Atlas Project

ENVIRONMENTAL REVIEW DOCUMENT

IMAGE RESOURCES NL

13 December 2022
Assessment Number: 2311
Document Number: IMA-ATL-ERD-01

PREPARED FOR IMAGE RESOURCES NL
BY PRESTON CONSULTING PTY LTD

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ACKNOWLEDGEMENT OF COUNTRY

In the spirit of reconciliation Image Resources NL and Preston Consulting Pty Ltd acknowledge that this project is proposed on the lands of the Yued People of the Noongar Nation. We pay our respects to Elders past, present and emerging and recognise their continuing connection to land, sea, culture and community.

DOCUMENT CONTROL

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Authorisation	Todd Colton – Chief Operating Officer, Image Resources		13/12/2022

INVITATION TO MAKE A SUBMISSION

The Environmental Protection Authority (EPA) invites people to make a submission on the environmental review for this proposal. Image Resources NL (Image) seeks to develop a mineral sands mine located in the Wheatbelt region of Western Australia (WA), approximately 170 kilometres (km) north of Perth and 18 km east of Cervantes.

The proposal includes the progressive development of mine pits, processing facilities, groundwater bores and water management infrastructure, temporary waste stockpiles, solar drying ponds and associated infrastructure (power supply, communications, workshop, laydown, offices, accommodation camp etc.).

This Environmental Review Document (ERD) has been prepared in accordance with the EPA's Procedures Manual (Part IV Divisions 1 and 2). The ERD is the report by the proponent on their environmental review which describes this proposal and its likely effects on the environment. This ERD is available for a public review period of six weeks from XX December 2022, closing on XX January 2023.

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

Why write a submission?

The EPA seeks information that will inform the EPA's consideration of the likely effect of the proposal, if implemented, on the environment. This may include relevant new information that is not in the ERD, such as alternative courses of action or approaches. In preparing its assessment report for the Minister for Environment, the EPA will consider the information in submissions, the proponent's responses and other relevant information. Submissions will be treated as public documents unless provided and received in confidence, subject to the requirements of the *Freedom of Information Act 1992* (WA).

Why not join a group?

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

Developing a submission

You may agree or disagree with, or comment on information in the ERD. When making comments on specific elements in the ERD, ensure that you:

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

What to include in your submission

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

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

The closing date for public submissions is: XX January 2023.

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

Alternatively submissions can be:
- Posted to: Chairman, Environmental Protection Authority, Locked Bag 10, Joondalup DC, Joondalup WA 6919, or
- Delivered to: the Environmental Protection Authority, 8 Davidson Terrace, Joondalup, WA 6027.

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

SCOPING CHECKLIST

Task No.	Required Work	Section and Page No.
Flora and Vegetation		
1	A desktop review of available technical reports, relevant databases and spatial data to identify the potential flora and vegetation that may be present. Demonstrate how surveys are relevant, representative and demonstrate consistency with current EPA and the Department of Agriculture, Water and the Environment (DAWE) policy and guidance. Ensure database searches and taxonomic identifications are up to date.	Section 5.3.1 Appendix 3-6 & 11
2	Flora and Vegetation surveys conducted in accordance with current EPA Technical Guidance and DAWE guidance for specific flora species including: • A Detailed and Targeted survey of the MDE; and • A Basic and Targeted survey of the EIDE.	Section 5.3.1 Appendix 3-5
3	If potential impacts from weed species are considered significant, a targeted program of works will be provided to identify, map and manage weeds.	Section 5.3.6 Appendix 3-5
4	If multiple surveys have been undertaken by the same consultant to support the assessment, a consolidated report should be provided including the integrated results of the surveys.	Section 5.3.1
5	The survey report and data should be submitted via the Index of Biodiversity Surveys for Assessments (IBSA) Submissions with the IBSA number provided for verification.	Appendix 35
6	Provide a figure depicting survey effort applied in relation to the study area and DEs, identifying the direct and indirect impact areas.	Section 5.3.1 Appendix 3-6
7	A comprehensive Dieback survey of all proposed disturbance areas associated with the Project.	Appendix 6
8	Prepare a Dieback management plan addressing Dieback risks, impacts and management strategies for all areas of disturbance associated with the Proposal.	Section 5.3.3 & 5.6 Appendix 7
9	Determine whether any flora species recorded are significant including species listed as Priority species under the *Biodiversity Conservation Act 2016* (BC Act, WA), and provide an analysis of local and regional context, (refer to Environmental Factor Guideline – Flora and Vegetation for definition of significant flora).	Section 5.3 & 5.5 Appendix 4
10	Determine whether any vegetation identified is significant including ecological communities listed under the BC Act, and provide an analysis of local and regional context, (refer to Environmental Factor Guideline – Flora and Vegetation for definition of significant vegetation).	Section 5.3 & 5.5 Appendix 4
11	Provide maps showing the recorded locations of significant flora in relation to the Proposal and species distributions. Provide maps showing the extent of all vegetation, and significant vegetation, in the study area, the DEs, direct and indirect impact areas, and in the local and regional contexts.	Section 5.3 & 5.5
12	Assess the potential direct and indirect impacts of the construction and operational elements of the Proposal on identified environmental values. Describe and assess the extent of cumulative impacts as appropriate. Assessment is to consider Commonwealth guidelines regarding radiation as appropriate. Include figures showing the predicted extent of loss and corresponding vegetation quality breakdown.	Section 5.5

Task No.	Required Work	Section and Page No.

13	Provide a quantitative assessment of impact:
	• For significant flora, this includes;
	  ○ Number of individuals and populations in a local and regional context;
	  ○ Numbers and proportions of individuals and populations directly or potentially indirectly impacted; and
	  ○ Numbers/proportions/populations currently protected within the conservation estate (where known).
	• For all vegetation units (noting threatened and priority ecological communities and significant vegetation) this includes;
	  ○ Area (in hectares) and proportions directly or potentially indirectly impacted; and
	  ○ Proportions/hectares of the vegetation unit currently protected within conservation estate (where known).
		Section 5.5

14	Describe the application of the mitigation hierarchy in the Proposal design, construction, operation and closure, demonstrating that the design of the Proposal has addressed the mitigation hierarchy in relation to impacts on flora and vegetation. Detail actions undertaken to avoid, minimise and mitigate Proposal impacts. For significant impacts include management and/or monitoring plans (presented in accordance with EPA and DAWE instructions) to be implemented pre- and post-construction to demonstrate that residual impacts are not greater than predicted.	Section 5.6
15	Provide an evidence-based Rehabilitation Strategy that includes details of the methods for collecting seed, topsoil management, planting strategies, success metrics and predicted timeframes. Details of the post-mining landform are to be included.	Sections 5.5 & 5.6
16	Discuss, and determine significance of, potential direct, indirect (including downstream) and cumulative impacts to vegetation as a result of the Proposal at a local and regional level.	Sections 5.4, 5.5 & 15
17	Demonstrate how the Proposal will be developed to avoid impacts to the Nambung National Park.	Section 5.6
18	Demonstrate that all practicable measures have been taken to reduce the area of the proposed disturbance footprint based on progress in the Proposal design and understanding of the environmental impacts.	Section 2.3.3
19	Demonstrate how the final post-mining landform will be designed to conserve pre-mining hydrology of the site.	N/A
20	Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (page 11) and WA Offset Template (Appendix 1) in the WA Environmental Offsets Guidelines (2014), the EPBC Act Environmental Offsets Policy (Department of Sustainability, Environment, Water, Population and Communities; DSEWPaC, 2012a) and include reference to the Commonwealth Offset Assessment Guide for any MNES.	Section 12
21	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines and the EPBC Act Environmental Offsets Policy. Any proposed offsets package will be assessed against the EPBC Act Environmental Offsets Policy and the six offset principles in the WA Environmental Offsets Policy. Spatial data defining the area of significant residual impacts will also be provided. Demonstrate how the proposed offset (if needed) is consistent with the EPBC Act *Environmental Offsets Policy* including, but not limited to the extent to which the proposed offset correlates to, and adequately compensates for, the residual significant impacts on MNES (this is to include completion of an offsets guide and justification), and the conservation gain to be achieved by the proposed offset (i.e., future loss, degradation or damage to the protected matter).	Section 5.5 & 12
22	Demonstrate and document in the ERD how the EPA objective for this factor can be met	Section 5.7
23	Demonstrate and document in the ERD information sufficient to allow the Commonwealth Minister to make an informed decision on whether or not to approve, under Part 9 of the EPBC Act, the taking of the action for the purposes of each controlling provision.	Section 5.5 & 12

Task No.	Required Work	Section and Page No.
Terrestrial Fauna		
24	In accordance with EPA Guidance, conduct a desktop study to identify and characterise the vertebrate and Short Range Endemic (SRE) invertebrate fauna and fauna habitats in a local and regional context; and based on the results of the desktop study conduct: • A Basic survey and fauna habitat assessment; and/or • A Detailed survey including sampling inside and outside the impact areas that may be directly or indirectly impacted; and/or • Targeted surveys for significant fauna (including those listed in Appendix A) that may be directly or indirectly impacted'; and • If multiple surveys have been undertaken by the same consultant to support the assessment, a consolidated report should be provided including the integrated results of the surveys.	Section 6.3.1 Appendix 5 & 8-13
25	All surveys and data should be submitted via the IBSA Submissions with the IBSA number provided for verification.	Appendix 5, 8-13 & 35
26	A map of the survey effort applied in relation to the Proposal, identifying the direct and indirect impact areas.	Section 6.3.1 Appendix 5 & 8-13
27	Identify and describe the fauna habitats identified by the studies and surveys. Describe significant fauna habitats, including but not limited to SRE invertebrate microhabitats, refugia, breeding areas, key foraging habitat, movement corridors and linkages.	Section 6.3.9 Appendix 5 & 8-13
28	Provide figure(s) and maps showing the extent of fauna habitats in relation to the Proposal and species distributions.	Section 6.3
29	Identify and describe the fauna assemblages present and likely to be present within the DEs that may be impacted by the Proposal.	Section 6.3
30	Identify significant and restricted fauna and describe in detail their known ecology, likelihood of occurrence, habitats and known threats.	Section 6.3
31	Assess the extent of direct and indirect disturbance in addition to known existing threats on significant and other fauna species, including amount of habitat and percentages of habitat types to be disturbed or otherwise impacted, to assist in determination of significance of impacts. Consider whether the remaining habitat has adequate carrying capacity.	Section 6.5
32	Map the locations of significant and restricted fauna records in relation to the fauna habitats, the study area, the DEs, and direct and indirect impact areas.	Section 6.5
33	Describe and quantify the extent of potential direct, indirect and cumulative impacts, including percentages, to habitats and significant species that may occur following implementation of the Proposal during both construction and operations, in a local and regional context.	Section 6.3, 6.5 and 15
34	Provide a table of the proportional extents of each habitat within the study area and DEs and the predicted amount to be directly impacted and remaining. Consider any local or regional cumulative impacts.	Section 6.5.1
35	Outline the proposed avoidance and mitigation measures to reduce the potential impacts of the Proposal. Include proposed management and/or monitoring plans for significant impacts that will be implemented pre- and post-construction to demonstrate and ensure residual impacts are not greater than predicted. Management and/or monitoring plans are to be presented in accordance with the EPAs Instructions.	Section 6.5
36	Discuss proposed management, monitoring and control/mitigation methods to be implemented so that the radiological impacts do not pose an unacceptable risk to fauna. Assessment is to consider Commonwealth guidelines regarding radiation as appropriate.	Section 6.5
37	Predict the residual impacts from the Proposal on terrestrial fauna after considering and applying the mitigation hierarchy.	Section 6.7
38	Discuss closure and rehabilitation management measures, outcomes / objectives to be implemented.	Appendix 2
39	Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (page 11) and WA Offset Template (Appendix 1) in the WA Environmental Offsets Guidelines (2014), the EPBC Act Environmental Offsets Policy (DSEWPaC, 2012a) and include reference to the Commonwealth Offset Assessment Guide for any MNES.	Section 12

Task No.	Required Work	Section and Page No.
40	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines and the EPBC Act Environmental Offsets Policy. Any proposed offsets package will be assessed against the EPBC Act Environmental Offsets Policy and the six offset principles in the WA Environmental Offsets Policy. Spatial data defining the area of significant residual impacts will also be provided. Demonstrate how the proposed offset (if needed) is consistent with the EPBC Act *Environmental Offsets Policy* including, but not limited to the extent to which the proposed offset correlates to, and adequately compensates for, the residual significant impacts on MNES (this is to include completion of an offsets guide and justification), and the conservation gain to be achieved by the proposed offset (i.e, future loss, degradation or damage to the protected matter).	Section 12
41	Demonstrate and document in the ERD how the EPA objective for this factor can be met.	Section 6.7
42	Demonstrate and document in the ERD information sufficient to allow the Commonwealth Minister to make an informed decision on whether or not to approve, under Part 9 of the EPBC Act, the taking of the action for the purposes of each controlling provision.	Section 6.5 & 12
Inland Waters		
43	Desktop water supply assessment to identify potential water supply sources for the Proposal and estimate potential yields based on available hydrogeological information.	Section 7.3.5 Appendix 14
44	Characterisation of the baseline hydrological and hydrogeological regimes in a local and regional context. Include regional and local hydrogeological description, including representative hydrogeological profiles across the site and contour maps of groundwater levels, flow directions, aquifer structure, seasonal and long-term trends, recharge/ discharge areas (vertical leakage), water quality (including gross alpha and gross beta levels) and identification of other groundwater users. Modern climate data for the study area consistent with reducing rainfall and recharge trends will be used.	Section 7.3 Appendix 14-18 & 21
45	Hydrogeological investigations / modelling and analysis to identify sustainable water supply sources for the Proposal and predicted drawdown.	Section 7.3.5 Appendix 18, 19 & 21
46	Hydrogeological investigations / modelling and analysis to identify the predicted drawdown of the superficial aquifer. The investigation is to include groundwater drawdown contours for depth and rate for each stage of the mine life.	Section 7.3.5 Appendix 18, 19 & 21
47	Provide a water balance for the mining operations.	Section 7.3.5 Appendix 18
48	Sensitivity analysis to identify areas that may be impacted by changes in superficial groundwater levels within the mapped drawdown extent.	Section 7.3.5 Appendix 18, 19 & 21
49	Characterisation and assessment of the impacts of groundwater drawdown within the entire drawdown footprint on other users, overlying aquifers, groundwater dependant ecosystems (GDE), surface water expressions and other environmental values.	Sections 7.3 and 7.5 Appendix 18, 19 & 21
50	Hydrogeological and ecological / modelling and analysis to characterise all potential water-dependent ecosystems including GDEs, surface flow systems, wetlands, rivers/ creeks, springs, karstic and calcrete habitats (stygofauna) and phreatophytic (groundwater dependent) vegetation that may be directly or indirectly impacted by the Proposal.	Sections 7.3 & 7.5 Appendix 4, 14-18 & 21
51	Description of the design and location of temporary surface water diversions, with the potential to impact surface water or groundwater. Define whether the diversions will be permanent or temporary.	Section 7.5.1 Appendix 17 & 20

Task No.	Required Work	Section and Page No.
52	The conceptual design of any temporary surface water diversions that may be required to allow mining to occur.	Section 7.6 Appendix 20
53	Hydrological investigations / modelling and analysis to determine suitable options to utilise excess dewater and avoid or minimise discharge (if discharge is required).	Section 2.3.3, 7.3 & 7.5 Appendix 18, 19 & 21
54	Characterisation and assessment of the resultant changes to surface water regimes (including volumes, discharge timing and velocity) as a result of the implementation of the Proposal.	Sections 7.3.3 & 7.5.1 Appendix 17 & 20
55	Mapping and spatial data that shows and defines the extent of the predicted direct and indirect hydrogeological and hydrological impacts to environmental values.	Section 7.4 & 7.5
56	Waste characterisation study to determine if leaching from waste materials has the potential to contaminate inland waters.	Section 7.3.7 & 8.3
57	Desktop Acid Sulphate Soils (ASS) risk assessment to determine the risk of presence of ASS. Undertake an ASS survey if results from the desktop risk assessment identify this to be necessary.	Sections 7.3.1 & 8.3.5
58	Analyse, discuss and assess surface water and groundwater impacts. The analysis will include: • Changes in groundwater levels and changes to surface water flows associated with the Proposal; • Changes in groundwater and surface water quality associated with the Proposal; • Potential impacts from storage and leaching of materials with elevated concentrations of naturally occurring radionuclides on surface water and groundwater. Assessment is to consider Commonwealth guidelines regarding radiation as appropriate; • The nature, extent and duration of impacts; • Impacts to other water users; and • Impacts on the environmental values of any sensitive receptors.	Section 7.5
59	A quantitative assessment of potential hydrological risks and impacts (e.g., groundwater drawdown, groundwater discharge and changes to surface water expressions and flows) on the values of the adjacent Nambung National Park.	Section 7.5
60	Outline the proposed avoidance and mitigation measures to minimise the potential groundwater and surface water impacts of the Proposal. Include proposed management and/or monitoring plans for significant impacts that will be implemented pre- and post-construction to demonstrate and ensure residual impacts are not greater than predicted. Management and/or monitoring plans are to be presented in accordance with the EPAs Instructions.	Section 7.6
61	Targeted eco-physiological studies to identify level of groundwater dependence of phreatophytic terrestrial and wetland/ riparian vegetation within any areas that may be impacted by groundwater drawdown.	Sections 7.3 & 5.3
62	Demonstrate and document in the ERD how the EPA's objective for this factor will be met.	Section 7.7
63	Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (page 11) and WA Offset Template (Appendix 1) in the WA Environmental Offsets Guidelines (2014).	Section 12
64	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines. Spatial data defining the area of significant residual impacts should also be provided.	Section 12

Task No.	Required Work	Section and Page No.
Terrestrial Environment Quality		
65	Undertake a soils and waste characterisation study including: • Mapping of the soil-landform associations of the MDE; • Assessment of the physical and chemical characteristics of the soil, overburden, tailings and tailings/soils/overburden blends and their suitability for rehabilitation; • A soil and waste resource inventory detailing the volumes and characteristics of soil and waste resources available; • A materials balance presenting both volumes of materials required for rehabilitation and materials available for rehabilitation; and • Implications for materials management.	Section 8.3 Appendix 23 & 24
66	Desktop ASS risk assessment to determine the risk of presence of ASS. Undertake an ASS survey if results from the desktop risk assessment identify this to be necessary.	Section 8.3 & 8.5 Appendix 22
67	Analyse, discuss and assess impacts to terrestrial environmental quality. The analysis will include: • Changes in soil quality associated with the Proposal; • The nature, extent and duration of impacts; and • Impacts on the environmental values of any sensitive receptors.	Section 8.3 & 8.5
68	Discuss the proposed management, monitoring and mitigation to avoid and minimise impacts to terrestrial environmental quality as a result of implementing the Proposal.	Section 8.6
69	Discuss closure and rehabilitation measures to be implemented, and outcomes/ objectives to be achieved.	Section 5.5.4 & 8.6 Appendix 2
70	Demonstrate and document how the EPA's objective for this factor can be met.	Section 8.7
71	Determine and quantify any significant residual impacts by applying the: • Residual Impact Significance Model (page 11 of WA Environmental Offsets Guidelines) for all direct and indirect impacts, including an explanation of how the information and values within the model have been determined; and • WA Offset Template (Appendix 1) in the WA Environmental Offsets Guidelines (2014), including the provision of supporting information, such as evidence of rehabilitation success.	Section 12
72	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines and the EPBC Act Environmental Offsets Policy. Any proposed offsets package will be assessed against the EPBC Act Environmental Offsets Policy and the six offset principles in the WA Environmental Offsets Policy. Spatial data defining the area of significant residual impacts will also be provided.	Section 12
Social Surroundings		
73	Undertake a heritage assessment (Aboriginal and European), utilising desktop information, and archaeological and ethnographic heritage surveys as required in order to: • Make an assessment of listed heritage sites; • Determine the importance of the site from an Aboriginal perspective (including heritage sites, and traditional uses such as bush tucker and medicine); and • Assess the likelihood of significant European or Aboriginal heritage sites being present on site.	Section 9.3 & 9.5 Appendix 26 & 27
74	Conduct consultation with traditional owners (Yued People) during the assessment process to determine the heritage values of the DEs.	Section 9.3.2

Task No.	Required Work	Section and Page No.
75	Undertake a dust assessment including identification of sensitive receptors and characterisation of dust emission sources, based on defined dust control strategies. Conduct air dispersion modelling that complies with *Air Quality Modelling Guidance Notes* (Department of Environment; DoE, 2006), based on typical worst-case meteorological conditions and an analysis of modelling results against guidelines and relevant thresholds. Modelling will be conducted using a non-steady state modelling approach which evaluates the effects of spatial changes in the meteorological and surface characteristics. Air dispersion modelling will be conducted to predict deposition rates of total suspended particulate, ambient concentrations, PM10 and PM2.5 across the MDE.	Section 9.5 Appendix 30
76	Prepare a dust management plan that details how dust will be avoided or minimised at each stage of the mining process. The dust management plan is to be revised following the outcomes of the dust assessment described below.	Appendix 25
77	Undertake a noise assessment including ambient baseline noise monitoring, identification of sensitive receptors, noise modelling based on proposed noise mitigation strategies, typical worst-case meteorological conditions and an analysis of modelling results against Environmental Protection (Noise) Regulations 1997. The modelling will also consider how ambient noise levels will be increased by the Proposal.	Section 9.5 Appendix 28 & 29
78	Conduct hydrological and hydrogeological investigations and assessments as described in the Inland Waters section.	Sections 7.3 & 9.5
79	Provide details on the night works and associated lighting required at the Proposal to determine the scale of potential light pollution.	Sections 2.2.3 & 9.3.6
80	Assess potential impacts on visual amenity, and potential impacts of noise, light and dust on Nambung National Park.	Section 9.5
81	In accordance with EPBC Act requirements, provide an assessment of the social and economic impacts (both beneficial and adverse) of the Proposal, at the local, regional and national level. This may include, but is not limited to: • An indication of the financial investment the Proposal represents; and • Projected costs and benefits of the Proposal, including the basis for their estimation through cost / benefit analysis or similar studies e.g., employment opportunities expected to be generated by the Proposal.	Section 13.8
82	Characterise the values and significance of social surroundings in the vicinity of the Proposal.	Section 9.3
83	Identify the proposed activities and the potential scale and significance of direct and indirect impacts to social surroundings.	Sections 9.3 and 9.5
84	Discuss the proposed management, monitoring and mitigation to prevent and minimise impacts to social surroundings as a result of implementing the Proposal.	Section 9.6
85	Discuss closure and rehabilitation management measures, outcomes / objectives to be implemented.	Appendix 2
86	Demonstrate how the EPA's objective for this factor will be met.	Section 9.7
Human Health		
87	Collection and analysis of radiological baseline data.	Section 10.3 Appendix 31
88	Characterisation of expected levels of radioactivity associated with each stage of the process including transportation of the final product.	Section 10.3
89	Assessment of the potential radiological impacts on workers (including transport workers) and members of the public both during operation and post closure, including a radiological dose assessment. Assessment is to consider Commonwealth guidelines regarding radiation as appropriate.	Sections 10.3 - 10.5 Appendix 31 & 32

Task No.	Required Work	Section and Page No.
90	Discussion of proposed best practice management, monitoring and control/mitigation methods to be implemented so that the cumulative impacts from all sources do not pose an unacceptable risk to the health and amenity of site personnel, the public and any other identified critical groups.	Section 10.6
91	Outline the outcomes/objectives, management, monitoring, trigger and contingency actions, within environmental management plans, to ensure impacts (direct and indirect) are not greater than predicted.	Section 10.6 Appendix 25 & 32

EXECUTIVE SUMMARY

THE PROPOSAL

Image is seeking to develop the Proposal, a mineral sands mine located in the Wheatbelt region of Western Australia (WA), approximately 170 kilometres (km) north of Perth and 18 km east of Cervantes (Figure 2).

The development envelopes, disturbance footprint and indicative infrastructure footprint is provided in Figure 3.

A summary of the Proposal is provided in Table ES1 and the key proposal elements (e.g., development, action, activities or processes) which are likely to cause an impact on the environment are summarised in Table ES2.

Table ES1: General Proposal content description

Proposal Title	Atlas Project
Proponent Name	Image Resources NL
Short Description	Image Resources NL is seeking to develop a greenfields mineral sands project, located at Nambung, approximately 18 km east of Cervantes in the Wheatbelt region of Western Australia. The proposal includes the progressive development of mine pits, processing facilities, groundwater bores and water management infrastructure, temporary waste stockpiles, solar drying ponds and associated infrastructure (power supply, communications, workshop, laydown, offices, accommodation camp etc.).

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

Proposal element	Location / description	Maximum extent, capacity or range
Physical elements		
Mine Development Envelope • Open cut mine pits; • Temporary topsoil/ subsoil/ waste stockpiles; • Processing facilities; • Solar drying ponds; and • Supporting infrastructure.	Figure 3, Figure 4	Disturbance of no more than 302 ha within the 457 ha Mine Development Envelope, including no more than 292 ha of native vegetation clearing.
External Infrastructure Development Envelope • Transport infrastructure upgrades; • Accommodation Camp; and • One or more extraction bore/s and associated pipeline corridors.	Figure 3, Figure 4	Disturbance of no more than 70 ha within the 70 ha External Infrastructure Development Envelope, including no more than 26 ha of native vegetation clearing.
Construction elements		
Pit dewatering	Superficial aquifer	Dewatering of up to 1.1 GL/yr

Proposal element	Location / description	Maximum extent, capacity or range
Operational elements		
Heavy Mineral Concentrate (HMC) production	Figure 4 (Plant Area and Loadout Area)	Production of up to 250 ktpa of HMC
HMC storage	Figure 4 (Indicative HMC Stockpile Location)	Short term stockpiling of up to 30 kt HMC prior to haulage for export.
Mining method	Figure 4 (Pit)	Dry mining
Pit dewatering	Superficial aquifer	Dewatering of up to 0.75 GL/yr (first year) with an average rate of 0.6 GL/yr.
Groundwater abstraction	Yarragadee, Eneabba and/or Lesueur Aquifer	Abstraction of up to 2.2 GL/yr from one or more borefields.
Power generation	Onsite diesel generators (potentially supplemented/replaced by grid or renewable generation)	Approximately 2-3 MW
Proposal elements with greenhouse gas emissions		
Construction elements:		
Scope 1	Land use change – vegetation clearing: less than 22 kt CO_2-e Plant, equipment: Less than 2 kt CO_2-e Power generation: Less than 7 kt CO_2-e Maximum of: 31 kt CO_2-e	
Operation elements:		
Scope 1	Land use change – vegetation clearing: less than 35 kt CO_2-e/yr Plant, equipment: Less than 5 kt CO_2-e/yr Power generation: Less than 15 kt CO_2-e/yr Maximum of: 55 kt CO_2-e/yr Maximum over life of Proposal: 165 kt CO_2-e	
Rehabilitation		
Rehabilitation and closure will be progressive and in accordance with the Mine Closure Plan. Mining pits will be progressively filled and rehabilitated to pre-mining profile with the pre-existing land use reinstated as mining advances.		
Commissioning		
Commissioning of the processing facility to be undertaken subject to operational limits above.		
Decommissioning		
Removal of all process related infrastructure within 12 months of cessation of operations (excluding periods of care and maintenance).		
Other elements which affect extent of effects on the environment		
Proposal time	Maximum project life	Approximately 5 years
	Construction phase	Approximately 12 months
	Operations phase	Approximately 3 Years
	Decommissioning phase	Approximately 12 months

KEY ENVIRONMENTAL FACTORS

The EPA has identified Flora and Vegetation, Terrestrial Fauna, Inland Waters, Terrestrial Environment Quality, Social Surroundings and Human Health as Key Environmental Factors relevant to the Proposal.

