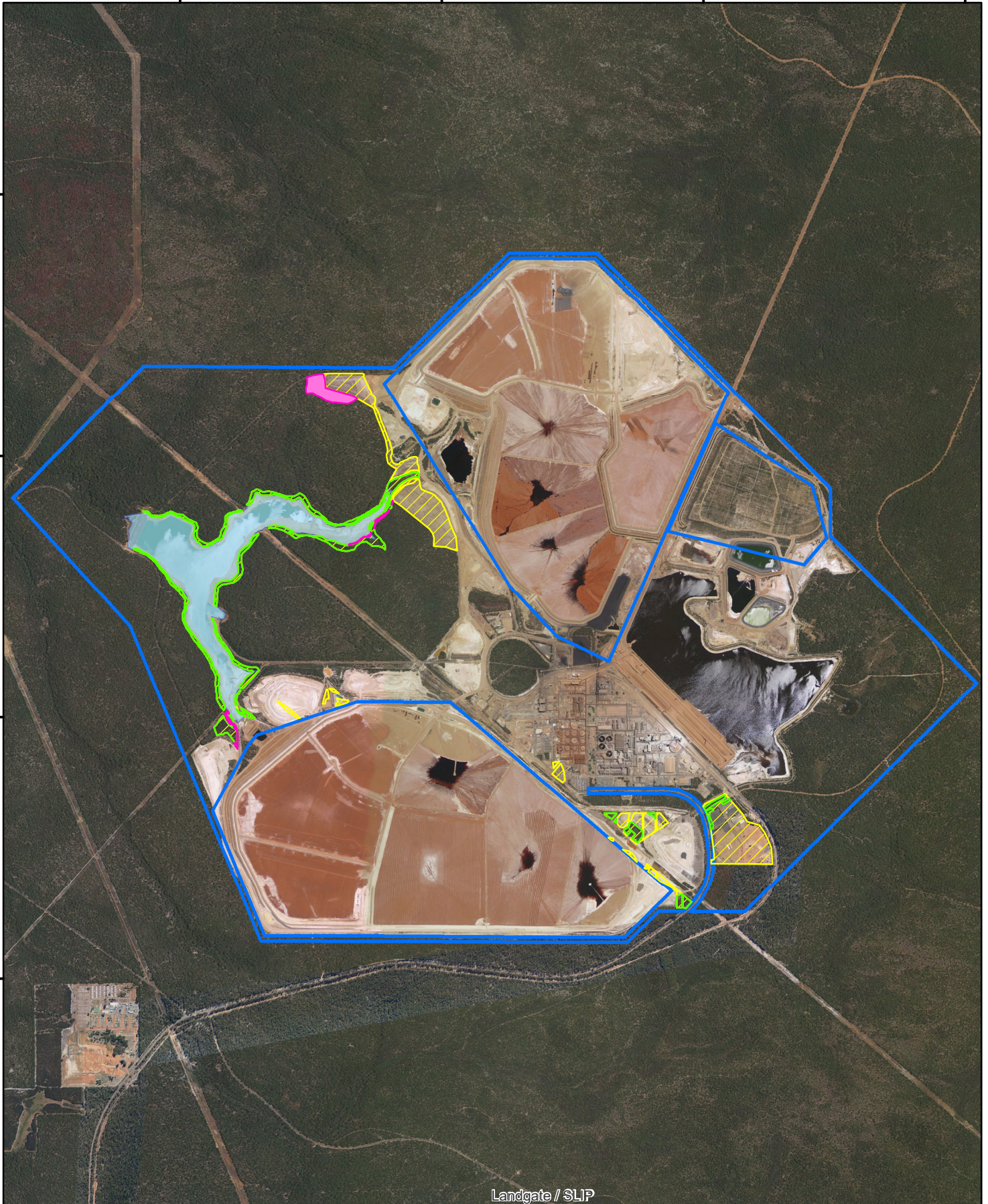
416000

6326000

6324000

6322000

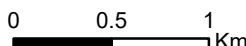
6320000



Landgate / SLIP

Legend

- Proposed Additional Clearing Areas (4.5 ha)
- Existing Approved Areas for Maintenance - Not cleared (20.46 ha)
- Existing Approved Areas for Maintenance - Cleared (46.14 ha)
- Freshwater Lake
- Refinery Lease Area



South32 Worsley Alumina Pty Ltd

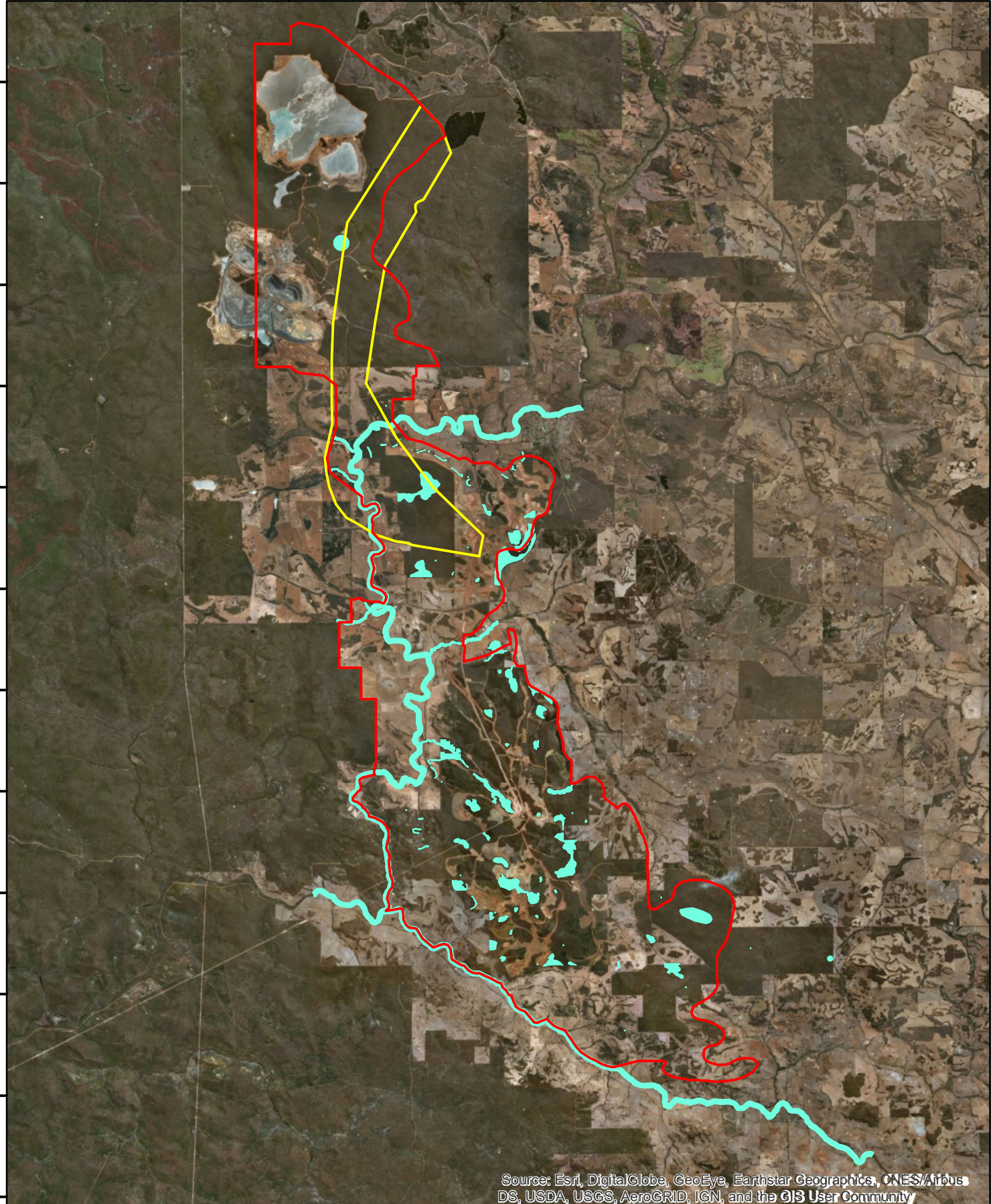
Proposed Clearing for Maintenance Within Refinery Lease Area

Created by: KNN
 Created: March 2019
 Co-ordinate System: GDA 1994 z50
 Ref: WME Referral - RLA Clearing.mxd

Figure 5

432000 436000 440000 444000 448000 452000 456000 460000 464000

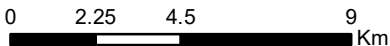
6384000
6380000
6376000
6372000
6368000
6364000
6360000
6356000
6352000
6348000
6344000
6340000



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Proposed Worsley Mining Development Envelope
- Proposed Bauxite Transport Corridor
- Indicative Protected Areas (as per Worsley Protected Areas Procedure)



South32 Worsley Alumina Pty Ltd

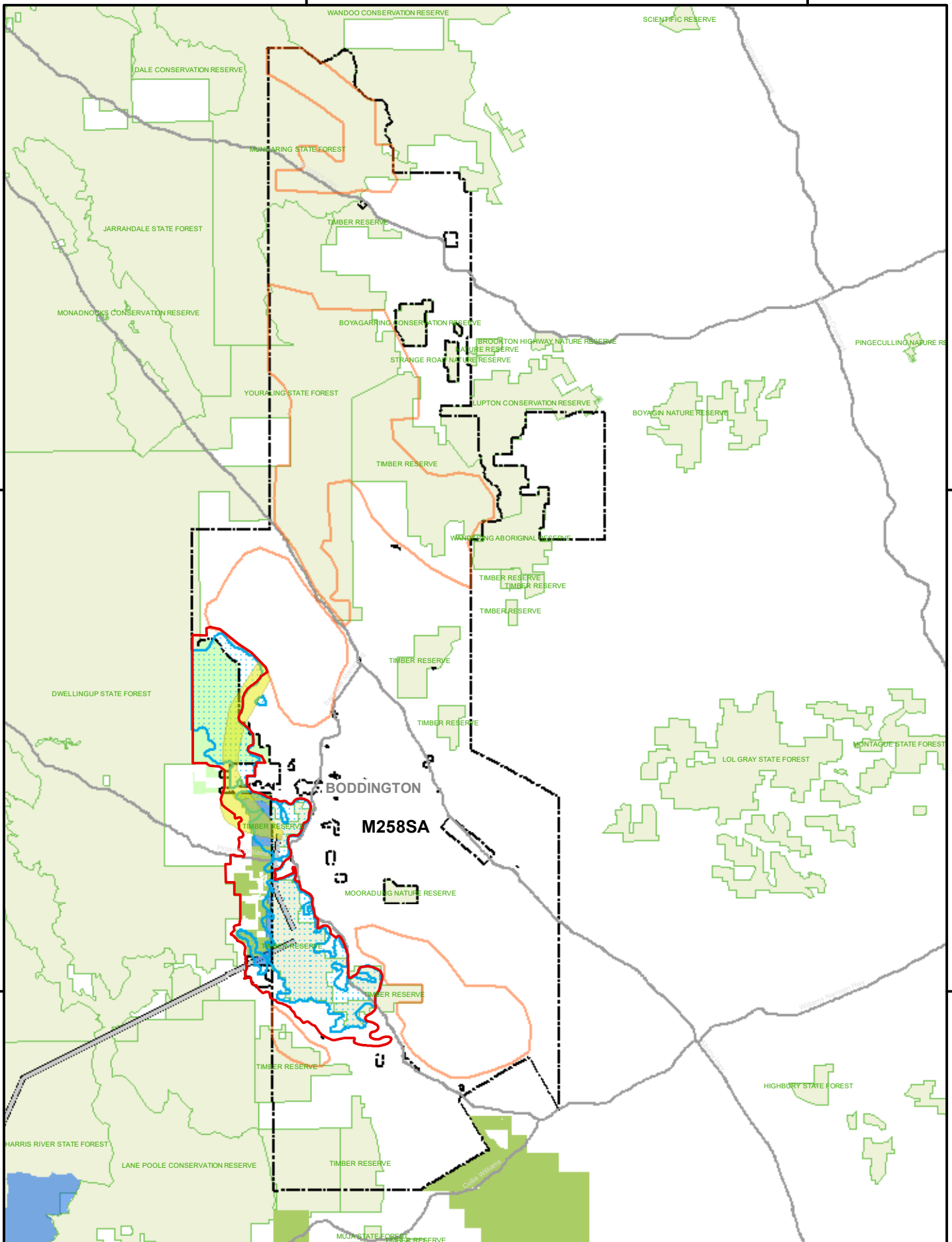
Indicative Protected Areas within the Worsley Mining Development Envelope

Created by: KNN
Created: March 2019
Co-ordinate System: GDA 1994 z50
Ref: WME Referral - Areas of Potential HCV.mxd

Figure 6

450000

500000



6400000

6400000

6350000

6350000

450000

500000



0 17.5
Kilometres

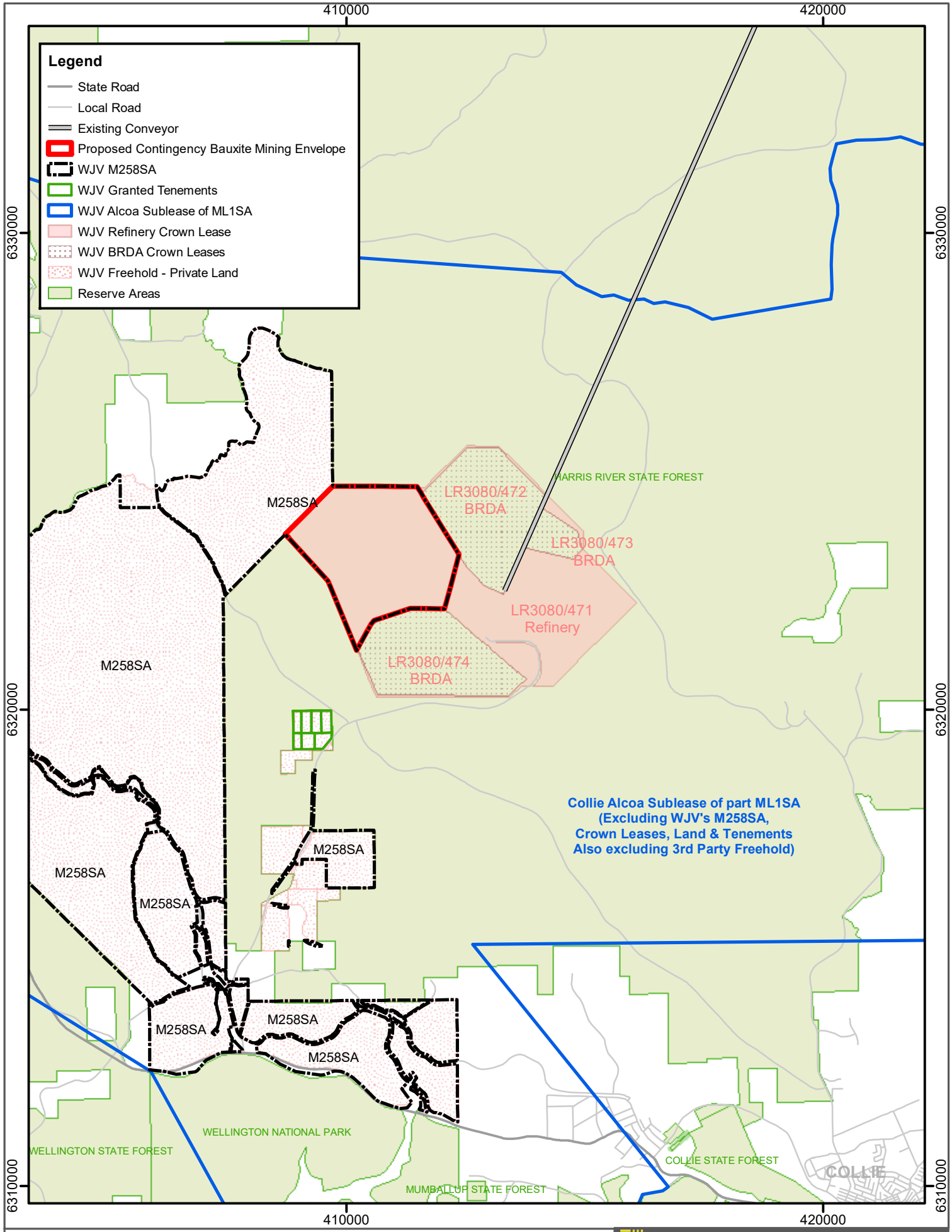
Coordinate System: GDA 1994 MGA Zone 50

- Proposed WMDE
- Proposed Bauxite Transport Corridor
- Pre-existing Approval Area
- Extended Mining Areas
(Part B MS719 and EPBC Act approval 2004/1566)
- State Road
(Part B MS 719 and EPBC Act approval 1566/2004)
- M258SA
- WJV Tenement Granted - WJV managed
- WJV Tenement Granted - NBG managed
- WJV Alcoa Sublease of ML1SA
- WJV Existing Conveyor
- Reserve Areas

SOUTH32 WORSLEY JOINT VENTURE

WORSLEY MINING
Worsley Mine Development Envelope
Summary of Tenure Arrangements

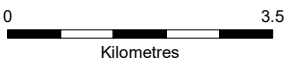
Date: 06/03/2019	Author: C Sullivan	Plan No: WME Referral
Scale: 1:500,000	Figure No: 7	Land & Tenure V1



Legend

- State Road
- Local Road
- Existing Conveyor
- ▭ Proposed Contingency Bauxite Mining Envelope
- ▭ WJV M258SA
- ▭ WJV Granted Tenements
- ▭ WJV Alcoa Sublease of ML1SA
- ▭ WJV Refinery Crown Lease
- ▭ WJV BRDA Crown Leases
- ▭ WJV Freehold - Private Land
- ▭ Reserve Areas

Collie Alcoa Sublease of part ML1SA
(Excluding WJV's M258SA,
Crown Leases, Land & Tenements
Also excluding 3rd Party Freehold)



Coordinate System: GDA 1994 MGA Zone 50

SOUTH32 WORSLEY JOINT VENTURE

WORSLEY REFINERY
Contingency Bauxite Mining Envelope
Summary of Tenure Arrangements

Date: 06/03/2019	Author: C Sullivan	Plan No:
Scale: 1:100,000	Figure No: 8	Land & Tenure Refinery

3. STAKEHOLDER ENGAGEMENT

3.1. ENGAGEMENT FOR THE PROPOSAL

Worsley has undertaken significant and ongoing engagement with stakeholders and community members throughout the evolution of this proposal. Whilst engagement continues, some of the key stakeholders have included:

- State Government agencies, including the EPA, DWER, DBCA, DMIRS, Department of Planning, Lands and Heritage, and the Department of Jobs, Tourism, Science and Innovation;
- The Commonwealth Department of Environment and Energy (DoEE);
- Local Government agencies including the Shires of Boddington, Collie, Harvey, Williams and Wandering;
- Traditional Owners and Heritage representative groups, including the Gnaala Karla Booja and SWALSC;
- Individual landowners in the area surrounding BBM;
- Other mining companies operating in and around the southwest;
- Environmental groups including the Friends of Reserves Boddington; and
- Community representatives.

A summary of stakeholder engagement to date is provided in **Table 4**. Worsley will continue to engage with all relevant stakeholders, community groups and Non-Governmental Organisations (NGOs) throughout the environmental impact assessment process and established liaison will continue.

3.2. WORSLEY COMMUNITY ENGAGEMENT

Worsley convenes a Community Liaison Committee (CLC) meeting every quarter for the mine and the Refinery. The CLC comprises members of the community, local government and local businesses. Topics discussed in the committee meetings include environmental management, community development, community complaints, energy supply, local procurement and other South32 business-wide information. The proposal to expand existing operations at the mine has been discussed at the CLC meetings since 2017 and any questions regarding the approvals process or the details of the proposal in general have been answered by the South32 team.

At the Refinery, there is a 'Friends of Worsley' group comprising neighbours and landowners. Meetings are held bimonthly to discuss matters, such as land management and local history. Attendees to the meeting have also been updated on the progress of the proposal and its ongoing development since 2016. Worsley also provides information to the community about its mining, refining and shipping activities through displays, brochures, newsletters, tours, the South32 website and local media.

Other ongoing community engagement undertaken includes regular contact between the South32 Worsley company representatives and current mine neighbours, engagement with future mine neighbours, community forums for the Shire of Boddington, presentations to interested groups and meetings with Local and State Government stakeholder agencies. Worsley also maintains communication with State Government and the various agencies that sit on the EMLG, a long standing representative committee that oversees Worsley's activities and advises on planning matters such as the 10 Year Mine Plan.

Table 4: Summary of Stakeholder Engagement associated with the Proposal

Stakeholder	Date of Communication	Topics/Issues Raised	Proponent Response/Outcome
Department of Water and Environmental Regulation (EPA Services Unit)	21 February 2017.	This pre-referral meeting discussed the proposal including activities and potential impacts relating to flora and vegetation.	Inform only.
	7 November 2018	South32 formally sent request letter to Chairman of EPA requesting termination of Hotham Mining Extension referral. Followed up by phone and email with Nyomi Bowers.	Termination process formally commenced.
	19 November 2018	Pre-referral meeting with EPA to discuss approach to Revised Proposal, and termination of previous Hotham Mine Expansion referral.	EPA and South32 agreed on approach to Revised Proposal. Referral was formally terminated on 28 November 2018.
	10 December 2018	Pre-referral meeting to discuss Revised Proposal, impacts and management measures associated with proposal.	Expected Referral submission end of December 2018.
	12 February 2019	Joint pre-referral meeting with DoEE to discuss proposal scope clarification, assessment starting point, alignment of EP and EPBC referral documents, and potential for an accredited assessment.	Expected Referral submission March 2019.
Premier of Western Australia, Mark McGowan	4 November 2018	South32 CEO, Graham Kerr, met with Premier of Western Australia Mark McGowan for a general meeting on a range of issues. Expansion proposal and S38 Referral process generally discussed.	Inform only.
Department of Environment and Energy	16 October 2018	Phone call with DoEE officers to provide an update on referral process and potential changes to the proposal. Discussion on general offset requirements and process.	General advice provided by DoEE on offsets. No concerns with the potential changes to the proposal.
	6 December 2018	Termination of previous Hotham Mine Extension referral from EPBC Act assessment process.	South32 sent notice of request.

Stakeholder	Date of Communication	Topics/Issues Raised	Proponent Response/Outcome
	6 December 2018	Termination of previous Hotham Mine Extension referral from EPBC Act assessment process.	DoEE confirmation of valid request for termination of previous referral from EPBC Act assessment process.
	January 2019	Liaison with Matt Whitting and Rod Whyte at the DoEE to set up a meeting to provide an overview of the Project, the proposal and approvals history.	Meeting scheduled for 30 January 2019.
	30 January 2019	Pre-referral with Angela Gilman and Cassandra Elliot to discuss overview of proposal and historical context, identification of key issues for DoEE under the EPBC Act (WMDE, MNES and Offsets) and possibility of an accredited assessment.	Joint meeting scheduled with DoEE on 12 February 2019.
	12 February 2019	Joint pre-referral meeting with DoEE to discuss proposal scope clarification, assessment starting point, alignment of EP and EPBC referral documents, and potential for accredited assessment.	Expected Referral submission March 2019.
Department of Biodiversity, Conservation and Attractions (DBCA)	18 October 2016	Requirements for flora and fauna surveys on State Forest and private property were discussed at this meeting. Meeting outcomes included agreement on Level 1 surveys for private property.	Inform only.
Department of Planning, Lands and Heritage (DPLH)	7 September 2018	South32 requesting that the spatial boundary of Hotham River be corrected.	Request tracking through the system.
	November 2018	Following discussion Worsley has applied for consent to conduct geotechnical investigations within Unallocated Crown Land around the Hotham River.	Application submitted on 3 December 2018.
	December 2018	Emails between DPLH Heritage unit and South32 on spatial update to boundary of Hotham River heritage site.	Spatial update approved by the Aboriginal Cultural Material Committee and progressing through system.

Stakeholder	Date of Communication	Topics/Issues Raised	Proponent Response/Outcome
Department of Jobs, Tourism, Science and Innovation (DJTSI)	29 August 2018	Meeting between South32 (Mine Planning, Corporate Affairs and Environment) and Project Facilitation on general mine matters including an update of S38 Referral.	Inform only. South32 to keep DJTSI updated as the project progresses.
	12 September 2018	Telephone conversation between South32 and DJTSI – update on progress with S38 Referral.	Inform only.
	12 October 2018	Telephone conversation between South32 and DJTSI - update on progress with S38 Referral.	Inform only.
	November 2017	Telephone conversation between South32 and DJTSI - update on progress with S38 Referral and feedback from EMLG meeting.	Inform only.
Department of Mines and Industry Regulation (DMIRS)	Ongoing	South32 seeking general information about Mining Proposals, Programmes of Work and Miscellaneous tenure applications.	N/A
Environmental Management Liaison Group			
Various State Government departments including EPA, DMIRS, DJTSI, DBCA and DWER	November 2017	Annual EMLG meeting held at the Worsley operations involving various State Government departments. Overview of environmental approvals was provided by South32 personnel. No major concerns were raised.	Inform only.
	November 2018	Annual EMLG meeting held at the Worsley operations involving various State Government departments. Overview of environmental approvals was provided by South32 personnel including the likely termination of the previous referral due to internal changes to the proposal. No major concerns were raised. DBCA queried the level of change and clearing differences between both proposals – at that stage the indicative mining footprint was being	Inform only.

Stakeholder	Date of Communication	Topics/Issues Raised	Proponent Response/Outcome
		determined but South32 indicated that the footprint would be greater.	
Local Government			
Shire of Boddington	1 December 2016	Meeting with the CEO and Shire President to advise that South32 are investigating the expansion of the operation and referral to the EPA under Section 38 of the EP Act likely to commence.	Discussions regarding the proposal are ongoing.
	20 December 2017	Meeting with CEO and Shire President to advise that South32 is still in the process of environmental approvals for the proposed expansion.	Ongoing discussions.
	22 March 2018	Meeting with the CEO to provide an update on Lower Hotham Road crossing, other future projects and seek information on Shire approvals processes.	Ongoing discussions.
	7 July 2018	Meeting with the CEO and staff to provide an update on the 10 Year Mine Plan with specific discussion on intersections of the plan with Tullis Reserve, North Bannister Area and proposed bike track locations.	Ongoing discussions.
	23 August 2018	Meeting with CEO and Economic Development Officer to provide an update on the expansion project.	Ongoing discussions.
	6 November 2018	South32 presented to the Shire Council on the expansion of the project into the Hotham area, with request for consent to conduct geotechnical investigations on Shire managed locations.	Ongoing discussions.
	6 November 2018	South32 requested formally via letter for Shire consent to conduct geotechnical investigations on Shire managed locations (once environmental approvals are obtained).	Preliminary advice received from Shire in relation to works in Shire managed areas.

Stakeholder	Date of Communication	Topics/Issues Raised	Proponent Response/Outcome
Shire of Williams	20 December 2016	Meeting with the CEO and Shire Present to advise that South32 are investigating the expansion of the operation and referral to the EPA under Section 38 of the EP Act likely to commence.	Inform only.
Shire of Wandering	20 February 2017	Meeting with the CEO and Shire Present to advise that South32 are investigating the expansion of the operation and referral to the EPA under Section 38 of the EP Act likely to commence.	Inform only.
Other Commercial Operators			
NBG	Ongoing	Access for geotechnical, biological investigations and potential infrastructure agreements. Quarterly meetings are held between Worsley and NBG to discuss commercial arrangements and agreements.	Discussions ongoing.
Heritage			
SWALSC	10 December 2018	Meeting between South32 to discuss Noongar Heritage Agreement.	No major concerns with draft agreement. Discussions ongoing.
	8 March 2019	Meeting between South32 to discuss Noongar Heritage Agreement.	Minor changes to draft agreement. Discussions ongoing.
Gnaala Karla Booja	17 March 2017	South32 attended the Gnaala Karla Booja Working Party Meeting to present about the expansion proposal and the proposed approach to heritage assessment.	Survey has been carried out with the Gnaala Karla Booja representatives of part of the Hotham River heritage site with Brad Goode and Associates (consultant).

	22 May 2019 (Tentative)	South32 scheduled to provide an overview and update on the Worsley Mine Expansion (Revised Proposal).	Inform only.
Worsley Community Meetings			
Community Liaison Committee	12 January 2016	The CLC was advised by the Worsley Mine Planning team of the proposed mining extension area and the expected environmental approval process under the EP Act.	Informed during meeting. No further actions.
	3 September 2017	The CLC was further updated by the Worsley Mine Planning team of the proposed mining extension area and the environmental approvals process under the EP Act.	Informed during meeting. No further actions.
	23 August 2018	Worsley presented an update on the Hotham Mining Extension and stages of the environmental approvals process.	Informed during meeting. No further actions.
	29 November 2018	Presentation including an overview of the proposed mining expansion and specifically the geotechnical investigation works planned for early 2019.	Informed during meeting. No further actions.
	28 February 2019	Presentation including an overview of the Worsley Mine Expansion environmental approval process.	Informed during meeting. No further actions.
Broader Community	6 March 2019	Story published on the Worsley Mine Expansion environmental approvals process included in 'Worsley News' newsletter insert in Bodd News community newsletter.	Information only. No further actions.
Environmental Groups			
Friends of Reserves Boddington	1 December 2016	South32 advised the group of the proposed mining expansion. Concerns were raised regarding the banding of the birds.	Informed during meeting. No further actions.
	9 February 2017	Discussions were held regarding the proposed expansion of mining activities. No major concerns but the group	No further actions.

		wanted to ensure that Worsley did their best to protect the area of West Marradong where the banding of birds occurs.	
--	--	---	--

4. ASSESSMENT OF PRELIMINARY KEY ENVIRONMENTAL FACTORS

The following preliminary key environmental factors in the Primary Assessment Area have been identified as applicable to the key expansions revisions and amendments which are part of this referral:

- Flora and vegetation;
- Terrestrial environmental quality;
- Terrestrial fauna;
- Inland waters;
- Air quality; and
- Social surroundings.

Preliminary key environmental factors considered for the proposed continuation of existing operations (such as ongoing transport or Refinery operations), which are being referred for operation post approval of the expansions, revisions and amendments (only) are also included below where this is warranted by the level of ongoing and / or cumulative risk to the environment associated with these continuing operations.

4.1. FLORA AND VEGETATION

4.1.1. EPA Objective

The EPA applies the following objective from the *Statement of Environmental Principles, Factors and Objectives (EPA, 2016e)* in its assessment of proposals that may affect vegetation and flora:

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

4.1.2. Policy and Guidance

The following EPA guidelines and guidance have been considered in the assessment of flora and vegetation with respect to the EPA objective:

- EPA Statement of Environmental Principles, Factors and Objectives (EPA, 2016e);
- EPA Environmental Factor Guideline: Flora and Vegetation (EPA, 2016b); and
- EPA Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016f).

4.1.3. Receiving Environment

Extensive baseline flora and vegetation surveys have been undertaken over the life of the Project, with additional baseline flora studies conducted as operations have extended into new areas. A summary of the flora and vegetation studies undertaken for the Project is provided in **Table 5**.