Table ES3 summarises relevant information on the potential impacts, mitigation, residual impacts, outcomes and offsets for each of the relevant key environmental factors. The appendices provided include supporting studies and investigations undertaken to inform this Environmental Review Document, the key elements of which are included in this document.

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

Flora and Vegetation	

Potential impacts	**General native flora and vegetation**
	• Up to 318 ha of native vegetation clearing (292 ha within the Mine Development Envelope (MDE), and 26 ha in the External Infrastructure Development Envelope (EIDE)) of which:
	  ○ 126 ha of native vegetation cleared for the mine pit will be progressively rehabilitated during operations;
	  ○ 192 ha is to be rehabilitated post-closure; and
	• Reduction in vegetation health due to indirect impacts.
	Priority Flora
	• Clearing of known individuals of 21 Priority Flora species;
	• Clearing of up to 318 ha of potential habitat of which:
	  ○ 126 ha of native vegetation cleared for the mine pit will be progressively rehabilitated during operations;
	  ○ 192 ha is to be rehabilitated post-closure; and
	• Reduction in habitat health due to indirect impacts.
	Range Extensions Flora
	• Clearing of known individuals of 13 different Range Extensions Flora;
	• Clearing of up to 318 ha of potential habitat of which:
	  ○ 126 ha of native vegetation cleared for the mine pit will be progressively rehabilitated during operations,
	  ○ 192 ha is to be rehabilitated post-closure; and
	• Reduction in habitat health due to indirect impacts.
	Banksia woodlands of the Swan Coastal Plain TEC / PEC
	• Up to 236.2 ha of clearing (210 ha within the MDE, and 26.0 ha in the EIDE) of which:
	  ○ 75.6 ha cleared for the mine pit will be progressively rehabilitated during operations;
	  ○ 0.6 ha will remain cleared permanently; and
	  ○ 160 ha to be rehabilitated post-closure.
	• Reduction in vegetation health due to indirect impacts.
	Locally significant vegetation
	• Clearing of:
	  ○ 192.1 ha of BaBm;
	  ○ 26.8 ha of Bp;
	  ○ 45.5 of BtRc;
	  ○ 6.4 ha of BtRc / Bp;
	  ○ 2.4 ha of MsVdCaf;
	  ○ 2.0 ha of MbTi / BtRc;
	  ○ 1.8 ha of BtRc / BaBm;
	  ○ 0.05 ha of MbTi / MbGcVp / BtRc; and
	• Reduction in vegetation health due to indirect impacts.

Mitigation hierarchy	**Avoid** • Eight of the 21 Priority Flora species recorded within the survey areas; • Direct and indirect impacts to native vegetation including Groundwater Dependant Ecosystems (GDEs); and

	• The Mt Jetty and Bibby Creeks and wetland and associated vegetation. **Minimise** • Implement industry best practice management measures for flora and vegetation; • Obtain and comply with approvals under the *Environmental Protection Ac*t 1986 (WA) (EP Act) and *Mining Act 1978* (WA) (Mining Act); • Prepare a Final Infrastructure Design Plan; • Ensure groundwater abstraction (mine pit and water supply) and recharge is managed in accordance with the measures described in Section 7.6 to minimise drawdown impacts to vegetation; • Implement hydrocarbon storage and spill mitigation measures to minimise the risk and impact of hydrocarbon spills; • Comply with Water Quality Protection Guidelines and guidance notes; and • Implement Dieback Management Plan. **Rehabilitate** During and after the mining stage of the Proposal the site will be rehabilitated to reinstate the flora and vegetation of areas that were disturbed. The mining pits will be progressively filled and rehabilitated to the pre-mining profile with the pre-existing land use reinstated as mining advances and actioned in accordance with the MCP. An interim MCP has been prepared to accompany this ERD (Appendix 2) which was developed according to DMIRS Guidelines (2020a; 2020b). Key rehabilitation measures captured within the MCP are summarised below: 1. All infrastructure will be removed from site; 2. All long-term disturbance areas will be respread with topsoil (or ripped and seeded if topsoil is no longer viable) and rehabilitated; 3. All earthmoving equipment will be cleaned free of any soil material to minimise the risk of weed or dieback introduction; 4. Rehabilitation specific to Banksia woodlands will be conducted in areas previously vegetated by this vegetation type, utilising best-practice methods; and 5. Impacted Priority Flora will be included in the rehabilitation seed mix. Image also proposes to develop a specific Banksia Woodland Rehabilitation Management Plan which will be developed and implemented prior to the disturbance of any Banksia Woodland TEC / PEC. This Plan will be an appendix to the final MCP and will draw on current rehabilitation practices for Banksia woodlands and is intended to be developed in consultation with DBCA and relevant rehabilitation experts. The Plan will include details of planned rehabilitation and revegetation methods for proposed offset sites. The MCP will be submitted to DMIRS for assessment and approval prior to the construction of the Proposal and will be reviewed and revised at least every three years, or prior to closure, whichever is the earliest.
Proposed environmental outcomes	The EPA's environmental objective for this factor is "to protect flora and vegetation so that biological diversity and ecological integrity are maintained". In the context of this objective: "ecological integrity" is listed as the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements (EPA, 2016a). Image conducted extensive flora and vegetation surveys of the areas within and surrounding the development envelopes. Targeted significant flora surveys were also conducted over the development envelopes and in surrounding areas. Image has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes, however direct impacts to flora and vegetation are unavoidable. The Proposal will result in the clearing of up to 318 ha of native vegetation, which will be progressively rehabilitated during operations and following mine closure. With the implementation of controls, the Proposal will not result in significant residual impacts to regional vegetation associations, locally significant vegetation communities, or significant flora. Management and monitoring is proposed during the operational phase to further minimise indirect impacts to general native flora and vegetation (refer to Section 5.6). The residual impacts to Banksia Woodlands TEC / PEC are however considered to remain significant, despite the avoidance, minimisation and rehabilitation measures proposed. Rehabilitation methods are relatively well-established for Banksia woodlands, however Image acknowledges the effort and complexity involved with achieving the desired outcomes of re-establishing a functional and sustainable ecological community, and that success cannot be

	guaranteed. The conservative position is therefore that the residual impacts associated with the disturbance to the Banksia Woodlands TEC / PEC is considered to be significant given the conservation status of this ecological community, and the cumulative losses of this TEC / PEC throughout the Swan Coastal Plain.. Up to 218.83 ha of Proposal Banksia Woodlands TEC / PEC disturbance will be rehabilitated as the mining front progresses, or at the completion of the Proposal. The Proposal will therefore result in a loss of 218.83 ha of this ecological community for up to an estimated 15 years, until rehabilitated areas have qualities that align with this TEC / PEC (i.e. up to five years of construction and operations, and an estimated ten years of rehabilitation). After this period the community will not be of the same quality, however the quality is predicted to improve gradually over time. A small area (0.05 ha) is likely to remain cleared permanently as it will form part of the Bibby Road / Brand Highway intersection. The residual impacts are therefore predicted to be: • A loss of 218.83 ha of predominantly Excellent – Pristine quality Banksia Woodlands TEC / PEC for a period of 11 – 15 years; • A permanent loss of 0.05 ha of Good to Excellent quality Banksia Woodlands TEC / PEC; and • A reduction in the quality of 218.83 ha of the Banksia Woodlands TEC / PEC after rehabilitation (in comparison to pre-mining quality). Offsets have been proposed to counterbalance these residual impacts. These offsets are described in detail in Section 12, including an assessment of the benefits of the offset to this environmental value. If the Proposal is approved, the Ministerial Statement is likely to contain a condition requiring the development and implementation of an Offset Strategy. The offset measures will be reviewed and refined in the Offset Strategy and will be informed by discussions with DMIRS, DBCA, DCCEEW and EPA Services to ensure they adequately counterbalance the residual impacts. Based on the above, Image considers that the Proposal can be implemented such that the EPA objective can be met.
Assessment of offsets (if relevant)	After the implementation of the mitigation measures described above, it is predicted that the Proposal will have unavoidable significant residual impacts on the Banksia Woodlands TEC / PEC. Proposed offsets for the unavoidable residual impacts on these flora and vegetation values are discussed in Section 12.
Terrestrial Fauna	
Potential impacts	**<u>General fauna species and habitat</u>** • Clearing of up to 318 ha of fauna habitat; • Death or injury of fauna due to vehicle strike or earthmoving equipment; • Fauna entrapment in excavations; • Radiation exposure; and • Some indirect impacts to fauna habitat health and fauna behavioural impacts. **<u>Carnaby's Cockatoo (*Zanda latirostris*; Endangered)</u>** • Clearing of up to 289 ha of very high value foraging habitat. • Some indirect impacts to habitat health and behavioural impacts. **<u>SRE Invertebrate Fauna</u>** • Clearing of up to 318 ha of potential SRE habitat. • Some indirect impacts to habitat health.
Mitigation hierarchy	**Avoid** • Direct and indirect impacts to general fauna habitats including habitat types that may be used by significant fauna; • Direct and indirect impacts to Carnaby's Cockatoo foraging and potential roosting habitat; and • Potential SRE records and habitat. **Minimise** • Implement industry best practice management measures for terrestrial fauna • Obtain and comply with approvals under the EP Act and Mining Act; • Ensure record location for *Maratus* 'BAR130' and adjoining area remains undisturbed;

	• Prepare and implement a Fauna Habitat Management Plan (FHMP). • Ensure groundwater abstraction (mine pit and water supply) and recharge is managed in accordance with the measures described in Section 7.6 to minimise drawdown impacts to vegetation; • Implement hydrocarbon storage and spill mitigation measures to minimise the risk and impact of hydrocarbon spills • Comply with Water Quality Protection Guidelines and guidance notes • Implement Dieback Management Plan (DMP; Appendix 7) **Rehabilitate** During and after the mining stage of the Proposal the site will be rehabilitated to reinstate the flora and vegetation of areas that were disturbed. The mining pits will be progressively filled and rehabilitated to the pre-mining profile with the pre-existing land use reinstated as mining advances and actioned in accordance with the MCP. An interim MCP has been prepared to accompany this ERD (Appendix 2) which was developed according to DMIRS Guidelines (2020a; 2020b). Key rehabilitation measures captured within the MCP are summarised below: 1. All infrastructure will be removed from site; 2. All long-term disturbance areas will be respread with topsoil (or ripped and seeded if topsoil is no longer viable) and rehabilitated; 3. All earthmoving equipment will be cleaned free of any soil material to minimise the risk of weed or dieback introduction; 4. Rehabilitation specific to Banksia woodlands will be conducted in areas previously vegetated by this vegetation type, utilising best-practice methods; and 5. Impacted Priority Flora will be included in the rehabilitation seed mix. Image also proposes to develop a specific Banksia Woodland Rehabilitation Management Plan which will be developed and implemented prior to the disturbance of any Banksia Woodland TEC / PEC. This Plan will be an appendix to the final MCP and will draw on current rehabilitation practices for Banksia woodlands and is intended to be developed in consultation with DBCA and relevant rehabilitation experts. The Plan will include rehabilitation and revegetation of proposed offset sites. The MCP will be submitted to DMIRS for assessment and approval prior to the construction of the Proposal and will be reviewed and revised at least every three years, or prior to closure, whichever is the earliest.
Proposed environmental outcomes	The EPA's environmental objective for this factor is to "protect terrestrial fauna so that biological diversity and ecological integrity are maintained". In the context of this objective: "ecological integrity" is listed as the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements (EPA, 2016d). Image conducted extensive ecological surveys of the areas within and surrounding the development envelopes. Targeted significant fauna surveys were also conducted over the development envelopes and in surrounding areas. Image has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes, however some direct and indirect impacts to terrestrial fauna are unavoidable. The Proposal will result in the clearing of up to 318 ha of native fauna habitat which will be rehabilitated progressively and following mine closure. All of the impacted habitats are well distributed throughout the region and species that potentially use the development envelopes generally have relatively wide-ranging distributions and/or will persist in adjoining unaffected areas given the presence of extensive areas of similar habitat nearby. This includes the Beekeepers Nature Reserve and Nambung National Park which lie in proximity to the Proposal, providing protection for an estimated 13,433 ha of similar native fauna habitat. With the implementation of controls, the Proposal will not result in significant residual impacts to regional fauna habitats and general fauna species. Management and monitoring is proposed during the operational phase to further minimise indirect impacts to general fauna species and habitats (refer to Section 6.5). Carnaby's Cockatoo was recorded in the survey areas and is listed as Endangered under the EPBC Act and BC Act. It is primarily threatened by the loss and fragmentation of breeding and foraging habitat as a result of vegetation clearing (EPA, 2019). While no Carnaby's Cockatoo breeding trees were identified, the majority of the development envelopes was identified as containing very high quality foraging habitat for this species. After the implementation of avoidance, minimisation and rehabilitation mitigation measures, the residual impacts to Carnaby's Cockatoo foraging habitat, summarised as: Loss of up to 289 ha of very high value

	Carnaby's Cockatoo foraging habitat for a period of 15 years (up to five years construction and operation plus ten years before rehabilitation is suitable for foraging by Carnaby's Cockatoo). These residual impacts were deemed to be significant and are proposed to be counterbalanced by offsets to ensure that the EPA objective can be met. The proposed offset site takes advantage of similar habitat in excellent to pristine condition in close proximity and provides connectivity to the Proposal. If the Proposal is approved, the Ministerial Statement is likely to contain a condition requiring the development and implementation of an Offset Strategy. The offset measures will be reviewed and refined in the Offset Strategy and will be informed by discussions with DMIRS, DBCA, DCCEEW and EPA Services to ensure they adequately counterbalance the residual impacts. Based on the above the Proposal is expected to be able to meet the EPA's objective for this factor.
Assessment of offsets (if relevant)	After the implementation of the mitigation measures described above, it is predicted that the Proposal will have an unavoidable significant residual impact on very high value Carnaby's Cockatoo foraging habitat. Proposed offsets for the unavoidable residual impacts on Carnaby's Cockatoo foraging habitat are discussed in Section 12.
Inland Waters	
Potential impacts	**Surface Water** • Small area of intersection with a minor sub-catchment of the Nambung River; • Minor creek crossings for road upgrades; • Contamination from hydrocarbon or chemical spills; and • Sedimentation during earthmoving or as a result of slurry pipeline spills. **Superficial / Tamala Limestone Aquifer System** • Dewatering of up to 1.1 GL/yr during construction and up to 0.75 GL/yr during operation; • Drawdown potentially impacting other water users and GDEs; • Contamination of groundwater from hydrocarbon, chemical spills or disturbance of ASS; • Mesozoic Aquifer System; and • Abstraction of up to 2.2 GL/yr from one or more borefields during operation.
Mitigation hierarchy	**Avoid** • Groundwater drawdown impacts to GDEs; • Seasonal ponds; • Mount Jetty Creek; and • Bibby Creek. **Minimise** • Obtain and comply with Works Approval and Licence issued under Part V of the EP Act; • Obtain and comply with a Mining Proposal issued under the Mining Act; • Obtain and comply with a 5C Licence for groundwater abstraction; • Implement Flood and Stormwater Controls; • Implement hydrocarbon storage and spill mitigation measures to minimise the risk and impact of hydrocarbon spills; • Comply with Water Quality Protection Guidelines and guidance notes; • Inspect for erosion within the mine and along the access corridor; • Implementation of the SWMP (Appendix 20); • Prepare a Final Infrastructure Design Plan; • Implement a Drawdown Mitigation Scheme (DMS); • Ensure abstraction within the Mesozoic Aquifer System does not result in drawdown impacts to wetlands, GDEs or other groundwater users; and • Develop and implement a Groundwater Operating Strategy (GOS; Appendix 19). **Rehabilitate** Rehabilitation and closure of the Proposal will be progressive and in accordance with the MCP. Mining pits will be progressively filled and rehabilitated to pre-mining profile with pre-existing land use reinstated as mining advances. This includes deposition of clay fines, overburden, tailings, subsoil and topsoil into the mine void before surface drainage and re-vegetation works

	are undertaken. One of the planned outcomes of all rehabilitated areas will be to reinstate inland water regimes. An interim MCP has been prepared to accompany this ERD (Appendix 2) which was developed according to DMIRS Guidelines (2020a; 2020b). Key rehabilitation measures captured within the MCP are summarised below: 1. Land will be made physically safe, stable and non-polluting; 2. Soil profile will be reestablished to support native vegetation growth; 3. The site will be left in a safe, stable, non-polluting and tidy condition with no remaining plant or infrastructure that is not required post-mining use or agreed used by other stakeholders; 4. Any identified site contamination is to be reported in accordance with the *Contaminated Sites Act 2003* (WA) (CS Act); and 5. No contaminated soils post-closure. The MCP describes the associated management and monitoring proposed during the closure phase including: • Materials balance for closure and rehabilitation demonstrating the quantities, availability and management for all rehabilitation materials; • Identified knowledge gaps to be filled prior to closure; • Closure tasks; and • Completion criteria, monitoring and reporting during closure. The MCP will be submitted to DMIRS for assessment and approval under the Mining Act prior to any disturbance at the Proposal and will be reviewed and revised every three years, or prior to closure, whichever is the earliest.
Proposed environmental outcomes	The EPA's environmental objective for this factor is "maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected" (EPA, 2018). The Proposal has been designed to ensure that hydrological regimes are maintained. The project disturbance area is relatively isolated from the natural creek-lines and hence does not present a particular contaminant risk. Minor flows are retained locally within the South Catchment and there are no defined drainage lines in these areas. During moderate to large stormwater flow events, there is no potential for measurable water quantity or quality impact due to the dilution factor imposed by the large catchment area active during such events. There is one crossing of a seasonal drainage line that only contains flow during flood events. Image will ensure that the existing floodway crossing is maintained and pipeline infrastructure is supported on concrete risers to ensure flows are maintained with minimal restrictions. The Proposal is not expected to significantly impact the quality of groundwater or surface water. Leaks and spills of slurry sand are able to be managed such that impacts are rare and restricted in extent if they were to occur. Erosion and hydrocarbon spills are able to be mitigated such that significant impacts are unlikely. The design and operation of the FPP, slurry pipeline, water pipeline WCP and WWTP will be regulated under Part V of the EP Act and the Mining Act. The key risk to the inland waters is the drawdown of the superficial aquifer beyond the mine area potentially impacting GDEs. The DMS has been designed and will be implemented to limit drawdown to the Proposal's disturbance footprint and therefore restricting drawdown impacts to areas that have been cleared for the Proposal. The implementation of design and operation mitigation measures, and regulation under Part V of the EP Act and the Mining Act, are expected to ensure that the Proposal does not significantly impact inland waters. The EPA objective for this factor is therefore able to be met.
Assessment of offsets (if relevant)	N/A
Terrestrial Environmental Quality	
Potential impacts	• Discharge of an estimated 30 kL/day of treated sewage via irrigation • Contamination of soil from seepage from the solar drying ponds • Hydrocarbon spills causing contamination • Erosion from active or rehabilitated structures spreads sediment into terrestrial environment • Disturbance of ASS
Mitigation hierarchy	**Avoid**

	• The Proposal has been designed to avoid permanent waste dump impacts by progressively backfilling the mine pit. Other potential impacts could not be avoided and require mitigation (refer below). **Minimise** • Obtain and comply with Works Approval and Licence issued under Part V of the EP Act; • Implementation of ASSMP (Appendix 22); • Obtain and comply with a Mining Proposal issued under the Mining Act; and • Implement hydrocarbon storage and spill mitigation measures to minimise the risk and impact of hydrocarbon spills. **Rehabilitate** The mining pits will be progressively filled and rehabilitated to the pre-mining profile with the pre-existing land use reinstated as mining advances and actioned in accordance with the MCP. An interim MCP has been prepared to accompany this ERD (Appendix 2) which was developed according to DMIRS Guidelines (2020a; 2020b). Key rehabilitation measures captured within the MCP are summarised below: 1. Land will be made physically safe, stable and non-polluting; 2. Soil profile will be reestablished to support native vegetation growth; 3. The site will be left in a safe, stable, non-polluting and tidy condition with no remaining plant or infrastructure that is not required post-mining use or agreed used by other stakeholders; 4. Any identified site contamination is to be reported in accordance with the CS Act; and 5. No contaminated soils post-closure. The MCP describes the associated management and monitoring proposed during the closure phase including: • Materials balance for closure and rehabilitation demonstrating the quantities, availability and management for all rehabilitation materials; • Identified knowledge gaps to be filled prior to closure; • Closure tasks; and • Completion criteria, monitoring and reporting during closure. The MCP will be submitted to DMIRS for assessment and approval under the Mining Act prior to any disturbance at the Proposal and will be reviewed and revised every three years, or prior to closure, whichever is the earliest.
Proposed environmental outcomes	The EPA's environmental objective for this factor is "to maintain the quality of land and soils so that environmental values are protected" (EPA, 2016k). In the context of this objective: "terrestrial environmental quality" is defined as the chemical, physical, biological and aesthetic characteristics of soils (EPA, 2016k). The specific environmental values to be protected are 'the ecosystem health values that the soils support, including biodiversity and seed banks'. The Proposal is not expected to significantly impact terrestrial environmental quality. Seepage from topsoil and overburden stockpiles is to be managed through neutralisation and isolation during mine operation in a sufficient manner that significant impacts are unlikely. Hydrocarbon spills are able to be mitigated such that significant impacts are unlikely. The key risks to terrestrial environmental quality is the disturbance of ASS, seepage from solar drying ponds, process plant and the wastewater treatment plant and erosion from active or rehabilitated structures, topsoil stockpiles and overburden. The design and operation of all of these items will be regulated under Part V of the EP Act and the Mining Act. The implementation of design and operations mitigation measures, and regulation under Part V of the EP Act and the Mining Act, are expected to ensure that the Proposal does not significantly impact this factor. The EPA objective for this factor is therefore able to be met.
Assessment of offsets (if relevant)	N/A

Social Surroundings	
Potential impacts	**Areas of Aboriginal cultural and heritage significance** • Disturbance of up to 4 avoidance areas and, in addition to losses incurred during clearing for agriculture; • Potential indirect impacts to 2 areas of cultural concern, 1 avoidance area and Bibby and Mount Jetty Creeks; • Land use for traditional purposes; • Clearing of up to 318 ha and potential indirect impacts in addition to losses incurred during clearing for agriculture. **Local Residents and Community** • Noise and dust emissions from construction and operation; • Reduction in visual amenity; • Increased traffic movements; and • Light emissions.
Mitigation hierarchy	**Avoid** The key avoidance mechanism implemented by Image was the extensive revision of the development envelopes and the infrastructure layout to avoid all areas of cultural concern, Bibby Creek and Mount Jetty Creek from the Development Envelopes, via S43A of the EP Act. This revision was undertaken after consultation with the Yued Noongar People about the significance of these sites. In addition, one avoidance area was also able to be excluded from the Development Envelopes. **Minimise** • Obtain and comply with Works Approval and Licence issued under Part V of the EP Act; • Negotiate Access Agreement with Yued People; • Develop a Social Cultural Heritage Management Plan in consultation with the Yued People; • If required, obtain and comply with approvals under the ACH Act for any Aboriginal Heritage sites (or Other Heritage Places that are likely to be sites) that are to be disturbed (none expected); • Development and Implementation of a Noise Management Plan; • Implementation of the Dust Environmental Management Plan (DEMP; Ramboll, 2022b; Appendix 25); • Conduct regular consultation with surrounding landholders regarding amenity impacts; and • At the detailed design stage, each significant light sources will assessed in terms of its purpose, location and intensity in order to minimise light spill. **Rehabilitate** The mining pits will be progressively filled and rehabilitated to the pre-mining profile with the pre-existing land use reinstated as mining advances and actioned in accordance with the MCP. An interim MCP has been prepared to accompany this ERD (Appendix 2) which was developed according to DMIRS Guidelines (2020a; 2020b). Key rehabilitation measures captured within the MCP are summarised below: 1. Land will be made physically safe, stable and non-polluting; 2. Soil profile will be reestablished to support native vegetation growth; 3. The site will be left in a safe, stable, non-polluting and tidy condition with no remaining plant or infrastructure that is not required post-mining use or agreed used by other stakeholders; 4. Any identified site contamination is to be reported in accordance with the CS Act; and 5. No contaminated soils post-closure. The MCP describes the associated management and monitoring proposed during the closure phase including: • Materials balance for closure and rehabilitation demonstrating the quantities, availability and management for all rehabilitation materials; • Identified knowledge gaps to be filled prior to closure; • Closure tasks; and • Completion criteria, monitoring and reporting during closure. The MCP will be submitted to DMIRS for assessment and approval under the Mining Act prior to any disturbance at the Proposal and will be reviewed and revised every three years, or prior to closure, whichever is the earliest.