Table 5: Summary of Flora and Vegetation Surveys undertaken for the Project

Report	Consultant	Survey Area	Survey Date	Purpose of Survey/Study and Details
Assessment of Flora and Vegetation within Expansion Survey Areas (Mattiske Consulting Pty Ltd 2019)	Mattiske	Primary Assessment Area	19 th – 22 nd November 2018	A study commissioned to define the flora and vegetation values of all the areas within the Primary Assessment Area that had not been previously mapped. The survey report consolidates scientific data obtained over the Worsley Project Area and is provided in Appendix A . Site Vegetation Units have been mapped to a detailed level across the entire Primary Assessment Area with the exception of 6 ha of native vegetation that could not be mapped due to restricted access and future mapping will occur to support studies for the Environmental Review Document. Appendix A also outlines a wealth of conservation significant flora details based on surveys undertaken over the years. The report essentially consolidates all known flora and vegetation data for Worsley's Project since the 1980s.
Assessment of Flora and Vegetation of Private Properties within the Extension Survey Areas (Mattiske Consulting Pty Ltd 2017)	Mattiske	Bauxite Mine Expansion Area. Equivalent to the HME	15 th – 18 th November 2016	Defines the flora and vegetation values of the private properties located in the Hotham region. The survey included sampling from 25 vegetation sites.
Assessment of Flora and Vegetation of Private Properties within the Extension Survey Areas (Mattiske 2014)	Mattiske	PBA Extension Survey Areas	30 th September to 9 th October 2014	Define the flora and vegetation values of the private properties located within PBA Extension Area. The survey included sampling from 207 sites to sample all vegetation types within the PBA Extension Areas.
Assessment of Flora and Vegetation Values on the Proposed WRL, the Potential Land Swap Area and the Southern Section of Hotham Farm, Boddington Gold Mine (Mattiske Consulting Pty Ltd 2013b)	Mattiske	BGM	2013	Site Vegetation Type classification, description and mapping, Threatened and Priority flora.
Vegetation Monitoring Plots Sotico Property (Mattiske Consulting Pty Ltd 2013b)	Mattiske	Sotico, north of BGM	November 2013	Re-assessment of nine permanent plots and an additional 12 permanent plots established in representative site-vegetation types on Sotico property.
Flora and Vegetation Survey of Hotham Farm Survey Area (Mattiske 2013a)	Mattiske	Hotham Farm	30 th October to 1 st November 2012	Define the flora and vegetation values of Hotham Farm. Specifically, characterises the vegetation communities, their condition, vascular flora presence, Threatened and Priority flora counts and locations, review of the local and regional

				significance of the identified vegetation communities and review of the conservation status of the flora. The survey included sampling from 22 sites to sample all vegetation types within the area.
Flora and Vegetation Survey of Nullaga Property Adjacent to Marradong Section of the Boddington Bauxite Mine (Mattiske 2012a)	Mattiske	Nullaga Property Intersects the PBA	30 th October to 1 st November 2012	Define the flora and vegetation values of Nullaga Property. Specifically, characterise the vegetation communities, their condition, vascular flora presence and review of the conservation status of the flora. The survey included sampling from 55 sites to sample all vegetation types within the area.
Flora and Vegetation of the Sotico Survey Area (Mattiske Consulting Pty Ltd 2012b)	Mattiske	Sotico, north of BGM	January 2012 to July 2012	Site Vegetation Type classification, description and mapping, Threatened and Priority flora. Recordings at 5847 sites.
Threatened and Priority Flora Assessment of the Hotham Pipeline and Hedges Dam, Newmont Boddington Gold Mine (Mattiske Consulting Pty Ltd 2012c)	Mattiske	Newmont Boddington Gold Mine	2012	Threatened and Priority Flora Assessment.
Vegetation Monitoring Plots Sotico Property (Mattiske Consulting Pty Ltd 2012d)	Mattiske	Sotico, north of BGM	November 2011	Nine permanent plots established in representative site-vegetation types on Sotico property.
Flora and Vegetation of Littleton's Cut Area (Mattiske Consulting Pty Ltd 2010a)	Mattiske	Littleton's Cut Area	2010	Site Vegetation Type classification, description and mapping, Threatened and Priority flora.
Flora and Vegetation Survey of Dobrowolskyi, Farmer, Hulls 1, Hulls 2, Nullaga, Pringles, Robins, Nichols, Salmeri and Spencer properties, Boddington (Mattiske Consulting Pty Ltd 2010c - I)	Mattiske	Dobrowolskyi, Farmer, Hulls 1, Hulls 2, Nullaga, Pringles, Robins, Nichols, Salmeri and Spencer properties, Boddington	2010	Site Vegetation Type classification, description and mapping, Threatened and Priority flora.
Flora and Vegetation on Marradong Forest Block Boddington (Mattiske 2008)	Mattiske	Marradong Timber Reserve Within the PBA	2007	Update earlier botanical studies on the Marradong Timber Reserve as undertaken Mattiske (1990). Specifically, update flora records with recent taxonomic name changes, establish vegetation monitoring sites and extend the vegetation mapping program to include nearby and adjacent private land holdings.

Flora and Vegetation on the Collie RLA (Mattiske Consulting Pty Ltd 2007)	Mattiske	Collie Refinery	2007	Update earlier botanical studies on the Collie Refinery.
Review of Flora and Vegetation located in the Boddington Gold Mine and Hedges Lease Areas (Mattiske Consulting Pty Ltd 2005)	Mattiske	Newmont Boddington Gold Mine	2005	Flora and Vegetation Review of BGM and Hedges Lease Area.
Review of Flora and Vegetation located in the Boddington Gold Mine and Hedges lease areas (Mattiske Consulting Pty Ltd 2005)	Mattiske	BGM and Hedges Lease areas	2005	Extension and update of earlier Flora and Vegetation Studies on the BGM and Hedges areas. Recording on grids and in plots and targeted flora searches.
Assessment of Tunnell Road Heath Communities, Boddington Bauxite Mine (Mattiske Consulting Pty Ltd 2004a)	Mattiske	Tunnell Road heath, Mt Saddleback operations	2004	Assessment of heath communities, monitoring of quadrats in plots and transects.
Bennett Environmental Consulting (2004)	Bennett	Brookton and Central mining envelopes	August 2004	Define the flora and vegetation values of Brookton and Central mining envelopes.
Review of declared rare and priority flora species located in the Worsley Alumina Boddington Bauxite Mine lease areas (Mattiske Consulting Pty Ltd 2003)	Mattiske	Boddington lease areas	2003	Review of threatened and priority flora status and taxonomy.
Flora and Vegetation Survey Remnant Vegetation Devereux, Nichols and Veitch Properties - Boddington Bauxite Mine (Mattiske Consulting Pty Ltd 2002)	Mattiske	Devereux, Nichols and Veitch properties, Boddington	2002	Site Vegetation Type classification, description and mapping, Threatened and Priority flora.
Flora and Vegetation of the Quindanning Timber Reserve (Mattiske & Assoc. 1999b)	Mattiske	Quindanning Timber Reserve	1999	Forest Site Vegetation Type classification, description and mapping, Declared Rare Flora (DRF), Priority flora.
Worsley Alumina Boddington Gold Mine Project Flora and Fauna studies (Worsley Alumina Pty Ltd, 1999)	N/A	Hotham North	Surveyed in 1999 Further studies proposed prior to mining operations	Forest Site Vegetation Type classification, description and mapping, DRF, Priority flora.

Flora and Vegetation of the Quindanning Timber Reserve (E.M. Mattiske and Associates 1993a, 1993b, 1999b)	Mattiske	Quindanning Timber Reserve	1993a, 1993b, 1999	Site Vegetation Type classification, description and mapping, Threatened and Priority flora based on gridding of areas and regular recordings and plots and targeted searching for flora.
Vegetation Complexes of the Darling System, Western Australia. Regional Forest Agreement (RFA) Vegetation Complexes, Pinjarra, Western Australia. (Mattiske and Havel 1998)	Mattiske and Havel	Pinjarra component of RFA Vegetation Mapping	1998	Vegetation Complexes of the Darling System, based on broad relationships with underlying geology, landforms and soils and climatic zones with reference to key structural and floristic components of regional vegetation patterns.
Flora and Vegetation Studies on the Mount Saddleback Survey Area (Mattiske & Assoc. 1993a)	Mattiske	Mount Saddleback	1993a	Forest Site Vegetation Type classification, description and mapping.
Flora and vegetation studies on the southern Mount Saddleback survey area (Mattiske Consulting 1993d)	Mattiske	Mount Saddleback	1993d	Forest Site Vegetation Type classification, description and mapping.
Flora and Vegetation, Eastern Anomaly, Boddington Gold Mine (Mattiske Consulting Pty Ltd 1992)	Mattiske	BGM	1992	Site Vegetation Type classification, description and mapping based on grid mapping and also plots. Also, extensive targeted searching for Threatened and Priority Flora species (in particular <i>Gastrolobium</i> sp. Prostrate Boddington (M. Hislop 2130).
Flora and Vegetation Marradong Timber Reserve (Mattiske 1990)	Mattiske	Marradong Timber Reserve	Spring 1989	Botanical survey to characterise the vegetation and flora of the Marradong Timber Reserve. Specifically, review the local and regional significance of the vegetation communities identified, review the conservation status of the flora, record a range of botanical and physical parameters, and establish and monitor a series of permanent vegetation plots.
Mattiske Consulting Pty Ltd Flora and Vegetation Studies in Worsley Alumina Project, Flora and Fauna studies, Phase Two (Worsley Alumina Pty Ltd, 1985)	Mattiske	Mt Saddleback and surrounds	1985	Site Vegetation Type classification, description and mapping based on grid mapping and also plots. Undertaken in early 1980's. Also, extensive targeted searching for Threatened and Priority Flora species. Supplemented earlier studies by Worsley Alumina Pty Ltd and Dames and Moore (1981) for Phase One areas.
Vegetation Complexes of the Darling System, Western Australia. In: Atlas of Natural Resources of the Darling System, Western Australia, Chapter 3, Department of Conservation and	(Mattiske (nee Heddle)	Darling System	1980	Vegetation Complexes of the Darling System, based on broad relationships with underlying geology, landforms and soils and climatic zones with reference to key structural and floristic components of regional vegetation patterns.

Environment, Perth (Hedde et al. 1980)				
--	--	--	--	--

Regional Biogeography

The Project is located in the Jarrah Forest bioregion and Northern Jarrah Forest subregion as described by the Interim Biogeographic Regionalisation for Australia (IBRA). This subregion is characterised by Jarrah-Marri forest on laterite gravels, and in the eastern part, by woodlands of Wandoo-Marri on clayey soils. Eluvial and alluvial deposits support *Agonis* shrublands and in areas of Mesozoic sediments, Jarrah forests occur in mosaic with a variety of species-rich shrublands (Williams and Mitchell 2001).

The Primary Assessment Area supports land uses including mining, agriculture, native vegetation, plantation vegetation, water bodies such as dams and the Hotham and Williams Rivers, and extensively cleared pasture land.

Vegetation Association

Beard (1990) described the Jarrah forest as one of only two forest formations in Western Australia. Jarrah (*Eucalyptus marginata*) is the dominant tree species within this area and is commonly found in association with the Marri (*Corymbia calophylla*) in varying proportions. The Primary Assessment Area is entirely located within the Beard vegetation unit 17 – Eucalyptus woodland (Woodland; Jarrah, Forest; Jarrah).

Vegetation Types

Broad scale (1:250,000) pre-European vegetation mapping of the Pinjarra area was completed by Beard (1979). Beard has also recently updated the vegetation map for Western Australia (Beard *et al.* (2013). More detailed regional mapping of vegetation complexes by Heddle *et al.* (1980) and Mattiske and Havel (1998) for the System 6 and Regional Forest Agreement areas respectively provides a more detailed summary of the vegetation in the region.

The extent of these vegetation complexes as defined by Heddle *et al.* (1980) and Mattiske and Havel (1998) within the Primary Assessment Area are provided in **Table 6**, **Table 7** and **Table 8**, respectively.

Table 6: Extent of Vegetation Complexes within the WMDE

Vegetation Complex	Description	Pre-European Extent (ha)	Current Extent on Public Lands (ha)	Current Extent in Formal and Informal Reserves (ha) (%)	Extent within WMDE (ha)	Indicative Extent to be cleared (ha)
Ce	Cooke - Mosaic of open forest of <i>Eucalyptus marginata</i> subsp. <i>marginata</i> – <i>Corymbia calophylla</i> (sub humid zone) and open forest of <i>Eucalyptus marginata</i> subsp. <i>thalassica</i> – <i>Corymbia calophylla</i> (semiarid and arid zones) and on deeper soils adjacent to outcrops, closed heath of <i>Myrtaceae</i> – <i>Proteaceae</i> species and lithic complex on granite rocks and associated soils in all climatic zones, with some <i>Eucalyptus laeliae</i> (semiarid), and <i>Allocasuarina huegeliana</i> and <i>Eucalyptus wandoo</i> (mainly semiarid and perarid zones).	35,311.49	23,944.83	11,466.90 (34.85%)	2,595.04	559.28
Ck	Coolakin - Woodland of <i>Eucalyptus wandoo</i> with mixtures of <i>Eucalyptus patens</i> , <i>Eucalyptus marginata</i> subsp. <i>thalassica</i> and <i>Corymbia calophylla</i> on the valley slopes in arid and perarid zones.	133,887.40	34,491.35	21,281.14 (17.5%)	3,621.17	464.33
D4	Dwellingup 4 - Open forest of <i>Eucalyptus marginata</i> subsp. <i>thalassica</i> – <i>Corymbia calophylla</i> on lateritic uplands in semiarid and arid zones.	132,413.70	98,031.36	33,945.18 (26.14%)	9,021.16	2742.97
Mi	Michibin - Open woodland of <i>Eucalyptus wandoo</i> over <i>Acacia acuminata</i> with some <i>Eucalyptus loxophleba</i> on valley slopes, with low woodland of <i>Allocasuarina huegeliana</i> on or near shallow granite outcrops in arid and perarid zones.	134,538.90	8,850.98	7,692.71 (7.11%)	4,707.45	397.05
Pn	Pindalup - Open forest of <i>Eucalyptus marginata</i> subsp. <i>thalassica</i> – <i>Corymbia calophylla</i> on slopes and open woodland of <i>Eucalyptus wandoo</i> with some <i>Eucalyptus patens</i> on the lower slopes in semiarid and arid zones.	166,693.90	111,738.98	57,254.77 (35.1%)	1,998.16	602.02
S	Swamp - Mosaic of low open woodland of <i>Melaleuca preissiana</i> – <i>Banksia littoralis</i> , closed scrub of <i>Myrtaceae</i> spp., closed heath of <i>Myrtaceae</i> spp. and sedgelands of <i>Baumea</i> and <i>Leptocarpus</i> spp. on seasonally wet or moist sand, peat and clay soils on valley floors in all climatic zones.	53,656.45	36,097.78	25,381.85 (47.5%)	872.77	57.01

Wi	<i>Williams</i> - Mixture of woodland of <i>Eucalyptus rudis</i> – <i>Melaleuca raphiophylla</i> , low forest of <i>Casuarina obesa</i> and tall shrubland of <i>Melaleuca</i> spp. on major valley systems in arid and perarid zones.	23,485.85	524.47	105.38 (0.49%)	1,194.03	9.59
Y5	<i>Yalanbee 5</i> - Mixture of open forest of <i>Eucalyptus marginata</i> subsp. <i>thalassica</i> – <i>Corymbia calophylla</i> and woodland of <i>Eucalyptus wandoo</i> on lateritic uplands in semiarid and perarid zones.	124,375.00	56,414.66	30,522.62 (29.6%)	1,457.03	709.94
Y6	<i>Yalanbee 6</i> - Woodland of <i>Eucalyptus wandoo</i> – <i>Eucalyptus accedens</i> , less consistently open forest of <i>Eucalyptus marginata</i> subsp. <i>thalassica</i> – <i>Corymbia calophylla</i> Mixture of open forest of <i>Eucalyptus marginata</i> subsp. <i>thalassica</i> – <i>Corymbia calophylla</i> on lateritic uplands and breakaway landscapes in arid and perarid zones.	158,390.00	47,445.98	34,464.76 (22.9%)	2,329.39	387.70

The alignment of the proposed infrastructure within the Bauxite Transport Corridor has not yet been determined. It is proposed that the construction of this infrastructure will require the clearing of up to 940 ha based on indicative infrastructure calculations and that the actual footprint will be significantly less once a final route is determined. It is also expected that the routes will be located on already disturbed land (in the form of pastoral area) where practicable, reducing the overall environmental impact. Further information on the alignment will be presented in the Environmental Review Document. Therefore, at this stage, the clearing requirement of each vegetation complex within the Bauxite Transport Corridor in **Table 7** cannot be provided. The areas as shown in **Figure 6** (protected areas in this figure are indicative only and will be ground-truthed in Environmental Review Document technical studies) will also be avoided, where practicable, for the transport routes within the Bauxite Transport Corridor.

Table 7: Extent of Vegetation Complexes within the Bauxite Transport Corridor

Vegetation Complex	Description	Pre-European Extent (ha)	Current Extent on Public Lands (ha)	Current Extent in Formal and Informal Reserves (ha)	Indicative Extent within the Bauxite Transport Corridor (ha)
Ce	<i>Cooke</i> - Mosaic of open forest of <i>Eucalyptus marginata</i> subsp. <i>marginata</i> – <i>Corymbia calophylla</i> (sub humid zone) and open forest of <i>Eucalyptus marginata</i> subsp. <i>thalassica</i> – <i>Corymbia calophylla</i> (semiarid and arid zones) and on deeper soils adjacent to outcrops, closed heath of Myrtaceae – Proteaceae species and lithic complex on granite rocks and associated soils in all climatic zones, with some <i>Eucalyptus laeliae</i> (semiarid), and <i>Allocasuarina huegeliana</i> and <i>Eucalyptus wandoo</i> (mainly semiarid and perarid zones).	35,311.49	23,944.83	11,466.9 (34.85%)	189.01
Ck	<i>Coolakin</i> - Woodland of <i>Eucalyptus wandoo</i> with mixtures of <i>Eucalyptus patens</i> , <i>Eucalyptus marginata</i> subsp. <i>thalassica</i> and <i>Corymbia calophylla</i> on the valley slopes in arid and perarid zones.	133,887.40	34,491.35	21,281.14 (17.5%)	153.94

Vegetation Complex	Description	Pre-European Extent (ha)	Current Extent on Public Lands (ha)	Current Extent in Formal and Informal Reserves (ha)	Indicative Extent within the Bauxite Transport Corridor (ha)
D4	Dwellingup 4 - Open forest of <i>Eucalyptus marginata</i> subsp. <i>thalassica</i> – <i>Corymbia calophylla</i> on lateritic uplands in semiarid and arid zones.	132,413.70	98,031.36	33,945.18 (26.14%)	1,355.99
Mi	Michibin - Open woodland of <i>Eucalyptus wandoo</i> over <i>Acacia acuminata</i> with some <i>Eucalyptus loxophleba</i> on valley slopes, with low woodland of <i>Allocasuarina huegeliana</i> on or near shallow granite outcrops in arid and perarid zones.	134,538.90	8,850.98	7,692.71 (7.11%)	885.41
Pn	Pindalup - Open forest of <i>Eucalyptus marginata</i> subsp. <i>thalassica</i> – <i>Corymbia calophylla</i> on slopes and open woodland of <i>Eucalyptus wandoo</i> with some <i>Eucalyptus patens</i> on the lower slopes in semiarid and arid zones.	166,693.90	111,738.98	57,254.77 (35.1%)	690.09
S	Swamp - Mosaic of low open woodland of <i>Melaleuca preissiana</i> – <i>Banksia littoralis</i> , closed scrub of Myrtaceae spp., closed heath of Myrtaceae spp. and sedgelands of <i>Baumea</i> and <i>Leptocarpus</i> spp. on seasonally wet or moist sand, peat and clay soils on valley floors in all climatic zones.	53,656.45	36,097.78	25,381.85 (47.5%)	85.69
Wi	<i>Williams</i> - Mixture of woodland of <i>Eucalyptus rudis</i> – <i>Melaleuca raphiophylla</i> , low forest of <i>Casuarina obesa</i> and tall shrubland of <i>Melaleuca</i> spp. on major valley systems in arid and perarid zones.	23,485.85	524.47	105.38 (0.49%)	254.00
Y6	Yalanbee 6 - <i>Yalanbee 6</i> - Woodland of <i>Eucalyptus wandoo</i> – <i>Eucalyptus accedens</i> , less consistently open forest of <i>Eucalyptus marginata</i> subsp. <i>thalassica</i> – <i>Corymbia calophylla</i> Mixture of open forest of <i>Eucalyptus marginata</i> subsp. <i>thalassica</i> – <i>Corymbia calophylla</i> on lateritic uplands and breakaway landscapes in arid and perarid zones.	158,390.00	47,445.98	34,464.76 (22.9%)	531.57

Table 8: Extent of Vegetation Complexes within the CBME and Indicative Clearing Requirements

Vegetation Complex	Description	Pre-European Extent (ha)	Current Extent on Public Lands (ha)	Current Extent in Formal and Informal Reserves (ha)	Extent within CBME (ha)	Indicative Extent to be cleared for contingency mining(ha)	Indicative Extent to be cleared for maintenance purposes (ha)
D1	Dwellingup 1 - Open forest of <i>Eucalyptus marginata</i> subsp. <i>marginata</i> – <i>Corymbia calophylla</i> on lateritic uplands in mainly humid and sub humid zones.	208,270.90 (ha)	172,012.10 (ha)	30,351.77 (ha) (14.68%)	320.74	175.82	4.15
My1	Murray 1 - Open forest of <i>Eucalyptus marginata</i> subsp. <i>marginata</i> – <i>Corymbia calophylla</i> – <i>Eucalyptus patens</i> on valley slopes to a fringing woodland of <i>Eucalyptus rudis</i> – <i>Melaleuca raphiophylla</i> on the valley floors in humid and sub humid zones.	68,617.87 (ha)	43,508.75 (ha)	24,574.69 (ha) (36.02%)	389.28	62.28	0.35
Yg1	Yarragil 1 - Open Forest of <i>Eucalyptus marginata</i> subsp. <i>marginata</i> – <i>Corymbia calophylla</i> on slopes with mixtures of <i>Eucalyptus patens</i> and <i>Eucalyptus megacarpa</i> on the valley floors in humid and sub humid zones.	80,060.95 (ha)	59,058.69 (ha)	23,746.40 (ha) (29.86%)	37.21	11.95	0

Site Vegetation Types

Flora and vegetation surveys have been undertaken at a local scale to further define and map site vegetation types based on the earlier studies of Havel (1975a and 1975b). These site vegetation types incorporate underlying landforms, soils and key indicator species that reflect the relationships between landforms, soils and plant species. At this juncture it is not feasible to determine the regional extent of the site vegetation types as the mapping at this scale has not been undertaken over the wider Jarrah forests.

The site vegetation types for the Primary Assessment Area have been expanded by Mattiske over decades from the early 1980's to 2018. The extent of the site vegetation types within the Primary Assessment Area and their indicative extents to be cleared are provided in **Table 9**, **Table 10** and **Table 11**, respectively. An overview of the Site Vegetation Types within the WMDE the Bauxite Transport Corridor is shown in **Figure 9** and in **Figure 10** for the CBME. Detailed vegetation mapping is provided in **Appendix A**.

Table 9: Extent of Site Vegetation Types within the WMDE

Site Vegetation Type Code	Description	Extent within the WMDE (ha)	Indicative Extent to be cleared (ha)
A	Tall shrubland of <i>Melaleuca lateritia</i> , <i>Hakea varia</i> , <i>Melaleuca viminea</i> and <i>Melaleuca incana</i> subsp. <i>incana</i> on clay-loams in seasonally wet valley floors.	123.4	18.8
A1	Mixed tall shrubland of <i>Melaleuca viminea</i> , <i>Melaleuca lateritia</i> , <i>Taxandria linearifolia</i> , <i>Astartea scoparia</i> over <i>Baumea juncea</i> and <i>Lepidosperma tetraquetrum</i> with occasional patches of <i>Banksia littoralis</i> and <i>Melaleuca raphiophylla</i> over low herbs on seasonally water-logged clays and clay loams on valley floors.	2.9	0.0
A2	Low open woodland of <i>Melaleuca raphiophylla</i> over <i>Astartea scoparia</i> and low herbs on seasonally water-logged clays and clay loams in seasonally wet valley floors.	1.7	1.7
AC	Open woodland of <i>Eucalyptus wandoo</i> and <i>Eucalyptus rudis</i> over <i>Juncus pallidus</i> , <i>Astartea scoparia</i> , <i>Taxandria linearifolia</i> and <i>Lepidosperma tetraquetrum</i> over herbs on clay loams in seasonally wet valley floors.	34.2	0.0
AD	Low open woodland of <i>Eucalyptus rudis</i> and <i>Eucalyptus marginata</i> over <i>Banksia littoralis</i> , <i>Hakea prostrata</i> and <i>Pericalymma ellipticum</i> over low shrubs and herbs on leached sands over sandy-gravel on lower slopes.	4.7	0.0
AX	Open woodland of <i>Eucalyptus rudis</i> over <i>Acacia saligna</i> , <i>Melaleuca incana</i> subsp. <i>incana</i> and <i>Hypocalymma angustifolium</i> on clay- loams on valley floors.	196.0	17.7
AY	Open woodland of <i>Eucalyptus rudis</i> and <i>Eucalyptus wandoo</i> over <i>Acacia saligna</i> , <i>Hakea prostrata</i> and <i>Hypocalymma angustifolium</i> on clay- loams on valley floors.	405.6	107.6
AY/D	Mosaic of AY and D	5.3	0.5
D	Open forest of <i>Corymbia calophylla</i> and <i>Eucalyptus marginata</i> over <i>Hakea lissocarpha</i> , <i>Macrozamia riedlei</i> , <i>Acacia alata</i> , <i>Babingtonia camphorosmae</i> , <i>Hypocalymma angustifolium</i> and <i>Phyllanthus calycinus</i> on clay-loams on lower slopes.	382.1	158.2

Site Vegetation Type Code	Description	Extent within the WMDE (ha)	Indicative Extent to be cleared (ha)
DG	Open forest of <i>Corymbia calophylla</i> and <i>Eucalyptus marginata</i> over <i>Hakea lissocarpha</i> , <i>Macrozamia riedlei</i> , <i>Pericalymma ellipticum</i> , <i>Grevillea bipinnatifida</i> , <i>Allocasuarina humilis</i> , <i>Acacia alata</i> , <i>Babingtonia camphorosmae</i> , <i>Hypocalymma angustifolium</i> and <i>Phyllanthus calycinus</i> on clay-loams on lower slopes with localized patches of outcropping.	7.9	1.5
G	Open Heath of <i>Grevillea bipinnatifida</i> , <i>Hakea undulata</i> , <i>Banksia squarrosa</i> subsp. <i>squarrosa</i> , <i>Hakea incrassata</i> , <i>Hakea undulata</i> and <i>Petrophile serruriae</i> over <i>Borya sphaerocephala</i> on shallow soils and outcrops.	66.4	To be avoided
G1	Mosaic of open heath of Proteaceae - Myrtaceae spp. with emergent patches of <i>Eucalyptus drummondii</i> on shallow soils on slopes.	1.5	To be avoided
G2	Mosaic of open woodland of <i>Allocasuarina huegeliana</i> and closed heath of Proteaceae Myrtaceae spp. to Lithic Complex on exposed or shallow granite outcrops.	9.6	To be avoided
G3	Open heath of <i>Banksia squarrosa</i> subsp. <i>squarrosa</i> , <i>Hakea incrassata</i> , <i>Hakea undulata</i> , <i>Petrophile heterophylla</i> and <i>Petrophile serruriae</i> on shallow soils over granite outcrops on slopes with occasional emergent <i>Eucalyptus drummondii</i> .	71.7	To be avoided
G4	Open scrub and tall shrubland of <i>Hakea trifurcata</i> and <i>Hakea undulata</i> with admixtures of mallee species including <i>Eucalyptus latens</i> and <i>Eucalyptus aspersa</i> on clay to clay-loam soils over outcrops on slopes.	11.7	To be avoided
H	Open forest to woodland of <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> over <i>Petrophile striata</i> , <i>Daviesia decurrens</i> , <i>Daviesia longifolia</i> and <i>Daviesia rhombifolia</i> on sandy loam to sandy gravels on slopes and ridges.	1550.8	817.5
H1	Open forest to woodland of <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> over <i>Petrophile striata</i> , <i>Daviesia decurrens</i> and <i>Daviesia longifolia</i> on sandy-gravel soils of slopes and less undulating hills.	138.0	68.2
H2	Open forest to woodland of <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> with occasional admixtures of <i>Banksia grandis</i> and <i>Persoonia longifolia</i> over <i>Acacia celastrifolia</i> , <i>Daviesia preissii</i> , <i>Leucopogon capitellatus</i> and <i>Styphelia tenuiflora</i> on gravel and sandy-gravel soils of slopes and less undulating hills.	577.4	287.2
HG	Open forest to woodland of <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> over <i>Petrophile striata</i> , <i>Lepidosperma squamatum</i> , <i>Styphelia tenuiflora</i> , <i>Daviesia preissii</i> , <i>Daviesia decurrens</i> , <i>Grevillea bipinnatifida</i> , <i>Allocasuarina humilis</i> and <i>Hakea undulata</i> on shallower sandy-gravel soils over granites or secondary laterisation areas on slopes and less undulating hills.	50.7	25.3
L	Open woodland of <i>Eucalyptus patens</i> with some <i>Eucalyptus wandoo</i> over <i>Xanthorrhoea preissii</i> , <i>Macrozamia riedlei</i> , <i>Trymalium ledifolium</i> , <i>Acacia saligna</i> and <i>Hakea prostrata</i> on clay and clay loam soils on lower slopes.	32.9	10.3

Site Vegetation Type Code	Description	Extent within the WMDE (ha)	Indicative Extent to be cleared (ha)
M	Open woodland of <i>Eucalyptus wandoo</i> over <i>Trymalium ledifolium</i> , <i>Macrozamia riedlei</i> and <i>Hakea lissocarpha</i> on clay loams with some gravel on mid to upper slopes and ridges.	1545.2	500.9
M2	Woodland to open woodland of <i>Eucalyptus accedens</i> , <i>Eucalyptus wandoo</i> , <i>Eucalyptus marginata</i> , <i>Corymbia calophylla</i> over <i>Hakea lissocarpha</i> , <i>Macrozamia riedlei</i> , <i>Banksia squarrosa</i> subsp. <i>squarrosa</i> , <i>Hypocalymma angustifolium</i> , <i>Babingtonia camphorosmae</i> , <i>Grevillea bipinnatifida</i> and <i>Allocasuarina humilis</i> on clay-loams over shallow granites on mid to upper slopes.	45.4	15.6
MG	Open woodland of <i>Eucalyptus wandoo</i> over <i>Trymalium ledifolium</i> , <i>Macrozamia riedlei</i> , <i>Pericalymma ellipticum</i> , <i>Hypocalymma angustifolium</i> , <i>Grevillea bipinnatifida</i> , <i>Allocasuarina humilis</i> and <i>Hakea lissocarpha</i> on clay-loams over shallow granite on mid to upper slopes and ridges.	219.8	37.0
P	Open forest of <i>Eucalyptus marginata</i> and <i>Allocasuarina fraseriana</i> with admixtures of <i>Corymbia calophylla</i> and <i>Banksia grandis</i> over <i>Lasiopetalum cardiophyllum</i> (P4), <i>Lasiopetalum floribundum</i> , <i>Lechenaultia biloba</i> and <i>Ptilotus drummondii</i> var. <i>drummondii</i> on sandy gravels on slopes and ridges.	1438.9	912.5
PS	Open forest of <i>Allocasuarina fraseriana</i> , <i>Eucalyptus marginata</i> , <i>Corymbia calophylla</i> and <i>Banksia grandis</i> over <i>Adenanthos barbiger</i> , <i>Leucopogon capitellatus</i> on gravels and sandy gravels on slopes and ridges.	1332.0	1062.4
PW	Open forest of <i>Allocasuarina fraseriana</i> , <i>Eucalyptus marginata</i> , <i>Corymbia calophylla</i> , <i>Banksia grandis</i> with scattered understorey, including <i>Adenanthos barbiger</i> , <i>Leucopogon capitellatus</i> and <i>Hypocalymma angustifolium</i> on seasonally moister and sandy gravels on slopes.	2.5	0.0
R	Open woodland of <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> over <i>Trymalium ledifolium</i> , <i>Phyllanthus calycinus</i> and <i>Hypocalymma angustifolium</i> on sandy-gravels associated with nearby shallow outcropping.	1.3	0.5
S	Open forest of <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> with admixtures of <i>Allocasuarina fraseriana</i> , <i>Banksia grandis</i> and <i>Persoonia longifolia</i> over <i>Acacia celastrifolia</i> , <i>Hovea chorizemifolia</i> , <i>Daviesia preissii</i> , <i>Leucopogon capitellatus</i> and <i>Styphelia tenuiflora</i> on sandy-gravels on slopes and ridges.	1694.5	962.6
SP	Open forest of <i>Eucalyptus marginata</i> , <i>Corymbia calophylla</i> and <i>Allocasuarina fraseriana</i> with admixtures of <i>Banksia grandis</i> over <i>Lasiopetalum cardiophyllum</i> , <i>Acacia celastrifolia</i> , <i>Styphelia tenuiflora</i> , <i>Daviesia decurrens</i> and <i>Trymalium ledifolium</i> on sandy-gravel to gravel soils on slopes and ridges.	90.6	69.3
ST	Open forest of <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> with admixtures of <i>Allocasuarina fraseriana</i> , <i>Persoonia longifolia</i> and <i>Banksia grandis</i> over <i>Stygidium dichotomum</i> , <i>Acacia urophylla</i> , <i>Acacia celastrifolia</i> , <i>Leucopogon verticillatus</i> , <i>Clematis pubescens</i> and	386.1	246.2

Site Vegetation Type Code	Description	Extent within the WMDE (ha)	Indicative Extent to be cleared (ha)
	<i>Leucopogon capitellatus</i> on sandy-loam gravel soils on slopes and ridges.		
SW	Open forest of <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> over <i>Hypocalymma angustifolium</i> , <i>Babingtonia camphorosmae</i> , <i>Acacia celsa</i> , <i>Hovea chorizemifolia</i> , <i>Daviesia preissii</i> , <i>Leucopogon capitellatus</i> and <i>Styphelia tenuiflora</i> on seasonally moister sandy-gravels on slopes.	9.2	0.5
W	Open forest of <i>Corymbia calophylla</i> , <i>Eucalyptus marginata</i> and <i>Eucalyptus patens</i> over <i>Hakea lissocarpa</i> , <i>Hypocalymma angustifolium</i> , <i>Acacia extensa</i> and <i>Synaphea petiolaris</i> on loam soils on lower slopes.	0.8	0.0
Y	Open woodland of <i>Eucalyptus wandoo</i> over <i>Gompholobium marginatum</i> , <i>Acacia nervosa</i> , <i>Babingtonia camphorosmae</i> , <i>Hypocalymma angustifolium</i> , <i>Macrozamia riedlei</i> , <i>Phyllanthus calycinus</i> and <i>Gastrolobium calycinum</i> on clay and clay-loam soils on lower slopes.	604.0	141.2
YG	Open woodland of <i>Eucalyptus wandoo</i> over <i>Gompholobium marginatum</i> , <i>Acacia nervosa</i> , <i>Babingtonia camphorosmae</i> , <i>Hypocalymma angustifolium</i> , <i>Macrozamia riedlei</i> , <i>Pericalymma ellipticum</i> , <i>Grevillea bipinnatifida</i> , <i>Allocasuarina humilis</i> , <i>Phyllanthus calycinus</i> and <i>Gastrolobium calycinum</i> on clay and clay-loam soils with localized outcropping on lower slopes.	12.0	2.1
Z	Open forest of <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> over <i>Macrozamia riedlei</i> , <i>Xanthorrhoea preissii</i> , <i>Hakea lissocarpa</i> and <i>Phyllanthus calycinus</i> on sandy-loam to sandy-loam gravel soils on slopes.	832.6	445.0
CL	Cleared	12504.1	2140.8
DAM	Dam	1.4	0.0
PL	Plantations	420.4	89.4
Rehab	Rehabilitation Areas	2980.1	499.7

The alignment of the proposed infrastructure within the Bauxite Transport Corridor has not yet been determined. It is proposed that the construction of this infrastructure will require the clearing of up to 940 ha based on indicative infrastructure calculations and that the actual footprint will be significantly less once a final route is determined. It is also expected that the routes will be located on already disturbed land (in the form of pastoral area) where practicable, reducing the overall environmental impact. Further information on the alignment will be presented in the Environmental Review Document. Therefore, at this stage, the clearing requirement of each site vegetation type within the Bauxite Transport Corridor in **Table 10** cannot be provided. Where practicable, areas of potential high conservation value as shown in **Figure 6** (protected areas in this figure are indicative only and will be ground-truthed in Environmental Review Document technical studies) (in accordance with Worsley's Protected Areas Procedure) will also be avoided for the transport routes within the Bauxite Transport Corridor.

Table 10: Extent of Site Vegetation Types within the Bauxite Transport Corridor

Site Vegetation Type Code	Description	Indicative Extent within the Bauxite Transport Corridor (ha)
A	Tall shrubland of <i>Melaleuca lateritia</i> , <i>Hakea varia</i> , <i>Melaleuca viminea</i> and <i>Melaleuca incana</i> subsp. <i>incana</i> on clay-loams in seasonally wet valley floors.	39.8
AD	Low open woodland of <i>Eucalyptus rudis</i> and <i>Eucalyptus marginata</i> over <i>Banksia littoralis</i> , <i>Hakea prostrata</i> and <i>Pericalymma ellipticum</i> over low shrubs and herbs on leached sands over sandy-gravel on lower slopes.	0.9
AX	Open woodland of <i>Eucalyptus rudis</i> over <i>Acacia saligna</i> , <i>Melaleuca incana</i> subsp. <i>incana</i> and <i>Hypocalymma angustifolium</i> on clay-loams on valley floors.	98.2
AY	Open woodland of <i>Eucalyptus rudis</i> and <i>Eucalyptus wandoo</i> over <i>Acacia saligna</i> , <i>Hakea prostrata</i> and <i>Hypocalymma angustifolium</i> on clay-loams on valley floors.	154.0
AY/D	Mosaic of AY and D.	5.3
D	Open forest of <i>Corymbia calophylla</i> and <i>Eucalyptus marginata</i> over <i>Hakea lissocarpha</i> , <i>Macrozamia riedlei</i> , <i>Acacia alata</i> , <i>Babingtonia camphorosmae</i> , <i>Hypocalymma angustifolium</i> and <i>Phyllanthus calycinus</i> on clay-loams on lower slopes.	147.4
DG	Open forest of <i>Corymbia calophylla</i> and <i>Eucalyptus marginata</i> over <i>Hakea lissocarpha</i> , <i>Macrozamia riedlei</i> , <i>Pericalymma ellipticum</i> , <i>Grevillea bipinnatifida</i> , <i>Allocasuarina humilis</i> , <i>Acacia alata</i> , <i>Babingtonia camphorosmae</i> , <i>Hypocalymma angustifolium</i> and <i>Phyllanthus calycinus</i> on clay-loams on lower slopes with localized patches of outcropping.	5.1
G	Open Heath of <i>Grevillea bipinnatifida</i> , <i>Hakea undulata</i> , <i>Banksia squarrosa</i> subsp. <i>squarrosa</i> , <i>Hakea incrassata</i> , <i>Hakea undulata</i> and <i>Petrophile serruriae</i> over <i>Borya sphaerocephala</i> on shallow soils and outcrops.	6.5
G3	Open heath of <i>Banksia squarrosa</i> subsp. <i>squarrosa</i> , <i>Hakea incrassata</i> , <i>Hakea undulata</i> , <i>Petrophile heterophylla</i> and <i>Petrophile serruriae</i> on shallow soils over granite outcrops on slopes with occasional emergent <i>Eucalyptus drummondii</i> .	3.3
G4	Open scrub and tall shrubland of <i>Hakea trifurcata</i> and <i>Hakea undulata</i> with admixtures of mallee species including <i>Eucalyptus latens</i> and <i>Eucalyptus aspersa</i> on clay to clay-loam soils over outcrops on slopes.	2.1
H	Open forest to woodland of <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> over <i>Petrophile striata</i> , <i>Daviesia decurrens</i> , <i>Daviesia longifolia</i> and <i>Daviesia rhombifolia</i> on sandy loam to sandy gravels on slopes and ridges.	503.5
H2	Open forest to woodland of <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> with occasional admixtures of <i>Banksia grandis</i> and <i>Persoonia longifolia</i> over <i>Acacia celastrifolia</i> , <i>Daviesia preissii</i> , <i>Leucopogon capitellatus</i> and <i>Styphelia tenuiflora</i> on gravel and sandy-gravel soils of slopes and less undulating hills.	2.2
L	Open woodland of <i>Eucalyptus patens</i> with some <i>Eucalyptus wandoo</i> over <i>Xanthorrhoea preissii</i> , <i>Macrozamia riedlei</i> , <i>Trymalium ledifolium</i> , <i>Acacia saligna</i> and <i>Hakea prostrata</i> on clay and clay loam soils on lower slopes.	27.0

Site Vegetation Type Code	Description	Indicative Extent within the Bauxite Transport Corridor (ha)
M	Open woodland of <i>Eucalyptus wandoo</i> over <i>Trymalium ledifolium</i> , <i>Macrozamia riedlei</i> and <i>Hakea lissocarpha</i> on clay loams with some gravel on mid to upper slopes and ridges.	336.0
M2	Woodland to open woodland of <i>Eucalyptus accedens</i> , <i>Eucalyptus wandoo</i> , <i>Eucalyptus marginata</i> , <i>Corymbia calophylla</i> over <i>Hakea lissocarpha</i> , <i>Macrozamia riedlei</i> , <i>Banksia squarrosa</i> subsp. <i>squarrosa</i> , <i>Hypocalymma angustifolium</i> , <i>Babingtonia camphorosmae</i> , <i>Grevillea bipinnatifida</i> and <i>Allocasuarina humilis</i> on clay-loams over shallow granites on mid to upper slopes.	1.4
MG	Open woodland of <i>Eucalyptus wandoo</i> over <i>Trymalium ledifolium</i> , <i>Macrozamia riedlei</i> , <i>Pericalymma ellipticum</i> , <i>Hypocalymma angustifolium</i> , <i>Grevillea bipinnatifida</i> , <i>Allocasuarina humilis</i> and <i>Hakea lissocarpha</i> on clay-loams over shallow granite on mid to upper slopes and ridges.	28.3
P	Open forest of <i>Eucalyptus marginata</i> and <i>Allocasuarina fraseriana</i> with admixtures of <i>Corymbia calophylla</i> and <i>Banksia grandis</i> over <i>Lasiopetalum cardiophyllum</i> (P4), <i>Lasiopetalum floribundum</i> , <i>Lechenaultia biloba</i> and <i>Ptilotus drummondii</i> var. <i>drummondii</i> on sandy gravels on slopes and ridges.	259.1
PS	Open forest of <i>Allocasuarina fraseriana</i> , <i>Eucalyptus marginata</i> , <i>Corymbia calophylla</i> and <i>Banksia grandis</i> over <i>Adenanthos barbiger</i> , <i>Leucopogon capitellatus</i> on gravels and sandy gravels on slopes and ridges.	501.3
PW	Open forest of <i>Allocasuarina fraseriana</i> , <i>Eucalyptus marginata</i> , <i>Corymbia calophylla</i> , <i>Banksia grandis</i> with scattered understorey, including <i>Adenanthos barbiger</i> , <i>Leucopogon capitellatus</i> and <i>Hypocalymma angustifolium</i> on seasonally moister and sandy gravels on slopes.	2.5
S	Open forest of <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> with admixtures of <i>Allocasuarina fraseriana</i> , <i>Banksia grandis</i> and <i>Persoonia longifolia</i> over <i>Acacia celastrifolia</i> , <i>Hovea chorizemifolia</i> , <i>Daviesia preissii</i> , <i>Leucopogon capitellatus</i> and <i>Styphelia tenuiflora</i> on sandy-gravels on slopes and ridges.	325.7
SP	Open forest of <i>Eucalyptus marginata</i> , <i>Corymbia calophylla</i> and <i>Allocasuarina fraseriana</i> with admixtures of <i>Banksia grandis</i> over <i>Lasiopetalum cardiophyllum</i> , <i>Acacia celastrifolia</i> , <i>Styphelia tenuiflora</i> , <i>Daviesia decurrens</i> and <i>Trymalium ledifolium</i> on sandy-gravel to gravel soils on slopes and ridges.	28.9
ST	Open forest of <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> with admixtures of <i>Allocasuarina fraseriana</i> , <i>Persoonia longifolia</i> and <i>Banksia grandis</i> over <i>Stygidium dichotomum</i> , <i>Acacia urophylla</i> , <i>Acacia celastrifolia</i> , <i>Leucopogon verticillatus</i> , <i>Clematis pubescens</i> and <i>Leucopogon capitellatus</i> on sandy-loam gravel soils on slopes and ridges.	20.7
Y	Open woodland of <i>Eucalyptus wandoo</i> over <i>Gompholobium marginatum</i> , <i>Acacia nervosa</i> , <i>Babingtonia camphorosmae</i> , <i>Hypocalymma angustifolium</i> , <i>Macrozamia riedlei</i> , <i>Phyllanthus calycinus</i> and <i>Gastrolobium calycinum</i> on clay and clay-loam soils on lower slopes.	194.6
YG	Open woodland of <i>Eucalyptus wandoo</i> over <i>Gompholobium marginatum</i> , <i>Acacia nervosa</i> , <i>Babingtonia camphorosmae</i> , <i>Hypocalymma angustifolium</i> , <i>Macrozamia riedlei</i> , <i>Pericalymma ellipticum</i> , <i>Grevillea</i>	20.7

Site Vegetation Type Code	Description	Indicative Extent within the Bauxite Transport Corridor (ha)
	<i>bipinnatifida</i> , <i>Allocasuarina humilis</i> , <i>Phyllanthus calycinus</i> and <i>Gastrolobium calycinum</i> on clay and clay-loam soils with localized outcropping on lower slopes.	
Z	Open forest of <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> over <i>Macrozamia riedlei</i> , <i>Xanthorrhoea preissii</i> , <i>Hakea lissocarpa</i> and <i>Phyllanthus calycinus</i> on sandy-loam to sandy-loam gravel soils on slopes.	224.3
CL	Cleared	1,135.0
PL	Plantations	1.3
Rehab	Rehabilitation Areas	70.7

Table 11: Extent of Site Vegetation Types within the CBME and Indicative Clearing Requirements

Site Vegetation Type Code	Description	Extent within the CBME (ha)	Indicative Extent to be cleared for contingency mining (ha)	Indicative Extent to be cleared for maintenance purposes (ha)
CQ	Open Forest of <i>Eucalyptus marginata</i> - <i>Corymbia calophylla</i> - <i>Eucalyptus patens</i> on lower slopes with mixed understorey species, including <i>Trymalium floribundum</i> , <i>Agonis linearifolia</i> and <i>Astartea fascicularis</i> along the edges of the deeper incised valleys near the creek-lines.	9.6	1.2	0
CW	Woodland to Open Forest of <i>Eucalyptus patens</i> – <i>Eucalyptus megacarpa</i> - <i>Corymbia calophylla</i> - <i>Banksia littoralis</i> with dense <i>Taxandria linearifolia</i> and <i>Astartea scoparia</i> in understorey on creek-lines and water-courses.	17.9	1.3	0.03
Q	Open Forest of <i>Eucalyptus marginata</i> - <i>Corymbia calophylla</i> - <i>Eucalyptus patens</i> with mixed understorey species, including <i>Trymalium floribundum</i> , <i>Acacia extensa</i> and <i>Phyllanthus calycinus</i> on loam soils on lower slopes.	63.6	7.6	0.15
S	Open forest of <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> with admixtures of <i>Allocasuarina fraseriana</i> , <i>Banksia grandis</i> and <i>Persoonia longifolia</i> over <i>Acacia celastrifolia</i> , <i>Hovea chorizemifolia</i> , <i>Daviesia preissii</i> , <i>Leucopogon capitellatus</i> and <i>Styphelia tenuiflora</i> on sandy-gravels on slopes and ridges.	79.8	66.8	3.10
SP	Open forest of <i>Eucalyptus marginata</i> , <i>Corymbia calophylla</i> and <i>Allocasuarina fraseriana</i> with admixtures of <i>Banksia grandis</i> over <i>Lasiopetalum cardiophyllum</i> , <i>Acacia celastrifolia</i> , <i>Styphelia tenuiflora</i> , <i>Daviesia decurrens</i> and <i>Trymalium ledifolium</i> on sandy-gravel to gravel soils on slopes and ridges.	5.7	4.5	0

Site Vegetation Type Code	Description	Extent within the CBME (ha)	Indicative Extent to be cleared for contingency mining (ha)	Indicative Extent to be cleared for maintenance purposes (ha)
ST	Open forest of <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> with admixtures of <i>Allocasuarina fraseriana</i> , <i>Persoonia longifolia</i> and <i>Banksia grandis</i> over <i>Stylidium dichotomum</i> , <i>Acacia urophylla</i> , <i>Acacia celastrifolia</i> , <i>Leucopogon verticillatus</i> , <i>Clematis pubescens</i> and <i>Leucopogon capitellatus</i> on sandy-loam gravel soils on slopes and ridges.	229.3	140.7	0.74
SW	Open forest of <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> over <i>Hypocalymma angustifolium</i> , <i>Babingtonia camphorosmae</i> , <i>Acacia celastrifolia</i> , <i>Hovea chorizemifolia</i> , <i>Daviesia preissii</i> , <i>Leucopogon capitellatus</i> and <i>Styphelia tenuiflora</i> on seasonally moister sandy-gravels on slopes.	17.7	3.9	0.06
T	Open Forest of <i>Eucalyptus marginata</i> - <i>Corymbia calophylla</i> with scattered understorey, including <i>Leucopogon verticillatus</i> , <i>Pteridium esculentum</i> , <i>Clematis pubescens</i> and <i>Bossiaea aquifolium</i> subsp. <i>aquifolium</i> on sandy-loam gravelly soils on slopes and ridges.	14.0	1.5	0
TS	Open Forest of <i>Eucalyptus marginata</i> - <i>Corymbia calophylla</i> – <i>Banksia grandis</i> with scattered understorey, including <i>Leucopogon verticillatus</i> , <i>Pteridium esculentum</i> , <i>Clematis pubescens</i> and <i>Bossiaea aquifolium</i> subsp. <i>aquifolium</i> on sandy-loam gravelly to gravelly soils.	68.9	22.3	0
CL	Cleared	167.6	4.4	0.35
Dam	Dam	72.8	0.03	0.05

Vegetation Condition

The condition of the vegetation ranges within the Primary Assessment Area from Excellent to Completely Degraded based on the Keighery (1994) vegetation condition scale as reported in Mattiske (2019). A summary of the vegetation condition within the Primary Assessment Area is provided in **Table 12**, **Table 13** and **Table 14**, respectively. A total of 3 ha of the WMDE has not been mapped. Vegetation condition has been mapped for the WMDE and Bauxite Transport Corridor in **Figure 11**.

Table 12: Vegetation Condition within the WMDE

Vegetation Condition	Extent within WMDE (ha)	Extent within WMDE (%)	Indicative Extent to be cleared (ha)	Indicative Extent to be cleared (%)
Excellent	9,889.68	35.58	5,387.73	54.5
Very Good	729.25	2.62	176.06	24.1
Good	119.59	0.43	43.10	36.0
Degraded	4,024.13	14.48	776.80	19.3
Completely Degraded	13,033.55	46.89	2,271.39	17.5
Total	27,796.20	100	8,655.07	31.1

The alignment of the proposed infrastructure within the Bauxite Transport Corridor had not yet been determined. It is proposed that the maximum clearing of native vegetation could be up to 940 ha based on indicative infrastructure footprints. The actual amount of native vegetation clearing is expected to be significantly less once a route is selected and a design is finalised due to the route being located in already disturbed land where practicable. Further information on the alignment will be presented in the Environmental Review Document. Therefore, at this stage, clearing requirement by vegetation condition within the Bauxite Transport Corridor in **Table 13** cannot be provided.

Table 13: Vegetation Condition within the Bauxite Transport Corridor

Vegetation Condition	Extent within the Bauxite Transport Corridor (ha)	Indicative Extent (%)
Excellent	2,625.40	63.33
Very Good	179.52	4.33
Good	4.50	0.11
Degraded	157.95	3.81
Completely Degraded	1,178.33	28.42
Total	4,145.70	100

Table 14: Vegetation Condition within the CBME

Vegetation Condition	Extent within CBME (ha)	Extent within CBME (%)	Indicative Extent to be cleared for contingency mining (ha)	Indicative Extent to be cleared for maintenance purposes (ha)	Indicative Extent to be cleared (%)
Excellent	506.61	67.90	250	4.5	49
Very Good	-	-	-	-	-
Good	-	-	-	-	-
Degraded	-	-	-	-	-
Completely Degraded	240.45	32.10	4.5	-	0.02
Total	747.06	100	254.5	4.5	34

Threatened and Priority Ecological Communities

No TECs are known to occur within the Primary Assessment Area (Matisse Consulting Pty Ltd 2019). It is recognized from the database searches that the (TEC) – the *Eucalypt Woodlands* of the Western Australian Wheatbelt, has the potential to occur near the WMDE and Bauxite Transport Corridor, and the *Banksia Woodlands* of the Swan Coastal Plain has the potential to occur near the CBME (DBCA, 2018c, DoEE, 2018b). The Wheatbelt Eucalypt TEC occurs east and northeast of the WMDE and Bauxite Transport Corridor areas, but not within these areas. The *Banksia Woodlands* on the Swan Coastal Plain does not occur within the CBME as the CBME is on the Darling Ranges and this community as listed does not occur on the CBME.

One Priority Ecological Community (PEC) occurs within the WMDE, namely - The *Mount Saddleback Heath Communities* (PEC - P1) (DBCA, 2018d). The PEC as defined by DBCA has affinities with the site-vegetation types within the areas of heath on the Mount Saddleback area as defined and mapped by Matisse (i.e. G, G1, G3 and G4) (Matisse, 2019). This PEC was formerly aligned with the larger area of heath communities of the Tunnell Road area, however now includes the Mount

Saddleback Heath Communities covering some of the G1, G3 and G4 occurrences. These communities are identified within the areas of potential high conservation value (**Figure 6**) (protected areas in this figure are indicative only and will be ground-truthed in Environmental Review Document technical studies) in accordance with Worsley's Protected Areas Procedure.

The heath communities include:

- Site-vegetation Type G: Open Heath of *Grevillea bipinnatifida*, *Hakea undulata*, *Banksia squarrosa* subsp. *squarrosa*, *Hakea incrassata*, *Hakea undulata* and *Petrophile serruriae* over *Borya sphaerocephala* on shallow soils and outcrops.
- Site-vegetation Type G1: Mosaic of open heath of Proteaceae – Myrtaceae spp. with emergent patches of *Eucalyptus drummondii* on shallow soils on slopes.
- Site-vegetation Type G3: Open heath of *Banksia squarrosa* subsp. *squarrosa*, *Hakea incrassata*, *Hakea undulata*, *Petrophile heterophylla* and *Petrophile serruriae* on shallow soils over granite outcrops on slopes with occasional emergent *Eucalyptus drummondii*.
- Site-vegetation Type G4: Open scrub and tall shrubland of *Hakea trifurcata* and *Hakea undulata* with admixtures of mallee species including *Eucalyptus latens* and *Eucalyptus aspersa* on clay to clay-loam soils over outcrops on slopes.

These site-vegetation types are variants of the site-vegetation type G as defined by Havel (1975a and 1975b) and areas associated with shallow soils and granite outcrops (Mattiske, 2019). This PEC has already been identified by Worsley and processes to manage the avoidance of this PEC are captured by Worsley in the existing Protected Areas Procedure as part of the Biodiversity and Forest Management Plan (**Appendix H**).

Other Significant Vegetation Communities

The following vegetation complexes and site-vegetation types (**Table 6**) are considered to be significant for their restricted representation in the conservation estate (less than 10% representation in formal and informal reserves) and also as potential wildlife corridors along creek lines.

Vegetation Complexes

- Williams – Along the major creek lines and rivers – less than 0.45% in formal and informal reserves, provides corridors and protects riparian areas (Conservation Commission 2003).
- Michibin – On Valley slopes in eastern areas of Jarrah forest – less than 7.11% in formal and informal reserves (Conservation Commission 2003).

Site-Vegetation Types

- G Types (G1, G2, G3 and G4) – lithic complexes, heath, shrublands open scrubs and woodland communities associated with shallow soils over granite and exposed granite outcrop areas. Some of these areas (G1, G3 and G4 near Mt Saddleback) overlap with the Mt Saddleback Heath Communities PEC.
- Types DG, HG and MG are a mixture of different site-vegetation types over shallow granites in the WMDE and wider mapped areas near Boddington.
- L Type – Open woodland of *Eucalyptus patens* with some *Eucalyptus wandoo* on lower slopes. This site-vegetation type has been cleared in sections of the eastern Jarrah forest for agriculture activities as the earlier land holders recognized the alluvial soils associated with the occurrence of the *Eucalyptus patens* communities.
- M2 Type - Woodland to open woodland of *Eucalyptus accedens*, *Eucalyptus wandoo*, *Eucalyptus marginata* and *Corymbia calophylla* on eastern breakaways. Occurs in the eastern fringes on the upper slopes and ridges of the northern Jarrah forest.
- A, AY, AX, AC Types – Woodlands of *Eucalyptus rudis* and *Melaleuca* species on the swamps and creek lines that provide linkages for fauna species and also for variety of plant species on variable soils.

Other communities are significant as they support Threatened and Priority species. The main communities that support Threatened and Priority flora species include the Jarrah – Sheoak communities supporting *Lasiopetalum cardiophyllum* (P4), the lower slopes near the Hotham River and swamps (site-vegetation types A, AY, AX, AC, CW, SW and Y), the heath communities (G, G1 and G3) and open forests of *Eucalyptus marginata* subsp. *thalassica* – *Corymbia calophylla* – *Allocasuarina fraseriana* (site-vegetation types P and PS).

A detailed breakdown of the Site Vegetation Types for the WMDE and the Bauxite Transport Corridor and the CBME are provided in **Figures 5.1 to 5.14 of Appendix A**.

4.1.3.1. Flora

Flora Diversity

A total of 680 plant taxa from 72 families and 260 genera have been recorded in the main baseline studies undertaken on the WMDE and Bauxite Transport Corridor in the Boddington area and 289 vascular plant species from 54 plant families and 149 genera were recorded in the main baseline studies undertaken on the Collie area (Mattiske C, 2019). Since this time various studies have added taxa when additional targeted searches, baseline and rehabilitation studies have been undertaken. These are further clarified in **Appendix A**. Several of the taxa have undergone taxonomic changes since the earlier studies and several species have been changed from introduced to naturalised and some from Priority species to non-Threatened species.

The vast majority of these were recorded regularly and have been used to refine and update the seeding and planting of native species in Worsley's rehabilitation areas for the Project since 1986. The Mattiske Consulting teams have been involved with recording of progress on rehabilitation areas in most years since 1987 at 9 months, 15 months and at 2, 4, 7, 10, 15, 20 and 30 years for most years, as well monitoring of the forest monitoring plots and the Tunnell Road heath communities. The botanical studies have been based on monitoring of 114 control plots on the Mt Saddleback Area, 14 plots on the Quindanning Area and 20 plots on the Marradong Area, in addition to plots and transects within the rehabilitation areas that have been assessed at different times during the period from 1981 to 2018.

Recent surveying by Mattiske Consulting in November 2018 of areas not previously mapped within the WMDE and Bauxite Transport Corridor recorded 149 plant taxa from 42 families and 94 genera and as such reflect the largely degraded and cleared nature of substantial areas within the WMDE and Bauxite Transport Corridor (**Appendix A**).

Conservation Significant Flora

Desktop searches of the EPBC Act Protected Matters database, the DBCA *NatureMap* database, the Western Australian Herbarium (WAH) and Threatened and Priority Flora databases have identified the potential occurrence of 80 conservation significant flora species within 20 km of the WMDE and the Bauxite Transport Corridor, and 32 conservation significant flora species within 20 km of the CBME (**Appendix A**). This information, together with a literature review of all available datasets from previous flora and vegetation surveys for the Project, has formed the basis of a likelihood assessment for conservation significant flora within the areas the subject of the proposal. A summary of the likelihood of occurrence of Threatened flora species (BC Act and EPBC Act) occurring within the Application Area has been provided in **Table 15**. Further detail on these species and DBCA Priority listed species is provided in **Appendix A**.

Of the potential conservation significant species, 15 (one Threatened and 14 Priority flora species) conservation significant species have been recorded within the WMDE and the Bauxite Transport Corridor, and one conservation significant species (*Pultenaea skinneri* P4) has been recorded within the CBME.

Three Threatened flora species have been recorded in proximity to the WMDE (**Appendix A, Figure 3** (DBCA records) and **Figures 5.1 to 5.13**) *Caladenia hopperiana*, *Caladenia dorrienii* and *Eleocharis keigheryi*. *Caladenia hopperiana* (formerly recorded as *Caladenia* sp. Quindanning (K. Smith & P. Johns 231 (DBCA, 2018b) is the only one of the three Threatened species recorded in the proposal area. The species is listed Threatened under the BC Act and Endangered under the EPBC Act. It has been recorded within and outside of the WMDE in a localised area to the south-east (**Appendix A**). *Caladenia dorrienii* and *Eleocharis keigheryi* (listed Threatened under the *Biodiversity Conservation Act 2016* (WA) and Endangered and Vulnerable respectively under the EPBC Act) have been recorded outside and to the east of the WMDE.

Of the Priority species, the most significant species includes the *Gastrolobium* sp. Prostrate Boddington (M. Hislop 2130) which is mainly concentrated to the lower slopes near the Hotham River and the eastern anomaly north of the current BGM operation on the lower valley slopes, and the range of Priority species restricted to the Heath communities. The species in the heath communities are to some degree protected from clearing as their occurrences overlap with the PEC community – Mt Saddleback Heath Communities, which was listed after initial mining commenced at Mt Saddleback in the BBM. *Pultenaea skinneri* (P4) has been recorded in the valley systems and lower slopes on the southern boundary of the CBME.

Table 15: Threatened Flora potential occurrence within the Primary Assessment Area

Species	Status under EPBC Act	Status under BC Act	WMDE and Bauxite Transport Corridor Potential Occurrence / Recorded Location	CBME Potential Occurrence / Recorded Location
<i>Acacia brachypoda</i>	EN	T	Low	Unlikely
<i>Anthocercis gracilis</i>	VU	T	Moderate	Unlikely
<i>Caladenia bryceana</i> subsp. <i>bryceana</i>	EN	T	Unlikely	Low
<i>Caladenia dorrienii</i>	EN	T	Moderate - Identified to the east of the WMDE	Unlikely
<i>Caladenia hopperiana</i>	EN	T	WMDE – Recorded - 20 plants identified inside and 261 outside.	Highly Unlikely
<i>Caladenia leucochila</i>	EN	T	Unlikely	Moderate
<i>Diuris micrantha</i>	VU	T	Low	Low
<i>Diuris purdiei</i>	EN	T	Low	Unlikely
<i>Eleocharis keigheryi</i>	VU	T	Low- Identified to the east of the WMDE	Low
<i>Grevillea thelemanniana</i>	CR	T	Low	Unlikely
<i>Grevillea rara</i>	EN	T	Unlikely	Moderate
<i>Tetraria australiensis</i>	VU	T	Low	Unlikely
<i>Thelymitra stellata</i>	EN	T	Moderate	Unlikely
<i>Tribonanthes purpurea</i>	VU	T	Low	Unlikely
<i>Verticordia fimbriolepis</i> subsp. <i>fimbriolepis</i>	EN	T	Moderate	Unlikely

Introduced Flora

A total of 80 introduced flora species have been recorded within the WMDE, Bauxite Transport Corridor and broader Boddington area. A total of 15 introduced flora species have been recorded within and immediately surrounding the CBME. Of the introduced species, the following are Declared Plants under the *Biodiversity and Agricultural Management Act 2007* (BAM Act) (DAFWA, 2018), including:

- *Gomphocarpus fruticosus*;
- *Silybum marianum*; and
- *Asparagus asparagoides*.

None of these three were recorded in the most recent survey to the north of the WMDE and Bauxite Transport Corridor. The majority of the weeds are short term annual species that establish on disturbed agricultural lands and although some establish in the early phase of rehabilitation the majority are quickly outgrown by more perennial and larger shrub and tree species.

Invasive Species and Pathogens

Phytophthora cinnamomi, commonly known as Dieback, is a microscopic soil-borne fungus that kills susceptible plants by attacking their root systems and preventing the plant from absorbing water and nutrients. The fungus is spread through the movement of soil and mud, especially by vehicles and footwear. Dieback also moves in free water and via root-to-root contact between plants.

Armillaria luteobubalina, also known as Australian Honey Fungus, is a native fungal pathogen that contributes to the death of trees and other plants that have been weakened or stressed by factors, such as drought or lack of light. The disease spreads primarily by root-to-root contact and susceptible plant species include those from Proteaceae, Myrtaceae, and Fabaceae families.

Worsley manages mining activities in accordance with a Forest Hygiene Management Procedure (Worsley, 2014a) together with Working Arrangements with the DBCA to avoid spreading forest diseases through operations. This procedure requires any forest areas to be mapped and interpreted for the presence of Dieback up to three years prior to disturbance. These assessments are either undertaken by the DBCA or an independent accredited interpreter. Worsley will continue to manage mining operations in accordance with this existing procedure.

4.1.4. Proposal Activities

Activities associated with the Proposal that have the potential to impact flora and vegetation include mining activities, bauxite transport, exploration, construction and contingency bauxite mining.

4.1.5. Potential Impacts

Implementation of the proposal is likely to result in the following potential impacts to vegetation:

- Direct loss of up to 7,119.5 ha of native vegetation, as well as plantation and rehabilitated vegetation (excluding mining activities up to the existing approved extent in the Pre-existing Approval Area);
- Further fragmentation of vegetation in the local area through partial or complete clearing of isolated remnant bands or patches;
- Vegetation death from invasive pathogens through the introduction and/or spread of *Phytophthora cinnamomi* (Dieback) and/or *Armillaria luteobubalina* (Australian Honey Fungus);

- Increased competition from invasive species (weeds) through the introduction and/or spread into adjacent areas of vegetation; and
- Changes to vegetation structure and floristic composition through altered surface water drainage patterns and flows.

4.1.6. Mitigations

Worsley has applied the mitigation hierarchy (avoid, minimise, rehabilitate, offset) to reduce the potential environmental impacts of the proposal activities including:

- Avoid – avoiding the adverse environmental impact;
- Minimise – limit the degree or magnitude of the adverse impact;
- Rehabilitate – restore the maximum environmental value that is reasonably practicable; and
- Offset – offset likely to be proposed to provide environmental benefits to counterbalance significant residual environmental impacts or risks if any are assessed to remain after the above measures have been adopted.

The proposed mining footprint for this proposal has been designed to avoid, wherever practicable, the areas of high environmental value as shown in **Figure 6** (protected areas in this figure are indicative only and will be ground-truthed in Environmental Review Document technical studies) in accordance with the Protected Areas Procedure in the Biodiversity and Forest Management Plan (**Appendix H**). These areas include Threatened or Priority flora, TECs and PECs, poorly represented (less than 30% of pre-European extent) vegetation complexes, Aboriginal heritage sites, high value areas such as caves and breakaways, and river protection buffers.