Proposed environmental outcomes	The EPA's environmental objective for this factor is to "protect social surroundings from significant harm" (EPA, 2016f). The Proposal has incorporated extensive avoidance, minimisation and rehabilitation measures into the Proposal design and operational processes to ensure that the social surroundings are protected from significant harm. The Proposal is expected to result in only minor impacts to local residents and the community given the setback distances of the Proposal to the nearest sensitive receptors and implementation of mitigation measures. Continued consultation is planned to ensure impacts are kept as low as practicable. As a result of the above, the Proposal is not expected to result in significant 'harm' to this social value. Image Resources has conducted extensive Aboriginal Heritage, archaeological, ethnographic and work area clearance investigations on proposed disturbance areas. Disturbance to Bibby Creek, Mount Jetty Creek and all areas of cultural concern identified during those surveys have been avoided during Proposal design, eliminating direct impacts. Indirect impacts are possible; however, they are expected to be managed by licencing under Part V of the EP Act and approval under the Mining Act. Based on the above, the Proposal is not expected to result in significant harm to Aboriginal Heritage. The Proposal will result in clearing of native vegetation within the development envelopes. This clearing is to be progressively rehabilitated. The extent of clearing is not considered significant at a regional scale. The Proposal will result in restrictions to some of the land within the development envelopes. Restricted areas are to be limited to areas that are under rehabilitation, are actively being mined or contain infrastructure, therefore the proposed restricted areas will be relatively small. Image Resources has also committed to maintaining access to land for the Yued People, and minimising disturbance within any areas that may be used for traditional purposes. As a result, the Proposal is not expected to significantly impact land used for traditional purposes. Based on the above, Image Resources considers that the Proposal can be implemented such that there are no significant residual impacts to this factor, and the EPA objective can be met.
Assessment of offsets (if relevant)	N/A
Human Health	
Potential impacts	**Health of workers at the Proposal** • Radiation exposure. **Health of residents in proximity to the Proposal** • Radiation exposure.
Mitigation hierarchy	**Avoid** The radiation at the Proposal is naturally-occurring and occurs within the ore, therefore there are few opportunities to completely avoid this impact. The focus is therefore to minimise exposure levels such that they are not significant. **Minimise** The following mitigation measures are proposed to ensure that direct and indirect impacts to human health are minimised: • Compliance with approvals under the EP Act and Mining Act; • Implementation of the Radiation Management Plan (RMP; Appendix 32); • Implement Records Management and Reporting as outlined in the RMP; • Dust suppression and cleaning techniques will be used as defined in Section 9.6; • Implement spill management procedures to ensure spilt ore or concentrate is contained quickly; and • Conduct training and enforce internal radiation exposures and mitigation techniques on a personal level. **Rehabilitate** The mining pits will be progressively filled and rehabilitated to the pre-mining profile with the pre-existing land use reinstated as mining advances and actioned in accordance with the MCP. An interim MCP has been prepared to accompany this ERD (Appendix 2) which was developed according to DMIRS Guidelines (2020a; 2020b). Key rehabilitation measures captured within the MCP are summarised below: 1. Land will be made physically safe, stable and non-polluting; 2. Soil profile will be reestablished to support native vegetation growth;

	3. The site will be left in a safe, stable, non-polluting and tidy condition with no remaining plant or infrastructure that is not required post-mining use or agreed used by other stakeholders; 4. Any identified site contamination is to be reported in accordance with the CS Act; and 5. No contaminated soils post-closure. The MCP describes the associated management and monitoring proposed during the closure phase including: • Materials balance for closure and rehabilitation demonstrating the quantities, availability and management for all rehabilitation materials; • Identified knowledge gaps to be filled prior to closure; • Closure tasks; and • Completion criteria, monitoring and reporting during closure. The MCP will be submitted to DMIRS for assessment and approval under the Mining Act prior to any disturbance at the Proposal and will be reviewed and revised every three years, or prior to closure, whichever is the earliest.
Proposed environmental outcomes	The EPA's environmental objective for this factor is "to protect human health from significant harm" (EPA, 2016f). Radiation has been identified as being one of the hazards associated with mining of mineral sands ore at the Proposal. However, with the application of appropriate measures to control and minimise radiation exposure, the radiation hazard level is low. While some exposures to radiation are expected to be detectable, it is believed that neither personnel, nor members of the public, nor the environment would be harmed by radiation from the Proposal. In each and every case radiation levels will be well within the accepted radiation safety standards. Image has conducted extensive radiation (baseline) surveys to inform the Proposal, alongside a RMP as stipulated in RPS-9 (Australian Radiation Protection and Nuclear Safety Agency, 2005). Predicted levels of gamma radiation and airborne radioactivity concentrations associated with different materials and areas at the Proposal have been modelled against conservative assumptions of the amount of time this exposure may actually take place. In accordance with Subdivision 3B – Radiation in mines of the Work Health and Safety (Mines) Regulations 2022, a RMP will need to be approved by DMIRS prior to commencement of mining at the Proposal. Calytrix Consulting Pty Ltd (Calytrix; 2021) have therefore developed a RMP to address the overall management of radiation in relation to the safety, occupational health and environmental aspects of the Proposal. Its successful implementation will ensure achievement of the legislative standards on radiation protection for company employees, contractors, the general public and the environment arising from mining, processing, storage, transport, waste management and transport operations. The RMP is currently based on pre-mining assumptions and draws from experience of similar mining and processing operations, such as Image's Boonanarring Mineral Sands Project. The RMP will undergo revision as the Proposal develops and more relevant data becomes available. Further revisions will be undertaken when mining commences and statistically valid measurements of actual radiation levels and exposures of personnel will be available. The RMP will additionally be reviewed every two years and will be revised should future mining or processing methods change significantly. Image has additionally incorporated extensive avoidance, minimisation and rehabilitation measures into the Proposal design and operational processes to ensure that human health is protected from significant harm. The Proposal is expected to result in negligible impacts to Proposal personnel and local residents. As a result of the above, the Proposal is not expected to result in significant 'harm' to human health.
Assessment of offsets (if relevant)	N/A

Holistic Impact Assessment

For each relevant Key Environmental Factor, the ERD provides a detailed assessment of the potential impacts associated with the Proposal, application of the mitigation hierarchy and the management strategies proposed. The Key Environmental Factors relevant to the Proposal include:

- Flora and Vegetation;
- Terrestrial Fauna;
- Inland Waters;
- Terrestrial Environment Quality;
- Social Surroundings; and
- Human Health.

Each relevant Key Environmental Factor has been assessed separately in Sections 5 – 10. Linkages of varying strengths exist between the relevant Key Environmental Factors. The potential impacts of the Proposal have been considered in a holistic context and a conceptual model demonstrating links between key environmental factors is provided in Figure 1. A linkage is considered to be present if any two Key Environmental Factors share the same impact. The strength of the links are based on the significance of the impact and the interconnectivity of each Key Environmental Factor with another. Linkages are represented by lines, strong linkages are shown as solid black lines and weaker linkages are represented by grey dotted lines.

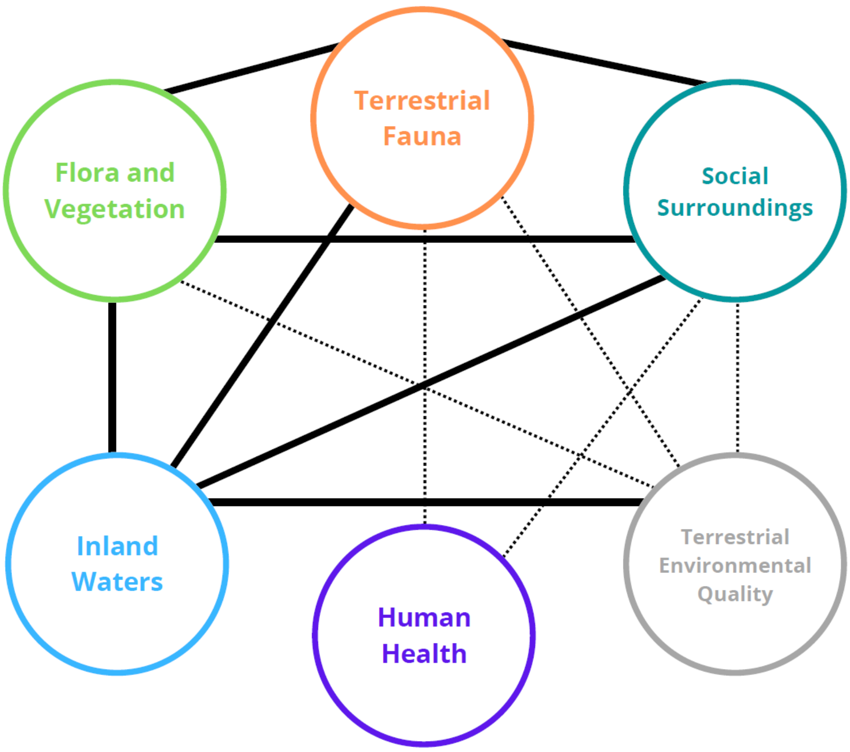

Figure 1: Conceptual model of linkages between Key Environmental Factors

Potential overarching impacts relevant to each Key Environmental Factor have been summarised in Table 1. While many potential impacts are shared between multiple factors, key impacts (those which have been identified as creating a strong linkage) have been identified with red ticks.

Table 1: Potential impacts shared by key environmental factors

Key Environmental Factor	Relevant Potential Impacts						
	Clearing	Dieback/ Weeds	Groundwater Abstraction	Contamination	Dust Emissions	Radiation Emissions	Noise
Flora & Vegetation	✓	✓	✓	✓	✓		
Terrestrial Fauna	✓	✓	✓	✓	✓	✓	✓
Inland Waters	✓		✓	✓			
Social Surroundings	✓	✓	✓	✓	✓	✓	✓
Human Health				✓		✓	
Terrestrial Environmental Quality				✓			

Clearing of native vegetation is identified as a key impact as it will directly impact three Key environmental factors. Clearing will impact the Flora and Vegetation and Terrestrial Fauna key environmental factors by removing or disturbing significant flora species, ecological communities and fauna habitat. Clearing will also impact the Social Surroundings factor by reducing the quality and availability of vegetation that may otherwise be used by the Yued People for bush tucker or bush medicine. Image also acknowledges that native vegetation values are related to the availability of faunal and botanical resources and represents a connection to Country.

While not a direct impact, the introduction and spread of dieback and weeds has the potential to impact three key environmental factors and therefore has also been considered as a key impact. Introduction and spread of dieback and weeds has the potential to impact the Flora and Vegetation and Terrestrial Fauna key environmental factors through mortality (flora) and a reduction in habitat extent and quality (flora and fauna). The introduction of dieback and weeds also impacts the Social Surroundings key environmental factor as it has the potential to result in plant deaths and a reduction in the quality and extent of native vegetation on Yued Country, including those that may be used for bush medicine or bush tucker.

The Proposal is not predicted to result in a significant impact to Groundwater provided mitigation measures are in place. Regardless, groundwater abstraction has been identified as a key impact due to the significance of the linkage between Flora and Vegetation, Terrestrial Fauna, Inland Waters and Social Surroundings key environmental factors. Generally, water is recognised as being of high importance to Traditional Owners typically through mythological associations, significance in song lines and represents a connection to Country.

Image acknowledges that other impacts of the Proposal (contamination, dust and air emissions, radiation and noise) provide linkages between the other key environmental factors however these impacts are unlikely to be significant and therefore linkages are not considered to be as strong as the others mentioned above. All linkages have been considered in the design of the Proposal, application of the mitigation hierarchy and proposed management measures.

The Proposal is a project that allows progressive rehabilitation, in contrast to projects such as housing and infrastructure that require large areas to be cleared permanently.

The Proposal lies within the range of the Carnaby's Cockatoo (Endangered; BC Act and EPBC Act) and contains the Banksia Woodlands TEC / PEC. Several significant flora species were also identified within the survey areas. The Proposal has unavoidable impacts associated with vegetation clearing and habitat loss, therefore it was imperative that these impacts were avoided and minimised as far as practicable, and rehabilitation methods are best-practice.

Given the above, Image incorporated extensive avoidance and minimisation measures into the Proposal design. The Proposal that was originally referred to the EPA under Section 38 of the EP Act included the direct disturbance of up to 396 ha of native vegetation. Image has since reduced the extent of the Development Envelopes to exclude key environmental and cultural values as much as practicable, and as a result the extent of clearing of native vegetation has been reduced by 78 ha to 318 ha.

In addition to the above, Image has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes, the key measures being:

- The adoption of a progressive mining and immediate rehabilitation approach;
- The backfilling of mine pits, to avoid leaving an excavation at closure;
- The avoidance of wetland, riparian and drainage areas to the north of the Mine Development Envelope;
- Revising the Mine Development Envelope to avoid Priority Flora populations and areas of cultural significance; and
- The use of existing cleared areas where available (access corridors).

There are some potential impacts that require management and monitoring to ensure that the impacts are not significant. Many of these potential impacts are adequately regulated under other legislation:

- Slurry spills and leaks and process plant emissions will be regulated under Part V of the EP Act;
- Mine pit design, and general environmental management will be regulated through a Mining Proposal assessed under the Mining Act; and
- Closure and rehabilitation will be regulated through a MCP assessed under the Mining Act.

There are some potential impacts however that are expected to require limits or conditions in the Ministerial Statement, including:

- Limits on total permanent and temporary disturbance within each development envelope;
- A limit on groundwater abstraction volumes;
- The implementation of a Final Infrastructure Design Plan, which will ensure that impacts on Priority Flora, the Banksia Woodland TEC / PEC and Carnaby's Cockatoo foraging habitat are minimised as far as practicable;
- The implementation of management plans for dust, noise and radiation;
- The implementation of a Social Cultural Heritage Management Plan; and
- The implementation of an Offset Strategy.

Based on the above, and the assessment provided in Sections 5 – 10, the Proposal avoidance, minimisation and rehabilitation measures are expected to be able to meet the EPA's objectives for all potential key environmental factors, with the exception of Flora and Vegetation and Terrestrial Fauna.

Residual impacts to the Banksia Woodlands TEC / PEC and Carnaby's Cockatoo foraging habitat are considered to remain significant once mitigation measures are implemented. Offset measures are required to counterbalance these residual impacts to ensure that the EPA objective for Flora and Vegetation and Terrestrial Fauna can be met. Image has proposed offsets and assessed the suitability of the offset against the WA and EPBC offset guidance, provided in Section 12. Specifics of these offset measures will be reviewed and refined during the development of an Offsets Strategy (expected to be a Ministerial Condition) through discussions with DMIRS, DBCA, DCCEEW and EPA Services to ensure they meet the required outcomes and adequately counterbalance the residual impacts.

Image considers that the residual impacts to the Banksia Woodlands TEC / PEC and Carnaby's Cockatoo foraging habitat is able to be counterbalanced by the implementation of the offsets detailed in Section 12, such that the EPA's objectives are able to be met for all Key Environmental Factors.

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1 INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of this Environmental Review Document (ERD) is to provide a detailed description of the Atlas Project (the Proposal) and to enable assessment of the potential environmental impacts that may result, should the Proposal be implemented. The ERD also outlines the key elements (characteristics) required for the construction and operation of the Proposal. The assessment will be completed by the Environmental Protection Authority (EPA) under the provisions of Part IV of the *Environmental Protection Act 1986* (WA) (EP Act).

This ERD has been prepared in accordance with the following EPA guidance:

- Environmental Impact Assessment (EIA) (Part IV divisions 1 and 2) Procedures Manual (EPA, 2021a);
- Statement of Environmental Principles, Factors and Objectives (EPA, 2021b);
- Instructions on how to prepare an Environmental Review Document (EPA, 2021c); and
- Instructions on how to identify the content of a proposal (EPA, 2021d).

This ERD focuses on the environmental factors that were deemed to be 'key' environmental factors by the EPA; those with the potential to be significantly impacted and could not be appropriately managed under other existing legislation. Potential impacts to these key environmental factors are described in detail and assessed using relevant studies specific to the Proposal. Therefore, this ERD describes the most relevant characteristics and impacts of the Proposal for environmental impact assessment (EIA) and provides all relevant biological and technical reports and survey results as Appendices (Appendix 1 – 34)

1.2 PROPONENT

The Proponent for the Proposal is Image Resources NL (Image) (ABN: 57 063 977 579).

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Email: tcolton@imageres.com.au
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Postal Address: PO Box 469, West Perth WA 6872

1.3 ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

1.3.1 PART IV OF THE *ENVIRONMENTAL PROTECTION ACT 1986*

Part IV of the EP Act makes provisions for the EPA to undertake EIA of significant proposals, strategic proposals and land use planning schemes. The Proposal was considered to be a significant proposal and as such requires assessment under Part IV of the EP Act.

The EPA uses environmental principles, factors and associated objectives as the basis for assessing whether a proposal or land use planning scheme's impact on the environment is acceptable. The environmental principles, factors and objectives, therefore, underpin the EIA process.

The Proposal was referred under Section 38 of the EP Act on 03 September 2021. The EPA released its decision to assess the Proposal as a Public Environmental Review (s. 40(2) (b) and s. 40(4)) on 13 October 2021. A proponent-prepared Environmental Scoping Document (ESD) was then submitted to the EPA and formally approved on 5 May 2022.

1.3.2 Section 87 of the *Environment Protection and Biodiversity Conservation Act 1999*

The Proposal was referred to the Department of Climate Change, Energy, the Environment and Water (DCCEEW; previously the Department of Agriculture, Water and the Environment (DAWE)) on 22 September 2021 (EPBC 2021/9056). DCCEEW determined that the Proposal was a 'controlled action' and required assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act), due to potential impacts on the following relevant controlling provisions:

- Listed threatened species and communities (sections 18 & 18A); and
- Nuclear actions (sections 21 & 22A).

The Proposal will be assessed as an 'accredited assessment' under Part IV of the EP Act. Section 87 of the EPBC Act makes provisions for the EPA to undertake this accredited assessment of the potential impacts to Matters of National Environmental Significance (MNES) on behalf of DCCEEW.

Further information on the potential impacts of the Proposal on MNES is provided in Section 12.

1.4 Other Approvals and Regulation

1.4.1 Land Tenure

Most Proposal aspects lie within mining tenement M 70/1305 held by Image. Some external supporting infrastructure aspects lie outside of the lease boundaries of M 70/1305. Image will obtain appropriate tenure under the *Mining Act 1978* (WA) (Mining Act) for these areas prior to construction.

Brand Highway intersection works will be conducted within the road corridor under the *Land Administration Act 1997* (WA) (LAA).

1.4.2 Other Decision-Making Authorities, Approvals and Regulation

Implementation of the Proposal is subject to other approvals in addition to Part IV of the EP Act and the EPBC Act. Table 2 identifies other approvals and associated legislation that will apply to the Proposal. The relevant decision-making authorities have also been identified for each approval or legislation.

Table 2: Other approvals and regulation

Decision-making authority and department (if relevant)	Legislation or Agreement regulating the activity	Approval required and relevant proposal element	Whether and how statutory decision-making process can mitigate impacts on the environment? (Yes/No and summary of reasons Include a separate line item for each relevant impact, and discuss how the EPA's factor objective will be met)		
			Relevant Impact	**Relevant Key Environmental Factor and Objective**	**Can the DMA mitigate impacts and how will the EPA's factor be met**
Minister for Environment (Cth)	EPBC Act (Cth)	**s.133 Approval** required for the assessment of the Proposal's impacts on MNES	Direct impacts to Threatened Fauna (Vehicle Strike)	**Terrestrial Fauna** EPA's objective: *To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.*	No While there is likely to be significant overlap in regulation, the EPBC Act is a Commonwealth Act and as such cannot be relied upon to regulate impacts under WA legislation.
			Clearing of potential Threatened Flora or Fauna habitat	**Flora and Vegetation** EPA's objective: *To protect flora and vegetation so that biological diversity and ecological integrity are maintained.* **Terrestrial Fauna** EPA's objective: *To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.*	
			Environmental impacts associated with the storage and transport of radioactive materials.	**Flora and Vegetation** EPA's objective: *To protect flora and vegetation so that biological diversity and ecological integrity are maintained.* **Terrestrial Fauna** EPA's objective: *To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.* **Inland Waters** EPA's objective: *To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.*	

<table>
<tr><th rowspan="2">Decision-making authority and department (if relevant)</th><th rowspan="2">Legislation or Agreement regulating the activity</th><th rowspan="2">Approval required and relevant proposal element</th><th colspan="3">Whether and how statutory decision-making process can mitigate impacts on the environment? (Yes/No and summary of reasons Include a separate line item for each relevant impact, and discuss how the EPA's factor objective will be met)</th></tr>
<tr><th>Relevant Impact</th><th>Relevant Key Environmental Factor and Objective</th><th>Can the DMA mitigate impacts and how will the EPA's factor be met</th></tr>
<tr><td></td><td></td><td></td><td></td><td>Human Health
EPA's objective: To protect human health from significant harm.</td><td></td></tr>
<tr><td rowspan="3">Minister for Environment (WA)
Chief Executive Officer (Department of Water and Environmental Regulation; DWER)</td><td rowspan="3">EP Act (WA)</td><td rowspan="3">Works Approval – required for the construction and commissioning of the Wet Concentrator Plant (WCP) and Solar Drying Ponds, and disposal of waste material back into the mine pits.
Licence – required for the operation of the WCP and Solar Drying Ponds, and disposal of waste material back into the mine pits.</td><td>Noise emissions</td><td>Social Surroundings
EPA's objective: To protect social surroundings from significant harm.</td><td>Yes
Mineral Sands mining is a prescribed activity under Part V of the EP Act and therefore the design, construction and operation of the mine will be regulated under a Works Approval and Licence to ensure noise emissions are minimised and do not result in significant impacts to any sensitive receptors.
Noise emissions from associated with external infrastructure are not expected to be significant and are unlikely to require additional regulation under Part IV of the EP Act in order to meet the objective for this factor.</td></tr>
<tr><td>Dust emissions</td><td>Flora and Vegetation
EPA's objective: To protect flora and vegetation so that biological diversity and ecological integrity are maintained
Social Surroundings
EPA's objective: To protect social surroundings from significant harm.</td><td>Yes
Mineral Sands mining is a prescribed activity under Part V of the EP Act and therefore the design, construction and operation of the mine will be regulated under a Works Approval and Licence to ensure dust emissions are minimised and do not result in significant impacts to any sensitive receptors.
Dust emission sources associated with external infrastructure are not expected to be significant and are unlikely to require additional regulation under Part IV of the EP Act in order to meet the objective for this factor.
Dust emissions from the WCP and all other aspects of the site are regulated under the Mining Act (refer below) and are not expected to be significant. These emissions are unlikely to require additional regulation under Part IV of the EP Act in order to meet the objective for this factor.</td></tr>
<tr><td>Disposal of waste material back into mine pits and unintentional</td><td>Inland Waters
EPA's objective: To maintain the hydrological regimes and quality of groundwater and surface water so</td><td>Yes
The Works Approval and Licence will regulate pollution of land or waters from the disposal of waste material or any spills of clay fines or hydrocarbons within the relevant Prescribed Premises.</td></tr>
</table>

Decision-making authority and department (if relevant)	Legislation or Agreement regulating the activity	Approval required and relevant proposal element	Whether and how statutory decision-making process can mitigate impacts on the environment? (Yes/No and summary of reasons Include a separate line item for each relevant impact, and discuss how the EPA's factor objective will be met)		
			Relevant Impact	**Relevant Key Environmental Factor and Objective**	**Can the DMA mitigate impacts and how will the EPA's factor be met**
			discharge of potentially contaminated water (stormwater), hydrocarbons, and/or clay fines	*that environmental values are protected.* **Terrestrial Environmental quality** EPA's objective: *To maintain the quality of land and soils so that environmental values are protected* **Flora and Vegetation** EPA's objective: *To protect flora and vegetation so that biological diversity and ecological integrity are maintained*	Leaks and spills from all other aspects of the Proposal are regulated under the Mining Act (refer below) and are not expected to be significant. These emissions are unlikely to require additional regulation under Part IV of the EP Act in order to meet the objective for this factor.
Minister for Environment (WA) Chief Executive Officer (Department of Biodiversity, Conservation and Attractions; DBCA)	*Biodiversity Conservation Act 2016* (BC Act) (WA)	**s.40 approval –** to take flora (where the flora to be taken is Threatened flora). **s. 45 approval** – to modify a Threatened Ecological Community (TEC).	Clearing of potential Threatened Flora or TEC.	**Flora and Vegetation** EPA's objective: To protect flora and vegetation so that biological diversity and ecological integrity are maintained.	Yes Species and ecological communities listed under the BC Act may differ from those listed in other states or territories, or under Commonwealth legislation. This is due to the different status of ecological communities in the different States and Territories and nationally. The BC Act provides the ability to impose conditions on authorisations to take Threatened species or modify TECs, that mitigate or offset the impact of such actions. DWER and DBCA coordinate assessment processes where a project being assessed under the EP Act involves the taking of a Threatened species or modification of an occurrence of a TEC. In accordance with longstanding agency practice, the assessment processes will be undertaken concurrently with advice being provided on the likelihood of an approval/permit being granted under the EP Act or an authorisation being granted under the BC Act.
Minister for Aboriginal Affairs	*Aboriginal Heritage Act 1972 (AH Act) (WA); or*	**Application for a permit under Part 6 of the ACH Bill** – required for consent to impact	Disturbance of Aboriginal Heritage Sites	**Social Surroundings** EPA's objective: *To protect social surroundings from significant harm.*	Yes. An application for a permit under Part 6 of the ACH Bill will assess the significance of the proposed disturbance and determine what mitigation measures are required to obtain consent for any disturbance to Aboriginal Heritage Sites. This consultation and assessment process will

Decision-making authority and department (if relevant)	Legislation or Agreement regulating the activity	Approval required and relevant proposal element	Whether and how statutory decision-making process can mitigate impacts on the environment? (Yes/No and summary of reasons Include a separate line item for each relevant impact, and discuss how the EPA's factor objective will be met)		
			Relevant Impact	Relevant Key Environmental Factor and Objective	Can the DMA mitigate impacts and how will the EPA's factor be met
	Aboriginal Cultural Heritage Bill 2021 (WA) (ACH Bill) *Note: the ACH Bill is likely to become law prior to Image disturbing any Aboriginal Heritage Sites.*	any Aboriginal Heritage sites (if not able to be avoided)			meet the EPA's objective for Social Surroundings by protecting registered Aboriginal Heritage sites from significant harm.
			Disturbance or indirect impacts to areas or artefacts of Aboriginal cultural value	**Social Surroundings** EPA's objective: *To protect social surroundings from significant harm.*	No (if avoidance is not possible). If disturbance or indirect impacts within areas or artefacts of significant Aboriginal cultural value cannot be avoided then assessment and potential regulation under Part IV of the EP Act may be required.
Minister for Water Chief Executive Officer (DWER)	*Rights in Water and Irrigation Act 1914* (RIWI Act) (WA)	**Application for a 26D licence** – required for the construction of a bore to abstract groundwater. **Application for a 5C licence** – required for the abstraction of groundwater	Abstraction of groundwater from the Yarragadee, Lesueur or Eneabba aquifers.	**Inland Waters** EPA's objective: *To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.*	Yes. A 26D Licence ensures that bores are drilled, constructed and maintained appropriately to ensure the aquifer and the groundwater resource is not compromised. A 5C Licence regulates the taking of water and assesses the impacts of the abstraction on the environment and other users. A 5C Licence is only granted if the impacts from the abstraction are shown to be sustainable with minimal environmental impacts or impacts to other users. Licence holders are obligated to comply with their resource allocation and any conditions included in the licence. Licence holders are also required to use water efficiently and responsibly, minimising impacts on the water resource. These Licences will ensure the Proposal meets the EPA's objective for Inland Waters by maintaining the hydrological regime of groundwater. Regulation of the potential impacts on the environment from the drilling and abstraction of groundwater is therefore not expected to be required under Part IV of the EP Act.
Minister for Mines and Petroleum	Mining Act	**Approval of a Mining Proposal and Mine Closure Plan**	Changes to the stability of the landscape	**Terrestrial Environmental Quality** EPA's objective: *To maintain the quality of land and soils so that environmental values are protected*	Yes. Approval of a Mining Proposal and MCP will ensure that the Factors defined in DMIRS's Environmental Objectives – Policy and Mining (DMIRS, 2020a) are met for the Proposal. A Mining Proposal will be

Decision-making authority and department (if relevant)	Legislation or Agreement regulating the activity	Approval required and relevant proposal element	Whether and how statutory decision-making process can mitigate impacts on the environment? (Yes/No and summary of reasons Include a separate line item for each relevant impact, and discuss how the EPA's factor objective will be met)		
			Relevant Impact	**Relevant Key Environmental Factor and Objective**	**Can the DMA mitigate impacts and how will the EPA's factor be met**
Executive Director Resource and Environmental Compliance (Department of Mines, Industry, Regulation and Safety; DMIRS) State Mining Engineer, (DMIRS)		**(MCP)** – required for any mining related disturbance within Mining Act tenements (i.e. all works apart from road intersection works).		**Inland Waters** EPA's objective: *To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.* **Flora and Vegetation** EPA's objective: *To protect flora and vegetation so that biological diversity and ecological integrity are maintained* **Terrestrial Fauna** *To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.*	submitted to DMIRS prior to any disturbance at the Proposal and will include auditable outcomes for the key DMIRS factors (Biodiversity, Water Resources, Land and Soils). These outcomes will be defined and approved by DMIRS to ensure that the impacts on the key DMIRS factors are mitigated to an acceptable level. In the context of landscape stability, this will include an auditable outcome that the landscape will be safe and stable during mining to prevent slumps or collapsed walls which could have environmental impacts. A MCP must be submitted to DMIRS with the Mining Proposal prior to any disturbance at the Proposal and is required to be revised every three years. It will include auditable closure and rehabilitation outcomes and criteria which will be defined and approved by DMIRS to ensure that impacts on key DMIRS factors are mitigated to an acceptable level. In the context of landscape stability this will include an auditable outcome that the landscape will be safe, stable and non-polluting post-closure to prevent slumps or collapsed pits which could have environmental impacts. The implementation of the Mining Proposal and MCP under the Mining Act is considered suitable to mitigate this impact such that the EPA's objectives can be met. By meeting DMIRS's Factors, the Proposal will also meet the EPA's objectives for the relevant factors. Additional regulation under Part IV of the EP Act is therefore unlikely to be required for this potential impact.
			Clearing of native vegetation	**Flora and Vegetation** EPA's objective: *To protect flora and vegetation so that biological diversity and ecological integrity are maintained* **Terrestrial Fauna** *To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.*	Partially. A Mining Proposal will be submitted to DMIRS prior to any disturbance at the Proposal and will include auditable outcomes for the key DMIRS factor: Biodiversity. These outcomes will include requirements for best-practice topsoil stripping and storage, minimising the clearing footprint and taking accurate records. A MCP must be submitted to DMIRS with the Mining Proposal prior to any disturbance at the Proposal and is required to be revised every three years. It will include auditable closure and rehabilitation outcomes and criteria which will be defined and approved by DMIRS to ensure that cleared areas are rehabilitated to an acceptable level. In the context of

Decision-making authority and department (if relevant)	Legislation or Agreement regulating the activity	Approval required and relevant proposal element	Whether and how statutory decision-making process can mitigate impacts on the environment? (Yes/No and summary of reasons Include a separate line item for each relevant impact, and discuss how the EPA's factor objective will be met)		
			Relevant Impact	**Relevant Key Environmental Factor and Objective**	**Can the DMA mitigate impacts and how will the EPA's factor be met**
					vegetation clearing this will include an auditable outcome that the rehabilitated areas will meet specific closure criteria designed to ensure flora, vegetation and fauna values are reinstated. The implementation of the Mining Proposal and MCP under the Mining Act is considered suitable to mitigate rehabilitation and impacts during clearing however, it is not considered suitable to mitigate impacts associated with the loss of vegetation. This is expected to require assessment under Part IV of the EP Act to ensure that the EPA's objectives can be met.
			Introduction and spread of weeds	**Flora and Vegetation** EPA's objective: *To protect flora and vegetation so that biological diversity and ecological integrity are maintained*	Yes. The DMIRS Factor: Biodiversity, is relevant to this impact. DMIRS's objective for this factor is to: *Maintain representation, diversity, viability and ecological function at the species, population and community level.* By meeting the objective of DMIRS's Biodiversity Factor, the Proposal will also meet the EPA's objectives for flora and vegetation. Therefore, further assessment of the impact of the introduction and spread of weeds on Flora and Vegetation is not required to be assessed by the EPA.
			Alteration to the post mining land use	**Social Surroundings** EPA's objective: *To protect social surroundings from significant harm.*	Yes. The DMIRS Factor: Rehabilitation and Mine Closure, is relevant to this impact. DMIRS's objective for this factor is: *Mining activities are rehabilitated and closed in a manner to make them physically safe to humans and animals, geo-technically stable, geo-chemically non-polluting / non-contaminating, and capable of sustaining an agreed post-mining land use, and without unacceptable liability to the State.* By meeting the objective of DMIRS's Rehabilitation and Mine Closure Factor, the Proposal will also meet the EPA's objectives for social surrounding that are relevant to this impact. Additional regulation under Part IV of the EP Act is therefore unlikely to be required for this potential impact.