Potential impacts to flora and vegetation associated with the proposal are proposed to be managed by Worsley consistently with existing management practices such as the following:

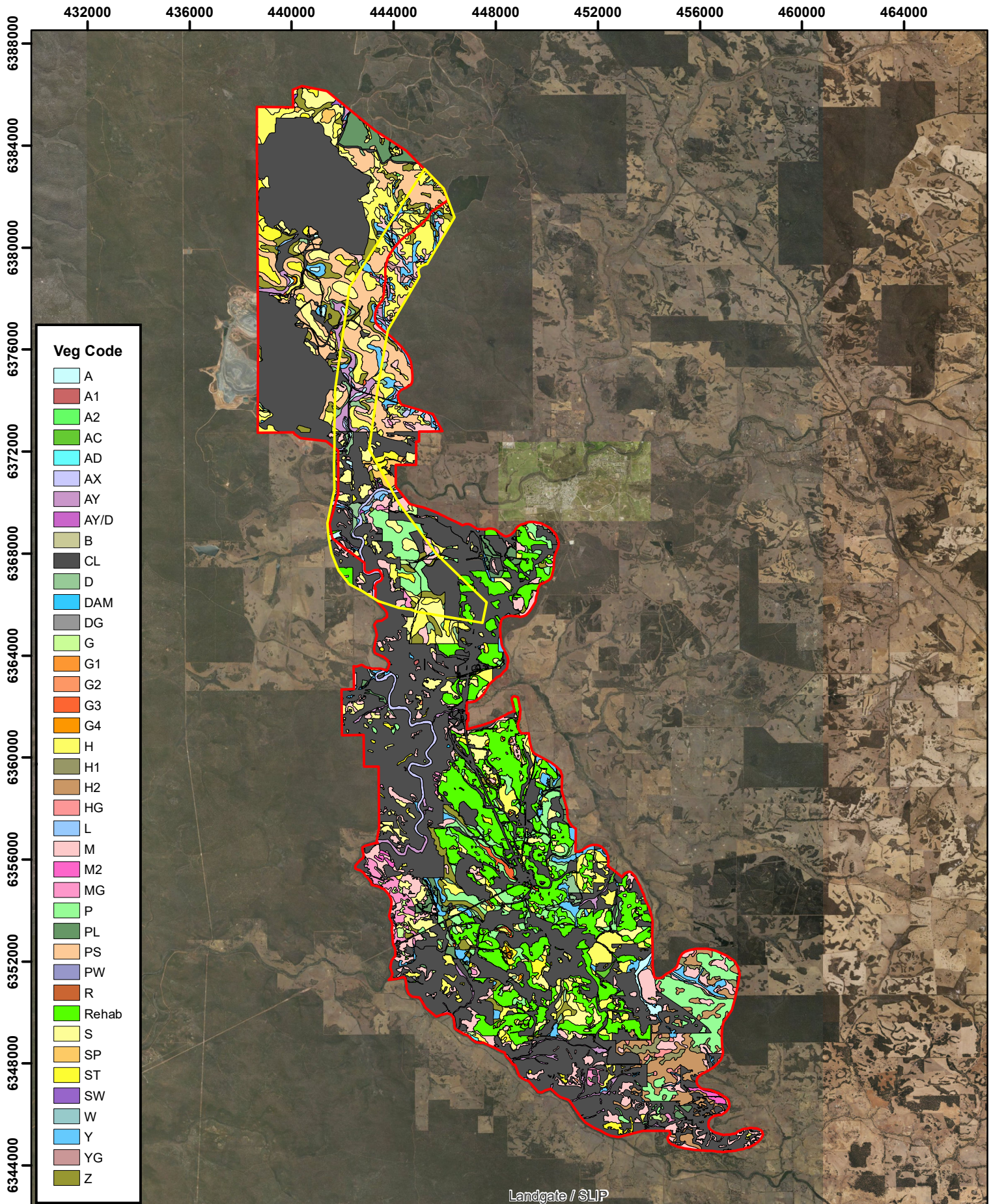
- Map and avoid the location of populations of the Threatened flora species (i.e. *Caladenia hopperiana* (T));
- Avoid wherever possible and minimise the direct and indirect impacts to the Priority flora species, in particular the Priority species *Gastrolobium* sp. Prostrate Boddington (M. Hislop 2130) (P1) as the species is geographically restricted to the Boddington area;
- Where disturbance has not already occurred prior to the identification of the PEC, avoid wherever possible and minimise direct and indirect impacts on the PECs – Mt Saddleback Heath Communities for any mining or transport activity within the WMDE or the Bauxite Transport Corridor;
- Design and engineer mining, construction and rehabilitation for maintenance of natural surface water flows across the Primary Assessment Area;
- Development and implementation of a CEMP for all construction activities relating to this proposal;
- Avoidance of areas of potential high conservation value wherever practicable utilizing the Protected Areas Procedure in the Biodiversity and Forest Management Plan (**Appendix H**);
- Avoidance and minimisation of clearing of native vegetation within the design phase to reduce the footprint of mine pits, mine haul and trunk roads, bauxite corridor road haulage and conveyor routes, and construction infrastructure support areas, wherever practicable;
- Continued implementation of the existing Biodiversity and Forest Management Plan (**Appendix H**), which includes the rehabilitation prescription for topsoil and overburden, compliance reporting and review;

- Continued implementation of internal clearing procedures and standards including the Native Vegetation Clearing Planning Procedure (Worsley, 2012), Mine Clearing Procedure (Worsley, 2015d), Mine Clearing Standard (Worsley, 2015e);
- Continued implementation of the Forest Hygiene Management Procedure (Worsley, 2014a), which sets out procedures for the management of weeds and forest disease, including Dieback;
- Progressive rehabilitation activities completed in accordance with internal rehabilitation procedures and standards, including the Rehabilitation Standard (Worsley, 2013c) that sets out the minimum standard for all rehabilitation activities for the Project (including rehabilitation planning, landholder communication and KPIs for rehabilitation success). Worsley will also continue to implement the Mine Rehabilitation Operations Procedure (Worsley, 2015f), the Private Land Rehabilitation Management Procedure (Worsley, 2015g), and BBM Revegetation Management Procedure (Worsley, 2015a); and
- Continued review, update and improvement of all relevant management plans and procedures for the Project.

4.1.7. Assessment of Impacts

Worsley has been operating the Project since the 1980s and has completed a significant amount of survey effort across the region. All existing baseline flora and vegetation data has been consolidated into a survey report that summarises the flora and vegetation values within the area, including recorded and potential conservation significant flora, vegetation complexes, site vegetation types and vegetation condition. This report is provided in **Appendix A**.

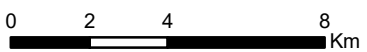
A detailed understanding of the significance of the impacts to flora and vegetation will be further defined in the Environmental Review Document as the impact assessment process progresses. It is expected that the direct, indirect and cumulative impacts associated with the Project will be able to be managed to meet the EPA's objectives for Flora and Vegetation, and EPBC Act objectives for MNES to an acceptable level once the mitigation hierarchy has been adopted.



Landgate / SLIP

Legend

- Proposed Bauxite Transport Corridor
- Proposed Worsley Mining Development Envelope



South32 Worsley Alumina Pty Ltd

Overview of Site Vegetation Types within the WMDE and Bauxite Transport Corridor

Created by: KNN
 Created: March 2019
 Co-ordinate System: GDA 1994 z50
 Ref: WME Referral - SVTs WMDE and BTC.mxd

Figure 9

410000

412000

414000

416000

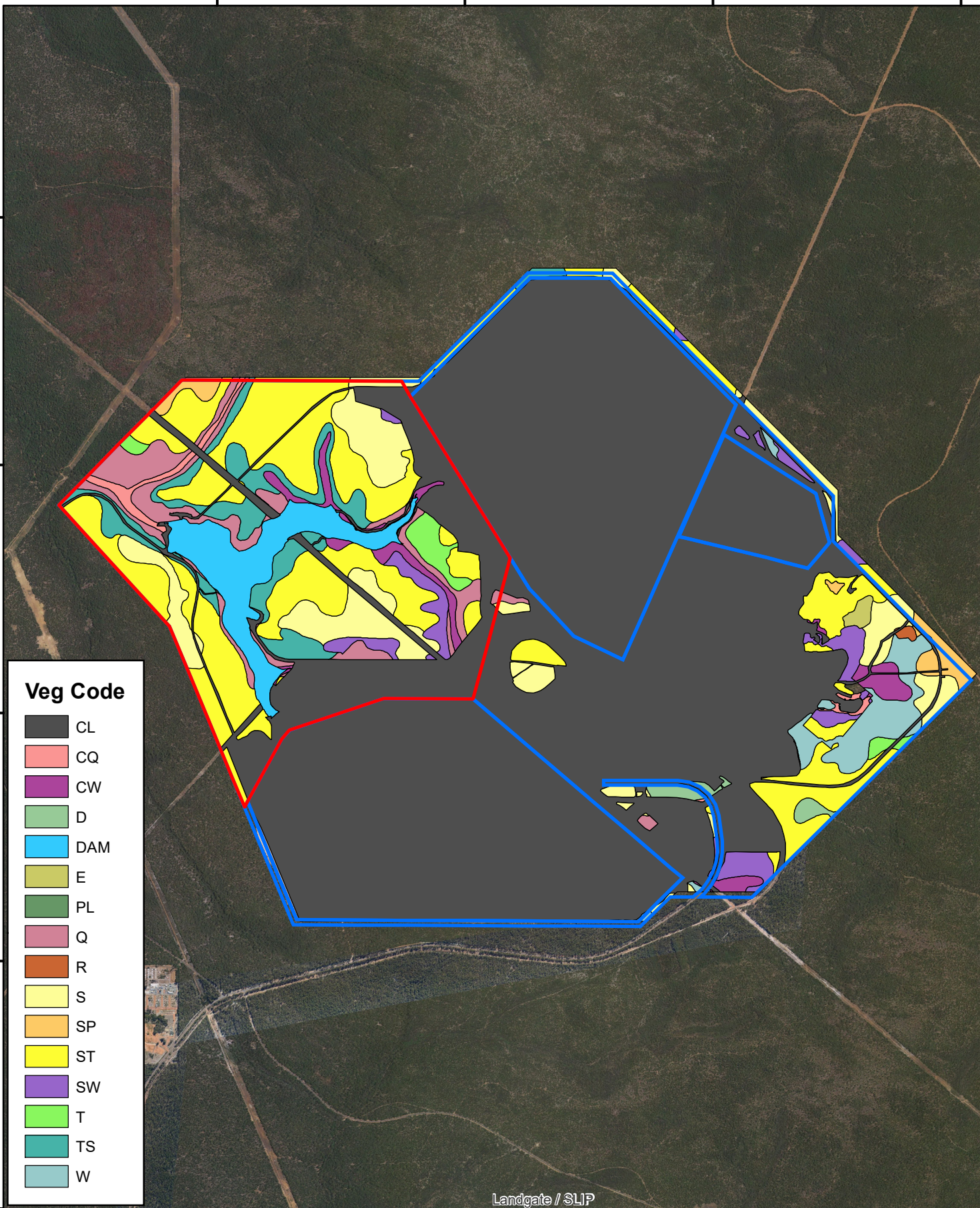
6326000

6324000

6322000

6320000

6318000



Landgate / SLIP

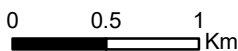
Veg Code

- CL
- CQ
- CW
- D
- DAM
- E
- PL
- Q
- R
- S
- SP
- ST
- SW
- T
- TS
- W

Legend

- Contingency Bauxite Mining Area
- Refinery Leases

N

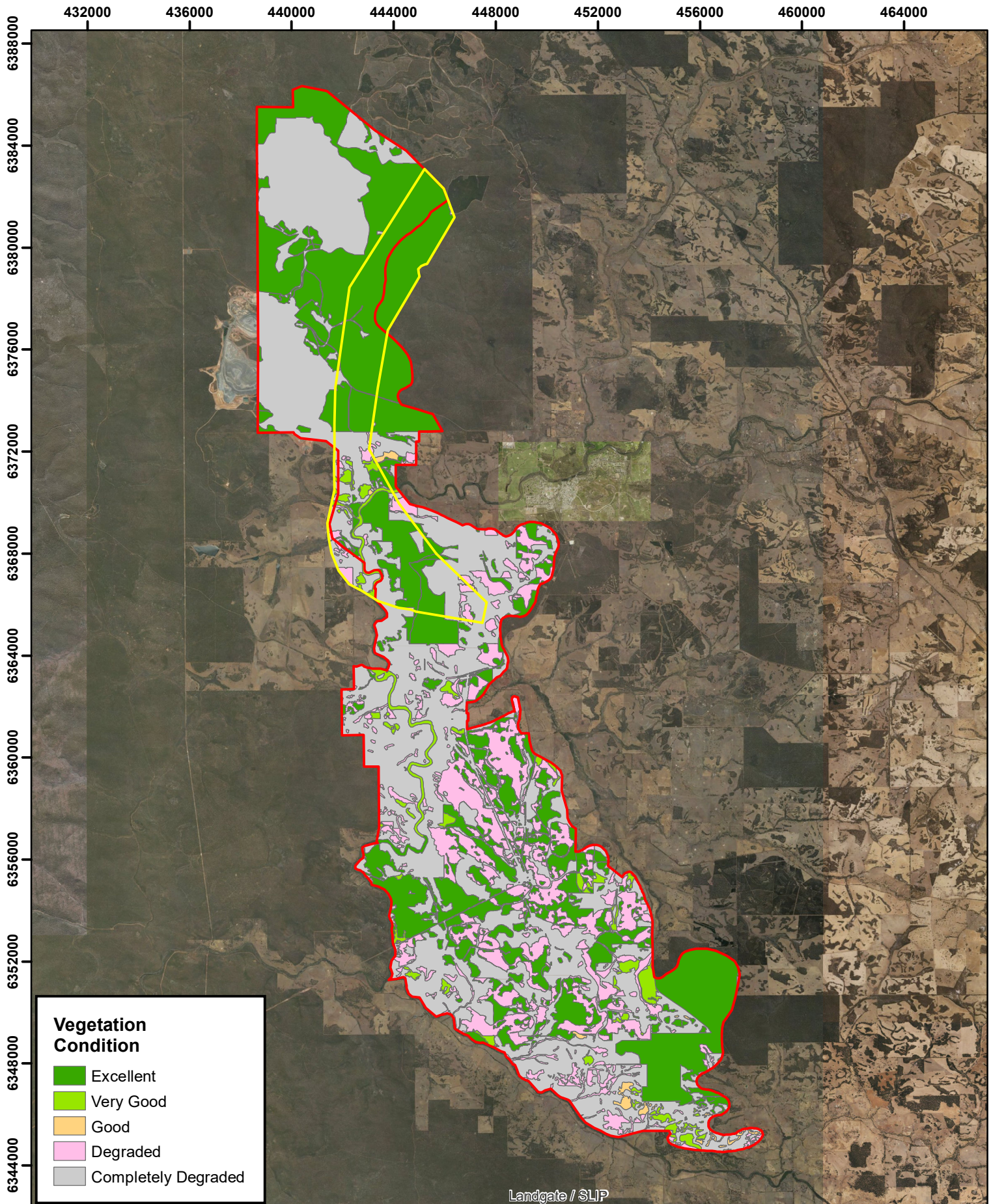


South32 Worsley Alumina Pty Ltd

Overview of Site Vegetation Types within the CBME

Created by: KNN
 Created: March 2019
 Co-ordinate System: GDA 1994 z50
 Ref: WME Referral - SVTs RLA.mxd

Figure 10



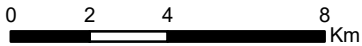
Vegetation Condition

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

Landgate / SLIP

Legend

- Proposed Bauxite Transport Corridor
- Proposed Worsley Mining Development Envelope



South32 Worsley Alumina Pty Ltd

Overview of Vegetation Condition within the WMDE and Bauxite Transport Corridor

Created by: KNN
 Created: March 2019
 Co-ordinate System: GDA 1994 z50
 Ref: WME Referral - Veg Condition WMDE and BTC.mxd

Figure 11

4.2. TERRESTRIAL FAUNA

4.2.1. EPA Objective

The EPA applies the following objective from the *Statement of Environmental Principles, Factors and Objectives* (EPA, 2016e) in its assessment of proposals that may affect terrestrial fauna:

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

4.2.2. Policy and Guidance

The following EPA guidelines and guidance have been considered in the assessment of flora and vegetation with respect to the EPA objective:

- EPA Statement of Environmental Principles, Factors and Objectives (EPA, 2016e);
- EPA Environmental Factor Guideline - Terrestrial Fauna (EPA, 2016h);
- EPA Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016f);
- EPA Technical Guidance – Subterranean Fauna Survey (EPA, 2016j); and
- EPA Technical Guidance – Sampling of Short-Range Endemic Invertebrate Fauna (EPA, 2016i).

4.2.3. Receiving Environment

4.2.3.1. Vertebrate Fauna

Extensive terrestrial fauna surveys have been undertaken over the life of the Project for baseline and monitoring purposes. South32 has commissioned BIOSTAT Pty Ltd (Biostat) to prepare a survey report compiling all available survey information pertaining to terrestrial fauna within the Primary Assessment Area for this proposal. This report has been provided in **Appendix B**, and results of which are summarised in this section. A summary of the terrestrial fauna survey effort for the Project is provided in **Table 16**.

Table 16: Summary of Terrestrial Vertebrate Fauna Surveys undertaken for the Project

Survey Area	Consultant	Survey Date	Purpose of Survey/Study and Details
Primary Assessment Area	Biostat	2017 - 2018	Desktop Review and Level 1 Fauna Assessment. This document reviewed and compiled information from previous documents (listed in this table) and is the primary source of information for this referral.
Quindanning Timber Reserve	Biostat	2017	Report in preparation. Three season systematic trapping survey with systematic area search bird surveys of the Quindanning Timber Reserve 2017-2018.
	Ninox Wildlife Consulting	2002	Three (3) season systematic trapping survey with systematic area search bird surveys.
Saddleback Timber Reserve	Biostat	2017	Report in preparation. Monitoring of vertebrate fauna within forest and rehabilitation at the BBM 2017-2018, including comparisons with previous sampling. Three (3) season systematic trapping survey with systematic area search bird surveys.
	Biostat	2015	Monitoring of vertebrate fauna within forest and rehabilitation at the BBM 2014-2015, including comparisons with previous sampling. Three (3) season systematic trapping survey with systematic area search bird surveys.
	Ninox Wildlife Consulting	2012	Monitoring of vertebrate fauna within forest and rehabilitation at the BBM 2009-2011 including comparisons with previous sampling. Three (3) season systematic trapping survey with systematic area search bird surveys.
	Ninox Wildlife Consulting	2006	Monitoring of vertebrate fauna within forest and rehabilitation at the BBM 2006-2007. Three (3) season systematic trapping survey with systematic area search bird surveys.
	Ninox Wildlife Consulting	2003	Monitoring of vertebrate fauna within forest and rehabilitation at the BBM 2002 – 2003. Three (3) season systematic trapping survey with systematic area search bird surveys.
	Ninox Wildlife Consulting	1998	A vertebrate fauna survey of the proposed Southern Saddleback mining area 1997-1998. Three (3) season systematic trapping survey with systematic area search bird surveys.
	Ninox Wildlife Consulting	1997	A vertebrate fauna survey of the proposed Northern Saddleback mining area 1996-1997. Three (3) season systematic trapping survey with systematic area search bird surveys.
	Ninox Wildlife Consulting	1992	Phase Three: Vertebrate Fauna Studies. A compilation and analysis of data collected to 1992.
	Ninox Wildlife Consulting	1985	Worsley Alumina Project. Flora and Fauna Studies, Phase Two. A compilation and analysis of data collected to 1985.
Marradong Timber Reserve	Ninox Wildlife Consulting	2012	Vertebrate fauna survey of Marradong Timber Reserve 2012. Three (3) season systematic trapping survey with systematic area search bird surveys.

Survey Area	Consultant	Survey Date	Purpose of Survey/Study and Details
	Ninox Wildlife Consulting	2006	Vertebrate fauna survey of Marradong Timber Reserve 2006-2007. Three (3) season systematic trapping survey with systematic area search bird surveys.
Boddington Gold Mine	Ninox Wildlife Consulting	2016	Vertebrate fauna translocation program from the waste rock dump extension area to be developed within Newmont Boddington Gold Mine. An intensive 2 month trapping program to translocate all terrestrial vertebrate fauna caught during the period prior to the clearing of vegetation.
	Ninox Wildlife Consulting	2012	Vertebrate fauna survey within Newmont Boddington Gold Mine: An assessment of potential waste rock disposal areas. Three (3) season systematic trapping survey with systematic area search bird surveys.
	Ninox Wildlife Consulting	2012	Vertebrate fauna translocation program from the waste rock dump extension area to be developed within Newmont Boddington Gold Mine. Three (3) season systematic trapping survey with systematic area search bird surveys.
	Ninox Wildlife Consulting	2003	Three (3) season systematic trapping survey with systematic area search bird surveys. Due to the very large number of Chuditch caught extra sites and additional survey events were undertaken purely to monitor the population of this species.
	Ninox Wildlife Consulting	1999	Worsley Alumina Boddington Gold Mine Project. Flora and Fauna Studies. A compilation and analysis of baseline surveys undertaken to 1998.
Refinery Lease Area (RLA)	Biostat	2016	Baseline 2 season vertebrate fauna survey of a rehabilitated tailings dam at the Refinery.
	Biostat	2015	Vegetation Clearing: Fauna Assessment. Habitat and fauna assessment of small areas at the edge of the current RLA clearing footprint.
	Bamford Consulting Ecologists	2011	Conservation significant fauna and habitat tree survey for proposed clearing areas, Worsley Alumina Refinery. Targeted survey for species of conservation significance.
	Ninox Wildlife Consulting	2007	An Assessment of the Presence of the Western Ringtail Possum at the Worsley Alumina Pty Ltd Refinery, near Collie, Western Australia. Desktop assessment undertaken using field data.
	Ninox Wildlife Consulting	2002	The vertebrate fauna of the RLA and Mornington Mills Block. Three (3) season systematic trapping survey with systematic area search bird surveys.
Existing Conveyor (RLA to BBM – Saddleback Operations)	Ninox Wildlife Consulting	2010	Three (3) season systematic trapping survey with systematic area search bird surveys. Included specific studies to determine fauna movements across the conveyor.
	Ninox Wildlife Consulting	2004	Three (3) season systematic trapping survey with systematic area search bird surveys. Included specific studies to determine fauna movements across the conveyor.
	Ninox Wildlife Consulting	1998	Three (3) season systematic trapping survey with systematic area search bird surveys. Included specific studies to determine fauna movements across the conveyor.

Fauna Habitat

The fauna habitats present in the Primary Assessment Area are typical for the bioregion and Northern Jarrah Forest subregion, representing and dominated by varying forms of forest and woodland communities.

The fauna habitats identified within the WMDE and Bauxite Transport Corridor are summarised in **Table 17** and those within the CBME are summarised in **Table 18**. The Extent of fauna habitat calculations in **Table 17** and **Table 18** are approximate.

WMDE and Bauxite Transport Corridor

The Jarrah-Marri communities (DL, JC, JM) cover a substantial area of the WMDE. The differentiation between these communities relates to their position in the landscape and the associated soil type and soil structure. In many cases these Jarrah-Marri woodlands within the Timber Reserves have been logged at some time and tend to support trees of similar age cohorts with minimal variation.

Generally, most upper slope and ridge Jarrah-Marri communities (JC/JM) are found on rockier soils and tend to have a lower tree layer characterised by the presence of Bull Banksia (*Banksia grandis*). Rocky lateritic outcrops or granite capping is common within these habitats. Understorey consists primarily of low shrubs and native grasses. Where they occur on mid and lower slopes (JM/JC/DL), these communities tend to be located on more humic soils with a relatively denser shrub understorey.

The presence of Western Sheoak (*Allocasuarina fraseriana*) is an important landscape characteristic for these Jarrah-Marri communities. These areas have the potential to support populations of Brush-tailed Phascogale (*Phascogale tapoatafa*) and Red-tailed Phascogale (*Phascogale calura*). Additionally, Western Sheoak fruit is a component of the food resource types for Black-Cockatoo.

The Wandoo woodland habitat is a common feature of the region. These areas occur on sandy to clay soils and can be found in all elevations in the landscape. Lower storeys and ground cover can vary widely, including *Xanthorrhoea* sp., *Acacia* sp. and *Hakea* sp. Wandoo form hollows readily, which makes these habitats an important component in the biodiversity of the landscape. The flowers and fruit also provide a feeding resource for several vertebrate fauna species. Most of the Wandoo woodlands, as with other native remnants, have been logged and display relatively homogenous age cohort demographics.

Combined these woodland habitats represent large but fragmented areas within the WMDE. In this type of landscape, they provide refuge for fauna as breeding, denning/roosting and foraging habitats. They also provide a means for movements across the fragmented landscape.

Heaths and perched heaths occur infrequently in the landscape. Heaths tend to occur on shallow soils usually over granite cap-rock. They offer a distinct habitat type within the landscape. The high diversity of flowering plant species in such habitats is favoured by such fauna as Honey Possum, *Tarsipes rostratus*, as well as other nectarivores and insectivores (i.e., Honeyeaters, *Sminthopsis* sp, Chiropterans).

Riparian communities are a focal point for fauna, including species not commonly associated with these habitats. The systems provide substantial connectivity in the landscape with the Hotham River (the dominant river flowing through the WMDE) travelling through areas of State Forest and parts of agricultural areas (Biostat, 2019; **Appendix B**).

There are several other habitats which are of varying ecological value. Remnants within agricultural lands are a ubiquitous feature in the agricultural landscape generally retained as shelter belts for stock. They are comprised of stands of trees of relatively homogenous age cohort, with poor understorey dominated by introduced pasture and grain species. These stands, however, provide a resource for native fauna, especially volant fauna (i.e., birds and bats). They can act as supplementary foraging resource or provide breeding/denning/roosting habitat. Remnants can also

provide some level of connectivity within the landscape allowing for movements of individuals or flocks between more suitable habitats. Conversely, introduced predators, such as fox (*Vulpes vulpes*) and cat (*Felis catus*), benefit from the less complex and homogeneity of agricultural landscapes (Carter & Luck, 2013; May & Norton, 1996; White et al., 2006).

Rehabilitated areas form an important component of the landscape with approximately 2,997 ha (including 27 ha of rehabilitated areas on agricultural landscapes) completed in 2018. Their value to fauna is further enhanced if they form part of the landscape connectivity joining less disturbed habitats. Within the controlled operations in mine sites, rehabilitated areas tend to progress along a relatively predictable path as they mature; from bare ground to heath-like habitat through to shrubland, low closed forest, and finally tall forest. After 5 - 8 years, these areas are useful foraging resource for black-cockatoo species, nectarivores and granivores (Lee, Finn & Calver, 2010).

Dams are present throughout the WMDE. They are artificial and, in most cases, non-permanent water sources. They do provide an additional water source for many native species and can act as temporary refugia for waterfowl.

Contingency Bauxite Mining Envelope

The CBME is part of a State Forest area that was logged prior to the establishment of the Refinery in the 1980s. The landscape consists of hills overlooking a valley at its southern boundary and is identified as supporting four general fauna habitats (Biostat, 2019). The valley has been dammed for a constructed freshwater source covering approximately 64 ha of the CBME (**Figure 4**).

The native vegetation associated with the lower landscapes in the area, include minor drainage systems including the Augustus River at the north west of the freshwater dam, comprising the more mesic woodlands and forests characterised by Blackbutt (*Eucalyptus patens*). The most abundant habitat type is a mosaic of Jarrah-Marri communities. The variations in this habitat include Marri-Jarrah forests on moister lower slopes (DL), although the more dominant habitat type are the Jarrah-Marri forests of the slopes and ridges with Bull Banksia and Western Sheoak (JC). Smaller stands dominated by Jarrah/Marri woodlands (JM) form the interface between BB/DL and JC.

The quality of remnant forest areas in the CBME is relatively high resulting primarily from the exclusion of logging within the area.

Table 17: Summary of Fauna Habitats identified within the WMDE and the Bauxite Transport Corridor

Fauna Habitats	Fauna Code	General Fauna Type	Approximate Extent within the WMDE (ha)	Approximate extent within the Bauxite Transport Corridor (ha)
Blackbutt woodlands on lower slopes	BB	Riparian/Wetland and associated communities	33.72	27.02
Mosaic of Marri/Jarrah on lower slopes and Flooded Gum on riparian communities	FD		5.35	5.35
Flooded Gum woodlands riparian community	FG		640.40	253.03
Jarrah/Marri valley floors/swamps	JS		0.47	0
Melaleuca shrublands on seasonally wet valley floors	MS		126.24	40
Flooded Gum/Melaleuca shrublands on seasonally wet valley floors	MW		1.66	0
Marri/Jarrah on lower slopes	DL	Jarrah/Marri communities	399.16	152.43
Jarrah/Marri/Allocasuarina woodlands on slopes and ridges	JC		4,944.75	1,138.18
Jarrah/Marri woodlands on slopes	JM		3,150.84	729.99
Low Eucalyptus woodland over low shrubs	ML	Mallee woodlands	11.75	2.07
Wandoo woodlands	WO	Wandoo communities	2,426.46	581.04
Heaths including perched heaths	PH	Heath communities	149.27	9.80
Rehabilitation	RE	Others	3,219.71	70.72
Plantations	PL		420.44	1.25
Dam	Dam		1	0
Cleared lands/agricultural areas	CL		12,504.13	1,135.05
Total			27,796.20	4,145.70

Table 18: Summary of Fauna Habitats identified within the CBME

Fauna Habitats	Fauna Code	General Fauna Type	Approximate extent within the CBME (ha)
Blackbutt woodlands on lower slopes	BB	Riparian/Wetland and associated communities	99.16
Marri/Jarrah on lower slopes	DL	Jarrah/Marri communities	17.68
Jarrah/Marri/Allocasuarina woodlands on slopes and ridges	JC		314.82
Jarrah/Marri woodlands on slopes	JM		82.98
Dam	Dam	Others	72.81
Cleared lands	CL		167.64
Total			747.10

Several assessments have also been carried out across the Primary Assessment Area investigating potential habitat trees for fauna with a secondary focus on the three Threatened Black-Cockatoo

species (**Appendix B**). Broadly, these assessments have recorded the most common tree species Jarrah, Marri and Wandoo with the majority of trees between 10 to 15 m in height and 50 to 100 cm in diameter. This likely reflects the extent of logging across the landscape. Hollows have most often been recorded in trees in the 10 to 15 m height category, with a hollow diameter of <15 cm (Biostat, 2019; Appendix B). A comparison of density of trees and hollows between fauna habitat sites indicates that the highest tree densities occur in the Jarrah-Marri fauna habitats.

Pre-clearance surveys as part of Worsley's mine operations have also resulted in the identification of 627 Potential Habitat Trees (PHT) as of November 2018. Not all of these trees are retained as part of mine operations. However, trees are assessed under a mitigation hierarchy for action (retention or removal) prior to clearing and mine operations. Potential retention of trees is applicable if they are:

- Identified as a confirmed Black-Cockatoo breeding tree;
- Offer extremely high potential without confirmation of Black-Cockatoo breeding; or
- Identified as a confirmed night roosting tree (regular or intermittently used night roost).

The existence of PHT increase the ecological values of the landscape for numerous volant and non-volant fauna species. The presence of larger hollows (>15cm diameter) is dictated by higher densities of larger and, therefore, older, trees and these are considered an essential resource for the three Threatened Black-Cockatoo species recorded in the area (Biostat, 2019).

Ecological Linkages

The vegetation within the area the subject of the proposal is highly fragmented, however some linkages and corridors between areas of native habitats and remnants are present. Several areas contain native forest remnants of relative high quality and connectivity, for example the northern area of the BGM.

An existing and important movement corridor system within the current landscape is the Hotham River, its tributaries and remnant feeder creek systems. These waterways are mostly fringed by narrow riparian and associated communities. The waterways provide habitat for aquatic and semi-aquatic species.

Conservation Significant Fauna

Desktop searches of the EPBC Act Protected Matters Search Tool, DBCA *NatureMap* databases and review of the DBCA Threatened and Priority Fauna List identified the presence or potential presence of ten bird and seven mammal conservation significant fauna species within the Primary Assessment Area. In addition, one bird species, five mammal species and three reptile species are listed under DBCA priority species categories (**Appendix B**).

The likelihood of occurrence of each of these species was assessed based on previous fauna surveys and an understanding of the habitat present within the WMDE, the Bauxite Transport Corridor and the CBME (collectively, the Primary Assessment Area). An assessment of the potential occurrence of conservation significant fauna is provided in **Table 19** and **Appendix B**. **Appendix B** also provides database and survey records of these species providing local and regional detail.

Table 19: Threatened Fauna within the Primary Assessment Area

Common Name	Species	Status: EPBC Act	Status: BC Act	CBME Likelihood	WMDE Likelihood
Noisy Scrub-bird	<i>Atrichornis clamosus</i>	EN	EN, S2	Extremely Unlikely	Extremely Unlikely
Australasian Bittern	<i>Botaurus poiciloptilus</i>	EN	EN, S2	Unlikely to Low	Unlikely to Low
Curlew Sandpiper	<i>Calidris ferruginea</i>	CR, IA, MI	MI, S3	Unlikely to Low	Unlikely to Low
Forest Red-tailed Black-Cockatoo	<i>Calyptorhynchus banksii naso</i>	VU	VU, S3	High, Recorded	High, Recorded
Baudin's Black Cockatoo	<i>Calyptorhynchus baudinii</i>	EN	EN, S2	High, Recorded	High, Recorded
Carnaby's Black Cockatoo	<i>Calyptorhynchus latirostris</i>	EN	EN, S2	High, Recorded	High, Recorded
Peregrine Falcon	<i>Falco peregrinus</i>	-	CD, S6	High, Recorded	High, Recorded
Malleefowl	<i>Leipoa ocellata</i>	VU	VU, S3	Unlikely to Low	Unlikely to Low
Eastern Curlew	<i>Numenius madagascariensis</i>	VU, IA, MI	MI, S3	Unlikely to Low	Unlikely to Low
Australian Painted Snipe	<i>Rostratula australis</i>	EN	EN, S2	Unlikely to Low	Unlikely to Low
Woylie	<i>Bettongia penicillata ogilbyi</i>	EN	CR, S1	Moderate to High	High, Recorded
Chuditch	<i>Dasyurus geoffroii</i>	VU	VU, S3	High, Recorded	High, Recorded
Bilby	<i>Macrotis lagotis</i>	VU	VU, S3	Highly Unlikely	Highly Unlikely
Numbat	<i>Myrmecobius fasciatus</i>	EN	EN, S2	Unlikely	Unlikely to Low
Red-tailed Phascogale	<i>Phascogale calura</i>	VU	CD, S6	Unlikely	High, Recorded
Western Ringtail Possum	<i>Pseudocheirus occidentalis</i>	CR	CR, S1	Moderate to High	Unlikely
Quokka	<i>Setonix brachyurus</i>	VU	VU, S3	High	Unlikely
Carter's Freshwater Mussel	<i>Westralunio carteri</i>	VU	VU, S3	High, Recorded	Unlikely to Low

4.2.3.2. Aquatic Fauna

Aquatic fauna surveys including those for macroinvertebrates crayfish, freshwater fish and species of conservation significance have been undertaken within and adjacent to the Project for baseline and monitoring purposes. A summary of aquatic fauna surveys conducted for the Project is provided in **Table 20**.

Table 20: Summary of Aquatic Fauna Surveys undertaken for the Project

Consultant	Survey Area	Survey Date	Purpose of Survey/Study and Details
Wetland Research and Management	Junglen Gully and Thirty-Four Mile Brook drainage entering Hotham River	2012	Systematic sampling of aquatic fauna (macroinvertebrates, crayfish and fish) and water quality assessment
Wetland Research and Management	Hotham River and Thirty-Four Mile Brook	2011	Determination of Ecological Water Requirements of the Hotham River downstream of Tullis Bridge
Wetland Research and Management	Thirty-Four Mile Brook drainage entering Hotham River	2012	Ecological Monitoring - Systematic sampling of aquatic fauna (macroinvertebrates, crayfish and fish). Comparison of water quality data against ANZECC/ARMCANZ (2000) guidelines
Wetland Research and Management	Gringer Creek drainage entering Hotham River	2012	Ecological Monitoring - Systematic sampling of aquatic fauna (macroinvertebrates, crayfish and fish). Comparison of water quality data against ANZECC/ARMCANZ (2000) guidelines
Wetland Research and Management	Boggy Brook, House Brook and Wattle Hollow Brook drainage entering Hotham River	2012	Systematic sampling of aquatic fauna (macroinvertebrates, crayfish and fish) and water quality assessment
Wetland Research and Management	Augustus River, Brunswick River	2005	Determination of Ecological Water Requirements of the Augustus River.
Murdoch University – Marine and Freshwater Research Laboratory	Worsley Refinery	2000	Water quality, aquatic macroinvertebrate and fish monitoring
Streamtec	Worsley Refinery	1993	Aquatic Monitoring Program including water quality, aquatic macroinvertebrate and fish monitoring
Natural Systems Research	Refinery Lease Area	1984	Aquatic biological baseline and monitoring investigations

WMDE and Bauxite Transport Corridor

Several brooks, streams and minor drainage lines enter the Hotham River upstream, within and downstream of the WMDE (including Thirty-Four Mile Brook, Junglen Gully, Gringer Creek, Boggy Brook, House Brook and Wattle Hollow Brook). These drainage systems and Hotham River have been assessed for their Ecological Water Requirements (EWR) by Wetland Research and Management during the period 2009 to 2012. Assessments have included multi-seasonal detailed systematic ecological surveys of the macroinvertebrate, crayfish and fish of the river and tributaries.

The following is a summary of the fauna ecology of the Hotham River and a larger tributary of the Hotham River, Thirty-Four Mile Brook conducted by Wetland Research and Management (WRM, 2011) most representative of the aquatic fauna relevant to the WMDE. Drainage lines are located within the WMDE. The study identified a total of 111 macroinvertebrate taxa. Taxa richness varied between site and season (Spring and Autumn). Of these taxa 9% (10 taxa) were endemic to the southwest, 4% restricted to Western Australia, 20% from the Australian continent, 4% across

southern Australia, 13% Australasian, 23% Cosmopolitan occurring widely across Australia and international and 27% indeterminate due to insufficient taxonomy. None of the species recorded are listed on Threatened or Priority lists. Locally endemic species included the freshwater crayfish *Cherax quinquecarinatus* and *Cherax preisii*, the dragonflies *Austrogomphus lateralis*, *Austroaeschna anacantha* and *Procordula affinis* and the damselfly *Austrolestes aleison*. No introduced species were recorded.

WRM (2012) recorded five native fish species and two introduced species from the Hotham River and Thirty-Four Mile Brook including the freshwater cobbler *Tandanus bostocki*, Swan River goby *Pseudogobius olorum*, western minnow *Galaxias occidentalis*, nightfish *Bostockia porosa* and western pygmy perch *Edelia vittata*. Introduced fish were the mosquitofish *Gambusia holbrooki* and the redfin perch *Perca fluviatilis*. Native species recorded were regional endemics, however, recognised as common throughout southwestern Australia.

The WMDE is located at the eastern edge of the current distribution of Carter's Freshwater Mussel *Westralunio carteri* (Department of the Environment and Energy, 2019c). This species is listed as 'Vulnerable' under the EPBC Act and BC Act (**Table 19**). Formerly its distribution extended into the interior of the southwest, but now it rarely occurs more than 50 km inland (Klunzinger et al, 2012; GHD, 2019). The decline of Carter's Freshwater Mussel in the southwest region has been due to increased salinity within the river systems (Klunzinger et.al, 2015; GHD, 2019). A review of database records by GHD (2019) identified a single record (record collected in 1969) of Carter's Freshwater Mussel to the south-west of the WMDE on a tributary of the Hotham River. There are no recent records available and the species has not been recorded in any of the recent systematic aquatic ecology surveys of the Hotham River and tributary surveys available for review in proximity to the WMDE (refer to **Table 20**).

Contingency Bauxite Mining Envelope

The Worsley Freshwater Lake (FWL) and Augustus River located downstream of the FWL are the significant aquatic resources within the CBME. The Freshwater Lake was constructed in 1983 to '...provide water to the Worsley Alumina bauxite processing plant and has a reservoir storage capacity of 6.0GL' (WRM, 2005). Its construction was complete by damming the headwaters of the Augustus River, a significant tributary of the Brunswick River. The confluence of the Augustus River with the Brunswick River is approximately 5 km downstream to the west of the CBME.

An assessment of the EWR for the Augustus River was undertaken in 2004/2005. This assessment included detailed systematic ecological surveys of the macroinvertebrate, crayfish and fish of the river.

WRM (2005) identified a total of 68 taxa of aquatic macroinvertebrate from the Augustus River survey. From a macroinvertebrate perspective, the Augustus River was concluded to be of high ecological value due to the considerable number of endemic, rare and indicator species present. For example, a number of endemic trichopteran (caddis fly) species, Gondwanic gripopterygid plecopterans (stoneflies) and sythemistid dragonfly which are essentially restricted in distribution and endemic to the south-west of Western Australia were identified. Two species of indigenous freshwater crayfish marron *Cherax cainii* and gilgies *C. quinquecarinatus*. were also recorded.

The Carter's freshwater mussel *Westralunio carteri* was recorded during the WRM (2005) aquatic fauna surveys of the Augustus River and Hale et al (1999) surveys of the Augustus River and Freshwater Lake of the Refinery. A review of records from the DBCA Naturemap database undertaken by GHD (2019), identify several recent records in the vicinity of the CBME (Augustus River recorded in 2017 approximately 4 km east north east of the CBME; 8.5 km west of the CBME in 2010, and records from the Collie River and Wellington Dam catchment area approximately 10 km south of the CBME in 2009 to 2011).

Carter's Freshwater Mussel rely on freshwater fish species in their larval lifecycle. The larvae attach to host fish gills enabling the mussel larvae to disperse upstream. After several weeks the juvenile mussels detach from the host fish and settle into the creek bed sediment or other suitable river bed substrate where they begin filter-feeding and growing (Klunzinger et al, 2012; GHD, 2019).

Three native fishes and one introduced species were recorded from the Augustus River during the 2004 survey. Species included the night fish *Bostockia porosa*, the western minnow *Galaxias occidentalis*, the western pygmy perch *Edelia vitatta*, and the exotic rainbow trout *Oncorhynchus mykiss*. Not all native fish species expected to occur within the study area were collected (WRM, 2005). Hale et al (1999) also identified similar species in their studies of the Augustus River and additional species in the Brunswick River.

The WRM (2005) study assessed the Augustus River as '...ecologically healthy with an apparently stable channel (no excessive, unnatural erosion), supporting a high diversity of habitats and aquatic fauna characteristic of a relatively pristine, forested south-west river (WRM, 2005).

4.2.3.3. Short-Range Endemic Invertebrate Fauna

Short-range Endemic (SRE) invertebrate fauna are defined as animals that display restricted geographic distributions, nominally less than 10,000 km², that may also be disjunct and highly localised (Harvey, 2002; Ponder & Colgan, 2002). Short-range endemism in terrestrial invertebrates is believed to have evolved through two primary processes (Harvey 2002), relictual short-range endemism – where drying climate has forced range contraction into small pockets with remaining moist conditions (i.e. south-facing rock faces or slopes of mountains or gullies) – and habitat specialist SREs that may have settled in particular isolated habitat types (i.e. rocky or granite outcrops) by means of dispersal and evolved in isolation into distinct species (Phoenix Environmental Sciences, 2019a).

SRE fauna need to be considered in environmental impact assessment as localised, small populations of species are generally at greater risk of changes in conservation status due to environmental change than other, more widely distributed taxa (EPA, 2016i). In the context of EPA survey requirements and the geographic location of the Primary Assessment Area, the following SRE groups are considered likely to occur; mygalomorph (trap-door spiders), pseudoscorpions, scorpions, millipedes, slaters and snails.

A summary of SRE surveys conducted for the Project over time is provided in **Table 21**. A risk assessment of potential habitat suitability and potential occurrence of the SRE was conducted in line with EPA guidance (EPA, 2016i) using the following:

- Two comprehensive baseline surveys for SRE;
- A desktop review of the Primary Assessment Area completed by Phoenix Environmental Sciences (2019a, 2019b, Appendix C), which incorporated findings for these studies; and
- Expert review of the Western Australian Museum (WAM) SRE database and spatial analysis of the dataset with respect to the most up to date vegetation datasets available for the Primary Assessment Area (Mattiske, 2019).

Table 21: Summary of SRE Surveys undertaken for the Project

Consultant	Survey Area	Survey Date	Purpose of Survey/Study and Details
Phoenix Environmental Sciences	Primary Assessment Area	2018	Desktop review and risk assessment for the potential occurrence of SRE within the Primary Assessment Area (Appendix C).
Phoenix Environmental Sciences	BBM and surrounding areas of the Northern Jarrah Forest	2012	Two-season SRE survey for the BHP Billiton Worsley Alumina Primary Bauxite Area Expansion Project – Regional Assessment
Outback Ecology	Newmont Boddington Gold Mine Waste Rock Dump and Residue Disposal Area Expansion	2011	Phase 1 Terrestrial SRE Desktop Assessment

WMDE and Bauxite Transport Corridor

Baseline SRE surveys of the BBM and the greater Boddington area PBA (Phoenix Environmental Sciences, 2012) are the most comprehensive in the context of the Primary Assessment Area. This study recorded a total of 21 taxa including 13 genera from 13 families and six orders (comprising 368 individuals). Five habitat types with the potential to harbour SREs were identified and sampled (Jarrah woodland, Wandoo woodland, heathland, rocky outcrops and a creek line in Wandoo woodland) at ten sites in spring 2011 and a further seven sites in the autumn 2012 survey. Of the confirmed and likely SREs, only two taxa (both millipedes) were found to be restricted to the study area, within the WMDE. The potential and likely SRE trapdoor spiders, harvestmen and slaters recorded were all considered likely to have distributions much larger than the study area, due to widespread, multiple records, often from different habitats (Phoenix Environmental Sciences 2012, 2019a).

The comprehensive SRE survey undertaken by Outback Ecology (2012) for the BGM, in the northern section of the WMDE, recorded 24 potential SRE species including two mygalomorph spiders, one scorpion, four millipedes, two slaters, two snails and 13 undescribed earthworms. Outback Ecology (2012) concluded that granite outcrops and *Melaleuca* swampland habitats had a high potential, *Allocasuarina* and Wandoo woodland had a medium potential and the remaining habitats had a low potential.

Spatial analysis of the WMDE and the Bauxite Transport Corridor by Phoenix Environmental Sciences (2019a) identified nine terrestrial fauna habitat units (from the thirty-six native vegetation units and four heavily modified landcover units mapped by Matiske Consulting (**Appendix A**)). These were rated for their potential to support SRE species. Six of the nine fauna habitat types (derived from 13 vegetation units) were determined to offer high potential to support SREs and together comprise 5% of the WMDE and Bauxite Transport Corridor.

A single fauna habitat type, open forest of Jarrah/Marri on sandy-loam gravelly soils on mid slopes and ridges, was determined to have Medium potential to support SREs (derived from 11 vegetation units) and comprises 30% of the WMDE and the Bauxite Transport Corridor. Two fauna habitat types were considered to have only a Low potential to support SREs (derived from six vegetation units), and together comprised 8% of the WMDE. Fauna habitats with low potential to support SREs together with the modified landcover units comprise 65% of the WMDE and the Bauxite Transport Corridor (Phoenix Environmental Sciences, 2019a).

Based on expert opinion the WAM SRE classification scheme (WAM, 2013), the database review (WAM, 2018) of the WMDE and a 5 km buffer; there are 27 taxa (listed below) that are considered

confirmed or potential SREs. However, many of these species are found within multiple, disparate fauna habitats and vegetation units, (suggesting SRE status requires revision) and outside the WMDE boundary. Of these species, uncertainty remains for only three of the 27 taxa (listed below), being one trap-door spider (*Eucyrtops`marradong`*), a sucking millipede (*Siphonotidae`Marradong`*) and an isopod (*Acanthodillo* sp. *worsley* B) (Phoenix Environmental Sciences, 2019a; **Appendix C**).

Phoenix Environmental Sciences (2019a) conclude that *Acanthodillo* sp. *Worsley B* is the most restricted SRE taxon within the WMDE and the Bauxite Transport Corridor, and that the remaining 26 confirmed or potential SRE taxa are, or are likely to be, widely distributed in the area. This species was recorded in rocky outcrop of laterite and granite. The area has since been mapped as vegetation unit MG, which comprises <1% of the mapped extent (Mattiske Consulting, 2019). Phoenix Environmental Sciences suggest that impacts to this taxa can be minimised by the identification of 'significant granite outcrops' (as defined in Worsley's Protected Areas Procedure; Worsley, 2013b) within the WMDE and the Bauxite Transport Corridor. Adherence to Worsley's existing principles and procedures should be sufficient to protect habitat for *Acanthodillo* sp. *Worsley B*.

Contingency Bauxite Mining Envelope

A review of literature for the CBME was unable to identify any SRE reports directly attributed to the Refinery and the immediate surrounding area. The most relevant are the comprehensive studies associated with the BBM discussed above, including Phoenix Environmental Sciences (2012), with a southern boundary of the study area located approximately 36 km north east of the CBME.

The WAM database results for the CBME revealed only two taxa that are considered potential SREs, both scorpions. All other species were considered widespread. Phoenix Environmental Sciences (2019b) state that there was little species overlap between the database search results for the CBME and the surveys considered in the literature review (Outback Ecology, 2012; Phoenix Environmental Sciences, 2012). The summary report is provided in **Appendix D**.

The general pattern of widespread species occurrence evident in the WAM database output (WAM, 2018) reflects the vegetation patterns and interpreted fauna habitats. That is, open forests of Jarrah/Marri dominate the CBME (67% of the extent of native vegetation). As a broadly occurring habitat unit it does not in itself represent habitat with a high to medium potential to support short-range endemism. Such habitat typically occurs as a distinct feature/unit within the broader open forest environment, such as significant granite outcrops, swamplands and creek lines; essentially features that tend to offer moisture refuges or unique features that drive isolation (Phoenix Environmental Sciences, 2019b; **Appendix D**).

Phoenix Environmental Sciences (2019b) identify five fauna habitat units that they considered to have a high potential to support SRE species within the CBME due to their association with water/moist conditions. High potential areas comprise approximately 15% of the CBME. The potential of fauna habitat types including Open Jarrah/Marri forest, mid slopes and ridges on sandy-loam gravelly soils (comprising 53% of the CBME) to support SREs was rated as medium because that unit was considered most likely to contain significant granite outcrops but would otherwise be rated as low. Phoenix Environmental Sciences (2019b) suggest that adherence to Worsley's existing principles and procedures should be sufficient to protect SRE habitat and minimise impacts to SRE species if mining is undertaken within the CBME.

4.2.3.4. Subterranean Fauna

For the purposes of environmental impact assessment, the EPA (2016j) defines subterranean fauna as fauna which live their entire lives (obligate) below the surface of the earth. They include

stygofauna (aquatic and living in ground water) and troglifaunal (air-breathing and living in caves and voids). The EPA's objective with respect to subterranean fauna is its protection so that biological diversity and ecological integrity are maintained.

The obligate underground existence of subterranean fauna greatly increases the likelihood of short range endemism and the possibility that a species' conservation status may be impacted as a result of the implementation of a proposal. Subterranean fauna species may therefore be considered to be significant due to (EPA 2016j):

- Being identified as Threatened or Priority species
- Locally endemic
- Potentially new species
- Occupying restricted habitats
- Forming part of a Threatened or Priority Ecological Community

The Primary Assessment Area is located in the southwest of WA, an area generally known to have low prospects for subterranean fauna presence for non-karst geologies (EPA, 2016g). The local geology and hydrogeology of the Primary Assessment Area is dominated by low permeability lithologies (lateritic duricrust often cemented) over pallid, kaolinitic (clay) zones of varying thickness, over bedrock; with only minor local aquifers present. Karst is not present (**Appendix E; Appendix F**).

Interrogation of WAM Arachnida/Myriapoda and Crustacea databases revealed no subterranean fauna species known within 5 km of the Primary Assessment Area and a review of published and unpublished literature has failed to find any additional data in close proximity to, or applicable to the areas the subject of the proposal, which may provide evidence to the contrary (**Appendix E; Appendix F**).

In addition, the EPA did not consider subterranean fauna to be a key environmental factor for other recent proposals in the Jarrah Forest Bioregion (JAF01 and JAF02; EPA, 2018c; Strategen, 2013), therefore it is considered that Subterranean Fauna is not a key environmental factor for this Referral.

Phoenix Environmental Sciences (2019d) conclude that subterranean fauna are unlikely to be present within the Primary Assessment Area, and that development of the proposal presents a very low risk to subterranean fauna. Refer to **Appendix E** and **Appendix F** for supporting information by Phoenix Environmental Sciences on subterranean fauna relevant to the Primary Assessment Area, respectively.

4.2.4. Proposal Activities

Activities associated with the proposal that have the potential to impact terrestrial fauna include mining activities, bauxite transport, construction and contingency bauxite mining.

4.2.5. Potential Impacts

The potential impacts to native fauna from the implementation of the proposal include:

- Loss of fauna habitat through the direct loss of native, plantation and rehabilitated habitat. This includes loss of habitat for EPBC Act and BC Act listed Threatened, Priority and

Migratory species, for example Black Cockatoo foraging habitat, potential habitat trees, habitat suitable for the Woylie and Chuditch.

- Further habitat fragmentation at the local level through partial or complete clearing of isolated bands or patches of native vegetation;
- Noise impacts associated with ongoing operations (existing conveyors, long-term infrastructure, mine operations and Worsley Refinery) have the potential to exacerbate fauna fragmentation impacts.
- Habitat fragmentation through the development of a bauxite transport route (and potential long-term conveyor) within the Bauxite Transport Corridor;
- Displacement, injury or death of fauna individuals during construction and mining activities including clearing and bauxite transport (vehicle strike);
- Increased potential exposure (via transport corridors, clearing and tracks) to native species predation and habitat disturbance from feral and invasive species;
- Freshwater impacts from silt entering drainage during construction activities; and
- Secondary impact from dust, noise and vibration during mining activities.

4.2.6. Mitigations

Worsley has applied the mitigation hierarchy (avoid, minimise, rehabilitate, offset) to reduce the potential environmental impacts of the proposal activities including:

- Avoid – avoiding the adverse environmental impact;
- Minimise – limit the degree or magnitude of the adverse impact;
- Rehabilitate – restore the maximum environmental value that is reasonably practicable; and
- Offset – offset likely to be proposed to provide environmental benefits to counterbalance significant residual environmental impacts or risks if any are assessed to remain after the above measures have been adopted.

The proposed mining footprint for this proposal has been designed to avoid, wherever practicable, areas of high environmental value as shown in **Figure 6** (protected areas in this figure are indicative only and will be ground-truthed in Environmental Review Document technical studies) in accordance with the Protected Areas Procedure in the Biodiversity and Forest Management Plan (**Appendix H**). These areas include the location of Threatened or Priority flora, TECs and PECs, poorly represented (less than 30% of pre-European extent) vegetation complexes, Aboriginal heritage sites, high value areas such as caves and breakaways, and river protection buffers.

Potential impacts to terrestrial fauna associated with the proposal are proposed to be managed by Worsley consistently with existing management practices such as the following:

- Avoidance of areas of potential high conservation value wherever practicable in accordance with the Protected Areas Procedure in the Biodiversity and Forest Management Plan (**Appendix H**);
- Biodiversity and Forest Management Plan (**Appendix H**), which includes the rehabilitation prescription for topsoil and overburden, compliance reporting and review;
- Internal clearing procedures and standards including the Native Vegetation Clearing Planning Procedure (Worsley, 2012), Mine Clearing Procedure (Worsley, 2015d), Mine Clearing Standard (Worsley, 2015e);

- Minimising the mining footprint where possible;
- Fauna Management – Pre-clearance Black-Cockatoo Surveys (Worsley, 2018a) and Animal Handling Procedure (Worsley, 2010);
- Feral and invasive species management in accordance with the BFMP (**Appendix H**);
- Continued implementation of the Forest Hygiene Management Procedure (Worsley, 2014a), which sets out procedures for the management of weeds and forest disease, including Dieback;
- Development and implementation of ecological linkages/corridors for the proposal area in accordance with the BFMP (**Appendix H**);
- Development and implementation of a CEMP for all construction activities relating to this proposal;
- Construction works within river crossings areas will be managed to ensure the duration and extent of any impacts are minimised;
- Site Drainage Standard (Worsley, 2015h) and Trunk Haul Road Design and Construction specifications;
- Development and implementation of appropriate fauna linkage structures promoting habitat connectivity, for example, fauna underpasses and overpasses for mid and long-term infrastructure;
- Progressive rehabilitation activities utilising internal rehabilitation procedures and standards including the Rehabilitation Standard (Worsley, 2013c) which sets out the minimum standard for all rehabilitation activities for the Project including rehabilitation planning, landholder communication and KPIs for rehabilitation success. Worsley also utilises the Mine Rehabilitation Operations Procedure (Worsley, 2015f), the Private Land Rehabilitation Management Procedure (Worsley, 2015g), and BBM Revegetation Management Procedure (Worsley, 2015a); and
- Continued review, update and improvement of all relevant management plans and procedures for the Project.

4.2.7. Assessment of Impacts

Worsley has been operating the Project since the 1980s and has completed a significant amount of survey effort across the region. A desktop assessment of existing fauna data covering the Primary Assessment Area has been carried out by Biostat for this proposal and has been provided in **Appendix B**. A detailed understanding of the impacts to conservation significant fauna and fauna habitats will be further addressed in the Environmental Review Document.

Two summary reports have been prepared by Phoenix Environmental Sciences summarising the potential for SRE invertebrate fauna within the WMDE and the Bauxite Transport Corridor (**Appendix C**), and the CBME/Refinery (**Appendix D**). Both desktop reports summarise that there is potential for SRE invertebrate fauna to be located within the Primary Assessment Area, however that a majority of these 'confirmed' or 'potential' SRE taxa have been found to occur in disparate fauna habitats and vegetation units as well as outside the Primary Assessment Area. Phoenix Environmental Sciences have also prepared two summary reports on the likely presence of subterranean fauna within the WMDE and the Bauxite Transport Corridor (**Appendix E**), and the CBME/Refinery (**Appendix F**). It can be concluded from this assessment the implementation of the proposal is not likely to impact subterranean fauna as the likelihood of subterranean fauna being located within the Primary Assessment Area is very low.

A detailed understanding of the significance of the impacts to fauna will be further demonstrated in the Environmental Review Document as the impact assessment process progresses. It is expected that the direct, indirect and cumulative impacts associated with the proposal will be able to be managed to meet the EPA's objectives for Terrestrial Fauna, and EPBC Act objectives for MNES, to an acceptable level once the mitigation hierarchy has been adopted.

4.3. TERRESTRIAL ENVIRONMENTAL QUALITY

4.3.1. EPA Objective

The EPA applies the following objective from the *Statement of Environmental Principles, Factors and Objectives* (EPA, 2016e) in its assessment of proposals that may affect terrestrial environmental quality:

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

4.3.2. Policy and Guidance

The following EPA guidelines and guidance have been considered in the assessment of terrestrial environmental quality with respect to the EPA objective:

- Environmental Factor Guideline - Terrestrial Environmental Quality (EPA, 2016d).

4.3.3. Receiving Environment

Soils

The BBM and the Refinery are located on the Darling Scarp, which is bounded to the west by the Swan Coastal Plain and to the east by the Collie Coal Basin. Generally, the soils in the upslope areas of BBM are shallow with lateritic duricrust and granitic bedrock at or close to the surface. The mid-slope regions are dominated by shallow soil with lateritic duricrust close to the surface, sandy piezolithic gravel dominates the upper strata. Clayey sandy silt is deposited by alluvial processes in the low-lying areas of the catchment (Strategen, 2005). Bauxite ore has developed in the upper part of the weathered lateritic profile of the upland areas.

The Refinery area in general straddles the broad dissected valleys of the tributaries of the Augustus River. The area comprises the existing Refinery, Bauxite Residue Disposal Areas (BRDAs) and dams. The topography has been substantially altered by the BRDAs, which lie on either side of a valley. The valley drains towards the Freshwater Lake (Worsley, 2016).

Soil-landscape mapping of Western Australia indicates that the Primary Assessment Area is primarily located within the following soil systems:

- The Marradong Upland System, with soils described as sandy gravel, loamy gravel, grey deep sandy duplex and loamy duplex;
- Quindanning System, with soils described as deep sandy duplex soils, shallow sand, loamy duplex and bare rock;
- Darling Plateau System, with soils described as duplex sandy gravels, loamy gravels and wet soils.

Salts derived from rainfall (mostly sodium chloride) are stored within the surface soils and sediments (regolith) in the region of the BBM, at levels from 100 to 10,000 tonnes per hectare (t/ha). These salts are concentrated in the root zone but by transpiration accumulate deeper into the saturated zones of the regolith. Low rainfall, low topography and higher rates of evaporation can also contribute to the retention of salt in the soil (Strategen, 2005).

An assessment of soil salinities at BBM by Water and Environmental Consultants revealed that Worsley soil salinities are less than surrounding areas by approximately 50 – 60% (Croton & Dalton, 2007). One explanation for this is that Worsley boreholes are in strong association with bauxite,

which is known to be an indicator of better vertical drainage and will store less salt in the soil. Croton & Dalton (2007) did not find a relationship between rainfall and soil salinity for the existing BBM.

Potential Acid Sulphate Soils

A review of the Australian Soil Resource Information System (ASRIS) indicates that there is an extremely low probability of acid sulphate soils (ASS) in the majority of the Primary Assessment Area. The banks of the Hotham River have a high probability of occurrence (ASRIS, 2017). Therefore, there is a high likelihood of ASS occurrence on the banks of the Hotham River within and adjacent to the WMDE and the Bauxite Transport Corridor.

Contaminated Sites

Worsley has submitted several Form 1 Reports of a Known or Suspected Contaminated Sites (including one in May 2005 for the Refinery, one on 29 May 2007 for the BBM and one in 2010 for the mining tenements). The BBM and Refinery have known and suspected contaminated sites. A Contaminated Site Assessment Strategy has been developed to assess and manage associated contaminated site risks and inform the Closure Plan for future decommissioning and rehabilitation planning.

4.3.4. Proposal Activities

Proposal activities that have the potential to impact the quality of land and soils include the clearing of vegetation and the excavation of soils associated with mining activities and the construction of river crossings for bauxite transport.

4.3.5. Potential Impacts

Potential impacts to terrestrial environmental quality from the implementation of the proposal include:

- Erosion impacts potentially leading to poor soil structure, reduced water infiltration and general loss of soil health from vegetation clearing and soil excavation activities;
- Salinisation of soils ('dryland salinity'), potentially leading to loss of plant species and decreased quality of water resources;
- Contamination of land and soils from fuel and chemical storage leaks, waste products being released into the environment and acid sulphate soils as a result of disturbance to river crossings.

4.3.6. Mitigation

Worsley has applied the mitigation hierarchy (avoid, minimise, rehabilitate, offset) to reduce the potential environmental impacts of the proposal activities including:

- Avoid – avoiding the adverse environmental impact;
- Minimise – limit the degree or magnitude of the adverse impact;
- Rehabilitate – restore the maximum environmental value that is reasonably practicable; and
- Offset – offset likely to be proposed to provide environmental benefits to counterbalance significant residual environmental impacts or risks if any are assessed to remain after the above measures have been adopted.

Potential impacts to terrestrial environmental quality associated with the proposal are proposed to be managed by Worsley consistent with current environmental management practices such as the following:

- Avoidance of areas of potential high conservation value wherever practicable utilising the Protected Areas Procedure in the Biodiversity and Forest Management Plan (**Appendix H**);
- Avoidance and minimisation of clearing of native vegetation within the design phase to reduce the footprint of mine pits, mine haul and trunk roads, bauxite corridor road haulage and conveyor routes, and construction infrastructure support areas, wherever practicable, which will reduce the potential development of dryland salinity;
- Biodiversity and Forest Management Plan (**Appendix H**), which includes the rehabilitation prescription for topsoil and overburden including the Topsoil and Overburden Handling procedures (Worsley, 2013d);
- Implementation of appropriate methods to avoid, manage and remediate potential ASS within river crossing areas;
- Development and implementation of a CEMP for all construction activities relating to this proposal including management of PASS;
- Biodiversity and Forest Management Plan (**Appendix H**), which includes the rehabilitation prescription for topsoil and overburden, compliance reporting and review;
- Progressive rehabilitation activities utilising internal rehabilitation procedures and standards including the Rehabilitation Standard (Worsley, 2013c) which sets out the minimum standard for all rehabilitation activities for the Project including rehabilitation planning, landholder communication and KPIs for rehabilitation success. Worsley also proposes to utilise the Mine Rehabilitation Operations Procedure (Worsley, 2015f), the Private Land Rehabilitation Management Procedure (Worsley, 2015g), and BBM Revegetation Management Procedure (Worsley, 2015a); and
- Continued review, update and improvement of all relevant management plans and procedures for the Project.

4.3.7. Assessment of Impacts

Worsley will commission a soil and landform study including a baseline soil quality assessment of the Primary Assessment Area to determine soil quality to further inform the environmental impact assessment. Depending on bridge design and construction techniques, Worsley may undertake ASS investigations in the vicinity of the Hotham River if construction activities are considered likely to disturb ASS.

A detailed understanding of the significance of the impacts to terrestrial environmental quality will be further defined in the Environmental Review Document as the impact assessment process progresses.

It is expected that the direct, indirect and cumulative impacts associated with the proposal will be able to be managed to meet the EPA's objectives for Terrestrial Environmental Quality, and EPBC Act objectives for MNES to an acceptable level once the mitigation hierarchy has been adopted.

4.4. INLAND WATERS

4.4.1. EPA Objective

The EPA applies the following objective from the *Statement of Environmental Principles, Factors and Objectives* (EPA, 2016e) in its assessment of proposals that may affect inland waters:

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

Inland waters include groundwater, such as superficial and confined aquifers, and surface water such as waterways, wetlands and estuaries. A 'waterway' is any river, creek, stream or brook including its floodplain and estuary or inlet (EPA, 2018a).

4.4.2. Policy and Guidance

The following EPA guidelines and guidance have been considered in the assessment of inland waters with respect to the EPA objective:

- Environmental Factor Guideline - Inland Waters (EPA, 2018a)

4.4.3. Receiving Environment

Surface Water

WMDE and Bauxite Transport Corridor

The WMDE and Bauxite Transport Corridor falls within the Murray River and Tributaries Surface Water Management Area, and over two Sub-areas (Hotham and Williams River). This area is also classified as a RIWI Act Surface Water Area (Murray River System).

All current operations are bordered to the north and west by the Hotham River, and to the south by the Williams River. To the east, tributaries of Marradong Brook border the existing BBM. The Marradong Brook intersects the current cleared boundary in one location, where a mine haul or trunk road crosses the river.

The areas of the Hotham River that intersect the Primary Assessment Area are within agricultural land, however two tourist attractions exist within the Primary Assessment Area, including the Tullis Bridge (currently burnt and no longer connected) and Walk Trail, and the Marradong Bike Route. The Tullis Bridge and Walk Trail is located near the intersection of Thirty Four Mile Brook and Hotham River (downstream), and includes a picnic area and a 3 km walking loop. The Marradong Bike Route follows Morts Road where it formerly crossed the Hotham River and also intersects the WMDE near the intersection of Thirty Four Mile Brook and Hotham River (upstream). This section of the river is not considered to have significant aesthetic value.