Decision-making authority and department (if relevant)	Legislation or Agreement regulating the activity	Approval required and relevant proposal element	Whether and how statutory decision-making process can mitigate impacts on the environment? (Yes/No and summary of reasons Include a separate line item for each relevant impact, and discuss how the EPA's factor objective will be met)		
			Relevant Impact	**Relevant Key Environmental Factor and Objective**	**Can the DMA mitigate impacts and how will the EPA's factor be met**
	Work Health and Safety (Mines) Regulations 2022	**Approval of a Radiation Management plan** – required when radioactivity levels or radiation exposure for workers or members of the public may exceed levels set out in the Work Health and Safety Regulations 2022	Radiation exposure to employees and members of the public	**Human Health** EPA's objective: To protect human health from significant harm.	Yes Potential radiation associated with mineral sands mining will be managed in accordance with relevant guidelines and codes of practice published by the Australian Radiation Protection and Nuclear Safety Authority and subject to control under Chapter 10 Part 10.2 Division 3 Subdivision 3b of the Work Health and Safety (Mines) Regulations 2022 The site will also be registered with the Radiological Council WA under Section 28 of the *Radiation Safety Act 1975* (WA). Through the implementation of the Radiation Management Plan, the Proposal will also meet the EPA's objective for Human Health. Therefore, further assessment of the impact of radiation exposure to members of the public is not required to be assessed by the EPA.
Minister for Mines and Petroleum Chief Dangerous Goods Officer, (DMIRS)	*Dangerous Goods Safety Act 2004* (WA)	**Dangerous Goods Licence** – may be required for the bulk storage of fuel if above specified limits (unlikely)	Contamination of soils, groundwater and surface water (hydrocarbon spills) Fire (combustion of stored fuel)	**Terrestrial Environmental Quality** EPA's objective: *To maintain the quality of land and soils so that environmental values are protected* **Inland Waters** EPA's objective: *To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.* **Flora and Vegetation** EPA's objective: *To protect flora and vegetation so that biological diversity and ecological integrity are maintained* **Terrestrial Fauna**	Yes. The storage and management of hydrocarbons will already be regulated under Part V of the EP Act and the Mining Proposal / MCP however, the Dangerous Goods Licence provides additional mitigation for the design and storage of larger volumes of dangerous goods (if large volumes of hydrocarbons (>100,000 L) are required to be stored on site). A Dangerous Goods Licence sets standards for the way in which dangerous goods are stored on site. These standards are aimed at ensuring dangerous goods are stored safely and in such a way that will not result in impacts to the environment. Having a Dangerous Goods Licence ensures potential spills and combustion risks from the Proposal are mitigated. A Dangerous Goods licence (in combination with the Part V and Mining Act approvals) will meet the objectives of the EPA for both factors by minimising the risk of contamination of soils and water, and protecting flora and vegetation, and terrestrial fauna by minimising the risk of fire. Regulation of the potential impacts on the environment from the storage of dangerous goods is therefore not expected to be required under Part IV of the EP Act.

Decision-making authority and department (if relevant)	Legislation or Agreement regulating the activity	Approval required and relevant proposal element	Whether and how statutory decision-making process can mitigate impacts on the environment? (Yes/No and summary of reasons Include a separate line item for each relevant impact, and discuss how the EPA's factor objective will be met)		
			Relevant Impact	Relevant Key Environmental Factor and Objective	Can the DMA mitigate impacts and how will the EPA's factor be met
				EPA's objective: *To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.*	
Chief Executive Officer, Shire of Dandaragan	*Local Government Act 1995* (WA) *Planning and Development Act 2006* (WA)	**Planning / Development Approval** – required for the development of works outside of Mining Act tenements	Noise emissions Dust emissions	**Social Surroundings** EPA's objective: *To protect social surroundings from significant harm.*	No. A development approval is only required for works outside of Mining Act tenure. This process considers the impacts from small portions of the Proposal to an extent but does not regulate emissions from the Proposal. Potential impacts including emissions of Noise and Dust are regulated under Part V of the EP Act and are discussed further in the section above.
Secretary Radiological Council of WA	*Radiation Safety Act 1975 (WA)*	**Registration with the Radiological Council WA –** required under Section 28 of the *Radiation Safety Act 1975* (WA) for the owner of any premises which is likely to be affected by the passage or use of any radioactive substance.	Radiation exposure to members of the public	**Human Health** EPA's objective: To protect human health from significant harm.	Yes The site will be registered with the Radiological Council WA under Section 28 of the *Radiation Safety Act 1975* (WA). Potential radiation associated with mineral sands mining will be managed in accordance with relevant guidelines and codes of practice published by the Australian Radiation Protection and Nuclear Safety Authority and subject to control under Part 16 of the Mines Safety and Inspection Regulations 1995. Through the implementation of the Radiation Management Plan the Proposal will also meet the EPA's objective for Human Health. Therefore, further assessment of the impact of radiation exposure to members of the public is not required to be assessed by the EPA.

2 THE PROPOSAL

2.1 BACKGROUND

Image originally referred the Proposal to the EPA on 16 October 2020 however, changes to the mine plan required a significant change to the scope of the original referral, and therefore that referral was withdrawn on 23 August 2021. The revised Proposal was then re-referred to the EPA on 3 September 2021. The level of assessment was set as Public Environmental Review (s.40(2)(b) and s.40(4)) on 13 October 2021. A proponent prepared ESD was then submitted to the EPA and formally approved on 5 May 2022.

Following extensive ecological, hydrological, hydrogeological and Aboriginal Heritage surveys and investigations, Image submitted an amendment to the Project layout under s.43A of the EP Act which was approved on 6 September 2022. Image also submitted an amendment under s.156 of the EPBC Act which was approved on 7 October 2022. The changes predominately consisted of a considerable reduction in the mine area resulting in less disturbance and clearing required for the Proposal. Several other impacts to environmental and social values have also been avoided by excluding northern sections of the deposit. These are discussed in more detail in Section 2.2.3.

Economic feasibility for the Proposal can still be realised as lower grade Ore Reserves dominate the excluded northern section, however, should appropriate mitigation be developed in the future, Image may develop and refer a separate Proposal for the northern deposits.

The previously referred second option for a dredge mining method has also been excluded from the Proposal as feasibility studies for the revised mine plan have concluded that the dry method is preferable.

This revised Proposal amended under s.43A of the EP Act forms the basis of this ERD.

2.2 PROPOSAL DESCRIPTION

2.2.1 PROPOSAL LOCATION

Image is seeking to develop the Proposal, a mineral sands mine located in the Wheatbelt region of Western Australia (WA), approximately 170 kilometres (km) north of Perth and 18 km east of Cervantes (Figure 2).

The Proposal occurs on Unallocated Crown Land, freehold farmland, public road reserves and within tenure issued under the Mining Act. The main mining operations and processing infrastructure for the Proposal will lie within the boundaries of Image's mining tenement M70/1305. Some external supporting infrastructure including an accommodation camp, access roads, bores and pipelines lie outside of the lease boundaries of M70/1305. Image will obtain appropriate tenure under the Mining Act for these areas prior to construction.

Two unsealed roads (Munbinea Road and Wongonderrah Road), and intersections along Bibby Road and Brand Highway are included in sections of the Proposal. Access to the mine site will be via a short access corridor connecting the Proposal to Munbinea Road and then primarily via Bibby Rd to Brand Highway.

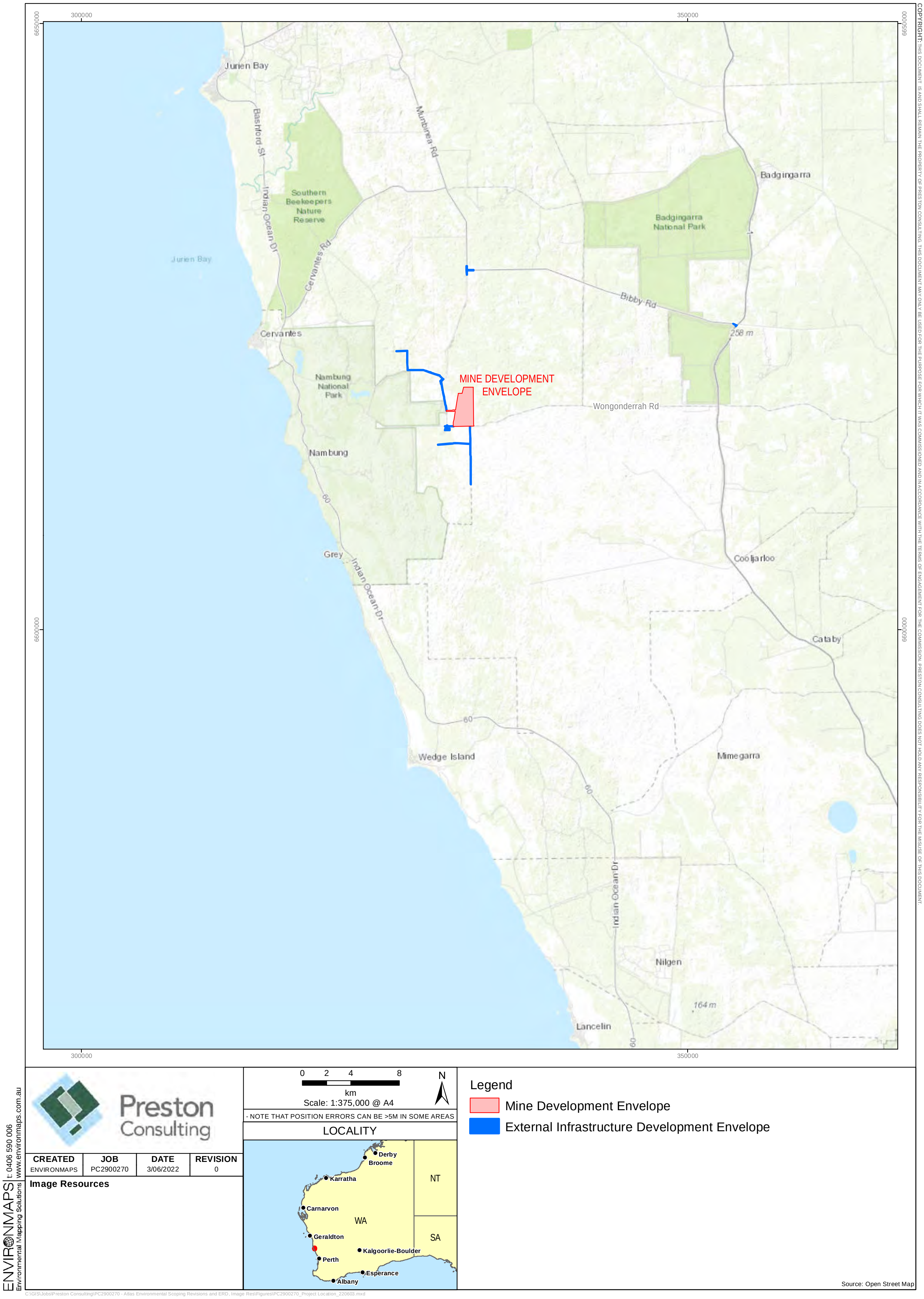


Figure 2: Regional Setting of the Proposal

2.2.2 Proposal Content Elements

Image has referred to the EPA's instructions 'How to Identify the Content of a Proposal' (EPA, 2021d) which focuses on how to define the Proposal elements for the purposes of an EIA under Part IV of the EP Act. In accordance with these instructions, a summary of the Proposal is provided in Table 3 and the Proposal elements (e.g., physical, construction and operational) which are likely to cause an impact on the environment are summarised in Table 4. Shapefiles for the development envelopes and indicative disturbance footprints are provided as Appendix 1.

Table 3: General Proposal content description

Proposal Title	Atlas Project
Proponent Name	Image Resources NL
Short Description	Image Resources NL is seeking to develop a greenfields mineral sands project, located at Nambung, approximately 18 km east of Cervantes in the Wheatbelt region of Western Australia. The Proposal includes the progressive development of mine pits, processing facilities, groundwater bores and water management infrastructure, temporary waste stockpiles, solar drying ponds and associated infrastructure (power supply, communications, workshop, laydown, offices, accommodation camp etc.).

Table 4: Location and proposed extent of physical and operational elements

Proposal element	Location / description	Maximum extent, capacity or range
Physical elements		
Mine Development Envelope • Open cut mine pits; • Temporary topsoil/ subsoil/ waste stockpiles; • Processing facilities; • Solar drying ponds; and • Supporting infrastructure.	Figure 2, Figure 3	Disturbance of no more than 302 ha within the 457 ha Mine Development Envelope, including no more than 292 ha of native vegetation clearing.
External Infrastructure Development Envelope • Transport infrastructure upgrades; • Accommodation Camp; and • One or more extraction bore/s and associated pipeline corridors.	Figure 2, Figure 3	Disturbance of no more than 70 ha within the 70 ha External Infrastructure Development Envelope, including no more than 26 ha of native vegetation clearing.
Construction elements		
Pit dewatering	Superficial aquifer	Dewatering of up to 1.1 GL/yr
Operational elements		
Heavy Mineral Concentrate (HMC) production	Figure 3 (Plant Area and Loadout Area)	Production of up to 250 ktpa of HMC
HMC storage	Figure 3 (Indicative HMC Stockpile Location)	Short term stockpiling of up to 30 kt HMC prior to haulage for export.
Mining method	Figure 3 (Pit)	Dry mining
Pit dewatering	Superficial aquifer	Dewatering of up to 0.75 GL/yr

Proposal element	Location / description	Maximum extent, capacity or range
Groundwater abstraction	Yarragadee, Eneabba and/or Lesueur Aquifer	Abstraction of up to 2.2 GL/yr from one or more borefields.
Power generation	Onsite diesel generators (potentially supplemented/replaced by grid or renewable generation)	Approximately 2-3 MW
Proposal elements with greenhouse gas emissions		
Construction elements:		
Scope 1	Land use change – vegetation clearing: less than 22 kt CO_2-e Plant, equipment: Less than 2 kt CO_2-e Power generation: Less than 7 kt CO_2-e Maximum of: 31 kt CO_2-e	
Operation elements:		
Scope 1	Land use change – vegetation clearing: less than 35 kt CO_2-e/yr Plant, equipment: Less than 5 kt CO_2-e/yr Power generation: Less than 15 kt CO_2-e/yr Maximum of: 55 kt CO_2-e/yr Maximum over life of Proposal: 165 kt CO_2-e	
Rehabilitation		
Rehabilitation and closure will be progressive and in accordance with the MCP. Mining pits will be progressively filled and rehabilitated to pre-mining profile with the pre-existing land use reinstated as mining advances.		
Commissioning		
Commissioning of the processing facility to be undertaken subject to operational limits above.		
Decommissioning		
Removal of all process related infrastructure within 12 months of cessation of operations (excluding periods of care and maintenance).		
Other elements which affect extent of effects on the environment		
Proposal time	Maximum project life	5 years
	Construction phase	12 months
	Operations phase	3 Years
	Decommissioning phase	12 months

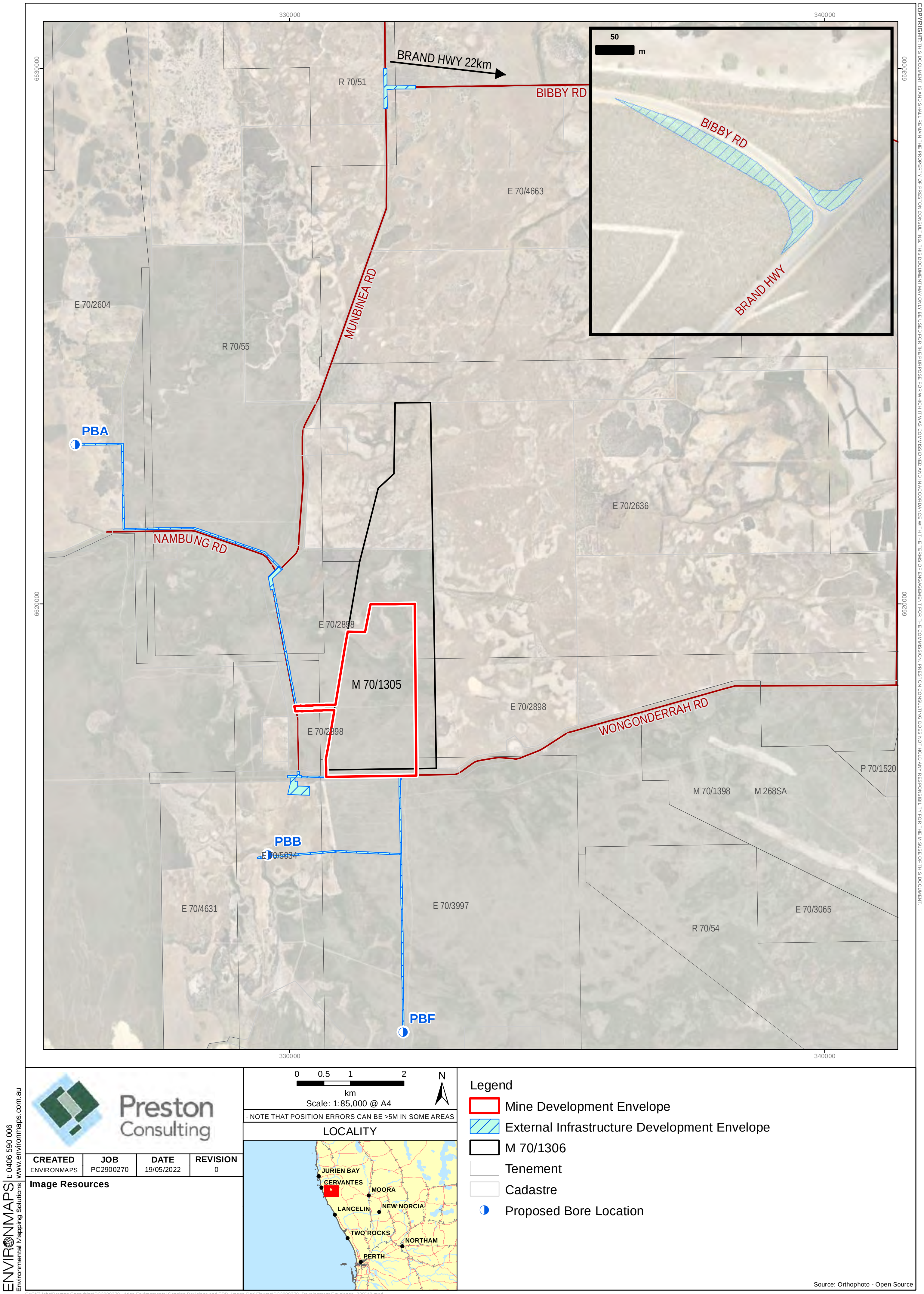
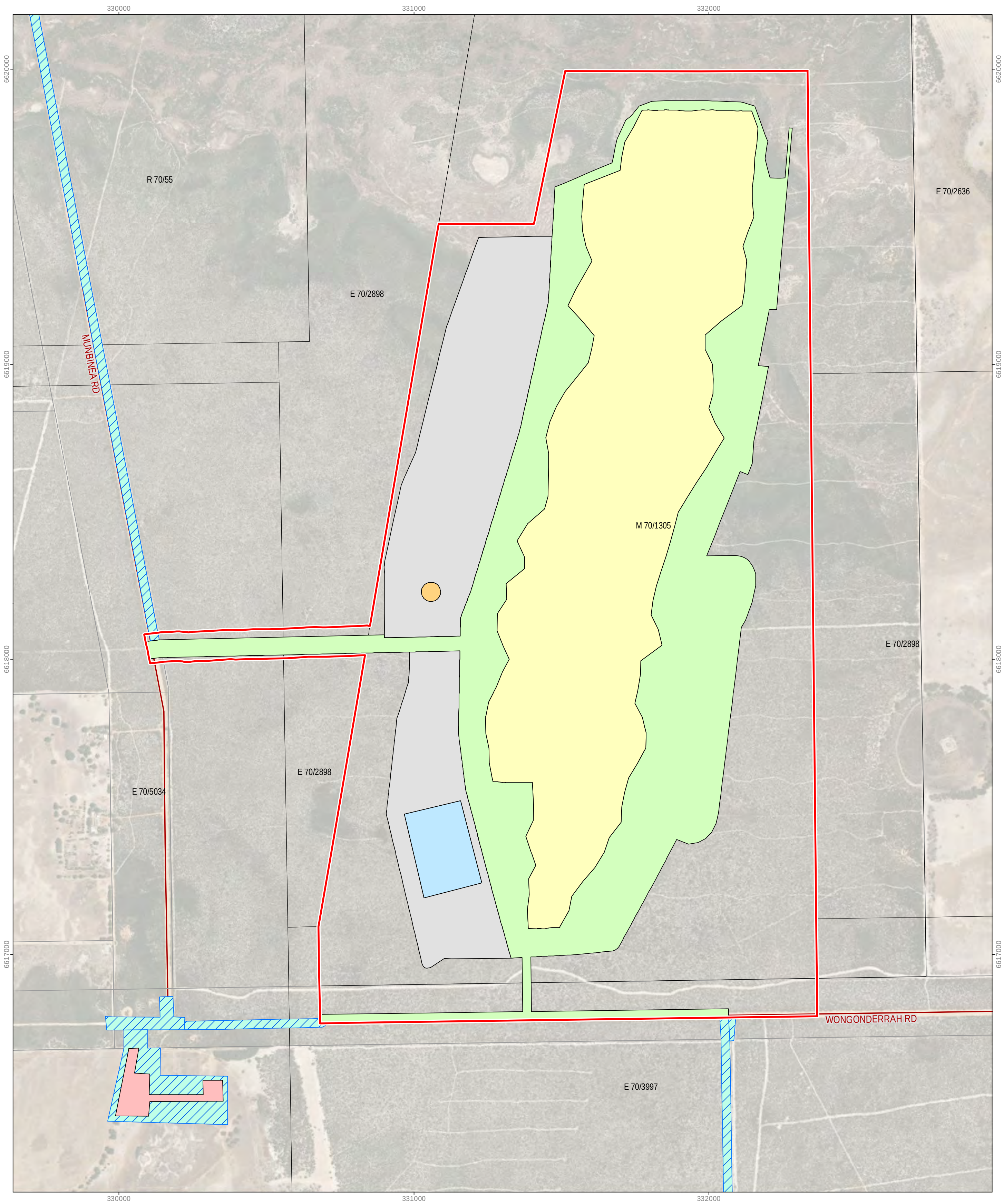


Figure 3: Proposal Development Envelopes



0 0.125 0.25 0.5

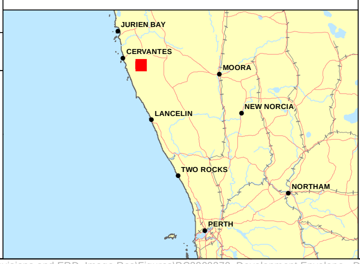
km

Scale: 1:12,500 @ A3

N

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY



Legend

- Mine Development Envelope
- External Infrastructure Development Envelope
- Tenement
- Cadastre

Disturbance Footprint - Dry

- Pit
- Pit Surrounds (access road, stockpiles, pipeline corridor)
- Solar Drying Cell Area
- Plant Area and Loadout Area
- Indicative HMC Stockpile Location
- Accommodation Camp

Preston Consulting

CREATED BY	JOB	DATE	REVISION
ENVIRONMAPS	PC2900270	19/05/2022	0

ENVIRONMAPS Environmental Mapping Solutions t 0406 590 006 www.environmaps.com.au

Figure 4: Indicative mine and infrastructure layout

Source: Orthophoto - Open Source Imagery

C:\GIS\Jobs\Preston Consulting\PC2900270 - Atlas Environmental Scoping Revisions and ERD, Image Res\Figures\PC2900270_Development Envelope - Disturbance Footprint - Dry_220519.mxd

2.2.3 Detailed Description

Overview

Image proposes to develop an open cut mine pit, processing plant, solar drying ponds and supporting infrastructure over an estimated mine life of approximately three years. Mining and progressive rehabilitation is planned in stages using conventional dry mineral sands mining techniques. The mine pit will be mined and progressively rehabilitated in stages with a total extent of approximately 2.8 km long, 200 – 600 m wide and 1 – 15 m deep.