Potential receiving environments for surface water quality are the Williams River, Hotham River and associated tributaries (Thirty Four Mile Brook and Marradong Brook), which fall within the Hotham River Catchment. These river catchments are brackish in salinity, with monthly sampling giving electrical conductivity within the Hotham River ranging from 6,300 to 20,000 $\mu\text{S}/\text{cm}$ (seawater is around 50,000 $\mu\text{S}/\text{cm}$) and 6,100 to 15,000 in the Williams River over the last five years. These high salinities are considered due to land clearing and agricultural practices in the broader Hotham River Catchment (Schlumberger, 2010). Sudden increases in salinity may occur during inflows after summer rains or after the first major flood events of winter (Morgan & Beatty, 2004). Given the nature of the saline conditions of these rivers, they are considered suitable for livestock drinking water only.

Water quality investigations in the Hotham River upstream of its union with Thirty Four Mile Brook indicated neutral pH (7.11 – 7.97). Metals were generally low, with all metals recorded below detection limits except for cadmium and lead, which exceeded the ANZECC & ARMCANZ freshwater 95% trigger value (2000) and slightly elevated levels of manganese (Streamtec, 2005).

Crustaceans are known to be the dominant benthic fauna in the river systems within the investigation area (Bunn and Davies, 1992). The Hotham, Murray and Williams Rivers are also important ecosystems for freshwater fish migration (Morgan & Beatty, 2004). However, the areas of the Hotham River within the WMDE are generally above the upper salinity tolerance of freshwater fishes known to occur in the area, therefore, it is unlikely that they would be present in large numbers.

Desktop searches were undertaken in December 2018 to determine significant surface and groundwater features of the Primary Assessment Area. The results are summarised in **Table 22**.

Table 22: Surface and Groundwater features within the Primary Assessment Area

Aspect	Details	WMDE and Bauxite Transport Corridor	CBME
Groundwater Areas	Groundwater areas proclaimed under the RIWI Act	None present	Collie
Surface Water Areas	Surface water areas proclaimed under the RIWI Act	Murray River System	Collie
Irrigation District	Irrigation Districts proclaimed under the RIWI Act	None present	Collie River Irrigation District
Rivers	Rivers proclaimed under the Rights in RIWI Act	None present	Augustus River Catchment
Public Drinking Water Source Areas (PDWSA)	PDWSAs is a collective term used for the description of Water Reserves, Catchment Areas and Underground Pollution Control Areas declared (gazetted) under the provisions of the <i>Metropolitan Water Supply, Sewage and Drainage Act 1909</i> or the <i>Country Area Water Supply Act 1947</i> .	None present	~650 m west from the Harris River Dam Catchment Area

Contingency Bauxite Mining Envelope

The Refinery is entirely contained within the Augustus River catchment. The Augustus River is a tributary of the Brunswick River, which is used primarily for agricultural purposes. The Refinery Lease Area is located on the crest of a broad ridge. The Freshwater Lake at the Refinery is a dam that was built in 1983 to provide the Refinery with a suitable water supply. Diversion structures have been built to feed fresh water directly to the Freshwater Lake, and thus prevent fresh water mixing with potential contaminants (GRM, 2009).

Water resources in the vicinity of the Refinery including aquatic ecosystems and formerly, a public water supply. Freehold land in the catchment is mainly used for agriculture.

Surface water quality is monitored at the Freshwater Lake and Augustus River gauging station, and an annual review is conducted of the results. The Freshwater Lake is monitored monthly for sodium, chloride, turbidity and aluminium. Real time stations record data for pH, EC and turbidity. A suite of other parameters are measured on a quarterly basis. Over time, data has shown that since monitoring has commenced, there have been no deleterious trends in water quality within the

Freshwater Lake and that there is no evidence the Refinery has affected water quality within the Augustus River (Worsley, 2016).

Groundwater and Hydrogeology

WMDE and Bauxite Transport Corridor

Site hydrogeology within the WMDE and Bauxite Transport Corridor area consists of three main aquifers formed by the in-situ weathering of basement rocks including, a shallow aquifer (shallow weathered zone aquifer), lower saprolite (deep weathered zone aquifer) and fractured bedrock aquifer (fracturing within the bedrock) (GRM, 2015). The lower saprolite aquifer is the principal aquifer and is the dominant aquifer of the Darling Plateau. The aquifer rests above the bedrock, with depth of between 15 to 40 m. The thickness of this aquifer ranges from one to ten metres. The groundwater flow direction is variable due to a number of factors including the sub-surface geometry, hydraulic properties and discharge locations. Broadly, groundwater levels within all aquifers appear to follow topography (i.e. groundwater level is highest in areas of highest topography and lowest in areas of lowest topography) (GRM, 2015).

The soil salt storages on the Darling Plateau are the result of meteoric salt fall, with soil salinities being relatively low in the high rainfall zone but increasing rapidly with decreasing rainfall. Golder Associates (2005) undertook an analysis of salinity trends for the existing BBM and found flow-weighted salinity ranged from 86 to around 6000 mg/L. To date, no salt storage hot spots have been identified within the existing mine footprint (Croton & Dalton, 2007).

Groundwater monitoring undertaken since 1995 indicates variable levels of the total dissolved solids (TDS) ranging from 10 mg/L (Karafil bore field, 1995) to 12,000 mg/L (Fawcett's bore field, 2005) (GRM, 2015). Croton and Dalton (2004) also found that groundwater quality is variable around the existing mining areas, ranging from fresh to around 15,000 mg/L (seawater is around 19,400 mg/L).

There are no gazetted groundwater areas proclaimed under the RIWI Act within the WMDE or the Bauxite Transport Corridor.

The Hotham River and associated riparian vegetation was identified as an ecosystem that is potentially dependent on shallow groundwater (Strategen, 2013). Winter flows are related to catchment-scale rainfall events, while summer flows are considered to result from groundwater baseflow throughout the catchment and leakage from Lions Weir in the Boddington town site (Golder, 2005).

Previous modelling (Schlumberger, 2013) has been undertaken for the Newmont Life of Mine Extension Project, which includes the section of the Hotham River within the WMDE. The model took a conservative approach and predicted drawdown of groundwater by 1 m by 2022 in the Hotham area of the proposal due to dewatering activities at the Newmont mine site. This drawdown may affect summer flows of the Hotham River long term, should the river be reliant on groundwater to maintain base flow. This proposal does not include dewatering activities and will not contribute to this drawdown effect.

Historically, all proposed mining areas at BBM have been subject to the flux density analysis (FDA) predictive modelling technique prior to the commencement of mining. A fundamental output of FDA is the prediction of water table rise associated with mine-related clearing. Worsley has used FDA as a key prediction tool since 2003.

Refinery and CBME

Wilkes *et al.* (2004) characterised the hydrogeology of the Refinery area. The area comprises three main aquifers:

- Shallow weathered zone aquifer (shallow aquifer)
- Deep weathered zone aquifer (locally referred to as the Zersatz aquifer)
- Fracturing within the bedrock (fractured bedrock aquifer).

Separating the shallow and Zersatz aquifers is a low permeability saprolite clay zone, which forms an aquitard. In those areas where the shallow aquifer is absent, saprolite clay overlies the Zersatz aquifer. The thickness of the aquitard varies from 5 m to over 25 m (Worsley, 2016).

Groundwater flows at the Refinery generally follow the topography and levels generally range from about 15 m to 0 m below the ground surface. Groundwater level information across the site indicates that the horizontal hydraulic gradient for groundwater flow ranges between 0.001 and 0.05. Although groundwater levels may vary up to 5 m seasonally in some places (based on historical measurements), there are negligible variations in groundwater flow directions on a seasonal basis.

Baseline groundwater quality data was collected between 1980 and 1983 prior to the commencement of operations at the Refinery (GRM, 2015). A summary of the groundwater quality within the Refinery Lease Area during the post-operational period to 2005 is as follows:

- Groundwater within all aquifers is fresh to brackish with the electrical conductivity (EC) ranging from about 100 to 3,300 $\mu\text{S}/\text{cm}$ at 25 °C and generally increasing towards discharge areas. The EC generally increases slightly with depth and can vary seasonally by a factor of about 2 to 4.
- Concentrations of total dissolved solids/salts (TDS) in the groundwater are generally less than 500 mg/L and seldom more than 1,000 mg/L.
- The predominant ions are sodium and chloride with significant proportions of calcium and magnesium.
- Groundwater level and EC show a negative correlation (i.e. a low water level in autumn will correspond with a peak EC and vice-versa). This reflects seasonal recharge by infiltrating rainfall, which is estimated to be about 7% (Wilkes, *et al.*, 2004).
- Groundwater varies from acid to alkaline with a field pH usually between about 3 and 9 (average is about 5.6).
- There is a difference in groundwater chemistry between the fractured rock and other aquifer systems. The fractured rock aquifer is in general enriched in sodium and bicarbonate when compared with the other aquifers (Worsley, 2016).

The Bauxite Residue Disposal Areas (BRDA) are located within the refinery lease area and contains residue from ore reserves. Risks associated with storage of contaminated waste slurry and surface runoff are managed through the operation of a closed water circuit with all contaminated water directed to a central storage area (Refinery Catchment Lake) and uncontaminated water directed to a separate temporary area (FWL) away from production areas.

The BRDAs are designed with low permeability clay liners with two underdrainage systems to separate groundwater from any potentially contaminated seepage from the residue areas and uncontaminated groundwater. Regular groundwater monitoring is undertaken, including below the BRDAs to detect changes in water quality in accordance with a Water Resources Management Plan

required by MS 719. Periodic clearing of regrowth vegetation on embankments around the residue disposal area will be required as ongoing maintenance.

Waste processing and containment infrastructure for the BRDAs are managed according to Environmental Licence L4504/1981/17.

4.4.4. Proposal Activities

Activities associated with the proposal that have the potential to impact inland waters, include mining activities, bauxite transport, construction and contingency bauxite mining.

4.4.5. Potential Impacts

Potential impacts to inland waters from the implementation of the proposal include:

- Riverbank erosion, sedimentation, scouring of streams or release of excessively turbid water as a result of clearing riparian vegetation and alteration of surface water drainage patterns;
- Changes to groundwater levels (water table rise) in the shallow aquifer associated with clearing of native vegetation;
- Changes to vegetation structure in groundwater-dependent ecosystems as a result of groundwater level rise;
- Contamination of surface water as a result of spills or stormwater run-off;
- Contamination of groundwater as a result of seepage or storage/use of chemicals;
- Contamination of ground and/or surface water from exposure of PASS and contaminants during removal of soils and sediments at river crossings;
- Deterioration or change in background water quality, such as salinity, due to indirect impact of mining activities; and
- Potential drawdown impacts associated with increased water consumption during construction and mine operation.

4.4.6. Mitigation

Worsley has applied the mitigation hierarchy (avoid, minimise, rehabilitate, offset) to reduce the potential environmental impacts of the proposal activities including:

- Avoid – avoiding the adverse environmental impact;
- Minimise – limit the degree or magnitude of the adverse impact;
- Rehabilitate – restore the maximum environmental value that is reasonably practicable; and
- Offset – offset likely to be proposed to provide environmental benefits to counterbalance significant residual environmental impacts or risks if any are assessed to remain after the above measures have been adopted.

Potential impacts to inland waters associated with the proposal are proposed to be managed by Worsley consistently with existing management practices such as the following:

- Avoidance of areas of potential high conservation value wherever practicable utilising the Protected Areas Procedure in the Biodiversity and Forest Management Plan (**Appendix H**);
- Avoidance and minimisation of clearing of native vegetation within the design phase to reduce the footprint of mine pits, mine haul and trunk roads, bauxite corridor road haulage

and conveyor routes, and construction infrastructure support areas, wherever practicable, which will reduce the potential development of dryland salinity;

- Worsley Water Management Plan (Worsley, 2017a) including baseline water quality monitoring;
- Modelling of hydrological processes to identify groundwater dependent ecosystems and predict groundwater rise due to temporary vegetation removal for mining;
- Modelling techniques to identify possible salinity risk areas;
- Consultation with DWER prior to seeking a RIWI Act Bed and Banks permit for river crossing/s, to ensure that design, controls and construction options selected at each crossing location are suitable;
- Site Drainage Standard (Worsley, 2015h) and Trunk Haul Road Design and Construction specifications;
- Manage drainage from the emergency mining operational areas to avoid turbid run-off into the FWL;
- Rehabilitation of the CBME when emergency supply is mined;
- Rehabilitation of riparian vegetation utilising the Biodiversity and Forest Management Plan (**Appendix H**);
- Progressive rehabilitation activities completed utilising internal rehabilitation procedures and standards including the Rehabilitation Standard (Worsley, 2013c). This standard sets out the minimum standard for all rehabilitation activities for the Project, including rehabilitation planning, landholder communication and KPIs for rehabilitation success. Worsley also proposes to utilise the Mine Rehabilitation Operations Procedure (Worsley, 2015f), the Private Land Rehabilitation Management Procedure (Worsley, 2015g), and BBM Revegetation Management Procedure (Worsley, 2015a);
- Development of a CEMP outlining erosion and turbidity control measures during the construction of river crossings (i.e. sediment curtains, sumps and dust suppression);
- Construction works within river crossings areas will be managed to ensure the duration of any impacts are minimised;
- Management of spills of contaminated material in accordance with BBM Spill Management Procedures, including the Trigger Action Response Plan (TARP); and
- Continued review, update and improvement of all relevant management plans and procedures for the Project.

4.4.7. Assessment of Impacts

Worsley will commission a modelling study that will predict the degree and significance of any changes in surface and groundwater regimes associated with the proposal through development of relevant modelling. The results of the study will enable the identification of salinity risk areas and any future management requirements including monitoring.

A detailed understanding of the significance of the impacts to inland waters will be further defined in the Environmental Review Document as the impact assessment process progresses. This will include further refinement of the alignment of haulage routes within the Bauxite Transport Corridor and their associated impacts to inland waters.

It is expected that the direct, indirect and cumulative impacts associated with the proposal will be able to be managed to meet the EPA's objectives for Inland Waters, and EPBC Act objectives for MNES to an acceptable level once the mitigation hierarchy has been adopted.

4.5. AIR QUALITY

4.5.1. EPA Objective

The EPA applies the following objective from the *Statement of Environmental Principles, Factors and Objectives* (EPA, 2016e) in its assessment of proposals that may affect air quality:

To maintain air quality and minimise emissions so that environmental values are protected.

4.5.2. Policy and Guidance

The following EPA guidelines and guidance have been considered in the assessment of air quality with respect to the EPA objective:

- Environmental Factor Guideline - Air Quality (EPA, 2016a).

4.5.3. Receiving Environment

WMDE and Bauxite Transport Corridor

Potential sensitive receptors in the vicinity of the BBM include local residents (located at Boddington and in semi-rural areas) and mine employees. Local air emissions are influenced by the land use in the BBM area. In addition to bauxite mining, the land use is predominantly agricultural with the majority of air emissions likely to be attributed to agricultural activities and vehicles.

Air emissions of potential community concern at the BBM is dust produced from mining activities. Generation of dust from construction and operations depends on the type and frequency of activities, meteorological conditions, composition of dust and condition of the source. Dust emissions are usually highest during summer, and biased toward the southeast, due to wind conditions.

Current air emissions from crushing facilities at BBM are subject to Environmental Licence L5960/1983/11, which specifies conditions for recording and investigation of exceedances, and monitoring, annual reporting and notification of exceedances. Worsley is currently operating the BBM and the Refinery in accordance with environmental licence conditions.

On adjoining agricultural land, farming activities also contribute to background dust levels throughout much of the local and wider region. Dust levels show marked seasonal trends as the agricultural land ground cover changes on a seasonal basis. In addition, smoke from hazard reduction burning, cleared vegetation stockpiles and wildfires is a substantial contributor to elevated levels of airborne particulates.

An ambient dust monitoring program for mining and associated activities has been underway at the BBM since 2006. Dust from mining and associated activities is subject to an air quality standard as described by the *National Environment Protection Measure for Ambient Air Quality 2003* (NEPC).

The conveyor systems from Marradong to Saddleback and from Saddleback to the Refinery are not considered to be significant sources of dust (Envall, 2017).

Refinery and CBME

No changes to air emissions at the Refinery are proposed as part of the proposal, as alumina production rates will not increase from current approved rates. Current air emissions at the Refinery are subject to Environmental Licence L4504/1981/17, which specifies conditions for recording and

investigation of exceedances, and monitoring, annual reporting and notification of exceedances. Worsley is currently operating the Refinery in accordance with environmental licence conditions.

Air emissions of potential community concern at the Refinery and CBME include dust produced from crushing and hauling operations. Water for dust suppression is available from Refinery collection, storage and reticulation systems. Potential sensitive receptors in the vicinity of the Refinery include local residents (closest neighbour is 5 km away) and Refinery employees. SO₂ is a potential community concern within the Worsley and Collie communities, which is being separately assessed and addressed as part of the Collie Air Shed Study.

Proposal Activities

Proposal activities that have the potential to impact air quality include clearing and mine operation. This includes dust generated from mining activities, such as crushing and hauling, which are proposed to be managed under Dust Management Plan. Dust emissions resulting from the screening, crushing and reclaiming processes are minimised through the strategic location of watering points in the crushing plant and dust containment mechanisms on the conveyor belts and transfer points, and crushers. SO₂, CO and NO_x emissions will occur from the combustion of fuel in light and heavy earthmoving vehicles and stationary sources such as generators. NO_x and CO emissions also arise from blasting activities.

Crushing facilities at BBM are also regulated under MS719 and under Worsley's existing Environmental Licence L5960/1983/11. It is also proposed that crushing facilities, and any changes to them in the future, still be considered part of the Project which continues but be assessed and regulated solely under Part V of the EP Act through L5960/1983/11 (and its replacement and amendments from time to time).

The proposal will continue but not change emissions at the Refinery, which are currently regulated under existing EP Act environmental licence. It is proposed, however, that the following five air emissions elements, and any changes to them in the future, still be considered part of the Project which continues, but that they be assessed and regulated solely under Part V of the EP Act only, through L4504/1981/17 (and its replacement and amendments from time to time):

- Sulphur dioxide (SO₂) from coal fired facilities;
- Nitrogen oxides (NO_x) from combustion, liquor burner and calciner sources;
- Particulates (PM₁₀) from combustion, liquor burner and calciner sources;
- Carbon monoxide (CO) from combustion, liquor burner and calciner sources; and
- Total volatile organic compounds (VOCs) from all sources.

4.5.4. Potential Impacts (Mining)

Potential impacts to air quality from the implementation of the proposal include:

- Health impacts on sensitive receptors, native fauna and livestock as a result of increased dust emissions; and
- Social impacts, including nuisance and aesthetical problems that arise from visible dust emissions

Changes in the Greenhouse gases and air emissions produced through implementation of the proposal are minor, temporary and not considered a significant impact. Potential Impacts (Refinery)

4.5.5. Potential Impacts (Refinery)

Worsley has undertaken a detailed Air Quality Assessment (Envall, 2018) at the Refinery that included an Air Emission Inventory (V3) before and after the 4.7 Mtpa expansion project. The report was submitted to DWER in 2017 and was an existing licence condition at the Refinery. The health impacts of the main emission sources were explored, and a risk assessment conducted and subsequently managed. The 4.7 Mtpa health impacts were considered acceptable and managed under the Environmental Licences L4504/1981/17.

4.5.6. Mitigation

Worsley has applied the mitigation hierarchy (avoid, minimise, rehabilitate, offset) to reduce the potential environmental impacts of the proposal activities including:

- Avoid – avoiding the adverse environmental impact;
- Minimise – limit the degree or magnitude of the adverse impact;
- Rehabilitate – restore the maximum environmental value that is reasonably practicable; and
- Offset – offset likely to be proposed to provide environmental benefits to counterbalance significant residual environmental impacts or risks if any are assessed to remain after the above measures have been adopted.

Potential impacts to air quality associated with the proposal are proposed to be managed by Worsley consistently with existing management practices such as the following:

- Worsley Dust Management Plan – Bauxite Mining and Transport (Worsley, 2015);
- BBM Environmental License L5960/1981/11 (and its replacement and amendments from time to time), which includes dust license conditions;
- Seeking Landholder agreements to relocate impacted residents where applicable;
- Minimising gaseous and particulate emissions from light and heavy vehicle engine exhausts through the use of current generation diesel engine technology where practicable;
- Continued review, update and improvement of all relevant management plans and procedures for the Project; and
- Continued operation of the Refinery subject to L4504/1981/17 (and its replacement and amendments from time to time).

4.5.7. Assessment of Impacts

Worsley has commissioned a dust study for the proposal. The study will assess the potential dust emissions from both existing and proposed mining and transport activities associated with the proposal in the Primary Assessment Area, and model potential impacts on nearby sensitive receptors.

The results of these studies will inform risk assessments and subsequent analysis of suitable management measures to ensure that any impacts are minimised. This will be outlined in the Environmental Review Document.

It is expected that the direct, indirect and cumulative impacts associated with the proposal will be able to be managed to meet the EPA's objectives for Air Quality, and EPBC Act objectives for MNES, to an acceptable level once the mitigation hierarchy has been adopted.

4.6. SOCIAL SURROUNDINGS

4.6.1. EPA Objective

The EPA applies the following objective from the *Statement of Environmental Principles, Factors and Objectives* (EPA, 2016e) in its assessment of proposals that may affect social surroundings:

To protect social surroundings from significant harm.

4.6.2. Policy and Guidance

The following EPA guidelines and guidance have been considered in the assessment of social surroundings with respect to the EPA objective:

- Environmental Factor Guideline - Social Surroundings (EPA, 2016c).

4.6.3. Receiving Environment

European Heritage

Database searches have been undertaken to determine the presence of World Heritage Sites and Commonwealth Heritage Sites. No sites have been identified within areas the subject of the proposal.

A search on the inHerit Western Australia database in December 2018 has identified two State Registered Places within the Primary Assessment Area; the Quindanning Hotel and the Quindanning Inn. These sites are not expected to be impacted by the proposal.

The search identified 19 sites within the Primary Assessment Area listed as 'Other Heritage Listings' within the Primary Assessment Area, which include:

- Tullis Bridge – Municipal Inventory Adopted 18 Jul 2001 (Shire of Boddington).
- Tullis Mill – Municipal Inventory Adopted 18 Jul 2001 (Shire of Boddington).
- St Alban's Church and Marradong Graveyard – Municipal Inventory Adopted 15 Nov 1995 (Shire of Boddington).
- Jarrah Tree – Municipal Inventory Adopted 18 Jul 2001 (Shire of Boddington).
- Railway Line Precinct – Boddington to Dwellingup – Municipal Inventory Adopted 18 July 2001 (Shire of Boddington).
- Munday's Store Site – Municipal Inventory Adopted 5 April 2011 (Shire of Boddington).
- Mud Brick Homestead – Municipal Inventory Adopted 5 April 2011 (Shire of Boddington).
- Marradong School – Municipal Inventory Adopted 18 July 2001 (Shire of Boddington).
- Camballing Marradong School – Municipal Inventory Adopted 5 April 2011 (Shire of Boddington).
- First meeting of the Road Board – Municipal Inventory Adopted 18 July 2001 (Shire of Boddington).
- Boddington Public Buildings Group – to be assessed 23 March 2007 (Shire of Boddington).
- Red Hill Homestead – Municipal Inventory Adopted 15 Nov 1995 (Shire of Boddington).

- Marradong Hall – Municipal Inventory Adopted 15 Nov 1995 (Shire of Boddington).
- Mokine – Municipal Inventory Adopted 15 Nov 1995 (Shire of Boddington).
- Laura Hotel – Municipal Inventory Adopted 18 Jul 2001 (Shire of Boddington).
- Dilyan’s Grave – Municipal Inventory Adopted 15 Nov 1995 (Shire of Boddington).
- Lavender’s Track – Municipal Inventory Adopted 30 June 2000 (Shire of Williams).
- Quindanning Bridge over Williams River – Municipal Inventory Adopted 30 June 2000 (Shire of Williams).
- Wilson’s House – Municipal Inventory Adopted 30 June 2000 (Shire of Williams).

Aboriginal Heritage

A summary of Aboriginal heritage surveys undertaken for the Project is provided in **Table 23** and outlined in **Figure 12** and **Figure 13**.

Table 23: Summary of Aboriginal Heritage Surveys undertaken for the Project

Consultant	Survey Area	Survey Date	Purpose of Survey and Details
Brad Goode and Associates	Marradong West and surrounding private property	2017	Site identification survey to support a Section 18 application if required
R.H Pearce	Principal Mineralised Area and Refinery Lease Area	1981	Baseline heritage assessment
Brad Goode and Associates	Mt Saddleback (Mokine)	2015	To support a S18 application
WARU Consulting	BBM	2012	Verification of 17 heritage sites
WARU Consulting	BBM	2010	Verification of 10 heritage sites
Brad Goode and Associates	Wellington Dam Pipeline	2016	To support a S18 application
Brad Goode and Associates	Harris Pipeline	2017	Site identification survey

A search of the Aboriginal Heritage Inquiry System on 30 November 2018 identified 11 ‘Registered’ sites of Aboriginal heritage significance, and 122 sites lodged as ‘Other Heritage Places’ that intersect with the Primary Assessment Area. A summary of this search is provided in **Table 24**.

Table 24: Registered Aboriginal Heritage Sites and Other Heritage Places intersecting the Primary Assessment Area

Place ID	Name	Status	Type
4049	Tullis	Registered Site	Artefacts / Scatter
4060	Farmer’s Crossing	Registered Site	Modified Tree
4063	Boulder Hill (Cave 5)	Registered Site	Artefacts / Scatter
4064	Lower Hotham Road Bridge	Registered Site	Artefacts / Scatter
4230	Boddington Forest 36	Registered Site	Artefacts / Scatter
4237	Boddington Forest 43	Registered Site	Artefacts / Scatter, Quarry
5182	Hull Gully	Registered Site	Artefacts / Scatter
5255	Quindanning Farms 04	Registered Site	Artefacts / Scatter, Quarry

Place ID	Name	Status	Type
15126	The Harmony Engravings	Registered Site	Engraving, Grinding Patches / Grooves
17214	Mt Saddleback (Mokine)	Registered Site	Mythological
27935	Hotham River	Registered Site	Mythological
20216	Archer's Farm - Caves	Lodged	Mythological, Rockshelter
20219	Dilyan's Burial and Additional Burial Site	Lodged	Historical, Skeletal Material / Burial
5252	Quindanning Farms 01	Lodged	Artefacts / Scatter, Quarry
4277	Boddington Forest 31	Lodged	Artefacts / Scatter
4238	Boddington Forest 44	Lodged	Artefacts / Scatter
4214	Siding Road	Lodged	Artefacts / Scatter
21471	Dukatj (34 Mile) Creek	Stored Data / Not a Site	Mythological, Camp, Water Source, Other: food source
4050	Wandoo Flats	Stored Data / Not a Site	Artefacts / Scatter
4126	Worsley Timber 3	Stored Data / Not a Site	Artefacts / Scatter
4175	Lower Hotham River 1	Stored Data / Not a Site	Artefacts / Scatter
4180	Mt Saddleback 20	Stored Data / Not a Site	Artefacts / Scatter
4198	Corridor 18	Stored Data / Not a Site	Artefacts / Scatter
4223	Mt Saddleback 09	Stored Data / Not a Site	Artefacts / Scatter
4263	Boddington Forest 17	Stored Data / Not a Site	Artefacts / Scatter
4265	Boddington Forest 19	Stored Data / Not a Site	Artefacts / Scatter
4266	Boddington Forest 20	Stored Data / Not a Site	Artefacts / Scatter
4267	Boddington Forest 21	Stored Data / Not a Site	Artefacts / Scatter
4268	Boddington Forest 22	Stored Data / Not a Site	Artefacts / Scatter
4269	Boddington Forest 23	Stored Data / Not a Site	Artefacts / Scatter
4270	Boddington Forest 24	Stored Data / Not a Site	Artefacts / Scatter
4276	Boddington Forest 30	Stored Data / Not a Site	Artefacts / Scatter
4291	Westrail Survey 04	Stored Data / Not a Site	Artefacts / Scatter
4304	Boddington Forest 05	Stored Data / Not a Site	Artefacts / Scatter
5256	Quindanning Farms 05	Stored Data / Not a Site	Artefacts / Scatter
18447	Thirty four mile brook, north bank	Stored Data / Not a Site	Artefacts / Scatter

WARU Consulting Pty Ltd (WARU) (2012) was commissioned to confirm the locations of 15 Aboriginal heritage sites known within the active mine tenements and activities. Based on the outcome of the archaeological assessment 8 of the 15 Registered Sites' existence and position were verified including Site No. 4049, 4052, 4054, 4057, 4060, 4063, 4138 and 4230.

Brad Goode and Associates Consulting Anthropologists and Archaeologists (Brad Goode) (2015) was commissioned to undertake a Site Identification Ethnographic Aboriginal Heritage Survey. Brad Goode confirmed the location and extent of Mt Saddleback (Mokine) Aboriginal Registered Site (No.

17214). In addition, the Gnaala Karla Booja WC1998/058 Native Title Claim group (GKB) advised Brad Goode that this Site was of special importance and any disturbances within the buffer should be avoided. The GKB also reported a male initiation site, corroboree site and ochre deposit within the vicinity of the Mokine Site located east of Fletcher Road, however this Site could not be located. Based on the outcomes of the report, Brad Goode recommended further consultations with the GKB, ethnographic consultation and an archaeological inspection for a site east of Fletcher Road.

In 2017, Brad Goode was commissioned to conduct a Site Identification Aboriginal Heritage survey for the proposed extension of the BBM into Hotham West. The survey area covered areas to the north and west of the Marradong Timber Reserve and Saddleback Timber Reserve mostly on private farmland, the western portion of the Marradong Timber Reserve and three areas at the Hotham River (Site ID 27935) associated with potential river crossing locations (Brad Goode, 2017). A Section 18 application under the AHA will be made for consent to use the land within the Hotham River for the required purpose once the locations of the river crossing are determined. This report is provided in **Appendix G**.

Three Section 18 consents have been granted to Worsley for various purposes and areas at BBM over time. These are summarised in Figure 14 and Figure 15, and include:

- Mt Saddleback (Mokine) – for the purpose of Mining, associated infrastructure and rehabilitation activities;
- Mt Saddleback (Mokine) – for the purpose of exploration, mining, rehabilitation and agricultural activities; and
- Wellington Dam Pipeline – for the purpose of the Wellington Dam Pipeline.

Land Use

The WMDE and the Bauxite Transport Corridor is located predominately within private property and Crown Land. Crown Land includes the Marradong and Saddleback Timber Reserves. The DBCA manages the Timber Reserves for timber production, recreation and biodiversity conservation. The WMDE area also falls within a State Managed Forest Products Commission plantation of *Eucalyptus saligna*.

The CBME is located within the Refinery Lease Area, which is an existing lease area for the purpose of refining and associated activities.

Picnics, camping grounds and walking trails that form part of the Bibbulmun walking trail lie within, and to the northern extent of the WMDE and under the existing conveyor.

Noise

Mining operations result in emissions of noise and vibration, which may impact on the amenity of nearby residents (Strategen, 2005) and structural integrity of heritage sites. Mining operations include the following mine activities:

- Exploration and grade control drilling;
- Vegetation clearing;
- Removal and stockpiling of topsoil and overburden;
- Drilling and blasting;

- Mining and transport of bauxite ore;
- Primary and secondary crushing of ore; and
- Rehabilitation activities.

Under clause 12 (7) of the Worsley State Agreement, the Minister for the Environment, can approve that the noise limits in the Environmental Protection (Noise) Regulations 1997 do not apply, and that an alternative noise limit regime applies in its place. The Minister has approved these amended limits for the existing conveyors, and it is proposed that the amended limits be applied to the future conveyor in the Bauxite Transport Corridor as well.

Mining activities and the operation of the conveyors occurs on a continuous basis (24 hour operations) and is subject to Worsley's Noise Management Plans developed in accordance with MS719. Mining operations comply with noise regulations (*Environmental Protection (Noise) Regulations 1997*) through modelling and monitoring. The Noise Management Plans includes a noise monitoring program for mining operations, including the existing conveyors. Environmental Licences L5960/1983/11 and L4504/1981/17 also specifies that noise emissions from the BBM and Refinery must comply with the assigned noise levels set out in the *Environmental Protection (Noise) Regulations 1997*. There is an ongoing program to reduce noise emissions from the conveyor bridges, which involves routine inspection and maintenance.

Background noise levels during the night in the existing BBM region are typically very low and are dominated by agriculture and traffic related noise. Existing mining operations are situated predominantly in State Forest with few residential noise sensitive receptors, or on private land consisting of a small number of isolated premises. Several such premises are relatively close to mining operations, some of which are located within 500 m. The extent that mining noise may be audible at residences is strongly dependent on atmospheric conditions, proximity to mining activities and local topography. Noise characteristics include noise level, tonality, duration and impulsiveness.

A technical noise modelling study has been commissioned for the proposal, which will locate all current sensitive receptors within the proposed Primary Assessment Area.

Demography

The Worsley Bauxite-Alumina Project operates in the South West, Peel and Wheatbelt Regions of Western Australia. The BBM is located near the town of Boddington and in the Peel Region. Boddington town site has a population of approximately 2,523 (ABS, 2017). The Peel region of Western Australia has a population of 98,693 (ABS, 2017).

Visual Amenity

The Darling Plateau is characterised by an expansive undulating landscape with green forest vegetation and occasional rocky outcrops and peaks. Changes to amenity are greatest in areas with a high perceived scenic amenity value and are visible from public locations, such as roads, walk trails and lookouts (Strategen, 2013).

The existing operation is visible from public roads, the Bibbulmun Track and a number of elevated locations. Bibbulmun Track users generally experience an enclosed view, with the exception of high points along the track where the canopy vegetation reduces, and views extend across the landscape (Strategen, 2013). The Project will become a more dominant feature of the landscape when viewed from high points, however a significant portion of the proposal is located in agricultural land that does not have a high perceived amenity.

Contingency bauxite mining activities are proposed to be located at the Refinery Lease Area. The nearest neighbour to the Refinery is approximately 5 km away. The Refinery is partially visible from the Coalfields Highway.

A Visual Impact Assessment was carried out by ERM in 2018 for the purpose of determining potential landscape and visual impacts for the previous Hotham Mining Extension proposal, based on the difference of impacts to what is already approved. This assessment determined that some of the main components that have the potential of contributing to visual impact during mining operations at BBM include:

- The removal of vegetation;
- Stripping and stockpiling of topsoil and overburden;
- Material handling equipment;
- Hardstands, workshops and mine haul and trunk roads;
- Dams and water storage areas; and
- Landscaping and revegetation (ERM, 2018).

ERM determine the assessment of visual impacts from public viewpoints based on four criteria; visibility, distance, viewer and landscape sensitivity, and view numbers. Each of these criteria contributes to assessment of visual impact at viewpoint and the overall visual impact or scale of effects. The scale of effects ranges from Nil through to High or Unacceptable. For the assessment, views were selected from townships (Boddington and Quindanning), main roads and local roads to determine the impacts of the proposed Hotham Mining Extension (now superseded by this proposal). Overall visual impact from Boddington, the Boddington Cemetery, the Quindanning township and the Quindanning Cemetery, as well as the major road network, were assessed as Nil to Negligible (ERM, 2018).

4.6.4. Proposal Activities

Proposal activities that have the potential to impact social surroundings include clearing of native vegetation, mining activities and bauxite transport activities. Noise would be generated by the implementation of the proposal through construction, bauxite transport and mining activities, including blasting and excavation, haulage, disposal activities, and audible warning signals (such as reversing alarms and signals).

4.6.5. Potential Impacts

Worsley has applied the mitigation hierarchy (avoid, minimise, rehabilitate, offset) to reduce the potential environmental impacts of the proposal activities including:

- Avoid – avoiding the adverse environmental impact;
- Minimise – limit the degree or magnitude of the adverse impact;
- Rehabilitate – restore the maximum environmental value that is reasonably practicable; and
- Offset – offset likely to be proposed to provide environmental benefits to counterbalance significant residual environmental impacts or risks if any are assessed to remain after the above measures have been adopted.

Potential impacts to social surroundings from the implementation of the proposal include:

- Heritage site disturbance through clearing/excavation or blast vibration;

- Noise and vibration impacts to sensitive receptors from blasting, equipment operation and vehicle operation and operation of existing conveyors;
- Changes to land use through land acquisition or access agreements for the WMDE; and
- Reduced visual amenity where mining operations will become a more dominant feature of the landscape.

4.6.6. Mitigation

Potential social surroundings impacts associated with the proposal are proposed to be managed by Worsley consistently with existing management practices, such as the following:

- Avoidance of areas of potential high conservation value wherever practicable utilising with the Protected Areas Procedure in the Biodiversity and Forest Management Plan (**Appendix H**);
- Management of Aboriginal heritage through ongoing consultation, surveys where required and seeking an agreed Heritage Agreement with the SWALSC and the GKB;
- *Environmental Protection (Noise) Regulations 1997* regarding the BBM and Refinery, Worsley State Agreement limits regarding conveyors and utilisation of the Noise Management Plan (Worsley, 2014), which includes noise modelling to predict emissions from mining operations (noise and blast noise) and ongoing monitoring and compliance with environmental licences;
- Responding to community noise complaints and queries consistent with the Excessive Mining Noise Withdrawal procedure (Worsley, 2013a);
- Ongoing noise modelling for long and medium-term mine plans;
- Fitting vehicles and mining equipment with noise-attenuation equipment to reduce noise levels, such as rubber trays on haul trucks, silent alarm and low noise broadband reversing alarms;
- Seeking landholder agreements for land uses that intersect or are in close proximity to the mining footprint;
- Relocation of nearby sensitive receptors where required;
- Minimising the environmental footprint associated with the mine pits and mine haul and trunk roads, through environmentally sound designs to impacts to the surrounding community where possible;
- Maintaining vegetation buffers and planting of vegetation along boundaries to assist in screening the operations where they are visible to the public;
- Progressively rehabilitate vegetation utilising the Biodiversity and Forest Management Plan (**Appendix H**)
- Progressive rehabilitation activities completed utilising internal rehabilitation procedures and standards including the Rehabilitation Standard (Worsley, 2013c). This standard sets out the minimum standard for all rehabilitation activities for the Project, including rehabilitation planning, landholder communication and KPIs for rehabilitation success. Worsley also proposes to utilise the Mine Rehabilitation Operations Procedure (Worsley, 2015f), the Private Land Rehabilitation Management Procedure (Worsley, 2015g), and BBM Revegetation Management Procedure (Worsley, 2015a);
- Integrating mine landforms with the surrounding landscape, in accordance with standard mine closure planning management procedure; and
- Development of a CEMP that outlines measures to manage noise and visual amenity impacts throughout the construction phase of the proposal.

4.6.7. Assessment of Impacts

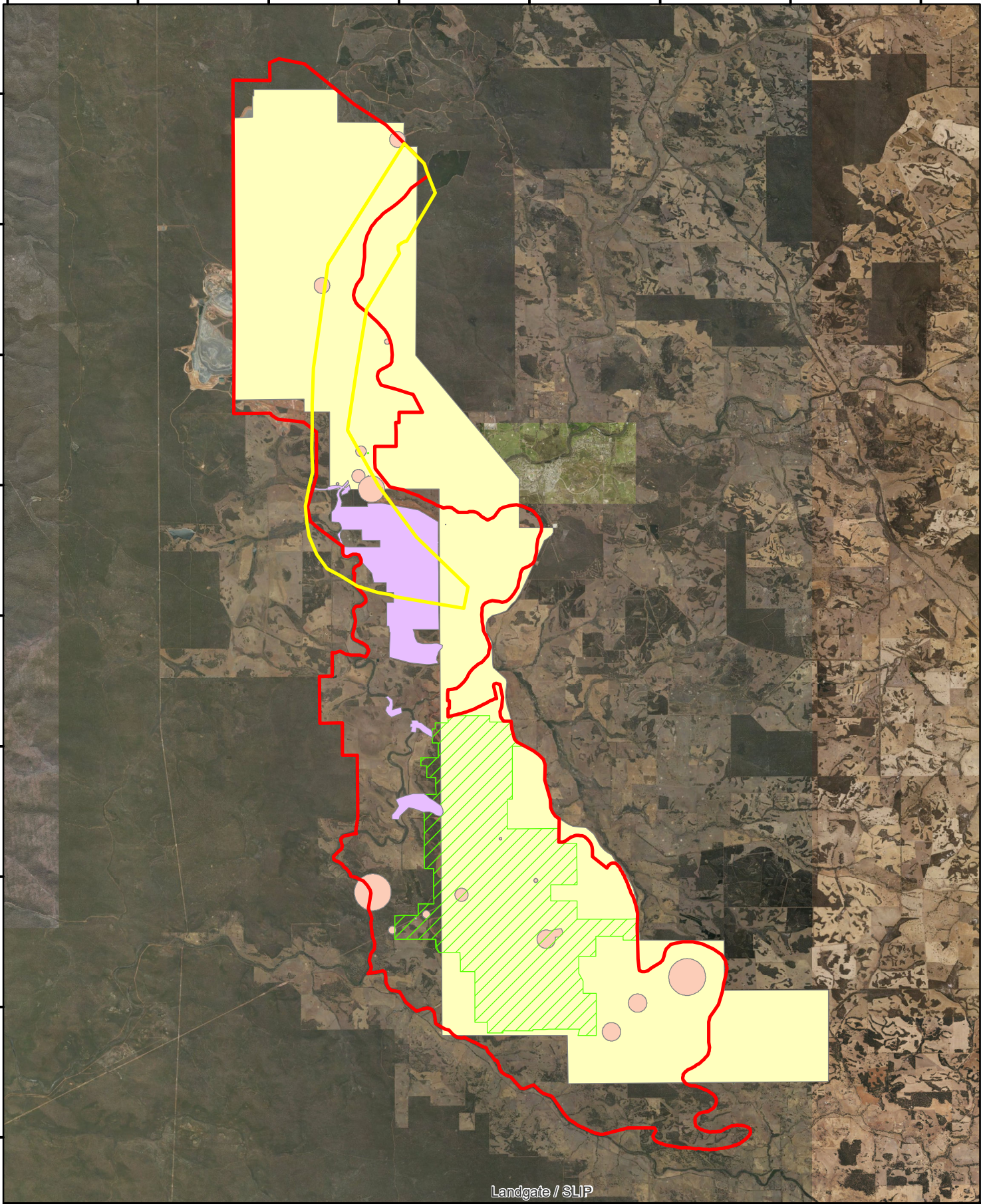
Worsley has commissioned a noise study for the proposal that will assess the noise emissions from both the current and proposed mining activities and identify impacts on nearby sensitive receptors under worst case meteorological conditions. The results of the study will inform a risk assessment and determination of management measures required to ensure that noise emissions will remain in compliance with assigned noise levels as required by the Worsley State Agreement, the Noise Management Plan and environmental licences (L5960/1983/11 and L4504/1981/17). Worsley will also commission an expanded visual assessment to incorporate the potential impacts associated with this proposal in the Primary Assessment Area.

Potential impacts to Aboriginal Heritage sites, including the Hotham River, are not expected to be significant and will be managed through the appropriate consent process under S18 of the *Aboriginal Heritage Act 1972 (WA)* (AHA). Worsley will continue to consult with the SWALSC and the GKB on the proposal.

It is expected that the direct, indirect and cumulative impacts associated with the proposal can be managed to meet the EPA's objectives for Social Surroundings, and EPBC Act objectives for MNES, to an acceptable level once the mitigation hierarchy has been adopted.

430000 435000 440000 445000 450000 455000 460000 465000

6385000
6380000
6375000
6370000
6365000
6360000
6355000
6350000
6345000



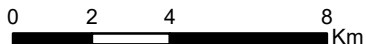
Landgate / SLIP

Legend

- Proposed Bauxite Transport Corridor
- Proposed Worsley Mining Development Envelope

Aboriginal Heritage Surveys

- Archaeological and Ethnographic - 2017
- Ethnographic - 2015
- Archaeological - 2010-2013
- Archaeological - 1980



South32 Worsley Alumina Pty Ltd

**Summary of
Aboriginal Heritage Surveys
within and surrounding the WMDE**

Created by: KNN
 Created: February 2019
 Co-ordinate System: GDA 1994 z50
 Ref: WME Referral - BBM Heritage Surveys Map.mxd

Figure 12

405000

410000

415000

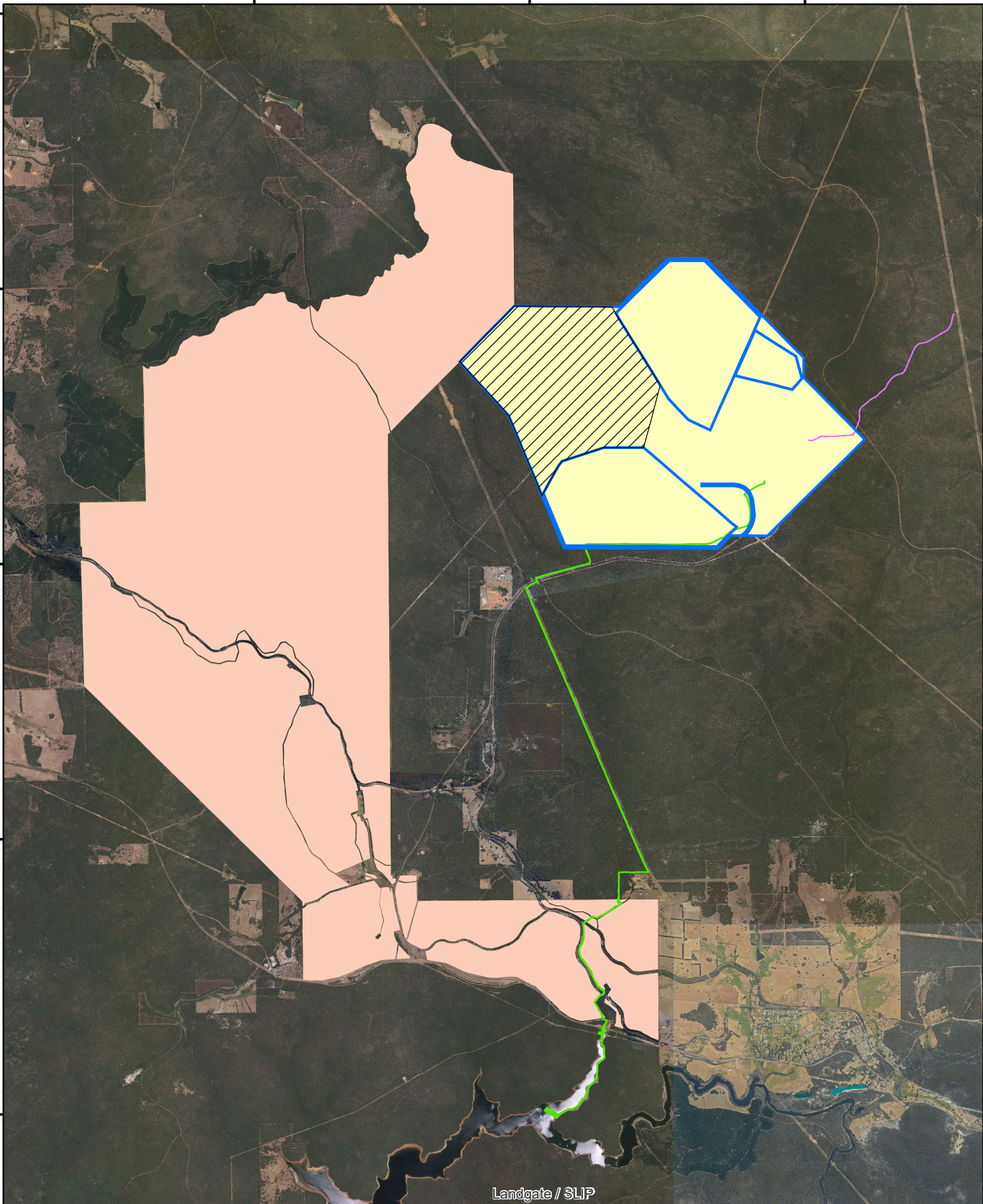
6330000

6325000

6320000

6315000



6310000





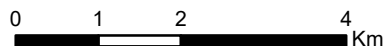
Landgate / SLIP

Legend

Worsley Heritage Surveys

-  Archaeological and Ethnographic - 2016
-  Archaeological - 2017
-  Archaeological - 2007
-  Archaeological - 1980

-  Contingency Bauxite Mining Area
-  Refinery Lease Area



South32 Worsley Alumina Pty Ltd

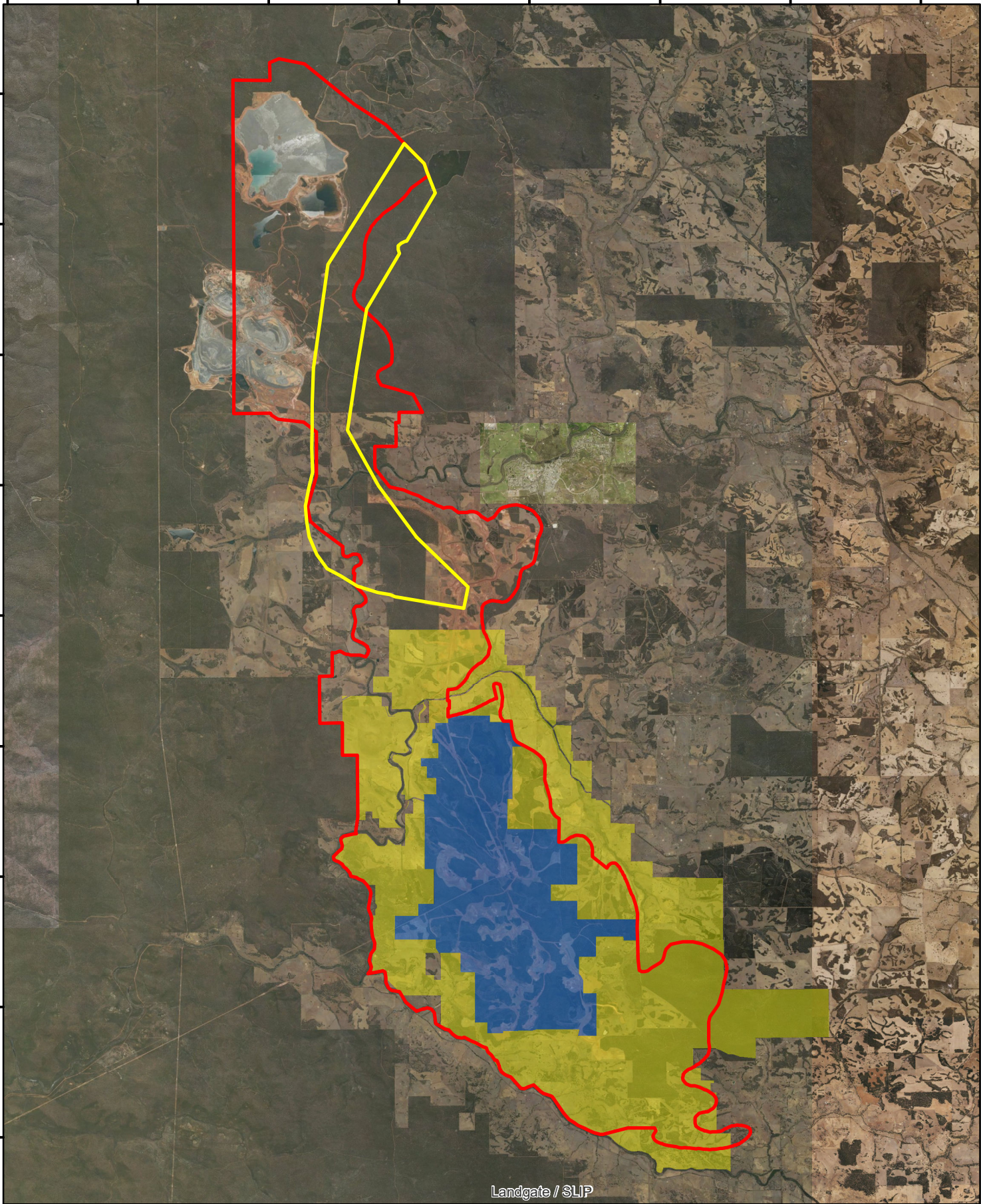
Summary of Aboriginal Heritage Surveys within and surrounding the Refinery Leases

Created by: KNN
 Created: March 2019
 Co-ordinate System: GDA 1994 z50
 Ref: WDME Referral - Refinery Heritage Surveys Map.mxd

Figure 13



430000 435000 440000 445000 450000 455000 460000 465000

6385000
6380000
6375000
6370000
6365000
6360000
6355000
6350000
6345000





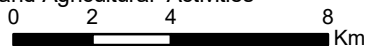
Landgate / SLIP

Legend

-  Proposed Bauxite Transport Corridor
-  Proposed Worsley Mining Development Envelope

s18 Consent Areas - Purpose of Consent

-  Mining, Associated Infrastructure and Rehabilitation Activities
-  Exploration, Mining, Rehabilitation and Agricultural Activities

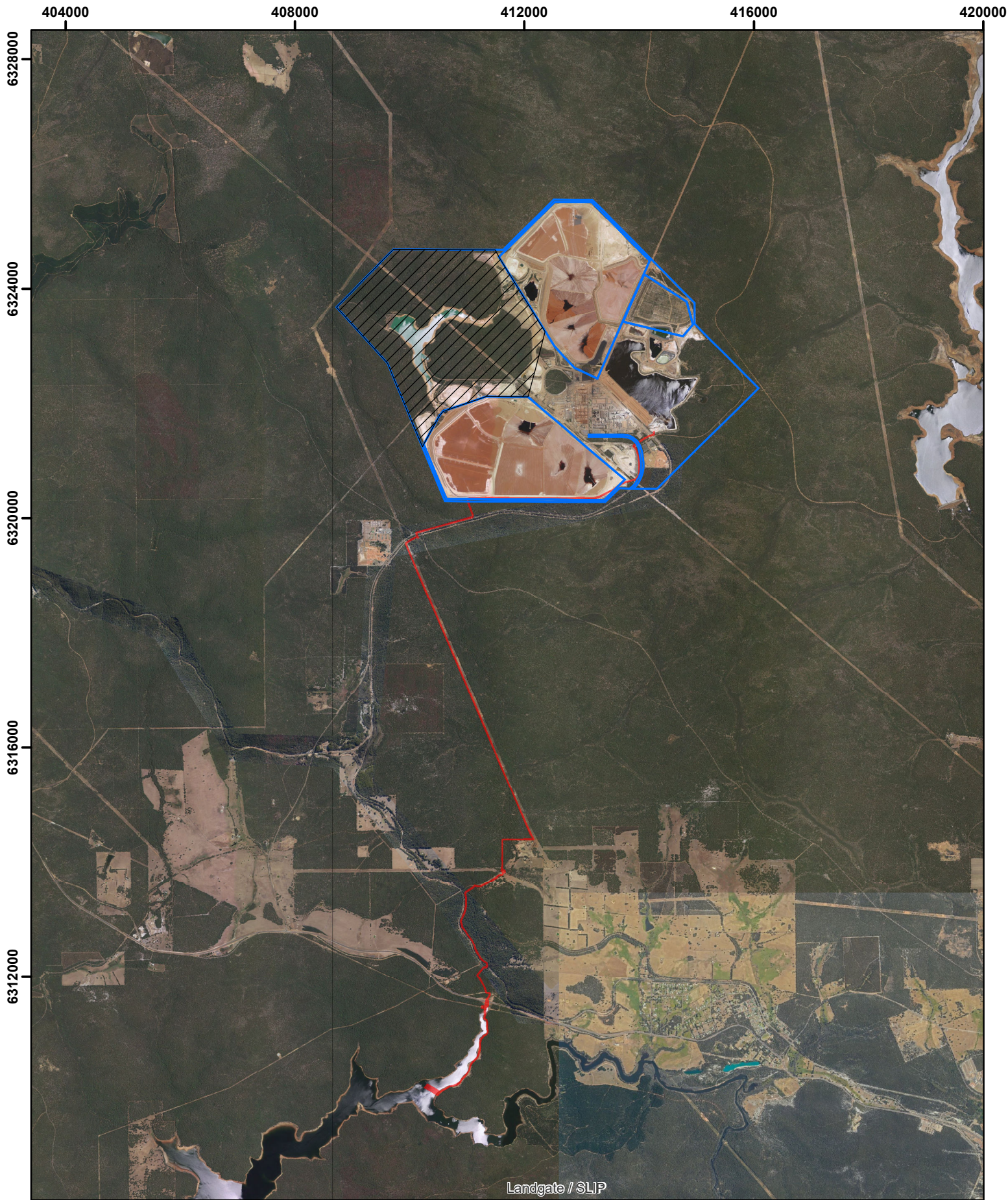


South32 Worsley Alumina Pty Ltd



Existing Section 18 Consent Areas over the WMDE

Created by: KNN
 Created: March 2019
 Co-ordinate System: GDA 1994 z50
 Ref: WDME Referral - BBM s18 Consent Areas.mxd


Figure 14



Legend

-  Contingency Bauxite Mining Area
-  Refinery Lease Area

s18 Consent Areas - Purpose of Consent

-  Wellington Dam Pipeline



South32 Worsley Alumina Pty Ltd

Existing Section 18 Consent Areas over the Refinery Lease Area

Created by: KNN
 Created: March 2019
 Co-ordinate System: GDA 1994 z50
 Ref: WDME Referral - Refinery s18 Consent Areas.mxd

Figure 15

4.7. OTHER FACTORS

The EPA identifies 'other' environmental factors that are not considered key factors but have the potential to be affected by the proposal. For this proposal, these include:

- Landforms – there are no significant landforms located within the Primary Assessment Area or affected by continuing activities.
- Subterranean Fauna – no significant impacts to subterranean fauna are expected as a result of this proposal. This has been addressed in **Section 4.2.3.4** with supporting documentation by Phoenix Environmental Sciences provided in **Appendix E** and **Appendix F**.

4.8. FACTORS NOT CONSIDERED RELEVANT

The following factors are not considered relevant to this proposal:

- Human Health;
- Benthic Communities and Habitats;
- Coastal Processes;
- Marine Environmental Quality; and
- Marine Fauna.

5. OFFSETS

The Environmental Review Document will include assessment of the application of the mitigation hierarchy to avoid impacts, minimise impacts (where avoidance is not possible) and rehabilitate impacts.

If the Environmental Review Document determines that a significant residual impact will remain, Worsley will propose a strategic biodiversity offsets package to be considered as part of the proposal.

Any strategic biodiversity offsets package will be developed in consultation with the EPA, DBCA and DoEE based on the principles as set out in WA Environmental Offsets Policy September 2011 (Government of Western Australia, 2011) (WA Policy) and the Australian Government Environmental Offsets Policy (DSEWPaC, 2012) (Cth Policy), to provide environmental offsets if there are expected significant residual impacts of the proposal.

In identifying any environmental offsets to be considered as part of the proposal, the following will be considered:

- The overall objective of the WA Policy is to protect and conserve environmental and biodiversity values for present and future generations. The policy aims to ensure that economic and social development may occur while supporting long term environmental and conservation values.
- The overall objective of the Cth Policy is to ensure the efficient, effective, timely, transparent, proportionate, scientifically robust and reasonable use of offsets under the EPBC Act to achieve an overall conservation outcome that improves or maintains the viability of the relevant aspect of the environment.
- The use of environmental offsets will not replace proper on-site environmental practices, such as avoidance and mitigation.
- Offsets should be used to compensate for significant residual environmental impacts and be designed to achieve long-term outcomes, building upon existing conservation programs and initiatives.
- In general terms, the WA and Cth policies describes three ways environmental offsets can be provided – direct proponent action to provide measurable conservation gain, funding by the proponent to a third party to undertake direct action to provide a conservation gain, and contributions by the proponent to a fund or program for other beneficial, but indirect compensatory measures, such as for the purpose of research or educational programs.
- There are generally three main types of environmental offsets – land acquisition, on ground management (such as restoration or threat abatement) and research/education. More traditional offsets, such as land acquisition are possible only where there is adequate freehold land available with appropriate values. The opportunity for this may be limited in this case because of the potential socio-economic impact of land acquisition in the region, particularly as offsets that deliver social, economic and/or environmental co-benefits are instead encouraged. The WA and Cth policies deal with this potentiality by noting that there are different ways to achieve good environmental outcomes and providing flexibility in delivering those outcomes.
- Environmental offsets should be strategic, focused on longer term strategic outcomes, noting that in some cases, better conservation gains and environmental outcomes can be achieved by considering offsets at a landscape rather than at a local scale. Strategic approaches could be based on a regional need or be focused on addressing issues related to a particular species. Overall the focus of any offsets proposal should be a package which enables the greatest environmental benefit/conservation gain to be achieved.

- Environmental offsets should consider, and contribute towards, broader State and Cth Government conservation objectives through existing programs, policies, initiatives and strategic funds. Offsets will be additional to existing obligations under other planning regimes, legislation, schemes or duty of care. This does not however preclude the recognition of State offsets that may be suitable as Cth Act offsets and vice versa.
- Environmental offsets should be proportionate to the significance of the environmental value being impacted with a preference for cost-effective solutions.
- Environmental offsets should be applied within a framework of adaptive management.

South32 has an Intelligent Land Management (ILM) program that enables South32's land holdings to contribute to climate resilience, environmental protection and shared financial and social value for South32 and its host communities. As part of this program, a Strategic Land Assessment has been completed for the Project to identify projects that could deliver outcomes aligned with ILM objectives for Worsley. These objectives for value creation are:

- Protecting biodiversity and ecosystem services;
- Sustaining financial mechanisms and scalability; and
- Lasting community legacy.

In any consideration of environmental offsets for any significant residual environmental impacts, South32 will be seeking ways in which a strategic biodiversity offsets strategy can complement Worsley's ILM program and deliver co-benefits. Consideration will also be given to long term strategic biodiversity offsets, including a staged approach to offsets, to ensure that any biodiversity offsets packages take into account Worsley's life of operation.

It is also noted that:

- The WA Policy will not apply offsets to impacts approved prior to the introduction of offsets, and the Cth policy does not apply to impacts that were approved prior to the (2012) introduction of the Cth policy (or prior to the EPBC Act in general). This means offsets will not apply to mining operations up to the existing approved extent in the Pre-Existing Approval Area; and
- If the proposal is being assessed in parallel under the EP Act and EPBC Act, agencies will consult to align offset assessment and requirements as far as possible. The WA policy notes that it is intended that as far as possible there will be minimal duplication between State and Commonwealth requirements for environmental offsets, and the Cth policy notes State offsets may be suitable as offsets under the EPBC Act for the same action.