Conventional earthmoving equipment will be used to remove topsoil, subsoil and overburden prior to accessing the ore. Topsoil and subsoil will be stockpiled adjacent the mine path, while overburden will initially be stockpiled external to the pit until sufficient mine void is available to allow progressive backfill. The mining void will be progressively rehabilitated to pre-mining profile with the pre-existing land use (native vegetation or agriculture) reinstated as mining advances. Where feasible, disturbance will be minimised by utilising existing disturbed areas and locating supporting infrastructure on the future or backfilled mine footprint (prior to commencing rehabilitation).

Ore will be delivered and stockpiled on a run-of-mine (ROM) pad then progressively loaded into a feed preparation plant (FPP) where process water is introduced before being slurried and pumped to the Wet Concentrator Plant (WCP) for processing. The WCP recovers the contained heavy minerals via standard spiral wet gravity separation, producing heavy mineral concentrate (HMC), and sand tails and clay fines as waste products. Sand tails will be pumped back into the pit void using tailing stackers, while clay fines will be pumped to solar drying ponds before being placed back into the pit void. The implementation of co-disposal of sands and clay fines, as adopted at Image's Boonanarring Project, will be investigated through the early development of the Proposal.

The final HMC product will be stacked on a drainage pad adjacent to the WCP, where it will be allowed to drain and dry for a short period of time prior to being transported by trucks off site for export.

Mining Method

The mining process will generally follow the following sequence:

- Vegetation is cleared, grubbed and stockpiled where necessary;
- Topsoil (nominal top 200 mm) is stripped and stockpiled adjacent to the mine path;
- Subsoil (nominally next 300 mm) is stripped and stockpiled adjacent to the mine path;
- Overburden is removed and initially stockpiled off the mining path, until sufficient void becomes available and direct deposition back in the mining void can occur;
- Ore is fed into the FPP where it is slurried with process water;
- Any >300 mm waste material and >3 mm oversize material is screened from the ore and returned to the void behind the mine face;
- Underflow from the FPP (<3 mm) is pumped via polyethylene pipelines to the WCP by slurry feed underflow pumps and where required, a series of surface feed booster pumps are used to extend field pumping capability;
- Sand tailings from the WCP are deposited in the mine void using tailings cyclone stackers;
- Clay fines from the thickener underflow is pumped to solar drying ponds;

- Overburden from the temporary stockpiles are returned over the sand tailings as a capping material;
- Once the clay fines are dried, tailings are backfilled to the pit and contoured to design;
- Subsoil is returned over profiled overburden or sand tailings;
- Topsoil is placed on top of contoured subsoil; and
- Surface drainage and re-vegetation works are undertaken.

The various steps involved in mining and processing are illustrated in Figure 5.

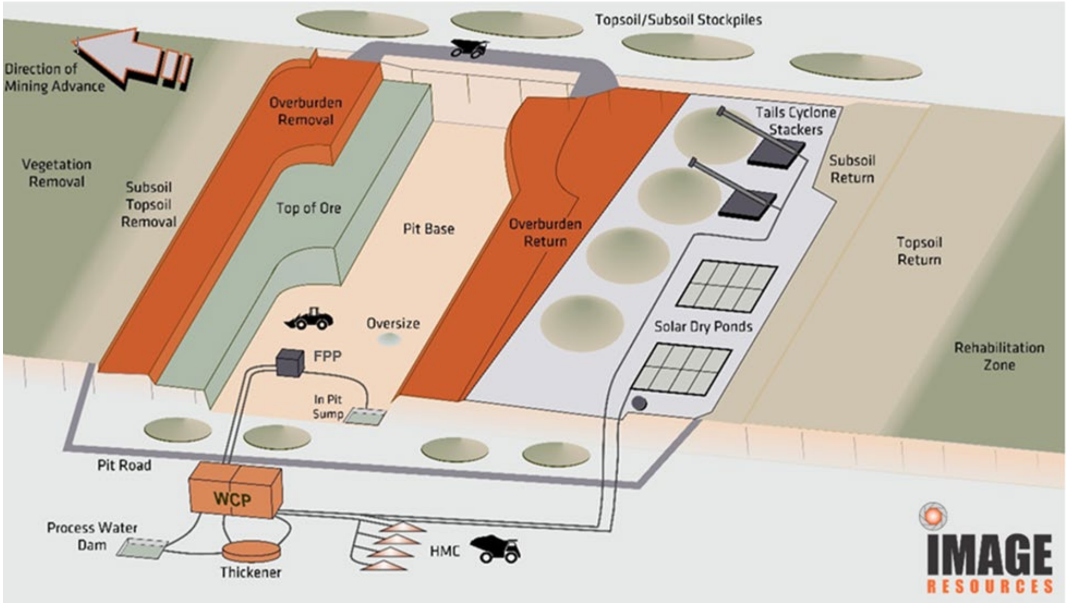


Figure 5: Mining method

Wet Concentrator Plant

The mining and processing operations will incorporate conventional dry mining, followed by wet concentrating, utilising industry standard mineral sands separation technology to produce the final HMC product. The WCP will be located to the western side of the mine pit and is shown as the Plant and Loadout area in Figure 6.

Closure of Image's Boonanarring Project is planned to coincide with commencement of the Proposal. Image plans to relocate sections of the existing Boonanarring WCP (Figure 6) and the majority of associated plant and equipment and reconstruct it on site for use at the Proposal. Components comprising improved spiral technology will be incorporated into the Atlas WCP, to improve efficiency and reduce footprint of the plant.

Figure 6: Photo – Wet Concentrator Plant

The processing circuit will be characterised by the following stages:

- A de-slime circuit comprising a cluster of de-slime cyclones followed by a Constant Density Tank (CD Tank), which provides steady state de-slimed feed to the gravity spiral circuit;
- A semi-modular WCP, which employs banks of wet separation spirals consisting of mainly rougher, scavenger, cleaner and recleaner gravity concentration, attritioner circuit and wet magnetic separation circuit to produce a HMC and a coarse tailings for direct placement back to the mining void; and
- A tailings and water management circuit, requiring water supply and comprising of settling and process water ponds, tails thickener and fines tailings disposal systems.

A flow chart showing the WCP process circuit is shown in Figure 7.

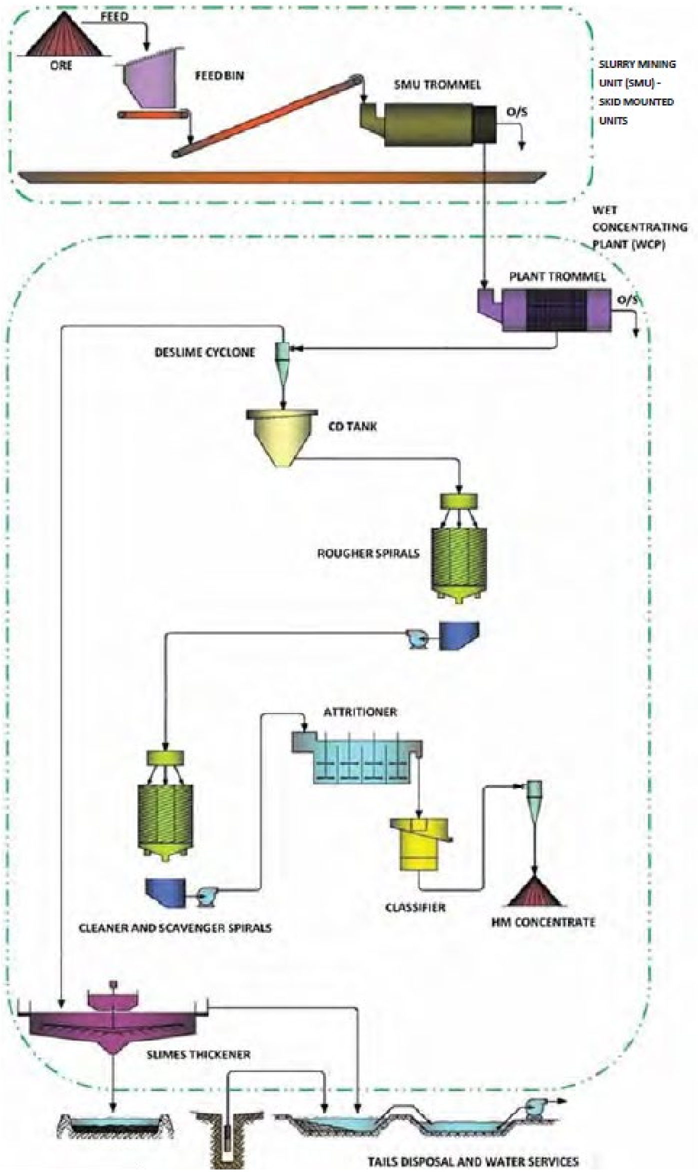


Figure 7: Processing circuit

Flocculant

An anionic flocculent will be added to the tails thickener at a rate of approximately 500 grams (g)/tonne.

Access Corridor

A short access corridor extends to the west connecting the Proposal to Munbinea Road. The access corridor will be comprised of the following infrastructure:

- Access road;
- Power lines; and
- Water supply pipeline.

The use of an existing powerline track will minimise vegetation clearing however, to meet electrical safety standards, setbacks from the powerlines will require some additional clearing.

Haulage and Product Export

HMC will be transferred from the final product stockpile by front-end loaders, loaded onto haul trucks and transported to port for export (not part of this Proposal) via Brand Highway. Haulage from site will be via Munbinea Road which connects to the Brand Highway via Bibby Road to the north of the Proposal.

Two unsealed roads (Munbinea Road and Wongonderrah Road) and intersections along Bibby Road and Brand Highway are included in some sections of the Proposal. There will not be a requirement for any substantial diversions of these roads for Proposal activities, however, some upgrades and crossings will be required to safely accommodate access. Some intersections and road sections will require upgrades to meet road safety requirements for haulage and increased traffic.

Power Generation

Power will be sourced either from onsite diesel generators, via connection to the existing power network or a combination of both. Diesel fuel for the generators will be stored onsite in self-bunded fuel storage tanks.

Water Supply

Water supply will be sourced from dewatering and from one or more abstraction bores. Three separate potential pipeline corridors and associated bore locations are included in the Proposal which, pending further feasibility studies, will provide for one or more groundwater supply options for the Proposal.

Supporting Infrastructure

To facilitate the Proposal, the following supporting infrastructure will be developed for Image and the mine contractor:

- Administration building;
- Infiltration trenches;
- Potable water storage;
- Accommodation camp;

- Workshop / Stores;
- Bores and water management; and
- Laydown areas.

An indicative mine and infrastructure layout is provided in Figure 4.

2.2.4 Development Envelopes and Disturbance Footprints

The development envelopes outline the boundaries for the Proposal, where all ground disturbance and key proposal elements listed below are proposed to occur. The Proposal will be developed within a Mine Development Envelope (MDE) and an External Infrastructure Development Envelope (EIDE; Figure 3). A total disturbance limit of 372 ha is proposed within a combined development envelope area of 527 ha.

The MDE is predominately located within M70/1305 and covers an area of 457 ha. Up to 302 ha of disturbance including no more than 292 ha of native vegetation clearing will be required within the MDE in order to develop the following:

- Open cut mine pits;
- Temporary waste dumps;
- Processing facilities;
- Solar drying ponds; and
- Supporting infrastructure (including power supply, haul roads, communications, workshop, laydown, bores, water management and offices).

The EIDE covers an area of 70 ha. Up to 70 ha of disturbance including no more than 26 ha of native vegetation clearing may be required within the EIDE in order to develop the following:

- Transport infrastructure upgrades;
- Accommodation Camp; and
- One or more extraction bore/s and associated pipeline corridors.

Shape files for the development envelopes have been provided in Appendix 1.

2.2.5 Water Balance

MWES (2022b) calculated the whole of mine water balance based on the quarterly mine dewatering pumping and DMS infiltration rates. The WCP and mining raw water consumptions were calculated to be a steady rate of 1.88 GL/yr (60 L/sec). This allowed for recycling of water inside of the process plant through a thickener and a tailings sand stacker cyclone recovery system.

The water balance was calculated by taking the mine dewatering production rate from the WCP, mining and infiltration pond consumptions. It was assumed that there will be no additional water recovered from within the mine from oversize discharge, stacked sand or from the solar drying ponds. The recovery from cyclone sand tailings was accounted for in the process plant raw consumption.

Figure 8 shows the calculated operational raw water requirement for the Proposal (red line). The water balance shows a deficit in water supply of approximately 70 L/sec during the second quarterly mining period which reduces to around 50 L/sec for the remainder of the mine life. The initial high requirement is due to the large perimeter of the combined first and second quarterly mining blocks.

The initial oversupply in the period 360-450 days is associated with pre-mine dewatering. This excess can be used for construction and road building. Full utilisation of dewatering volumes is expected therefore no discharge to the environment is planned. During isolated, extreme weather conditions, downstream discharge may be required to maintain safe operation. Discharge to the environment will be managed in accordance with a Licence under Part V of the EP Act.

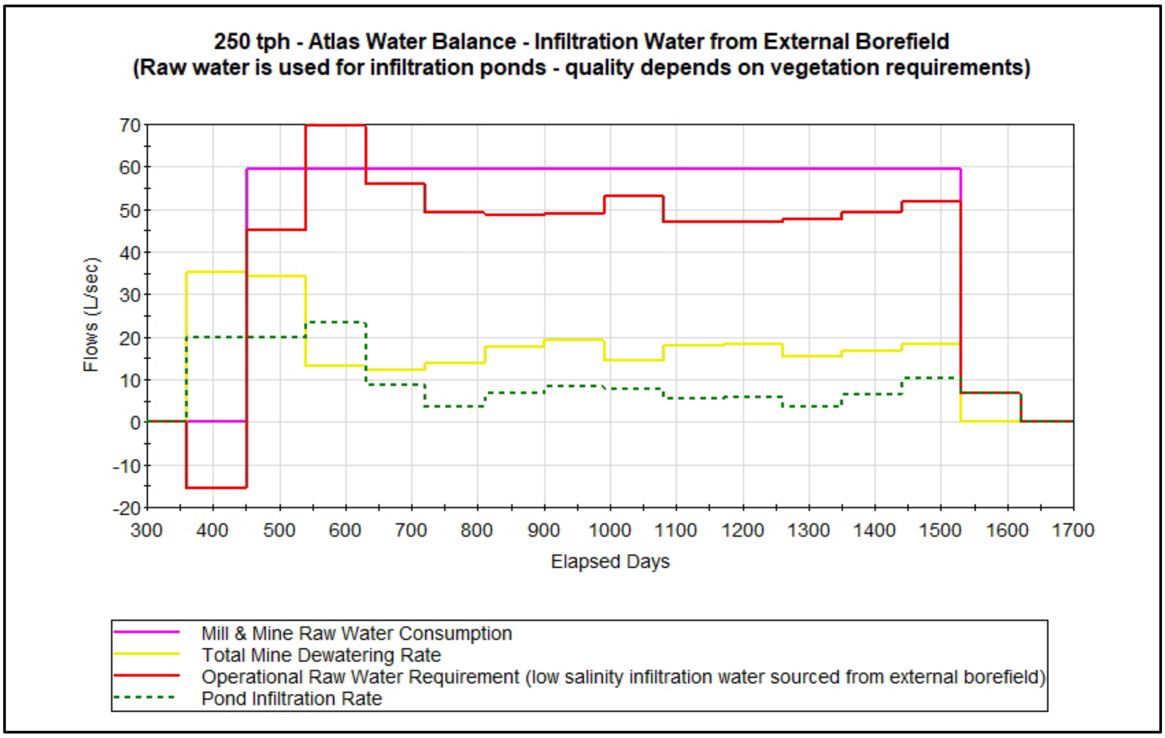


Figure 8: Water Balance

2.3 Justification

2.3.1 Do nothing approach to the Proposal

Demand for heavy minerals (HM) from mineral sands mining saw a steady upwards trend from early 1980 to 2010, followed by an unprecedented almost 500% price increase in the span of two years. Prices since declined towards the mid-2010s, although are steadily increasing as global supply decreases. This has provided an opportunity for WA to supply HM in the form of HMC for the increasing local and overseas demand for the product.

Image completed an Ore Reserve estimate in May 2017 for the Atlas Project. This Ore Reserve estimate was a component of the Bankable Feasibility Study for the combined Boonanarring and Atlas projects, also completed in May 2017. Summary information from the Ore Reserve estimate was released on the Australian Stock Exchange and can be accessed via the following link: https://cdn-api.markitdigital.com/apiman-gateway/ASX/asx-research/1.0/file/2995-01861180-6A822384?access_token=83ff96335c2d45a094df02a206a39ff4

The Proposal has been and will be subject to thorough feasibility studies to ensure that financial aspects are considered, and potential profits justify the capital and operational expenditure.

Based on this outlook, Image predicts a strong demand for its HMC product, consisting of zircon, rutile, leucoxene and ilmenite. The 'do nothing' approach to the Proposal represents a lost commercial opportunity to Image and the WA Government in the form of tax and royalties.

2.3.2 Other Technologies or Options

Image is proposing for processing facilities of the mineral sands on-site to produce the HMC product for local and overseas markets. Given that Ilmenite, Zircon, Rutile and Leucoxene all have vastly different uses it would be unfeasible to develop multiple, large infrastructure elements to utilise each resource individually.

2.3.3 Alternative locations and designs considered

During the initial planning phase of the Proposal, Image identified that environmental factors should have a significant influence on the design and location of the mine layout and infrastructure. Several baseline environmental surveys were conducted, which have enabled Image to incorporate avoidance and mitigation measures into the Proposal design. Since referral of the Proposal, Image has improved their understanding of the local environment and has sought to make changes to the Proposal during assessment under Section 43A (S43A) of the EP Act (approved 6 September 2022).

The key changes made to the Proposal are:

- A reduction in the overall extent of the Development Envelopes;
- A reduction in the overall disturbance;
- A reduction in the extent of clearing of native vegetation;
- Removal of the dredge mining option; and
- The addition of an accommodation camp.

Changes made to the development envelopes and the disturbance footprints are illustrated in Figure 9.

The proposed amendments will not result in any additional environmental effects. The amendments will result in a reduction to the Proposal's overall impacts. Proposed impacts reduced as a result of the proposed amendments are summarised below:

- Avoid disturbance of areas of cultural concern identified in recent Aboriginal heritage surveys and consultation with the Yued People (Traditional Owners);
- Avoid direct disturbance of the Mt Jetty and Bibby creek lines;
- Reduce the extent of direct and indirect impacts to native vegetation including '*Banksia* Dominated Woodlands of the Swan Coastal Plain' (federal Threatened Ecological Community (TEC) (Endangered)/ state Priority 3 Priority Ecological Community (PEC) and Groundwater Dependant Ecosystems;
- Reduce impacts to Priority flora;
- Reduce impacts to *Zanda latirostric* (Carnaby's Cockatoo; genus previously titled *Calyptorhynchus latirostric*) foraging habitat;
- Reduce groundwater abstraction volumes and the extent of groundwater drawdown;
- Reduce emissions (air and greenhouse gas); and
- Reduced impact to amenity through the reduction of local traffic from shift workers commuting to site (24 hours/day).

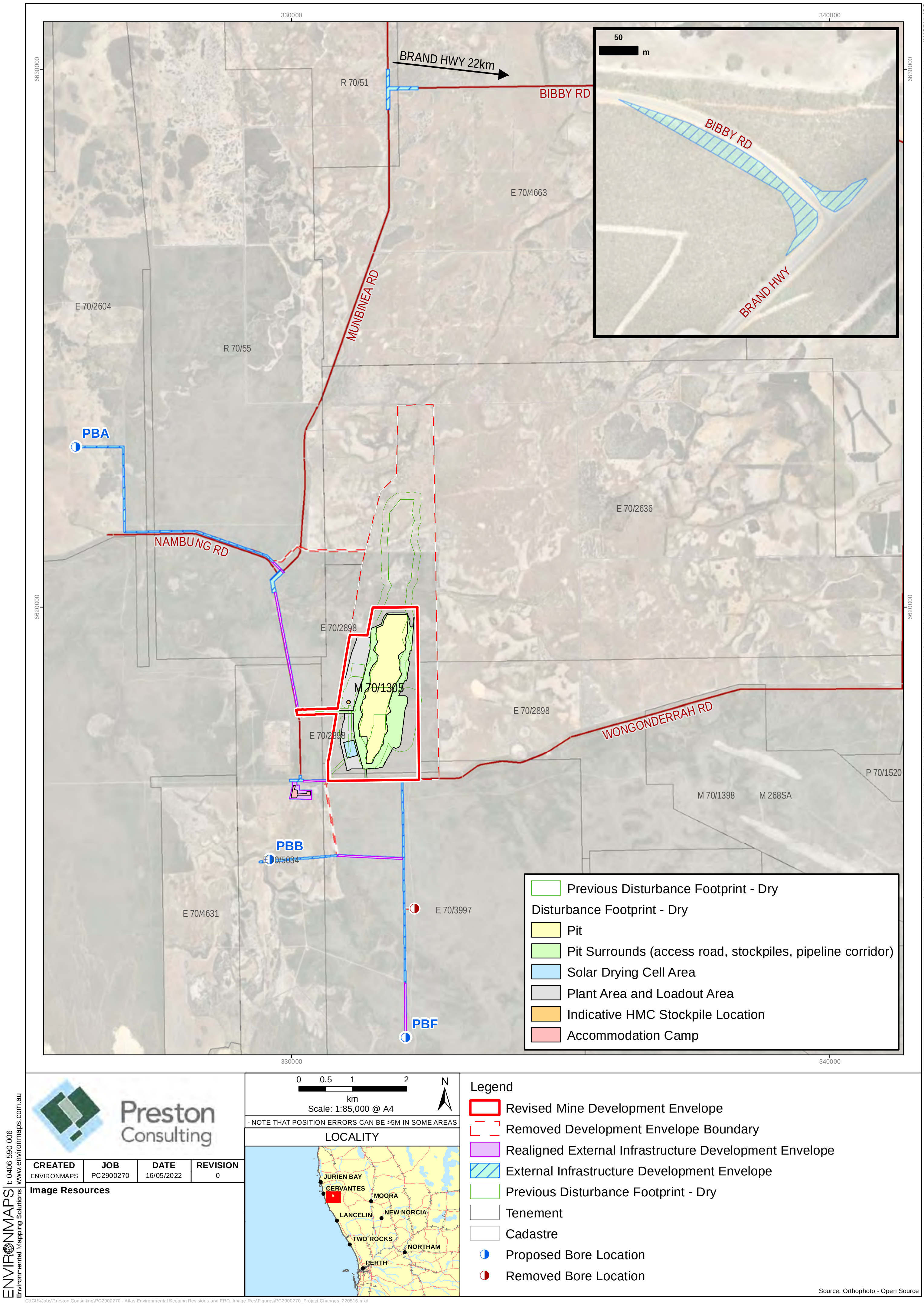


Figure 9: Changes to development envelopes and disturbance footprints since referral

2.4 LOCAL AND REGIONAL CONTEXT

The region has good existing infrastructure and logistical access, including:

- Regional centres of Cervantes, Jurien Bay, Eneabba and Lancelin;
- Sealed Brand Highway; and
- Access to existing ports.

The Proposal is located approximately 18 km southeast of Cervantes (12 km east of Indian Ocean Drive and 21 km west of Brand Hwy, in the Wheatbelt region of WA (Figure 2).

The Proposal lies within the Drummond Botanical District of the South-West Botanical Province (Beard, 1981), and comprises the Perth biogeographic subregion across majority of the disturbance footprint and some Lesueur Sandplain subregion across the northern transport corridors.

The underlying geology of the area was formed in surficial marine sediments eroded into Cretaceous basal sediments during the Pleistocene marine transgressions. The Proposal is predominantly comprised of pale deep Bassendean sands with areas of yellow deep sand, gravelly sands, sandy duplexes and wet soils (Desmond and Chant, 2001).

The land comprising the mining tenement (M70/1305) is mostly remnant vegetation, apart from the northern section which comprises degraded/cleared land. Local drainage rises on the Gingin scarp 15 – 20 km to the east at a ridge line elevation of 200–- 300 m. The Mount Jetty and Bibby Creeks flood-out and coalesce near the site in an area of very low surface gradients. The creek-lines reform and coalesce to the west as the Nambung River which discharges into Tamala Limestone 6 km east of the coast. Notable landscape features include Nambung National Park, Wongonderrah Nature Reserve and Nambung River.

2.4.1 LAND USE

The Proposal lies on land held by the Yued People, who have lived on approximately 29,000 km^2 of country between Yanchep and Coolimba for an estimated 40,000 years. The Proposal lies within the Yued Native Title (1997) determination area.

The dominant land within and surrounding the Development Envelopes include areas of remnant bushland, dry-land agriculture, conservation and Unallocated Crown Land. The greater agricultural area is located between the Badgingarra and Nambung National Parks (Figure 10). The eastern boundary of Nambung National Park is located approximately 1.5 km to the west of the mining areas and Badgingarra National Park is located approximately 16.5 km to the north-east of the MDE.

The current land use within the development envelopes is predominantly Unallocated Crown Land, Mining Act Leases and freehold farmland. Tenure and land use associated with the Proposal and surrounds are shown in Figure 3.

2.4.2 ENVIRONMENTAL ASSETS

No conservation reserves are located within the development envelopes.

The Lancelin Defence Training Area wetland system, listed in the Directory of Important Wetlands in Australia (WA119) covers approximately 25,000 ha and extends for approximately 30 km north from near Lancelin to the area located immediately to the south and southeast of the Development Envelopes (Figure 10). This wetland system is considered part of the regionally significant Bassendean Group and is recognised for its conservation values.

The eastern boundary of the Nambung National Park is located approximately 1,500 m to the west of the mine pit area. The main public access to the park is from Indian Ocean Drive to the west. The Nambung National Park Visitor Centre is located approximately 10 km SW of the Proposal area.

A portion of the survey area is mapped by DBCA as 'Banksia Dominated Woodlands of the Swan Coastal Plain' TEC (EPBC Act). '*Banksia attenuata*, *Banksia menziesii* low woodlands' and '*Banksia prionotes* low woodlands' were mapped in the survey area by 360 Environmental (2012b) and Brian Morgan (2022).

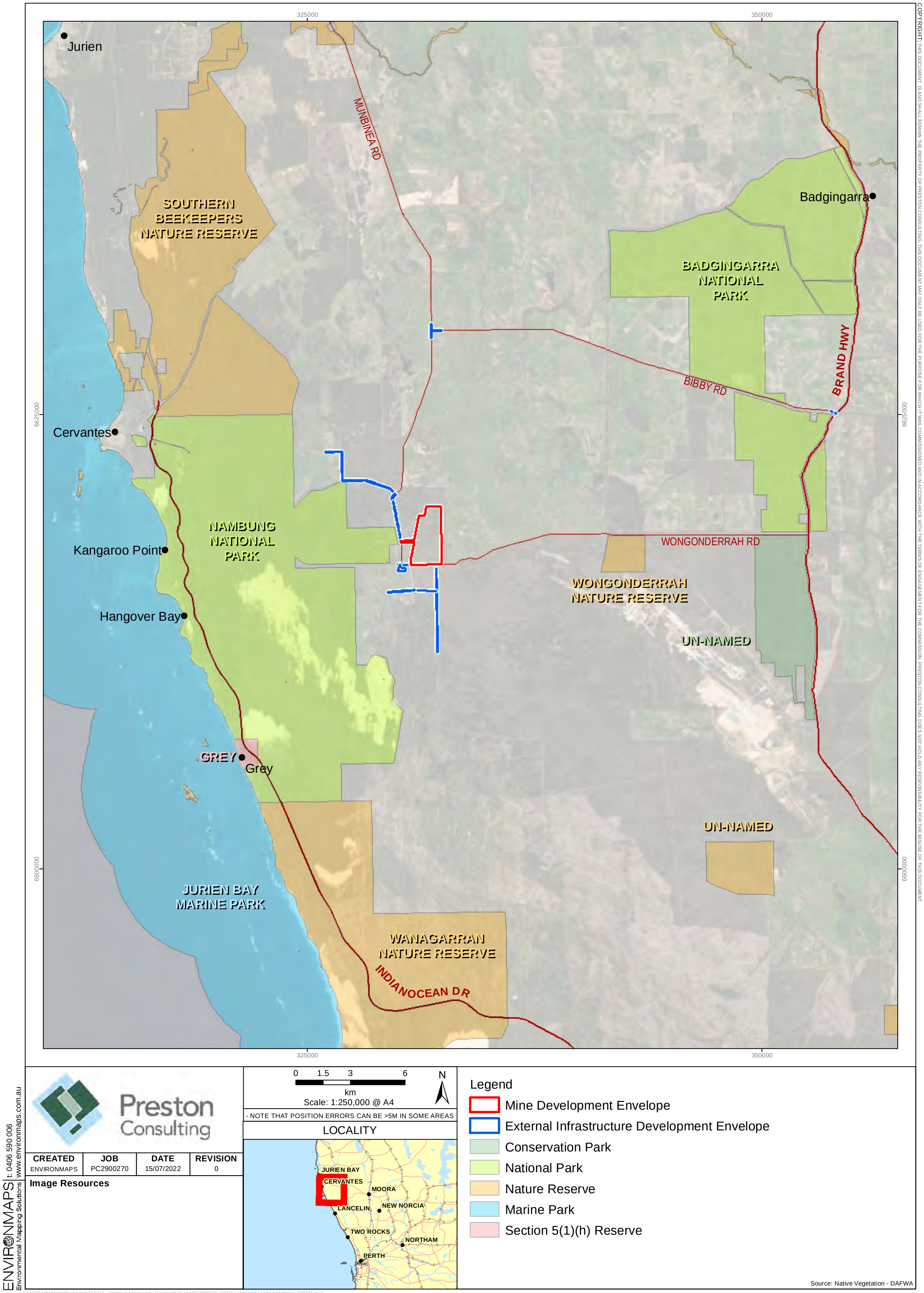


Figure 10: Conservation reserves and management areas

3 STAKEHOLDER ENGAGEMENT

3.1 KEY STAKEHOLDERS

3.1.1 GOVERNMENT STAKEHOLDERS

Commonwealth, State and Local Government authorities have been briefed on the Proposal to ensure any issues, concerns or suggestions are identified and, where appropriate, addressed or responded to by Image. The consultations have resulted in some changes to the Proposal design; however, in most cases the purpose was to provide the Government stakeholder with relevant information.

The following Government stakeholders have been consulted:

Commonwealth:
- DCCEEW.

State:
- DBCA;
- DMIRS;
- DWER (EPA Services and Water); and
- Water Corporation.

Local:
- Shire of Dandaragan.

3.1.2 CORPORATE AND COMMUNITY STAKEHOLDERS

Image recognises that individuals, companies and communities may also be interested in the impacts of the Proposal. The following corporate and community stakeholders were deemed to be relevant to this Proposal:
- South West Aboriginal Land and Sea Council (SWALSC);
- Local NGOs, community groups and Yued Traditional Owners (TOs); and
- Private Land Holders (including local communities; particularly the town of Cervantes).

3.2 STAKEHOLDER ENGAGEMENT PROCESS

Image has a Consultation Strategy which identifies key external stakeholders and determines how they will be impacted by the Proposal and what influence they have over its implementation. The aim of such extensive consultation is to develop productive relationships that ensure the Proposal is underwritten by sustainable agreements and necessary statutory approvals. The Consultation Strategy has also been developed to secure the approvals necessary for the construction and operation of the Proposal, which will require consultation with the following stakeholders:
- Local Government (including Shire);
- State Government;
- Commonwealth Government;
- Aboriginal groups with a connection to the Proposal lands; and
- Private landowners, corporate and community stakeholders.

3.3 STAKEHOLDER CONSULTATION

Image has a Stakeholder Consultation Register which maintains records of all consultations with stakeholders. The Register summarises key issues raised by stakeholders during the consultation process and describes how Image has responded to those issues. A summarised version of the Stakeholder Consultation Register is provided in Table 5 to provide details of the stakeholder consultation undertaken to-date for the Proposal. Image's stakeholder engagement plan for future engagements is summarised in Table 6.

Table 5: Stakeholder Consultation Register

Stakeholder	Date/s	Relevant issues / topics raised	Proponent response / outcome
Government Stakeholders			
DCCEEW	September 2020 (video conference) October 2020; and November 2020 (emails) November 2022	Present the Proposal EPBC Act referral and approval processes for the proposed action. Requests for additional information . Determination of Controlled Action based on: Listed threatened species and communities (section 18 & 18A); and Nuclear action (s21 & 22A). Assessment approach determined as accredited assessment at the level of public environmental review. Discussions on the DCCEEW's review of the draft ERD.	An EPBC Referral submitted in parallel with the EP Act Section 38 Referral. A memorandum addressing DCCEEW's questions was prepared by an independent radiation consultant and submitted as a response. DCCEEW to be engaged as required through the assessment process.
DBCA	April 2021 (video conference) May 2022 September 2022 October 2022 November 2022	General consultation regarding potential offsets sites and advisory to conduct site investigations and studies to determine suitability. Discussions on various programmes of work (POW) regarding investigative works on site. Discussions on DBCA's review of the draft ERD.	Image to keep DBCA informed of status of offset investigations. Discussions with Consultant Botanist regarding the applicability of Swan Coastal Plain (SCP) Floristic Community Types (FCT) to Proposal vegetation mapping. Discussion of Proposal and the approval process underway to facilitate understanding of the planned development of the Proposal.
DMIRS	January 2012 May and June 2015 August 2016 April, May and July 2021 September 2022 October 2022 November 2022	Lodgement of application for ML 70/1305. Application for Mining Tenement. Application for Mining Lease. Issue of s29 Notice from DMIRS regarding M70/1305. DMIRS refer matter to NNTT for meditation Mining Lease (ML) granted to Image. MMTS advise of grant of tenement application and reinstatement of partial block 2176 into E70/2636. Notification of survey requirements M70/1305. Letter regarding mining lease 70/1305 advising the lease had been granted and bringing attention to condition number 5. DMIRS online document receival-- Statutory declaration evidence of compliance of signed Noongar Standard Heritage Agreement (NSHA). PoW submission for water bores. Applied for disturbance of excess tonnage.	Lack of progress in reaching agreement with the Yued and noting options available to Image noted. Letter to DMIRS with update, stating commercial terms agreed, but finalisation deferred to July 2015 to enable Image to complete or progress arrangements to raise funding for projects. Notice given to SWALSC in accordance with clause 8.2(a) of Land Access Agreement. Discussion of Proposal and approval processes underway to facilitate understanding of the planned development of the Proposal.

Stakeholder	Date/s	Relevant issues / topics raised	Proponent response / outcome
		Discussions around various POWs regarding investigative works on site. Discussions DMIRS' review of draft ERD. Discussions on the Proposal Radiation Management Plan.	
DWER – EPA Services	September 2020 (video conference) October 2020 January 2021 (email) March – May 2021 (emails and phone call) July 2021 (video conference) May 2022 (video conference) August – November 2022	Present the Proposal and Pre-referral meeting. Proposal referral form submitted to the EPA under s38 of the EP Act. Chair determination provided by the EPA confirming the level of assessment as: Public Environmental Review in the form of an ERD (6-week public review) A proponent prepared ESD Preliminary key environmental factors identified Enquiries as to the progress of the ESD review. Consolidated comments on draft ESD provided by EPA. Present changes to the proposal: Revised layout. Inclusion of dredge mining option. Inclusion of water supply options and associated pipeline corridors. Discuss assessment approach. Referral of the S43A Revised layout (reduced extent of development envelopes, disturbance and clearing). Removal of dredge mining option. Addition of accommodation camp. Timing for ERD submission. ESD approval/content. Ongoing discussions on process timing and steps. Submission and responses to draft ERD	Prepare and submit Section 38 Referral in accordance with EPA advice. Prepare and submit draft ESD for EPA's review EPA advised of updated status at each point of enquiry EPA Services reviewed the document and considers amendments to be made as laid out in the letter. Revise and re-submit ESD. Termination of the assessment under Section 40A of the EP Act and re-referral. Prepare and submit 43A to EPA. Submit final ESD for approval. Finalise ERD for submission.
DWER – Water Licencing	March 2021 (email/phone calls) June 2021 (2x video conferences) July 2021 (video conference) April, May, June 2022 (email/phone calls)	Overview of hydrogeological characteristics and implications of the Proposal. Overview and discussion on modelled mitigation options. Discuss water supply options. 26D online application. Temporary allocations from target aquifers. 5G application for water allocation Further 26D applications to further investigate supply options.	Commence further hydrological investigations into water supply options Continue to liaise with DWER (Water Licencing) to discuss available allocation from target aquifers

Stakeholder	Date/s	Relevant issues / topics raised	Proponent response / outcome
	June 2022 video conference)		
Water Corporation	July 2021 May 2022	Access to Lesueur aquifer for water supply. Confirmation that Water Corporation have no immediate need for Lesueur water.	No response applicable.
Western Power	Sep 2020 Feb 2021 July 2022 through to November 2022	Powerline upgrade	Western Power designing possible upgraded powerline
Shire of Dandaragan	May, July, October, December 2021 May 2022 – November 2022	Briefing on Atlas accommodation/camp/village. Discuss the Proposal and provide information briefing. Update on the proposed haulage route. Discussion to understand the road reserves could be used for 3 phase–- power line reroute with Sunrise Energy personnel. Workforce Accommodation–- Lot 4113 Wongonderrah Rd Nambung–- Development approval. Email correspondence between Shire of Dandaragan employees with regards to the Application for Development. The Development Application had public commentary period with 6 submissions from various parties. Shire of Dandaragan proposed haulage route via Bibby/Munbinea roads. Ongoing discussions around road reserves, road usage and trial trucking.	Development of meeting minutes Discussion on Image's hesitancy to place camp accommodation at Cervantes. Travel in and out at dark /dawn or dusk is high risk to hit native fauna. Adds to the fatigue management requirements. Image to proceed with DA application. Technical Note on option analysis for Bibby / Munbinea roads to be circulated to the shire staff. Shire were open to Image's option investigation. A request was made to consider underground sections at road crossings/intersections to avoid any height restrictions on powerline and vehicles and maintenance of 10 m either side from centreline for road surface.
Community and Corporate Stakeholders			
SWALSC / Yued People Native Title Group	May 2012 (meeting) June 2012 (letter and email) July 2012 August 2012 (letter) September 2012 (email) October 2012 (meeting) April and September 2013.	Meeting with representatives of Image and Yued to enable Image to provide update on status of mining operations and intentions. Engaged with SWALSC to provide a report of suitable compensation for impact on Native Title claim. Letter to SWALSC seeking meeting. Heritage Survey request sent by SWALSC representative. Provision of final version as to compensation. Letter to SWALSC seeking meeting to negotiate access to land encompassed by M70/1305. Provision of negotiation protocol Image asked to agree with. Email to SWALSC with copy of part of expert report regarding compensation for access to land encompassed by M70/1305.	Further meetings scheduled. Development of archaeological and ethnographic Aboriginal heritage surveys. Continuing engagement between Image and SWALSC and Yued TOs throughout the life of the Proposal. No response applicable. Agreement to defer finalisation of land access agreement. Ongoing reviews and revisions of the Term Sheet. Mediation process continued until completion in November 2020 as parties had reached agreement and executed agreement.

Stakeholder	Date/s	Relevant issues / topics raised	Proponent response / outcome
	April and October 2014 November 2012 – May 2014 December 2016 June 2017 2018-– 2020 February – June 2021 December 2021 (meeting) December 2021 – January 2022 (email) March 2022 (email and video meeting); April 2022; and May 2022.	Redacted version of compensation for impact on NTC report sent to SWALSC. Meeting with SWALSC representatives prior to meeting with Yued. Yued negotiation protocol agreed and executed by all parties. Meeting in Gingin with team nominated by Yued Working Party to negotiate terms of agreement for access to land encompassed by M70/1305. Meeting to discuss heritage issues. Letter commenting on Term Sheet and seeking variation so that no payments to be made pending finance raising. Letter from SWALSC referring to meeting regarding heritage issues. Email to SWALSC seeking to defer finalisation of land access agreement until early 2015 to enable Image to undertake capital raising. Various draft Term Sheets exchanged First National Native Title Tribunal mediation. Meeting with members of the Yued Working Party to discuss changes to Term Sheet (dated Feb 2017). Only issue discussed was payment of compensation after registration of ILUA with State. Various communications to negotiate terms of Land Access Agreement. Notification of acceptance of lodgement of Image's application for a Future Act Determination to NNTT. SWALSC advised that court order to extinguish native title to be made in April 2021 Future Act Determination made by Tribunal Member Email to Image with invoice for payment due on grant of ML Initial consultation in preparation for Aboriginal heritage and Social Surroundings Surveys Multiple calls and communication with SWALSC to have the NAHA/NSHA signed for M70/1305 and activity notice for M70/1305 SWALSC and Yued heritage panel meeting cancelled following COVID19 lock down announcement Meeting to address who and how consultation with the Yued People will take place to progress the Atlas and Bidaminna projects as the ILUA has been extinguished resulting from the Atlas land compensation agreement no longer applicable. Multiple email correspondence between SWALSC representatives, Image and consultants Restarted and varied LACA correspondence Meeting organisation and meeting with SWALSC representatives	Further discussions regarding payment and compensation. Execution of Land Access Agreement by Image in July 2020 and by Yued & SWALSC in November 2020. Date of agreement agreed to be 24 November 2020. Image to submit activity notice to SWALSC to engage Yued People for proposed surveys. SWALSC to be informed of Proposal status as required. NSHA was signed and activity notice approved. SWALSC and Yued meeting to reschedule heritage survey rescheduled to suit all TOs. SWALSC agreed that all is in a flux with many proponents experiencing the same issues. It is the expectation of SWALSC that the Yued Incorporation to be registered March 2022, with the establishment of the 12-person Cultural Advisory Committee to be in place at the same time. SWALSC undertook to seek and consider how Image could commence relationship building with the Yued People and rerailing of Yued-Image land access and compensation agreement for the Atlas Project. SWALSC provided some clarity regarding the process of cultural monitors, activity notifications (email correspondence) on works planned. Main meeting discussion points developed and sent to SWALSC No outcome regarding follow up emails regarding main discussion point letter

Stakeholder	Date/s	Relevant issues / topics raised	Proponent response / outcome
		Several follow up contacts to SWALSC regarding main discussion points letter Submission of Activity Notice to SWALSC Reengagement of Cultural Monitors Social Surrounding workshop days and follow-up reporting and actions.	
Yued People	November and December 2021, March 2022 February 2022 March 2022 February – March 2022 May 2022 (message and phone calls)	Conversations with Yued representative. Meeting with Yued representative. Meeting with the Yued TOs to discuss the following: Upcoming PoW requiring cultural monitoring at Atlas; Nomination of Yued family members to conduct cultural monitoring Image representatives meet with TO Diane Yappo to discuss the Proposal. General emails and correspondence with TOs in relation to surveys and monitoring.	Email correspondence regarding Image meeting with Yued representative. Image to provide details of the next programme for nomination of culturing monitors for Atlas infiltration trenches. Image advise Diane Yappo of upcoming cultural monitoring, heritage surveys (including previous). Diane recommended other contacts to be involved in future surveys/monitoring. Discussion with Elder (Alice Worrell) regarding the involvement in survey and cultural monitoring. Image to monitor potential conflicts of interest regarding TO survey team.
NGOs and community groups	May and December 2021 (emails).	Email correspondence to NGO to include attachment regarding Accommodation Facility to receive feedback. Email to Image with feedback on Accommodation Facility.	Image to keep NGOs and community groups informed of progress.
Private landholders	2006 April 2008 – June - December 2009 February, March, October, November 2010 May 2012 July 2019 April – May, July, September 2020 February, March, May – July, September 2021 January – June 2022 November 2022	Compensation agreements Access to land for exploration Information packages Mineral Assessment Work Access agreement Survey works Project timeframe, related public road upgrades, compensation to farmers and communication pathway EPA approval status, clearing of Banksia woodland and surface water and groundwater sources on/at their property Research papers on the endemic species around Yewadabby Springs to provide to the fauna specialist on the Project Fire break, soaks on the property, bunds to reduce dust and noise and compensation Drilling activities Offset biodiversity surveys Water supply investigations	Groundwork completed on accessible parts of tenement. Access provided for surveys Image to continue liaison with private landowners

Table 6: Stakeholder Consultation Plan

Timing	Stakeholder	Type	Purpose of planned engagement	Issues to be raised
2022 – ongoing	EPA Services – DWER	Telephone, letters, email and meetings	Correspondence during assessment under Part IV of the EP Act. EPA Board meeting.	• Presentation of EIA • Draft conditions • EPA Board meeting • Compliance
2022 – ongoing	Industry Regulation – DWER	Telephone, letters, email and meetings	Correspondence to obtain works approvals under Part V of the EP Act and water Licences under the RIWI Act.	• Future Works Approvals and Licence requirements • Proposal timing (i.e., construction) • Potential environmental impacts • Compliance
2022 – ongoing	DMIRS	Telephone, letters, email and meetings	Correspondence to obtain approval for Permit of Works, Mining Proposal and MCP.	• Tenement applications • Mining Proposal and MCP assessment • Timing • Project specific requirements • Closure requirements • Compliance and Reporting • Mine Rehabilitation Fund
2022 – ongoing	DBCA	Telephone, letters, email and meetings	Advice into ongoing management of Proposal within close proximity to Priority Flora and Fauna Offset sites and management.	• Priority Flora • Priority Fauna • Offsets • Black Cockatoo monitoring and management
2022 – ongoing	Main Roads WA	Telephone, letters, email and meetings	Discussions regarding road upgrades at Bibby Road at Brand Hwy intersection.	• Future applications • Site access • Timing (i.e., construction & operation) • Operating hours • Site access/routes
2020 – ongoing	Western Power	Telephone, letters, email and meetings	Discussions regarding power supply options for site	• Powerline upgrade requirements • Potential temporary power disruption
2022 – ongoing	Mid-West Ports Authority (MWPA)	Telephone, letters, email and meetings	Correspondence to discuss terms for the export of ore as managed by MWPA.	• Future applications • Export options • Path forward for the Proposal

Timing	Stakeholder	Type	Purpose of planned engagement	Issues to be raised
2022 – ongoing	Relevant Ministers	Letters and meetings	Letter summarising the Proposal status (i.e. approvals to date and path forward).	• Approvals status • Future applications • Studies undertaken • Key findings • Path forward for the Proposal
2022 – ongoing	Local Government Authorities	Telephone, letters, email and meetings	Correspondence summarising the Proposal status (i.e. approvals to date and path forward).	• Approvals required • Future applications • Path forward for the Proposal • Local workforce availability • Export through Geraldton Port
2022 – ongoing	Yued TOs	Meetings, on Country consultation, letters and copies of approval documents	Social surroundings consultation Feedback on Proposed operations and Proposal design. Feedback on EIA documentation Engagement with Proposal development and rehabilitation	• Approvals to date • Future applications • Studies undertaken and key findings • Potential impacts and path forward for the Proposal • Potential for indigenous contracting and employment opportunities • Bush tucker/ bush medicine management • Offsets
2022 – ongoing	Non-government organisations, community groups and local land owners.	Telephone, letters, email and meetings	Input and provision of information.	• Provision of ecological information • Invitation for comment • Offsets

4 ENVIRONMENTAL PRINCIPLES

The EP Act identifies a series of principles for environmental management (Section 4a, EP Act, as amended). Image has considered these principles in relation to the development and implementation of the Proposal. Table 7 outlines how the principles relate to the Proposal.

Table 7: EP Act Principles

<table>
<tr><th>Principle</th><th>How it will be addressed by the Proposal</th></tr>
<tr><td>1. The precautionary principle
Where there are threats of serious irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
In the application of the precautionary principle, decisions should be guided by:
a. careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and
b. an assessment of the risk-weighted consequences of various options.</td><td>While Image has commissioned numerous ecological studies in order to inform the design of the Proposal, there are still several examples where a precautionary approach has been taken, such as:
• Reduction of the scale of the Proposal to negate impacts to surface water hydrology and Aboriginal cultural values;
• Minor alterations to the development envelopes to allow for better definition of water pipeline routes;
• Transporting ore as a slurry through a pipeline to avoid potential impacts to the environment caused by manual transport; and
• The addition of an accommodation camp within the EIDE to minimise traffic impacts.</td></tr>
<tr><td>2. The principle of intergenerational equity
The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.</td><td>The Proposal has been specifically designed to ensure the best-possible rehabilitation quality is achieved, with progressive rehabilitation proposed, in addition to pit backfill and seed collection. Image's Boonanarring project provides existing information and data to support rehabilitation management of the Proposal for future generations.</td></tr>
<tr><td>3. The principle of the conservation of biological diversity and ecological integrity
Conservation of biological diversity and ecological integration should be a fundamental consideration.</td><td>Ecological surveys commissioned by Image have been used to confirm the range and status of environmental values within the vicinity of the Proposal. Disturbance within areas of identified higher biological diversity (i.e., drainage lines and areas of concentrated priority flora) have been avoided by excluding them from the development envelopes. Priority has been given to maintaining natural ecological and landscape processes such as Mount Jetty Creek and Bibby Creek that comprise apart of the Nambung River system.</td></tr>
<tr><td>4. Principles relating to improved valuation, pricing and incentive mechanisms
a. Environmental factors should be included in the valuation of assets and services.
b. The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement.
c. The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste.
d. Environmental goals, having been established, should be pursued in the most cost-effective way, by establishing incentive structures, including market mechanisms, which benefit and/or minimise costs to develop their own solutions and responses to environmental problems.</td><td>As discussed in Section 2.3.3, the Proposal mine plan, design and management controls have been revised to reduce potential impacts to environmental factors.
Image has proposed for progressive backfill and rehabilitation of the mining void to reinstate the pre-existing land use.</td></tr>
</table>

Principle	How it will be addressed by the Proposal
5. The principle of waste minimisation All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment	Image propose for clay fines and sand tailings to be backfilled to the pit to reinstate the pre-mining landscape to a reasonable level. Sand tailings are deposited in the mine void using tailings cyclone stackers, followed by dried clay fines and overburden from the temporary solar ponds and stockpiles respectively. General putrescible waste will be minimised by adopting the hierarchy of waste controls; avoid, minimise, re-use, recycle and safe disposal.

5 FLORA AND VEGETATION

5.1 EPA Objective

The EPA Objective for this key environmental factor to "*protect flora and vegetation so that biological diversity and ecological integrity are maintained*".

5.2 Policy and Guidance

Relevant EPA and Commonwealth Government guidance documents for flora and vegetation are summarised in Table 8.

Table 8: Policy and guidance relevant to the Flora and Vegetation key environmental factor

Policy and Guidance	How guidance has been considered
WA Government	
Key EPA documents	
Statement of Environmental Principles, Factors and Objectives 2021 (EPA, 2021b)	This document was considered in the preparation of this ERD and to inform EIA. It was used identify the Key Environmental Factors likely to be impacted by the Proposal and the EPA's objective for each factor.
Statutory Guidelines for MCPs (DMIRS, 2020b)	This document has been considered in the design and planning of the Proposal, it has also been considered in the preparation of mitigation measures and a preliminary MCP for the Proposal.
EIA (Part IV Divisions 1 and 2) Administrative Procedures (EPA, 2021e)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
EIA (Part IV Divisions 1 and 2) Procedures Manual (EPA, 2021a)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
Instructions on how to prepare EP Act Part IV Environmental Management Plans (EPA, 2021f)	This document was considered, although not deemed to be relevant to the Flora and Vegetation environmental factor (no environmental management plan has been prepared for flora or vegetation).
Relevant EPA Factor Guidelines	
Environmental Factor Guideline-– Flora and Vegetation (EPA, 2016a)	This document was considered in the preparation of this section (Section 5) of the ERD.
Relevant EPA Technical Guidance	
Technical Guidance – Flora and Vegetation Surveys for EIA (EPA, 2016b)	This document was used to inform the survey effort required to undertake EIA for the Proposal and is referenced throughout the Flora and Vegetation report for the Atlas Project (Morgan, 2022).
Guidance Statement 6 – Rehabilitation of Terrestrial Ecosystems (EPA, 2006)	This document has been considered in the design and planning of the Proposal, it has also been considered in the preparation of mitigation measures for the Proposal, including the preparation of Image's rehabilitation strategy which forms part of the Proposal's interim MCP. (Appendix 2).
Environmental Protection Bulletin 20 – Protection of naturally vegetated areas through planning and development (EPA, 2013)	This document has been considered in scoping the location and size of the Proposal, rehabilitation and EIA.

Policy and Guidance	How guidance has been considered
Checklist for documents submitted for EIA of proposals that have the potential to significantly impact on Sea and Land factors (EPA, 2016c)	This document was considered prior to submission of the ERD.
Other Policy and Guidance	
Biosecurity and Agriculture Management Act 2007 (WA)	This document was considered during the assessment of weeds recorded in the survey area (Morgan, 2022).
Department of Parks and Wildlife (DPaW) *Phytophthora* dieback Interpreters' Manual (FEM047; DPaW, 2015)	This document was used during Terratree's dieback assessment (Terratree, 2020).
WA Environmental Offsets Policy (EPA, 2011)	This document was considered when determining and quantifying significant residual impacts and in the preparation of Image's offset package for the Proposal.
WA Environmental Offsets Guidelines (EPA, 2014a)	This document was considered when determining and quantifying significant residual impacts and in the preparation of Image's offset package for the Proposal.
WA Environmental Offsets Template (EPA, 2014b)	This document was considered when determining and quantifying significant residual impacts and in the preparation of Image's offset package for the Proposal.
Commonwealth Government	
Key Documents	
Generic guidelines for the content of a draft EPBC Act Public Environment Report (PER)/Environmental Impact Statement (EIS; including the objects and principles of the EPBC Act, 1999; DotEE, 2016a)	This document was considered in the preparation of this ERD and while undertaking EIA.
EPBC Act Environmental Offsets Policy (DSEWPaC, 2012a) – including the Offset Assessment guide	This document was considered when determining and quantifying significant residual impacts and in the preparation of Image's offset package for the Proposal.
Environmental Management Plan Guidelines (DotE, 2014a)	This document was considered, although not deemed to be relevant to the Flora and Vegetation environmental factor (no environmental management plan has been prepared for flora or vegetation).
Environmental Management Plan Guidelines – template (DotE, 2018)	This document was considered, although not deemed to be relevant to the Flora and Vegetation environmental factor (no environmental management plan has been prepared for flora or vegetation).
EPBC Act Condition Setting Policy (DAWE, 2020a)	This document was used as guidance when considering appropriate mitigation for the Proposal.
EPBC Act Outcomes-based conditions policy (DotE, 2016a)	This document was used as guidance when considering appropriate mitigation for the Proposal.
Relevant Technical Guidance	
Relevant EPBC Act listed species specific survey guidelines and protocols.	This document was used as guidance when undertaking surveys of EPBC listed species and potential survey limitations.
Relevant EPBC Act listed species specific Recovery plans, Threat Abatement Plans, Approved Conservation Advices and other documents.	This document was used as guidance to assess and manage EPBC-listed Threatened Ecological Communities (TECs) that may be impacted by the Proposal.