6. REFERENCES

- Allen, G.R., Midgley, S.H. and Allen, M. (2002). *Field Guide to the Freshwater Fishes of Australia*. Perth, WA.
- Anderson, P., Brundrett, M., Grierson, P. and Robinson, R. (2010). Impact of severe forest dieback caused by *Phytophthora cinnamomi* on macrofungal diversity in the northern jarrah forest of Western Australia. *Forest Ecology and Management* 259: 1033-1040.
- ANZECC/ARMCANZ (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australia and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand. Paper No. 4. Canberra.
- Athington, A.H., Bunn S.E., Gray M. (1993). *Stream Hydrology and Flow Management in the Tully Millstream Hydro-electric Scheme Area*. Report to the Wet Tropics Management Agency, Queensland (Qld).
- Australian Soil Resource Information System (ASRIS) (2017). Australian Soil Resource Information Viewer, retrieved March 2017, from http://www.asris.csiro.au/index_ie.html.
- Australian Bureau of Statistics (ABS) (2017). *Australian Demographic Statistics*. Retrieved March 2017. Available from www.abs.gov.au.
- Bain, K, Wayne, A & Bencini, R 2014. 'Overcoming the challenges of measuring the abundance of a cryptic macropod: is a qualitative approach good enough?', *Wildlife Research*, vol. 41, no. 1, pp. 84–93.
- Beard, J.S. (1979). *The Vegetation of the Pinjarra Area, Western Australia. Map and Explanatory Memoir, 1:250,000 Series*, Vegmap Publications, Perth.
- Beard, J. S. (1990). *Plant Life of Western Australia*. Kangaroo Press, Kenthurst NSW.
- Beard, J.S., Beeston, G.R., Harvey, J.M., Hopkins, A.J.M. and Shepherd, D.P. (2013). 'The Vegetation of Western Australia at the 1:3000000 scale Explanatory Memoir Second Edition' In: *Conservation Science Western Australia*, vol 9.
- Bennett, Environmental Consulting Pty Ltd (2004). *Vegetation and Flora Survey of Mining Lease ML258SA*. Unpublished report prepared for Worsley Alumina Pty Ltd, 2004.
- BIOSTAT Pty Ltd (Biostat) (2019). *Worsley Alumina Mining Expansion Desktop Fauna Assessment (Draft)*. Prepared for South32 Worsley Alumina Pty Ltd, February 2019.
- Brad Goode and Associates Consulting Anthropologists and Archaeologists (Brad Goode) (2015). *An Ethnographic Aboriginal Heritage Survey of Mt Saddleback (Mokine) in the Shire of Boddington Western Australia*. Prepared for South32 Worsley Alumina Pty Ltd.
- Brad Goode and Associates Consulting Anthropologists and Archaeologists (Brad Goode) (2017). *Report of an Aboriginal Heritage Survey for the Proposed Extensions to the Boddington Bauxite Mine at Hotham and Marradong in the Shire of Boddington, Western Australia*. Prepared for South32 Worsley Alumina Pty Ltd.
- Bunn, S.E. & Davies, P.M. (1992). Community structure of the macroinvertebrate fauna and water quality of a saline river system in south-western Australia. *Hydrobiologia*. 248:143.
- Carter, A. & Luck, G.W. (2013). Fox baiting in agricultural landscapes: preliminary findings on the importance of bait-site selection. *Wildlife Research*, Vol. 40, No. 3, pp. 184-195.
- Churchward, H.M and W.M. McArthur (1980). *Landforms and Soils of the Darling System, Western Australia*. In: Department of Conservation and Environment (1980) *Atlas of Natural Resources Darling System, Western Australia*. Published by the Department of Conservation and Environment, Perth, 1980.
- Commonwealth of Australia (2015). 'Draft referral guideline for 14 birds listed as migratory species under the EPBC Act'. Commonwealth of Australia. Conservation Commission (2003). *Forest*

- Management Plan 2004-2013. Data extracted for representation of Vegetation Complexes from former Department of Conservation and Land Management.
- Croton, JT & Dalton, JA (2007). Summary of soil salt storages for Boddington bauxite mine, Water & Environmental Consultant reports to Worsley Alumina Pty Ltd.
- Dames and Moore (1981). Worsley Alumina Project. Flora and Fauna Studies, Phase One. Prepared for Worsley Alumina Pty. Ltd.
- Department of Agriculture and Food (DAFWA) (2018). Western Australian Organism List (WAOL) <http://www.biosecurity.wa.gov.au/western-australian-organism-list-waol>. Accessed 15 December 2018. Department of Biodiversity, Conservation and Attractions (2018a). Wildlife conservation (rare flora) notice 2017, 16 January 2018, Minister for the Environment under section 23F (2) of the WC Act. Available from: <http://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-plants>.
- Department of Biodiversity, Conservation and Attractions (DBCA) (2018b), FloraBase – the Western Australian Flora, Department of Parks and Wildlife. Available from: <https://florabase.dpaw.wa.gov.au>.
- Department of Biodiversity, Conservation and Attractions (DBCA) (2018bc). List of threatened ecological communities endorsed by the Western Australia Minister for Environment, 28 June 2018, Species and Communities Branch, Government of Western Australia. Available from: <https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/wa-s-threatened-ecological-communities>.
- Department of Biodiversity, Conservation and Attractions (DBCA) (2018d). Priority ecological communities for Western Australia version 27, 30 June 2017, Species and Communities Branch, Department of Biodiversity, Conservation and Attractions. Available from: <https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/wa-s-threatened-ecological-communities>.
- Department of the Environment (2019). *Merops ornatus* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: <http://www.environment.gov.au/sprat>. Accessed Tue, 5 Mar 2019.
- Department of the Environment (2019a). *Setonix brachyurus* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: <http://www.environment.gov.au/sprat>. Accessed Tue, 5 Mar 2019.
- Department of Environment and Conservation (DEC) (2007). *Records held in DEC's Threatened Fauna Database and rare fauna files*. Department of Environment and Conservation, Perth, WA.
- Department of Environment and Conservation (DEC) (2008). Forest Black Cockatoo (Baudin's Cockatoo *Calyptorhynchus baudinii* and Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso*) Recovery Plan. Department of Environment and Conservation, Perth, WA.
- Department of Environment and Conservation (DEC) (2012a). Boddington Spider Orchid (*Caladenia* sp. Quindanning) Interim Recovery Plan 2013–2017. Interim Recovery Plan No. 332. Department of Environment and Conservation, Western Australia.
- Department of Environment and Conservation (DEC) (2012b). Chuditch (*Dasyurus geoffroii*) Recovery Plan. Wildlife Management Program No. 54. Department of Environment and Conservation, Perth, Western Australia.
- Department of Environment and Conservation (DEC) (2013). Quokka (*Setonix brachyurus*) Recovery Plan. Wildlife Management Program No. 56. Department of Environment and Conservation, Perth, WA.
- Department of Environment and Energy (2017). Revised referral guidelines for three threatened black cockatoo species: Carnaby's Cockatoo (endangered) *Calyptorhynchus latirostris*, Baudin's Cockatoo (vulnerable) *Calyptorhynchus baudinii*, Forest Red-Tailed Black-Cockatoo

- (vulnerable) *Calyptorhynchus banksii naso*, Department of Environment and Energy, Canberra, ACT.
- Department of the Environment and Energy (2019a). *Dasyurus geoffroii* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: <http://www.environment.gov.au/sprat>. Accessed Tue, 5 Mar 2019 21:05:03 +1100.
- Department of the Environment and Energy (2019b). *Phascogale calura* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: <http://www.environment.gov.au/sprat>. Accessed Tue, 5 Mar 2019 21:22:00 +1100.
- Department of the Environment and Energy (DoEE) (2019c). *Westralunio carteri* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: <http://www.environment.gov.au/sprat>. Accessed 15 Jan 2019.
- Department of Parks and Wildlife (DPW) (2007). NatureMap: Mapping Western Australia's biodiversity, Government of Western Australia. Available from: <https://naturemap.dpaw.wa.gov.au>.
- Department of Parks and Wildlife (DPW) (2013). Carnaby's cockatoo (*Calyptorhynchus latirostris*) Recovery Plan. Department of Parks and Wildlife, Perth, WA.
- Department of Parks and Wildlife (DPW) (2017). Western Ringtail Possum (*Pseudocheirus occidentalis*) Recovery Plan. Wildlife Management Program No. 58. Department of Parks and Wildlife, Perth, WA.
- Department of Primary Industries and Regional Development (2018). Western Australian Organism List, Government of Western Australia. Available from: <https://www.agric.wa.gov.au/bam/western-australian-organism-list-waol>.
- Department of the Environment and Energy (2018a). Protected Matters Search Tool. Available from: <https://www.environment.gov.au/epbc/protected-matters-search-tool>.
- Department of the Environment and Energy (2018b). EPBC Act list of threatened ecological communities, Commonwealth of Australia. Available from: <http://www.environment.gov.au/cgi-bin/sprat/public/publiclookupcommunities.pl>.
- Department of Premier and Cabinet (2018). South West Native Title Settlement, accessed November 2018. Available from www.dpa.wa.gov.au/swnts/South-West-Native-Title-Settlement.
- Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2012). Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy. Available from <http://www.environment.gov.au/epbc/publications/epbc-act-environmental-offsets-policy>.
- Department of Water (DoW) 2017. Water Information Reporting, retrieved March 2017, from www.water.wa.gov.au.
- De Tores, P. J., Hayward, M. W., Dillon, M. J. and Brazell, R. (2007). Review of the distribution, causes for the decline and recommendations for management of the quokka, *Setonix brachyurus* (Macropodidae: Marsupialia), an endemic macropod marsupial from south-west Western Australia. *Conservation Science Western Australia* 6 (1): 13-73.
- Doherty, T.S., Wingfield, B.N., Stokes, V.L., Craig, M.D., Lee, J.G.H., Finn, H.C. & Calver, M.C. (2016). 'Successional changes in feeding activity by threatened cockatoos in revegetated mine sites', *Wildlife Research*, vol. 43, no. 2, pp. 93–104.
- Envall (Environmental Alliances Pty Ltd) (2017). Dust Modelling for Hotham Mining Extension 2017 – Boddington Bauxite Mine. Prepared for South32 Worsley Alumina Pty Ltd.
- Envall (Environmental Alliances Pty Ltd) (2018). South32 Worsley Alumina Refinery, Air Quality Assessment for Proposed Production Increase to 5.1 Mtpa). Prepared for South32 Worsley Alumina Pty Ltd.

- Environmental Protection Authority (EPA) (2004). Guidance for the Assessment of Environmental Factors Assessment of Aboriginal Heritage No 41, Perth, Western Australia.
- Environmental Protection Authority (EPA) (2013). Protection of Naturally Vegetated Areas Through Planning and Development, Environmental Protection Bulletin No. 20, Perth, Western Australia.
- Environmental Protection Authority (EPA) (2016a). Environmental Factor Guideline - Air Quality, Perth, Western Australia.
- Environmental Protection Authority (EPA) (2016b). Environmental Factor Guideline - Flora and Vegetation, Perth, Western Australia.
- Environmental Protection Authority (EPA) (2016c). Environmental Factor Guideline - Social Surroundings, Perth, Western Australia.
- Environmental Protection Authority (EPA) (2016d). Environmental Factor Guideline - Terrestrial Environmental Quality, Perth, Western Australia.
- Environmental Protection Authority (EPA) (2016e). Statement of Environmental Principles, Factors and Objectives, Environmental Protection Authority, Western Australia.
- Environmental Protection Authority (EPA) (2016f). Technical Guidance – Flora and vegetation surveys for environmental impact assessment, Environmental Protection Authority.
- Environmental Protection Authority (EPA) (2016g). Technical Guidance – Sampling methods for subterranean fauna, Perth, Western Australia.
- Environmental Protection Authority (EPA) (2016h). Technical Guidance - Terrestrial Fauna Surveys, Perth, Western Australia.
- Environmental Protection Authority (EPA) (2016i). Technical Guidance – Sampling of Short-range Endemic Invertebrate Fauna, Perth, Western Australia.
- Environmental Protection Authority (EPA) (2016j). Environmental Factor Guideline: Subterranean Fauna. Perth, Western Australia.
- Environmental Protection Authority (EPA) (2018a). Environmental Factor Guideline Inland Waters, Perth, Western Australia.
- Environmental Protection Authority (EPA) (2018b). Instructions on how to define the key characteristics of a proposal. Perth, Western Australia.
- Environmental Protection Authority (EPA) (2018c). *Talison Lithium Australia Pty Ltd, Greenbushes Lithium Mine Expansion Referral Form*. Perth, Western Australia.
- Environmental Protection Authority (EPA) (2019). Technical Guidance: Mitigating Greenhouse Gas Emissions. Perth, Western Australia.
- Environmental Resource Management (ERM) (2018). *Hotham Mining Extension and Refinery Production Increase – Assessment of Landscape and Visual Impacts* (Draft, June 2018). Prepared for South32 Worsley Alumina Pty Ltd.
- Friend, T., & Friend, G. (1993). Conservation of the red-tailed phascogale (*Phascogale calura*). Wanneroo, Western Australia: Department of Conservation and Land Management, Perth, WA.
- Friend, J. A., & Scanlon, M. D. (1996). Assessment of the effect of fox control on populations of the red-tailed phascogale. Phase 4. Department of Conservation and Land Management, Perth, WA.
- GHD (2019). Environmental Support for South32's Proposal Mine Expansion in Relation to Carter's Freshwater Mussel *Westralunio carteri*. Unpublished report prepared for South32 Worsley Alumina Pty. Ltd.

- Golder Associates (2005). Possible Impacts on the Hotham River related to Drawdown: Boddington Gold Mine Stage 3 Feasibility Study, Boddington WA, unpublished report prepared for Newmont Boddington Gold Pty Ltd, Subiaco.
- Government of Western Australia (2011). WA Environmental Offsets Policy. Available from: <http://www.epa.wa.gov.au/policies-guidance/wa-environmental-offsets-policy-2011-and-guidelines>.
- Groundwater Resource Management (GRM) (2015). Boddington Bauxite Mine Triennial Aquifer Review Jul 2011 to Jun 2014. Prepared for BHP Billiton Worsley Alumina Pty Ltd.
- Hale, J., McGuire, M., Hambleton, S., Morgan, D., Davis, J., Gill, H. and Paling, E. (1999). Water Quality Aquatic Macroinvertebrate and Fish Monitoring of the Worsley Freshwater Lake and Brunswick River Catchment (March to December 1999). Unpublished report prepared for Worsley Alumina Pty. Ltd.
- Harvey, M (2002). Short-range Endemism among the Australian Fauna: Some examples from non-marine environments. *Invertebrate Systematics* 16: 555-570.
- Havel, J.J. (1975a). Site-vegetation mapping in the Northern Jarrah Forest (Darling Range). I. Definition of site-vegetation types. *Bull. For. Dept. West. Aust.* 86.
- Havel, J.J. (1975b). Site-vegetation mapping in the Northern Jarrah Forest (Darling Range). II. Location and mapping of site-vegetation types. *Bull. For. Dept. West. Aust.* 87.
- Hayward M. W., de Tores P. J., Augee M. L., Fox B.J., Banks P.B. (2004). Home range and movements of the quokka, *Setonix brachyurus* (Macropodidae: Marsupialia), and its impact on the viability of the metapopulation on the Australian mainland. *Journal of Zoology* 263: 219–228.
- Hedde, E.M., Loneragan, O.W. and Havel, J.J. (1980). 'Vegetation complexes of the Darling System, Western Australia' In: *Atlas of Natural Resources Darling System Western Australia explanatory text*, pp 37-72. University of Western Australia Press, Western Australia.
- Johnstone, RE & Kirkby, T 1999. 'Food of the Forest Red-tailed Black-cockatoo *Calyptorhynchus banksii* naso in south-west Western Australia', *The Western Australian Naturalist*, vol. 22, no. 3, pp. 167–178.
- Johnstone, RE, Kirkby, T & Sarti, K 2017. 'The distribution, status movements and diet of the Forest Red-tailed Black Cockatoo in the south-west with emphasis on the greater Perth regions, Western Australia', *The Western Australian Naturalist*, vol. 30, no. 4, pp. 193–219.
- Keighery, B.J. (1994). *Bushland plant survey: a guide to plant community survey for the community*, Wildflower Society of WA (Inc.), Western Australia.
- Kinney, J. E., Sumner, N. R. and Onus, M. L. (2002). The red fox in Australia - an exotic predator turned biocontrol agent. *Biological Conservation* 108: 335-359.
- Klunzinger MW, Beatty SJ, Morgan DL, Thomson GJ, Lymbery AJ (2012). Glochidia ecology in wild fish populations and laboratory determination of competent host fishes for an endemic freshwater mussel of south-western Australia. *Australian Journal of Zoology* 60: 26-36.
- Klunzinger, M.W., Beatty, S.J., Morgan, D.L., Pinder, A.M., and Lymbery, A.J. (2015). Range decline and conservation status of *Westralunio carteri* Iredale, 1934 (Bivalvia : Hyriidae) from south-western Australia. *Australian Journal of Zoology* 63(2) 127-135.
- Lee, J., Finn, H. and Calver, M. (2010). Mine-site revegetation monitoring detects feeding by Threatened Black-Cockatoos within 8 years, *Ecological Management and Restoration*, Vol.11, no. 2, pp. 141 – 143.
- Le Souef, A.L. (2012). Black Cockatoo (*Calyptorhynchus spp.*) *Conservation in Western Australia: Developing and improving tools for the clinical evaluation and management of rehabilitated birds*, PhD Thesis (currently under examination), Murdoch University.

- Mattiske, E.M. and Associates (Mattiske) (1985). Flora and Vegetation. Boddington Bauxite Mine. Unpublished report prepared for Worsley Alumina Pty Ltd, 1985.
- Mattiske, E.M. and Associates (Mattiske) (1985). Flora and Vegetation. Boddington Gold Mine. Unpublished report prepared for Worsley Alumina Joint Venture.
- Mattiske, E. M. & Associates (Mattiske) (1990). *Flora and Vegetation. Marradong Timber Reserve*. Unpublished report prepared for Worsley Alumina Pty Ltd, February 1990.
- Mattiske, E. M. & Associates (Mattiske) (1992). *Flora and Vegetation, Eastern Anomaly Area*. Unpublished report prepared for Worsley Alumina Pty Ltd, July 1992.
- Mattiske, E. M. & Associates (Mattiske) (1993a). *Flora and Vegetation Studies on The Mount Saddleback Survey Area*. Unpublished report prepared for Worsley Alumina Pty Ltd, July 1993.
- Mattiske Consulting Pty Ltd (Mattiske) (1993b). Assessment of Tunnell Road Heath Communities, Boddington Bauxite Mine. Unpublished report prepared for Worsley Alumina Pty Ltd.
- Mattiske, E.M. and Associates (Mattiske) (1993c). Flora and Vegetation Assessment of the Quindanning Timber Reserve. Unpublished report prepared for Worsley Alumina Pty Ltd, 1993.
- Mattiske, E.M. and Associates (Mattiske) (1993d). Flora and vegetation studies on the southern Mount Saddleback survey area. Unpublished report prepared for Worsley Alumina Pty Ltd, 1993.
- Mattiske, E. M. and Havel, J. J. (Mattiske) (1998). *Regional Forest Agreement Vegetation Complexes, Pinjarra, Western Australia*. Department of Conservation and Land Management, Como.
- Mattiske Consulting Pty Ltd (1999a). Assessment of Tunnell Road Heath Communities, Boddington Bauxite Mine. Unpublished report prepared for Worsley Alumina Pty Ltd.
- Mattiske, E.M. and Associates (1999b). Assessment of Vegetation Monitoring Plots in Quindanning Timber Reserve. Unpublished report prepared for Worsley Alumina Pty Ltd, July 1999.
- Mattiske, E.M. and Associates (1999c). Flora and Vegetation Studies. Quindanning Survey Area. Unpublished report prepared for Worsley Alumina Pty Ltd, 1999.
- Mattiske Consulting Pty Ltd (Mattiske) (2002). *Flora and Vegetation Survey Remnant Vegetation Devereux, Nichols and Veitch Properties - Boddington Bauxite Mine*, unpublished report prepared for Worsley Alumina Pty Ltd, May 2002.
- Mattiske Consulting Pty Ltd (Mattiske) (2003). *Review of declared rare and priority flora species located in the Worsley Alumina Boddington Bauxite Mine lease areas*. Unpublished report prepared for Worsley Alumina Pty Ltd, October, 2003.
- Mattiske Consulting Pty Ltd (Mattiske) (2004a). *Assessment of Tunnell Road Heath Communities – Boddington Bauxite Mine*. Unpublished report prepared for Worsley Alumina Pty Ltd, June 2004.
- Mattiske Consulting Pty Ltd (Mattiske) (2004b). *Vegetation Monitoring Plots Sotico Property*. Unpublished report prepared for Newmont Boddington Gold, December 2013.
- Mattiske Consulting Pty Ltd (Mattiske) (2005). *Review of Flora and Vegetation located in the Boddington Gold Mine and Hedges Lease Areas*. Unpublished report prepared for Boddington Gold Mine, 2005.
- Mattiske Consulting Pty Ltd (Mattiske) (2007). *Flora and Vegetation of Collie Refinery*, unpublished report prepared for BHP Worsley Alumina Pty Ltd, June 2007.
- Mattiske Consulting Pty Ltd (2008). *Flora and Vegetation on Marradong Forest Block Boddington*. Unpublished report prepared for BHP Billiton Worsley Alumina Pty Ltd, 2008.
- Mattiske Consulting Pty Ltd (Mattiske) (2010a). *Flora and Vegetation of Littleton's Cut Area*. Unpublished report prepared for BHP Billiton Worsley Alumina Pty Ltd, October 2010.

- Mattiske Consulting Pty Ltd (Mattiske) (2010b). *Flora and Vegetation Survey of Nichols, Black, Gibbs, Karafils, Nichols and Veitch properties, Boddington*. Unpublished report prepared for BHP Billiton Worsley Alumina Pty Ltd, 2010.
- Mattiske Consulting Pty Ltd (Mattiske) (2010c). *Flora and Vegetation Survey of the Dobrowski Private Property Survey Area*. Unpublished report prepared for BHP Billiton Worsley Alumina Pty Ltd, September 2010.
- Mattiske Consulting Pty Ltd (Mattiske) (2010d). *Flora and Vegetation Survey of Farmer Property*. Unpublished report prepared for BHP Billiton Worsley Alumina Pty Ltd, September 2010.
- Mattiske Consulting Pty Ltd (Mattiske) (2010e). *Flora and Vegetation Survey of Hulls 1 Property*. Unpublished report prepared for BHP Billiton Worsley Alumina Pty Ltd, June 2010.
- Mattiske Consulting Pty Ltd (Mattiske) (2010f). *Flora and Vegetation Survey of Hulls 2 Property*. Unpublished report prepared for BHP Billiton Worsley Alumina Pty Ltd, June 2010.
- Mattiske Consulting Pty Ltd (Mattiske) (2010g). *Flora and Vegetation Survey of Nullaga Property*. Unpublished report prepared for BHP Billiton Worsley Alumina Pty Ltd, September 2010.
- Mattiske Consulting Pty Ltd (Mattiske) (2010h). *Flora and Vegetation Survey of Pringles Property*. Unpublished report prepared for BHP Billiton Worsley Alumina Pty Ltd, June 2010.
- Mattiske Consulting Pty Ltd (Mattiske) (2010i). *Flora and Vegetation Survey of Robin Property Adjacent to Marradong Bauxite Mine*. Unpublished report prepared for BHP Billiton Worsley Alumina Pty Ltd, June 2010.
- Mattiske Consulting Pty Ltd (Mattiske) (2010j). *Flora and Vegetation Survey of Nichols Property*. Unpublished report prepared for BHP Billiton Worsley Alumina Pty Ltd, 2010.
- Mattiske Consulting Pty Ltd (Mattiske) (2010k). *Flora and Vegetation Survey of Salmeri Property*. Unpublished report prepared for BHP Billiton Worsley Alumina Pty Ltd, 2010.
- Mattiske Consulting Pty Ltd (Mattiske) (2010l). *Flora and Vegetation Survey of Spencer Property*. Unpublished report prepared for BHP Billiton Worsley Alumina Pty Ltd, 2010.
- Mattiske Consulting Pty Ltd (Mattiske) (2012a). *Flora and Vegetation Survey of Nullaga Property Adjacent to Marradong Section of Boddington Bauxite Mine*. Unpublished report prepared for BHP Billiton Worsley Alumina Pty Ltd, December 2012.
- Mattiske Consulting Pty Ltd (Mattiske) (2012b). *Flora and Vegetation of the Sotico Survey Area*. Unpublished report prepared for Newmont Boddington Gold, October 2012.
- Mattiske Consulting Pty Ltd (Mattiske) (2012c). *Threatened and Priority Flora Assessment of the Hotham Pipeline and Hedges Dam*, unpublished report prepared for Newmont Boddington Gold Mine, August 2012.
- Mattiske Consulting Pty Ltd (Mattiske) (2012d). *Vegetation Monitoring Plots Sotico Property*. Unpublished report prepared for Newmont Boddington Gold, 2012.
- Mattiske Consulting Pty Ltd (Mattiske) (2013a). *Flora and Vegetation Survey of Hotham Farm Survey Area*. Unpublished report prepared for BHP Billiton Worsley Alumina Pty Ltd, January 2013.
- Mattiske Consulting Pty Ltd (Mattiske) (2013b). *Assessment of Flora and Vegetation Values on the Proposed WRL, the Potential Land Swap Area and the Southern Section of Hotham Farm*. Unpublished report prepared for Newmont Boddington Gold Mine, December 2013.
- Mattiske Consulting Pty Ltd (Mattiske) (2014). *Assessment of Flora and Vegetation of Private Properties within the Extension Survey Areas*, unpublished report prepared for BHP Billiton Worsley Alumina Pty Ltd, December 2014.
- Mattiske Consulting Pty Ltd (Mattiske) (2017). *Assessment of Flora and Vegetation of Private Properties within the Extension Survey Areas*. Unpublished report prepared for South32 Worsley Alumina, 2017.
- Mattiske Consulting Pty Ltd (Mattiske) (2019). *Assessment of Flora and Vegetation within Expansion Survey Areas*. Unpublished report prepared for South32 Worsley Alumina, 2018.

- Mawson, PR 1995. 'Observations of nectar feeding by Carnaby's Cockatoo *Calyptorhynchus latirostris*.' The Western Australian Naturalist, vol. 20, no. 2, pp. 93–96.
- May S.A. & Norton T.W. (1996). Influence of fragmentation and disturbance on the potential impact of feral predators on native fauna in Australian forest ecosystems. *Wildlife Research*, Vol. 23, No. 4, pp. 387-400.
- Morgan, D & Beatty, S (2004). Monitoring the Lion's Weir Fishway – Hotham River, Western Australia. Centre for Fish and Fisheries Research, Murdoch University. Report prepared for the Department of Environment and Energy, February 2004.
- Orell, P. (2004). Fauna monitoring and staff training: Western Shield review – February 2003. *Conservation Science Western Australia* 5(2): 51-95.
- Outback Ecology (2012). Terrestrial Short-ranged Endemic Invertebrate Fauna Baseline Survey: Boddington Gold Mine. Outback Ecology Systems, Jolimont, WA. Unpublished report prepared for Newmont Boddington Gold Pty Ltd.
- Pacioni, C, Wayne, A.F. and Spencer, P.B.S. (2010). Effects of habitat fragmentation on population structure and long-distance gene flow in an endangered marsupial: the woylie. *Journal of Zoology*: 1-10.
- Ponder, W. F. & Colgan, D. J. (2002). What makes a narrow-range taxon? Insights from Australian freshwater snails. *Invertebrate Systematics* 16: 571–582.
- Phoenix Environmental Sciences (2012). *Two-season short-range endemic invertebrate survey for the BHP Billiton Worsley Alumina Primary Bauxite Area Expansion Project*. Phoenix Environmental Sciences Pty Ltd, Balcatta, WA. Unpublished report prepared for Strategen Environmental Consultants (on behalf of BHP Worsley Alumina Pty Ltd).
- Phoenix Environmental Sciences (2019a). Memo: Terrestrial short-range endemic fauna assessment conducted for the proposed Worsley Mine Expansion – Worsley Mine Development Envelope and Bauxite Transport Corridor. Unpublished report prepared for South32 Worsley Alumina.
- Phoenix Environmental Sciences (2019b). Memo: Terrestrial short-range endemic fauna assessment conducted for the proposed Worsley Mine Expansion – Contingency Bauxite Mining Envelope. Unpublished report prepared for South32 Worsley Alumina.
- Phoenix Environmental Sciences (2019c). Memo: Subterranean fauna likelihood of occurrence assessment conducted for the proposed Worsley Mine Expansion - Worsley Mine Development Envelope and Bauxite Transport Corridor. Unpublished report prepared for South32 Worsley Alumina.
- Phoenix Environmental Sciences (2019d). Memo: Subterranean fauna likelihood of occurrence assessment conducted for the proposed Worsley Mine Expansion – Contingency Bauxite Mining Envelope. Unpublished report prepared for South32 Worsley Alumina.
- Sampson, J.C. (1971). The biology of *Bettongia penicillata* Gray, 1837. PhD thesis, University of Western Australia.
- Saunders, D.A. (1974). Subspeciation in the White-tailed Black Cockatoo, *Calyptorhynchus baudinii*, in Western Australia. *Australian Wildlife Research*. 1: 55-69.
- Saunders, D.A., Mawson, P. and Dawson, R. (2011). The impact of two extreme weather events and other causes of death on Carnaby's Black Cockatoo: a promise of things to come for a threatened species? *Pacific Conservation Biology*. 17: 141-148.
- Schlumberger Water Services (Schlumberger) (2010). Boddington Gold Mine Summary of Groundwater, Surface Water and Hydrogeochemical Conditions and Implications for Closure, (draft), unpublished report to NBG.
- Schlumberger Water Services (Schlumberger) (2013). Newmont Boddington Gold Updated Assessment of Potential Regional Influences of Mine Dewatering, unpublished report to NBG.

- Strategen Environmental Consultants (Strategen) (2005). Worsley Alumina Pty Ltd Bauxite-Alumina Project Expansions – Environmental Review and Management Programme.
- Short, J., Hide, A. & Stone, M. (2011). 'Habitat requirements of the endangered red-tailed phascogale, *Phascogale calura*'. *Wildlife Research*, vol. **38**, no. 5, pp. 359–369.
- Short, J. & Hide, A. (2012). 'Distribution and status of the red-tailed phascogale (*Phascogale calura*)'. *Australian Mammalogy*, vol. **34**, no. 1, pp. 88–99.
- South 32 (7 September 2018). Annual Report 2018.
- Strategen Environmental Consultants (Strategen) (2013). Newmont Boddington Gold Life of Mine Extension Project, Environmental Management Plan, report prepared for Newmont Boddington Gold Pty Ltd, Subiaco.
- Streamtec (2005). Hedges Gold, River Water Dam 2005: during and post-water release ecological condition of the RWD, Junglen Gully and the Hotham River, unpublished report for Alcoa Australia, Booragoon.
- Thackway, R. and Cresswell, I.D. (1995). An Interim Biogeographic Regionalisation for Australia: A framework for establishing the national system of reserves, Version 4.0. Australian Nature Conservancy Agency, Canberra.
- Threatened Species Scientific Committee (TSSC) (2018). *Westralunio carteri* (Carter's freshwater mussel) Conservation Advice. Prepared by the Threatened Species Scientific Committee Established. Under the Environment Protection and Biodiversity Conservation Act 1999.
- Valentine, L & Stock, W (2008). 'Food resources of Carnaby's Black-cockatoo (*Calyptorhynchus latirostris*) in the Gngangara Sustainability Strategy study area', ECU Publications Pre. 2011, Edith Cowan University Research Online, p. 31.
- Western Australian Herbarium (1998). FloraBase—the Western Australian Flora. *Caladenia hopperiana*. Department of Biodiversity, Conservation and Attractions. Available from: <https://florabase.dpaw.wa.gov.au/browse/profile/44901>.
- Western Australian Museum (WAM) (2013). Short-range endemic categories and sub-categories. Western Australian Museum, Welshpool.
- Western Australian Museum (WAM) (2018). WA Museum Arachnology/Myriapodology, Crustacea and Mollusca database, Welshpool, WA.
- WARU Consulting Pty Ltd (WARU) (2012). Verification of 17 Heritage Sites Near Boddington Bauxite Mine Boddington. Prepared for BHP Billiton Worsley Alumina Pty Ltd. November 2012.
- White, J.G., Gubiani, R., Smallman, N., Snell, K. & Morton, A. (2006). Home range, habitat selection and diet of foxes (*Vulpes vulpes*) in a semi-urban riparian environment, *Wildlife Research*, Vol. 33, No. 3, pp. 175–180.
- Wilkes SM, Clement, TP. & Otto CJ. (2004). *Characterisation of the hydrogeology of the Augustus River catchment, WA*. *Hydrogeology Journal* V12:209-223.
- Williams, K. & Mitchell, D. (2001). 'Jarrah Forest 1 (JF1 – Northern Jarrah Forest subregion)' in A biodiversity audit of Western Australia's 53 biogeographical subregions in 2002, eds. JE May & NL McKenzie, Department of Conservation and Land Management, Western Australia, pp. [369-381].
- Worsley (1999). Contingency Bauxite Mining Plan (10 Year Plan), Worsley Refinery Site.
- Worsley (2010). Fauna Management – Animal Handling Procedure, Deployed November 2006.
- Worsley (2012). Native Vegetation Clearing Planning, BWAPL Procedure, Deployed September 2012.
- Worsley (2013a). Excessive Mining Noise Withdrawal, BWAPL Procedure, Deployed November 2013.

- Worsley (2013b). Protected Areas, BWAPL Procedure, Deployed August 2013.
- Worsley (2013c). Rehabilitation, BWAPL Standard (STA.021), Deployed August 2013.
- Worsley (2013d). Topsoil and Overburden Handling. BWAPL Standard, Deployed October 2013.
- Worsley (2014a). Forest Hygiene Management, BWAPL Procedure, Deployed April 2014.
- Worsley (2014b). Noise Management Plan – Bauxite Transport, Version 2.0, Deployed May 2014.
- Worsley (2014c). Noise Management Plan – Mining and Blasting, Version 2.0, Deployed June 2014.
- Worsley (2015a). BBM Revegetation Management, WAPL Procedure, Version 3.0 Deployed October 2015.
- Worsley (2015b). Dust Management Plan – Bauxite Mining and Transport Business Blueprint, Version 4.0, Deployed October 2015.
- Worsley (2015c). Environmental Noise Management, WAPL Technical Standard, Deployed November 2015.
- Worsley (2015d). Mine Clearing, BWAPL Procedure, Deployed February 2015.
- Worsley (2015e). Mine Clearing, BWAPL Standard (STA.401), Deployed February 2015.
- Worsley (2015f). Mine Rehabilitation Operations, WAPL Procedure, Version 4.0, Deployed August 2015.
- Worsley (2015g). Private Land Rehabilitation Management, BWAPL Procedure, Deployed March 2015.
- Worsley (2015h). Site Drainage – Boddington Bauxite Mine, BWAPL Standard (STA.402), Deployed February 2015.
- Worsley (2016). Worsley Refinery, Port, OBC Closure Plan, 2016. Version 1.0.
- Worsley (2017a). MS719 Management Plan – Water Management Plan, Business Blueprint, Version 3.0.
- Worsley (2017b). WAPL Standard 00111927 Fauna Habitat Construction – Standard Operating Procedure. Unpublished document.
- Worsley (2018a). Black Cockatoo Habitat Survey Procedure. Internal document in draft 2018.
- Worsley (2018b). Plan of Bauxite Mining Operations 2019 - 2018.
- Wetland Research and Management (WRM) (2005). *Ecological Water Requirements of Augustus River – Intermediary Assessment*. Unpublished report by Wetland Research and Management to Worsley Alumina Pty. Ltd. March 2005.
- Wetland Research and Management (WRM) (2011). *Hotham River - Ecological Water Requirements and Ecological Sustainable Yield Downstream of Tullis Bridge*. Unpublished report by Wetland Research & Management to Newmont Boddington Gold. January 2011.
- Wetland Research and Management (WRM) (2012). *Thirty-Four Mile Brook Ecological Monitoring*. Unpublished report by Wetland Research & Management prepared for Newmont Boddington Gold. August 2012.
- Yeatman, G.J. & C.J. Groom (2012). National Recovery Plan for the *woylie Bettongia penicillata*. Wildlife Management Program No. 51. Department of Environment and Conservation, Perth. Available from: <http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-woylie-bettongia-penicillata-ogilbyi>. In effect under the EPBC Act from 24-Jul-2012.

7. APPENDICES

Appendix A – Flora and Vegetation Report (Mattiske Consulting)

Appendix B – Vertebrate Fauna Report (Biostat)

Appendix C – Short-range Endemic Invertebrate Fauna Report – Mine (Phoenix Environmental Sciences)

Appendix D – Short-Range Endemic Invertebrate Fauna Report – Refinery (Phoenix Environmental Sciences)

Appendix E – Subterranean Fauna Report – Mine (Phoenix Environmental Sciences)

Appendix F – Subterranean Fauna Report – Refinery (Phoenix Environmental Sciences)

**Appendix G – Aboriginal Heritage Survey Report of the Hotham River
(Brad Goode and Associates)**

Appendix H – Worsley Biodiversity and Forest Management Plan 2016

Appendix I – Matters of National Environmental Significance