5.3 RECEIVING ENVIRONMENT

5.3.1 SURVEY EFFORT

Flora and vegetation desktop and field surveys have been undertaken within the development envelopes and surrounding areas. These surveys include:

- Level 2 Flora and Vegetation Survey (360 Environmental, 2012b; Appendix 3);
- Flora and Vegetation Survey for the Atlas Project (Morgan, 2022; Appendix 4);
- Spring Biological Assessment – Bibby Road, Cooljarloo (360 Environmental, 2021; Appendix 5); and
- Comprehensive and Broadscale *Phytophthora* Dieback Assessment of the Proposed Atlas Project (Terratree, 2020; Appendix 6).

The information contained within the following sections has been sourced from the reports listed above unless otherwise stated.

5.3.2 SURVEY AREA BOUNDARIES

Four survey areas are referenced in this Section:

1. Mine Envelope Survey Area (MESA; Morgan, 2022 and 360 Environmental, 2012b);
2. External Infrastructure Survey Area (EISA; Morgan, 2022);
3. Bibby Road and Brand Highway Survey Area (BBSA; 360 Environmental, 2021); and
4. Dieback Assessment Area (Terratree, 2020).

Respective Survey Areas are detailed in Figure 11 and Figure 12.

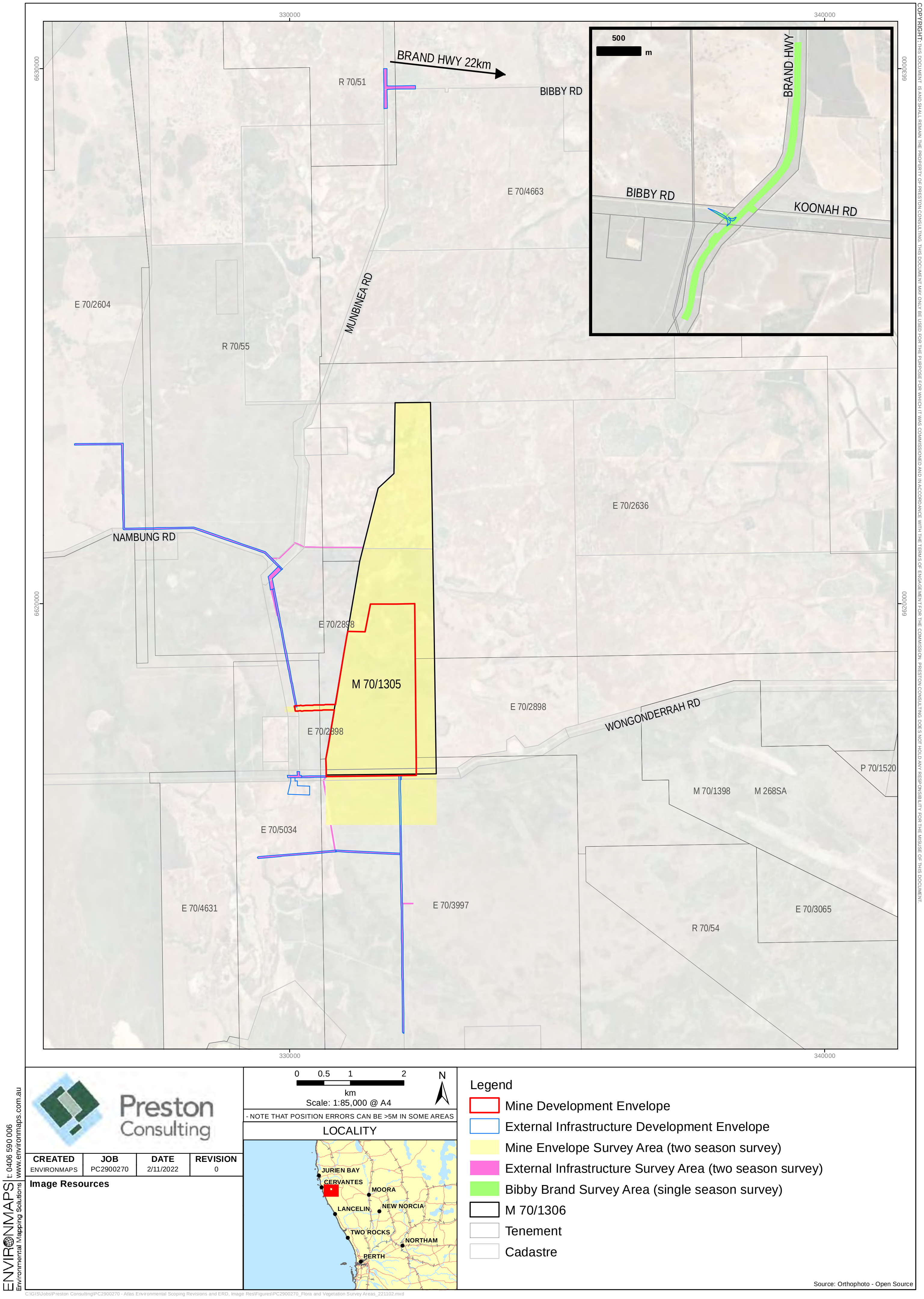
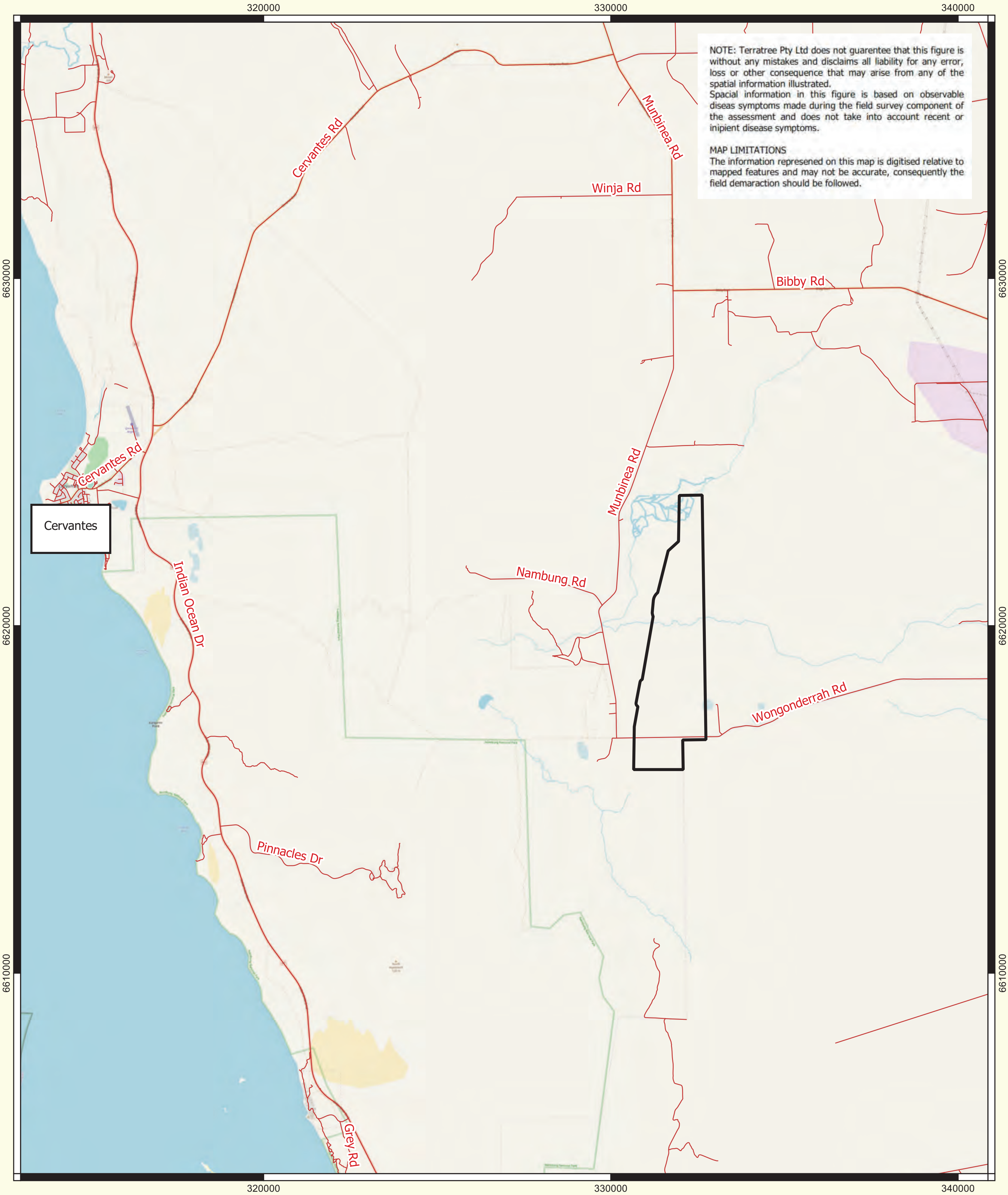


Figure 11: Flora and vegetation MESA, EISA and BBSA survey areas (360 Environmental, 2012b; 2021; Morgan, 2022)



Legend

- **▬** Assessment Area
- — Road Network

Project Location

Project Location Map

2020 Image Resources Ltd Atlas Mine Site Dieback Assessment

0 2 4 6 km

N

Datum: GDA 1994
Projection: MGA Zone 50

Scale: 1: 100000 at A3

Date: 26/11/2020	Prepared: A. Caubo	Project No: T20035
Expiry:	Checked: J. Grehan	Terratree
	Revision:	
	Review:	

Figure 12: Comprehensive and broadscale Dieback Assessment Area (Terratree, 2020)

5.3.3 Flora and Vegetation Assessments

Several flora and vegetation surveys have been conducted for the Proposal with a considerable effort focused on comprehensively surveying within M70/1305 where the main mining and processing activities are proposed. Additional surveys have also been undertaken in the local area to support various stages of mine planning including external infrastructure requirements.

A single-phase survey for flora and vegetation was initially undertaken by 360 Environmental in 2011 over part of the MESA (Figure 11; 360 Environmental, 2012b). Consultant botanist Brian Morgan was then commissioned to conduct a Detailed flora and vegetation survey in 2019, which was undertaken as a second-phase spring survey to renew and complete the 2011 survey, and include additional survey work to align the methodology with the EPA's *Technical Guidance for Flora and Vegetation Surveys* (EPA, 2016b). This survey also included new survey areas on the southern side of Wongonderrah Road, and an access corridor to Munbinea Road (the MESA, shown in Figure 11). Additional surveys were commissioned in 2021 within the EISA (Figure 11) for proposed road upgrades and water supplies from proposed bores. Second-phase surveys of EISA quadrats were undertaken by Brian Morgan in May 2022. Minor changes during project development required a re-alignment of some infrastructure corridors in the EIDE and Morgan (2022) included these areas in the EISA surveys in May 2022 (Figure 11). Morgan (2022; Appendix 4) therefore captures flora and vegetation surveys conducted between 2019 and 2022.

Following consultation with Main Roads Western Australia (MRWA), 360 Environmental were commissioned to conduct a spring biological survey focused on the intersection of Bibby Road and Brand Highway (the BBSA; Figure 11) in 2020 (360 Environmental, 2021). This survey included a Detailed flora and vegetation survey of the BBSA; a linear corridor along Brand Highway, covering approximately 30.3 ha.

A summary of flora and vegetation assessments undertaken for the Proposal is provided in the sections below. All information contained within the following sections is from Morgan (2022) unless otherwise referenced.

Desktop Assessment

Desktop assessment of relevant databases, literature and spatial data preceded the field assessments to:

- Produce a species list that represents the likely flora assembly of the survey areas;
- Identify the possible occurrence of threatened and priority flora;
- Identify the possible occurrence of TECs and PECs; and
- Identify the possible occurrence of important wetlands of the survey areas.

Databases and literature used to inform the objectives of the desktop assessments included:

- DBCA TEC and PEC database;
- FloraBase;
- DBCA NatureMap;
- EPBC Act Protected Matters Search Tool (PMST); and
- Historical documentation and vegetation mapping of the region.

Summary of Field Assessments

Field assessments of the flora and vegetation of the Proposal were conducted by 360 Environmental in 2011 and 2021, and Consultant Botanist Brian Morgan from 2019 – 2022. Table 9 details the flora and vegetation survey work undertaken to date. Figure 13 and Figure 14 show the locations of quadrats, relevés and mapping notes for the surveys.

Table 9: Survey timing

Survey Area	Spring Phase 1	Spring Phase 2	Autumn Revisit
360 Environmental, 2012b (Level 2 – Single Phase)			
Portion of MESA	29 Oct – 21 Nov 2011	-	-
360 Environmental, 2021 (Detailed and Targeted – Single Phase)			
BBSA	16 Sep – 8 Oct 2020	-	-
Morgan, 2022 (Detailed and Targeted – Multiple Phases)			
MESA	29 Oct – 21 Nov 2011	4 Oct – 13 Oct 2020	7 – 8, 18 Jun 2021
MESA	25 – 26 Oct 2019	4 – 10 Oct 2020	6 Jun 2021
MESA	10 Oct 2020	23 Nov 2020	6 Jun 2021
MESA	8 – 30 Nov 2019	5 – 12 Oct 2020	7, 8, 18 Jun 2021
MESA	13 – 14 Oct 2020	23 – 24 Nov 2020	7, 8, 18 Jun 2021
MESA	7 – 8 Nov 2020	24 Nov 2020	7, 8, 18 Jun 2021
MESA	29 Sep 2021	-	-
EISA	21 Sep – 1 Oct 2021	-	19 – 21 May 2022

The 360 Environmental (2012b) survey was conducted in accordance with methods outlined in the EPA's (2004) *Guidance for the assessment of Environmental Factors – Terrestrial Flora and Vegetation Surveys for EIA in WA (No 51)*. Subsequent surveys were conducted in accordance with revised guidance methods outlined in *Technical Guidance – Flora and vegetation surveys for EIA* (EPA, 2016b). All botanists held valid collection licences to collect flora for scientific purposes, issued under the *Biodiversity Conservation Act 2016* (WA) (BC Act).

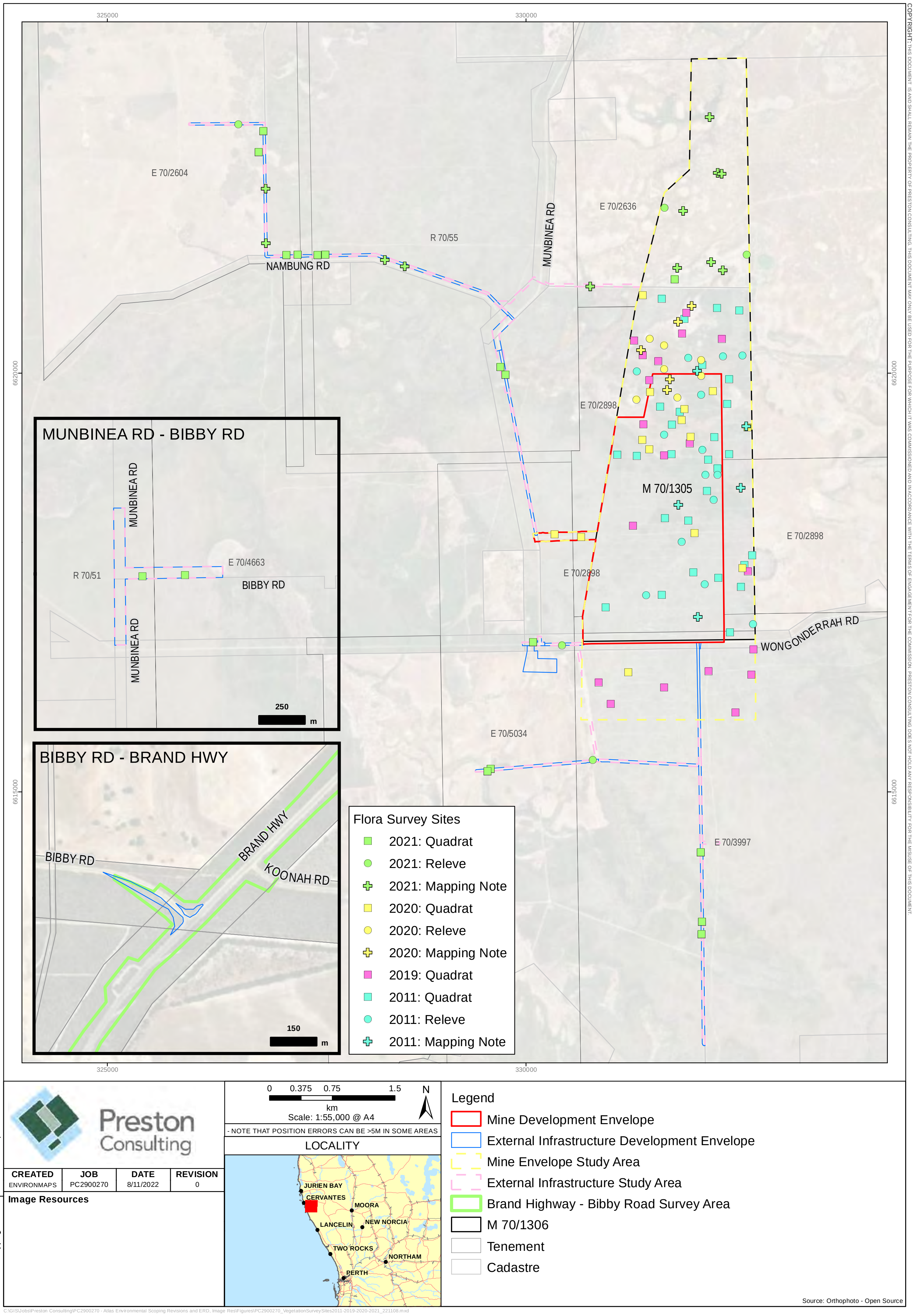


Figure 13: Locations of quadrats, relevés and mapping notes within the MESA and EISA (360 Environmental, 2014 and Morgan, 2022)

Figure 14: Locations of quadrats, relevés and mapping notes within the BBSA (360 Environmental 2021)

360 Environmental Survey (2011)

360 Environmental conducted a Level 2 flora and vegetation survey within a portion of the MESA. The purpose of this survey was to:

- Compile a comprehensive list of the flora in the survey area, including any significant flora;
- Map the vegetation and the vegetation condition;
- Assess the flora and vegetation values; and
- Report on the survey results.

The flora and vegetation survey was conducted over a 957 ha area between 29 October and 3 November 2011, and between 15 and 21 November 2011. The northern part of the MESA covered heavily disturbed freehold land predominately used for agricultural purposes, and the southern two thirds predominately consisted of remnant native vegetation on Unallocated Crown Land (UCL).

Flora and vegetation was described and recorded at quadrat, relevé and mapping note (abbreviated relevés) sites, which were selected at locations found to be representative of observed variations in vegetation. Suitable sites for the more detailed quadrats were limited to sites in 'Good' or better condition, where a good suite of species representative of each vegetation type were present. Flora species records were also compiled opportunistically while walking between the vegetation recording sites, while broadly traversing the area to map the vegetation units and when conducting general flora searches.

A total of 28, 10 m x 10 m quadrats (CQ1 – CQ28) were marked out with fence dropper stakes. All plant species occurring in a quadrat were recorded, along with their height, percentage cover and specimen number if collected. Each quadrat was photographed and the following floristic and environmental parameters were recorded:

- GPS location;
- Surrounding habitat;
- Surface soil texture and colour;
- Estimation of time since the site was last burnt;
- Description of vegetation structure using a modification of Specht's vegetation description table by Aplin (1979);
- Estimation of tree layer(s) cover (across a wider area around the quadrats); and
- Estimation of vegetation condition using the Keighery classification outlined in Bush Forever (Department of Environmental Protection, 2000b).

Where a plant species was not well known, GPS coordinates were recorded and specimens were collected, pressed, dried and later identified by comparison with specimens in the reference and research collections of the WA Herbarium (WAH), by the use of keys in various papers and books and by relevant experts on various groups of flora that occur on the Swan Coastal Plain (SCP). The DBCA Declared Rare and Priority Flora List (Smith, 2010) was consulted as required to confirm the status of plant species.

A total of 18 relevés (CBR1 – CBR16; CCR1 and 2) were also recorded to describe vegetation units. The composition of the relevé descriptions was similar to that of the quadrats, but the area described was 'open' (not a measured 10 m x 10 m space) and not all plant species in the relevé area were recorded, but rather the dominant, subdominant and some associated species were recorded. Seven mapping notes (CM1 – CBM7) were recorded.

Wetland vegetation units were classified if a number of obligate wetland species were present in the units as dominants. Obligate wetland species were considered to be those that only occur in wetland sites and therefore appeared to require wetland conditions for growth.

Vegetation condition mapping was undertaken at a broad scale by inferring vegetation condition from a sample point in a vegetation unit, across the full extent of the stand of that unit. Areas of particular disturbance that had a different condition classification to that of the same surrounding vegetation unit, were mapped discretely onto the vegetation unit map. The vegetation condition was classified according to the Bush Forever classification (Department of Environmental Protection, 2000b). Where the vegetation condition was assessed as varying between condition classes or where the subjective assessments of different field staff differed across an otherwise fairly uniform area, a vegetation condition range was applied (e.g., 'Excellent' to 'Pristine').

The Level 2 survey was conducted in partial accordance with the EPA's (2004) *Guidance for the assessment of Environmental Factors – Terrestrial Flora and Vegetation Surveys for EIA in WA (No 51)*. Full accordance was not achieved as this was a single phase survey only.

360 Environmental Survey (2021)

360 Environmental conducted a spring biological survey of the BBSA in 2020 (Figure 11; 360 Environmental, 2021). This survey included a Detailed flora and vegetation survey of a linear corridor along Brand Highway, covering approximately 30.3 ha. The purpose of the Spring Biological Survey was to:

- Undertake a desktop assessment that includes DBCA database searches and publicly available sources;
- Carry out a spring field survey of the BBSA to assess flora and vegetation;
- Report on survey results; and
- Map all spatial/mapping data collected during the survey.

The field survey included an assessment of six quadrats within the BBSA at the Bibby Road intersection, mapping notes, vegetation condition notes, opportunistic flora collections, observations, and a targeted search for significant flora. A minimum of three 10 x 10 m quadrats of (100 m^2) were installed in each representative vegetation type where possible and demarcated with fence droppers.

At each quadrat, the following was recorded:

- Site code – a unique identifier allocated to each quadrat;
- Date and recorder;
- GPS Location;
- Landform and soil description;
- Additional site descriptors – location information that might be useful in vegetation classification including slope, aspect, litter cover, bare ground cover and fire history;
- Inventory of vascular flora including the approximate height and percentage foliar cover for each taxon recorded;
- Vegetation description according to the National Vegetation Information System (NVIS), Level 5;

- Vegetation condition assessed according to the South West vegetation condition scale (EPA, 2016b); and
- Photograph of each quadrat.

Prior to the survey significant flora with the likelihood or potential to occur within the BBSA was compiled. Field personnel familiarised themselves with photographs, reference samples and descriptions of these species before conducting the survey.

The BBSA was traversed on foot and suitable habitats targeted. Where Threatened or Priority Flora were encountered in the field a GPS location was taken and individual counts were recorded, followed by a search in the local vicinity to determine if any other individuals were present nearby. Specimens of any potential significant flora that could not be identified in the field were collected for identification and lodgement at the WAH.

Broad vegetation and condition mapping was conducted in the field, with boundaries delineated over aerial photography, at a scale of 1:25,000. Broad vegetation units were refined based on taxonomic identification of flora collections, statistical analysis of data collected from the quadrats and mapping notes taken during the field survey. Vegetation condition mapping was refined based on site data and mapping notes. Finalised polygons were digitised and produced as electronic mapping data using GIS software.

Brian Morgan – Consultant Botanist Surveys (2022)

Previous flora and vegetation surveys were reviewed to define the scope of this survey. The survey was designed to update records, complete unfinished survey works and extend and where necessary, improve coverage (increase sampling intensity) to meet current Technical Guidance (EPA, 2016b) and to inform Proposal planning.

Data collected in 2011 (360 Environmental, 2012b) was considered relevant and current, given the survey area had not experienced noticeable disturbance since 2011. The 28 quadrats recorded by 360 Environmental (2012b) were permanently marked with fence droppers, and therefore allowed a second-phase re-visit in good Spring conditions, to capture the early season ephemeral herbs and complement the mid to late Spring first phase survey. Species observed in the 2020 Phase 2 survey that were also recorded in the 2011 survey were ticked off the 2011 quadrat species lists.

To ensure that overall survey results were current to Spring 2020, the 2011 vegetation unit mapping north of Wongonderrah Road was checked and the complex of vegetation units on the floodplain area was re-mapped to capture greater detail. Similarly, the 2011 vegetation condition mapping was re-assessed and re-mapped in Spring 2020, again with more detailed assessment and mapping of the floodplain area.

In the process of identifying plant specimens from the 2019/2020 survey seasons, 2011 identifications were reviewed and corrected where appropriate, to current names applied in the 2019/2020 surveys. Numerous species names and conservation statuses were updated according to taxonomic revisions since 2011.

Following a review of survey works in 2021, it was decided to undertake a site revisit in late Autumn 2021 and resample MESA quadrats to ensure that Technical Guidance (EPA, 2016b) recommendations for the supplementary survey were met.

Following the development of mining plans in 2020, external infrastructure corridors were added to the Proposal. Surveys of the EISA were therefore undertaken in September 2021 (Spring; Phase 1) with additional quadrats installed as necessary, vegetation mapped and the corridors searched for significant flora. Survey of the agricultural land to the north of MESA was also updated at this time. The Spring EISA survey was followed up in May 2022 (Autumn; Phase 2) whereby the additional quadrats and corridor realignments were surveyed and included as an addendum to Morgan(2022).

Vegetation Survey

Vegetation units were sampled at quadrat, relevé ('unbounded' sample sites) and mapping note (abbreviated relevé) sites. These sites were selected at locations that were in representative stands of the interpreted vegetation units. Suitable sites for quadrats were mostly limited to sites in 'Good' or better condition, demonstrating a good number of native species representative of that vegetation type.

During the 2019 and 2020 Spring surveys, 33 new 10 m x 10 m quadrats were established in the MESA: eight in the new area south of Wongonderrah Road (CSQ1 – CSQ8), two in the new access corridor (CNQ14, CNQ15) and 23 in the previously surveyed bushland north of Wongonderrah Road (CNQ1 – CNQ13; CNQ16 – CNQ25). The additional quadrats in the previously surveyed bushland (2011) were added to increase the number of quadrats in some of the already sampled units, and incorporate vegetation units and variation within these units that had not been previously sampled. The aim was to have recorded at least three quadrats in each vegetation unit, however, this was limited by the less than 'Good' condition of some vegetation units and the limited size of some vegetation units.

Each quadrat was photographed, and the following floristic and environmental parameters were recorded:

- GPS coordinates of quadrat corners;
- A description of the quadrat location and habitat;
- Surface soil texture and colour;
- Estimation of time since the site was last burnt;
- Description of vegetation using the NVIS structural formation classes and terminology (ESCAVI, 2003); and
- Description of vegetation condition using the classification scale for the South West Botanical Province in accordance with EPA Technical Guidance (EPA, 2016b).

All plant species observed in a quadrat were recorded, along with their height, percentage cover and specimen number if collected. Where a plant species was not well known, a specimen was collected and later identified by comparison to specimens in the reference and research collections of the WAH, by the use of keys in various papers and books and by relevant experts on various groups of flora that occur on the SCP. Where identifications could not be satisfactorily finalised, they were lodged with the WAH Identification Service (WA HIS).

When quadrats were resampled as part of a Phase 2 survey, they were re-photographed, searched for species not previously recorded and species covers were reviewed and revised where necessary. During the survey of quadrats initially recorded in Spring 2011, the Phase 2 resample included reviewing and where necessary revision of the quadrat descriptions (habitat, soils and 'time since fire' and vegetation condition), rerecording the quadrat (within the area marked by the 2011 corner pegs), ticking-off species observed that were recorded in 2011, adding any species not previously recorded, and review and where necessary revision of the species covers.

DBCA's FloraBase website was consulted as required to confirm the conservation category status of plant species in the survey areas.

Seven new relevés (CNR02 – 05, CNR07; CRK01 – 02) were also recorded in the 2019 and 2020 MESA surveys and used to describe vegetation units. Relevé descriptions was similar to that of the quadrats, however the area described was 'open' (not a measured 10 m x 10 m space) and sampling was generally less detailed, with only the dominant and subdominant species and a short list of associated plant species recorded. Twelve of the 16 relevés first recorded in 2011 were also used to describe the vegetation, with most revisited and some revised. Five new mapping notes were also recorded in the 2019 and 2020 surveys (MBN01 – 04; MNK01) and a further five that were first recorded in 2011 were retained and where necessary, revised, for use in referencing the vegetation mapping.

No new quadrats, relevés and mapping notes were recorded during the MESA supplementary survey in June 2021. All quadrats were revisited, with the exception of sites CNQ22, CNQ25 and CQ24, which were inundated or were isolated by inundation. Revisited quadrats were re-sampled and any species recorded that had not been previously listed or which provided better material for identification. While traversing to quadrats or for other survey purposes, opportunistic records were made of species not previously recorded in the survey areas.

Quadrats, relevés and mapping notes were also recorded in the 2021 and 2022 EISA survey and MESA farmland survey. The same methodology was adopted as outlined above. All of the EISA corridors were walked and searched for significant flora species.

Vegetation Unit Mapping

Vegetation units and their descriptions in the bushland portion of the MESA were derived from the 2019 and 2020 survey quadrat, relevé and mapping note site descriptions. It is estimated that the vegetation units were described at approximately the NVIS sub-association level (ESCAVI, 2003). Vegetation units and their descriptions in the farmland portion of the MESA and the EISA were made during the 2021 Spring survey and 2022 Autumn survey. Vegetation unit boundaries were mapped on a computer-generated aerial photograph while traversing the study areas, using a handheld GPS.

Vegetation was mapped in less detail to approximately 500 m beyond the MESA boundaries, by a combination of observations during searches for rare flora, aerial photograph interpretation, and broader observations from traverses along the few existing firebreaks and roads. The vegetation outside the MESA was assigned a vegetation unit code that had been applied inside the survey areas if it was considered similar or was otherwise only described using a few upper strata dominant species. External vegetation was not compared with survey areas vegetation units using detailed floristics.

Vegetation Condition Mapping

Vegetation condition mapping was largely extrapolated from the vegetation condition assessed at the sample points (quadrats, relevés and mapping notes) during the various surveys, where vegetation condition was largely consistent throughout vegetation unit stands. Substantial areas of disturbance such that the condition differed from the extrapolated vegetation condition of that stand, were mapped discretely.

Vegetation condition mapping was also informed by observations on opportunistic walks through the survey areas. This was particularly important on the MESA floodplain and associated vegetation north of Wongonderrah Road, where vegetation condition was more variable and complex. Extensive walking undertaken for the detailed vegetation unit mapping in this area also enabled more detailed vegetation condition mapping. In areas where vegetation condition of an area was very variable (ranged between two condition classes), a range of condition classes was assigned.

Wetland Vegetation and Groundwater Dependent Ecosystems (GDEs)

The wetland and GDE status of vegetation units was assigned after the field surveys. The wetland status of units was estimated by considering the presence/absence of obligate wetland species, considering the landform and drainage patterns, and by considering the 'depth-to-water table' data. Obligate wetland species were considered to be those that only occur in wetland sites and therefore appeared to require wetland conditions for growth (Hill *et al.,* 1996).

The GDE status of vegetation in the survey areas was estimated by assessing the 'type' of vegetation (wetland/terrestrial), the known GDE status of any species (particularly dominants) in the vegetation units, consideration of other habitat preferences of particular species, depth to groundwater mapping for the area and the consideration of the results of other GDE investigations undertaken in the region.

Analysis of vegetation data

Statistical analysis of the Atlas survey quadrats

To assist in synthesis of vegetation descriptions into vegetation units, Primer-7 version 7.0.13 (Primer-e, 2021) was used to quantify the similarity between quadrats. A site by species matrix with presence/absence of each species and a site by species matrix with percentage foliar cover (PFC) of each species were prepared from the quadrat data for multivariate analysis. The PFC data was transformed (square root) to improve data normality. For both data matrices, a similarity matrix based on Bray-Curtis similarities was calculated. A hierarchical agglomerative cluster analysis was undertaken and a dendrogram was computed. The strength of the analysis was checked using non metric multidimensional scaling (MDS), which produces an ordination diagram and quantifies stress. Stress of less than 0.2 represents a good fit (Clarke *et al*., 2014).

Statistical analysis for measures of sample completeness

Completeness of survey was tested by computing species accumulation curves from the presence-absence species data (Clarke *et. al.*, 2014) and comparing averages of a set of estimates of species richness (Chao1, Chao2, Jacknife1, Jacknife2, Bootstrap, Michaelis Menton (MM) and (UGE)) against actual observed richness (Sobs).

A set of species accumulation curves for the 78 quadrats recorded in the survey areas, excluding weeds, are shown in Figure 15. The different plots are different estimates of an accumulation curve. While quadrats captured 393 native species, an average of the accumulation curve indices suggests 458 species could potentially occur in the survey areas, indicating quadrats captured approximately 86% of the estimated potential number of species in the survey areas. This indicates the number of quadrats included in the survey was sufficient to capture a high percentage of the species in the survey area. It should be noted that, including opportunistic and other non-quadrat records, 487 native species were recorded in the survey areas.

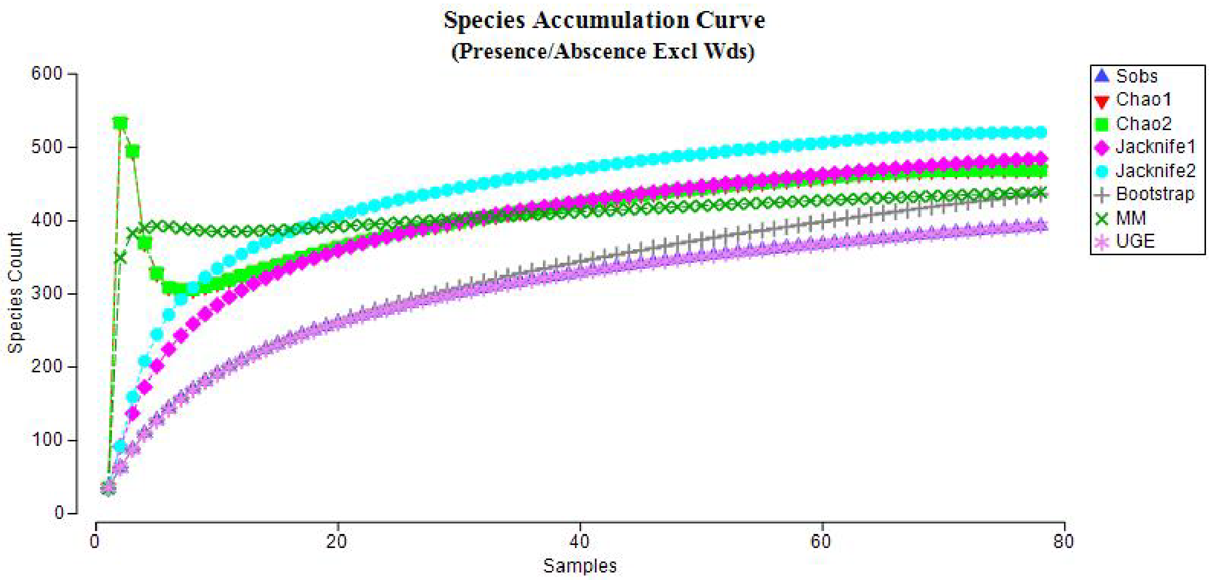


Figure 15: Atlas Species Accumulation Curves (based on Presence/absence data, excluding weeds) for the Atlas survey

Regional analysis of the Atlas quadrat data

Currently there is no suitable regional dataset with vegetation classification and conservation assessment for the northern part of the SCP, where the survey areas were located. The 'Weed and native flora data for the SCP' (DBCA, 2021c; Keighery, B. et al., 2012) dataset (2005 SCP dataset), includes 1,098 sites from the area between Dunsborough in the south to Lancelin and the Moore River in the north, but the most northerly sites in this dataset are estimated to be some 50 km south of the survey areas.

Morgan (2022) analysed the MESA and EISA quadrat data (78 quadrats) against the 2005 SCP dataset to see if some sites might be floristically similar to 'southern SCP' floristic community types (FCTs). There were significant limitations in interpreting the results of this analysis (see discussion of the limitations in Section 5.3.4). Presence/absence data, including weed species, was analysed with the 2005 SCP dataset. To improve compatibility of the two datasets, species names were reconciled with the names used in the older 2005 SCP dataset. PATN version 4.0 (PATN, 2013) was used to run the analysis as it was used by Gibson et. Al. (1994) to analyse the 1994 SCP dataset which assigned FCTs on the southern SCP. The analysis used:

- 'Two step' association measure for species;
- Agglomerative Hierarchical Fusion classification using 'Flexible UPGMA' and default group numbers;
- SSH (Semi-strong Hybrid multidimensional scaling) ordination technique; and
- Bray-Curtis association measure for columns (recommended for presence / absence (1 / 0) data where there are many more '0's than '1's (PATN, 2013)).

The single site insertion method was used to improve the PATN analysis results by reducing distortion of the site clustering. Analysis results were in the form of dendrograms and nearest neighbour lists.

Where the PATN analysis resulted in some interesting similarities, the degree of similarity between Atlas and 2005 SCP dataset sites was further explored using Primer (Primer-e, 2021) analysis. The analysis used:

- Cluster analysis and the SIMPROF test for significance;
- Ordination by Multi-Dimensional Scaling (non-metric MDS); and
- ANOSIM test 1-way layout (analysis of similarities – test for differences between groups of samples).

Flora Survey Methods

The flora survey was carried out in parallel with the vegetation survey, with records of flora species predominantly derived from quadrats, as well as relevé and mapping note data. Species records were collected through targeted flora searches, and opportunistically while broadly traversing the survey areas. Plant species not well known to the field botanists were collected and allocated a specimen number for later identification. Where observed plant species were of special interest, the location's coordinates and the numbers of species counted at these locations (and their immediate surroundings) were recorded.

Targeted significant flora searches were conducted broadly across the survey areas with focused effort in suitable habitat for target species identified in database searches and quadrat data. Surveys of Banksia Woodlands vegetation units included relevés, mapping notes, 21 individual quadrats and targeted searches. While the *Banks*ia *attenuata*, *Banksia menziesii* Low Woodland ('BaBm') vegetation unit was quite species rich (average of 56.9 native species per quadrat), it did not vary greatly floristically over most of the large area of the unit. Significant flora were only found occasionally on longer traverses through that vegetation type and more often in the fringes of adjoining wetland and heath vegetation units. As a consequence extensive targeted searches for significant flora were primarily focused on the floodplain and in the associated heath areas (preferred habitat for target species) in 2019 and 2020. In most cases, the particular habitat for a species had a meandering, convoluted form, and the targeted searches consequently followed the habitat rather than linear grids. In some areas, linear grids were walked. In the case of a few ephemeral species, searches were undertaken in the earlier Spring season when those species were in a vegetative state and flowering, while searches for perennial shrubs and rushes and sedges were generally undertaken later in the season.

An additional Targeted search took place in October 2021 with a particular focus on a search for the Threatened species *Paracaleana dixonii* and to a lesser extent *Drakaea elastica* and *Eremophila glabra* subsp. *Chlorella*. A range of habitats were visited and searched, including low heath areas on the palusplain, the transitional zone between *Banksia* woodland and the *Banksia telmatiaea* heath, the margins of *Banksia telmatiaea* heath damplands, *Callitris pyramidalis* Tall shrublands around the margins of the floodplain and some areas of *Banksia* woodlands. To improve the context of the Targeted search, a Cooljarloo site was visited where there was a past record of *Paracaleana dixonii*, and the habitat and associated vegetation observed, although no *Paracaleana dixonii* plants were seen. Similarly, another site, south of Wongonderrah Road and outside the survey areas, was visited where there was a past record of *Eremophila glabra* subsp. *Chlorella*, but no individuals were seen.

When significant flora were observed during Targeted searches, location coordinates were recorded and numbers of plants counted at that point and in the surrounding distance (up to about 20 m for the larger species). Where there was some uncertainty as to the identity of a particular plant of interest, it was collected and later identified as specified in the above Sections.

Extensive Targeted searches for significant flora were also undertaken outside the survey areas to obtain some insights into the distribution of these species and get some understanding of their abundance, allowing some comparison with numbers of species inside the survey areas. Targeted searches outside the survey areas were undertaken with a similar approach to searches inside the survey areas. Again, external searches mainly targeted the heaths and dampland areas where species of particular interest mostly occurred. External search areas included:

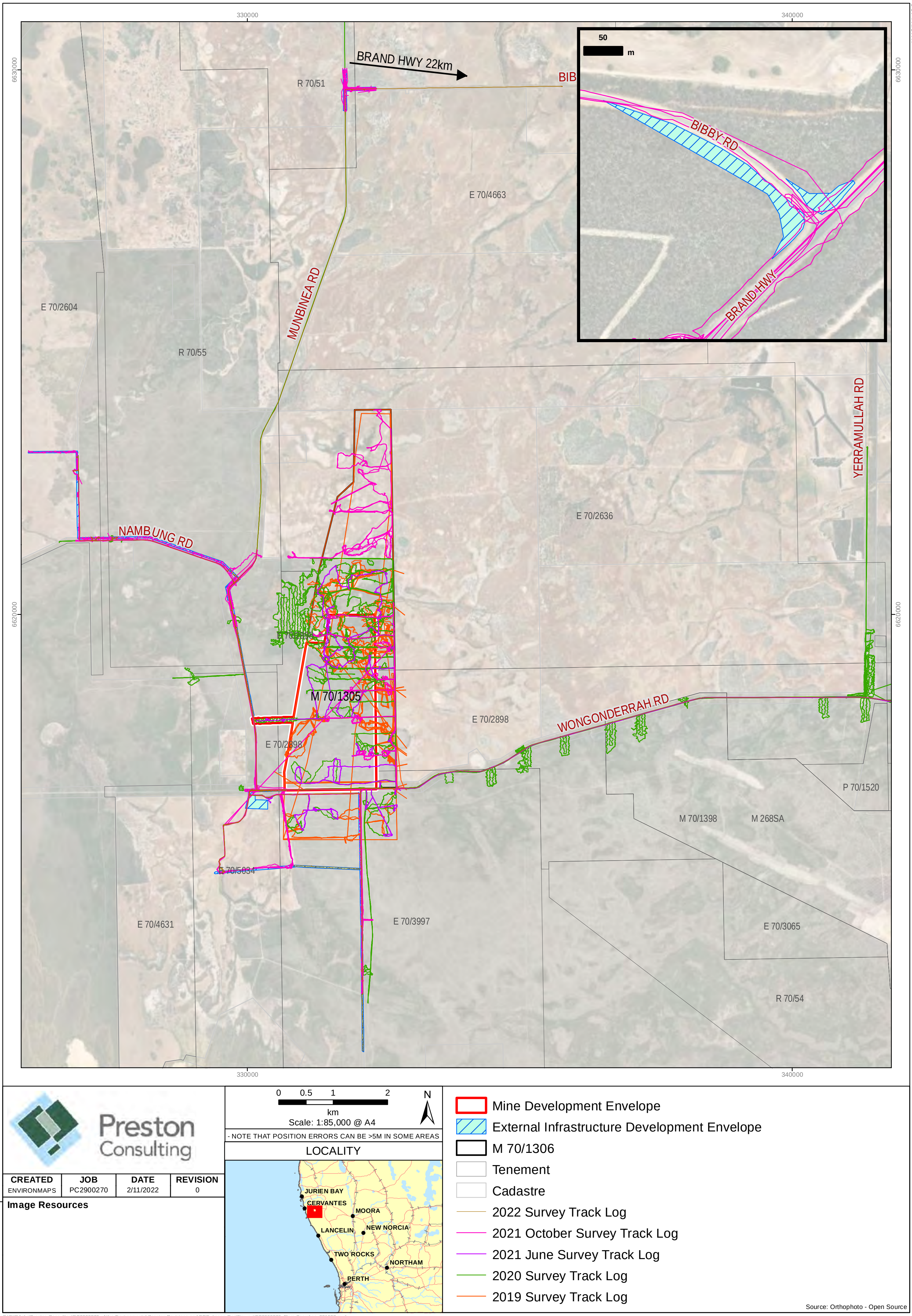
- Heaths along Wongonderrah Road (for up to 7 km east of the survey areas) and around the southern part of Yerramullah Road (north side of Wongonderrah Road) (numerous linear transects walked at a few spaced sample sites);
- In the bushland area immediately west of the MESA;
- A cursory search where a north-south track crossed Frederick Smith creek;
- Bushland on the north-west side of Munbinea Road-Wongonderrah Road intersection; and
- Flood banks of Nambung River, on the eastern side where the Nambung River crosses Munbinea Road.

Survey Timing

Figure 16 shows the timing for the recording of:

- New MESA quadrats (2019 and 2020);
- The phase 2 revisits of the new MESA quadrats and the MESA quadrats first recorded in 2011;
- The 'Supplementary' revisit of MESA quadrats;
- The update survey of the MESA area on farmland; and
- The EISA quadrat recordings.

Survey timing ensured quadrats were sampled at least once in a good season in mid-Spring (early to mid-October). Most of the Targeted significant flora searching was conducted in November of 2019 and 2020, after the other survey work was completed, as most of the species of interest were perennial species. However, Targeted searches of several ephemeral species (e.g., *Stylidium longitubum*, *Stylidium aceratum*) were undertaken in early October 2020.



Preston Consulting

CREATED	JOB	DATE	REVISION
ENVIRONMAPS	PC2900270	2/11/2022	0

Image Resources

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Environmental Mapping Solutions

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Figure 16: Survey effort

Dieback Assessment

Terratree Pty Ltd (Terratree) was commissioned in 2020 to conduct a comprehensive and broadscale survey for *Phytophthora cinnamomi* (dieback disease) within the previous (larger) MDE (the Dieback Assessment Area; Figure 12). The dieback survey was conducted in a two-stage process:

1. A desktop review of relevant, available information regarding site characteristics plus previous dieback mapping and sample results; and
2. A field assessment to observe disease symptoms, record dieback occurrence category data and collect soil and tissue samples for diagnostic testing.

The objective of the dieback survey was to map the extent of disease occurrence caused by *Phytophthora cinnamomi* within the Dieback Assessment Area, which would inform the development and implementation of a Hygiene Management Plan to be used during construction of the mine and associated infrastructure.

Desktop Study

A desktop assessment of the dieback Information Data Management System (DIDMS; Project Dieback, 2014) was conducted to collect information about the Dieback Assessment Area, surrounding landscape, and previous history of dieback surveying. The DIDMS was used to obtain data from the Vegetation Health Services (VHS) laboratory on dieback occurrence mapping and sample results from previous assessments in the area.

Field Survey

A comprehensive dieback field assessment was conducted on 3 – 13 November 2020 by a DBCA-registered dieback Interpreter in accordance with the *FEM047 Phytophthora Dieback Interpreter's Manual for Lands Managed by the Department produced by the Forest and Ecosystem Management Division* (FEMD, 2015). The field assessment included:

- A comprehensive foot search of transect corridors (maximum of 50 m wide) across the entire Dieback Assessment Area. High risk locations (including watercourses and disturbed areas) outside the Dieback Assessment Area were investigated where necessary to determine the broader landscape potential for dieback infestation; and
- Broadscale search of areas of interest and other possible disease vectors such as watercourses, historic disturbance or areas downstream/down gradient of known infestations.

The Keighery vegetation disturbance scale in the dieback Interpreter's Manual was used to determine the assess ability of vegetated areas, with a vegetation condition rating of 1-3 ('Pristine' – 'Very Good') and enough disease indicator species present enabling a diagnosis of disease status. Other areas of vegetation categorised as 'Possibly Assessable' (condition 4, 'Good') may have altered vegetation composition and structure so that it is unlikely to recover in the medium- to long-term (i.e., significant impacts including grazing, forestry harvesting, weed incursion and frequent fire events). Areas where native vegetation was significantly degraded or cleared (condition 5 – 6, 'Degraded' or 'Completely Degraded') were classified as 'Excluded from Assessment'. Non-vegetated areas were also excluded from assessment, including pasture, pits (including gravel pits), large roads (sealed and unsealed), permanently flooded areas and parkland tree stands.

The original Dieback Assessment Area was approximately 1,107 ha in size, however due to the degraded nature of the northern portion, 245 ha was excluded from the assessment resulting in a final Dieback Assessment Area is 862 ha. Spatial data, including potential disease evidence points and sample locations and photographs, were recorded using handheld GPS units.

5.3.4 Alignment with Technical Guidance

Flora and Vegetation Assessments

360 Environmental conducted the Level 2 flora and vegetation survey in partial accordance with the EPA's *Guidance for the assessment of Environmental Factors – Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (No 51)* (EPA, 2004a). Full accordance was not achieved as only a single phase survey was conducted.

Morgan's (2022) flora and vegetation field assessments were designed and conducted to renew and complete the 2011 surveys, and conducted additional works as required to include new survey areas. The Morgan (2022) and 360 Environmental (2021) surveys were conducted in accordance with the EPA's *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA, 2016b).

All surveys for the Proposal were conducted by botanists with valid collection licences to collect flora for scientific purposes, issued under the BC Act. Assessment methods were deemed to align with the EPA's guidance, however there were some unavoidable limitations, detailed in Table 10.

Table 10: Potential limitations of the Flora and Vegetation surveys

Potential Survey Limitation	Impact on Survey
Morgan (2022)	
Availability of contextual information at a regional and local scale	Not considered a limitation. Contextual information was available for flora and vegetation from broad regional studies, and from some detailed studies that were centred at Cooljarloo (about 15 km to the south-east) and extended up to the southern part of the survey areas. Considerable past Threatened and Priority flora searching has been undertaken in the Cooljarloo area. There were no regional scale quadrat-based datasets, such as the SCP datasets, that include vegetation sites from the northern end of the SCP and therefore an appropriate regional statistical analysis could not be undertaken. The most extensive SCP dataset available is the 'Weed and native flora dataset for the Swan Coastal Plain' (DBCA, 2021c; Keighery *et al.,* 2012). This dataset includes SCP site data for as far north as Lancelin and the Moore River ('southern SCP', after Keighery *et al.,* 2012) and classified vegetation in that part of the SCP into Floristic Community Types (FCTs). Lancelin and the Moore River are about 50 km south of the Atlas survey areas. Floristic variation in the vegetation on the SCP north of the Lancelin and the Moore River area (including the survey areas) was not sampled and included in the FCT classification and may not fit into that classification. Nevertheless, PATN analysis of the survey areas' quadrats was undertaken with the 'Weed and native flora dataset for the Swan Coastal Plain' dataset to see if there was some similarity of Atlas sites with 'southern SCP' FCTs.
Competency and experience of the team carrying out the survey, including experience in the bioregion surveyed	Not considered a limitation. The lead consultant botanist for the survey has eighteen years of botanical survey experience and had undertaken previous botanical survey work in the survey areas in 2011. He has undertaken other surveys in the northern SCP at Jurien Bay, Boonanarring, Bidaminna (on the north and south sides of Moore River), as well as along the Indian Ocean Drive road reserve as far north as Seabird. Kelli McCreery, Chris Hancock (quadrating) and Julia Mattner (rare flora searching) assisted with the botanical field work and all are experienced botanists.
Proportion of flora recorded and/or	Not considered a limitation. 78 quadrats were recorded in the survey areas and it is estimated that more than 2,000 specimen collections were made during the surveys. Computing species

Potential Survey Limitation	Impact on Survey
collected, any identification issues	accumulation curves suggest that the level of sampling was such that more than 90% of species are likely to have been recorded. A number of identification issues were encountered, but these were resolved by lodging a selection of specimens with the WA HIS. Generally, a major limitation of a flora survey is that any such survey is a sampling procedure of a variable environment with plant populations of variable growth habit, life span and flowering season. Some species, including annuals, are only observable for part of the year. This means that to locate all species that grow in an area is a substantial task, the success of which is related to the time available and the size and diversity of habitat in the survey areas. Consequently, it is possible that there are species present in the survey areas that were not recorded during this survey. However, this limitation was mitigated by conducting primary surveys during good Spring season and a supplementary survey and recording a substantial number of quadrats.
Was the appropriate area fully surveyed (effort and extent)	Not considered a limitation. The survey areas were fully surveyed. The survey effort is displayed in Figure 16.
Access restrictions within the Survey Area	Not considered a limitation. The wet nature of parts of the survey areas was a limiting factor in vehicle access in the MESA. Another related limitation was a self-imposed restriction of field work to in dry soil conditions, as a dieback precaution (a *Phytophthora cinnamomi* dieback survey had not been completed prior to the botanical survey). These limitations were not considered significant.
Survey timing, rainfall, season of survey	Not considered a limitation. Most quadrats had at least one sampling before mid-October, in good Spring season. However, seven of the 78 quadrats were surveyed in the MESA between the 7 – 8 November 2020. All of these 7 sites were on or adjacent to the floodplain and the vegetation was in good seasonal condition at that time, with small annual plants present. Particular limitations for the survey of the EISA Addendum Survey Area included that it was a single phase survey conducted in Autumn (Morgan, 2022b). This limitation however is mitigated by the previous (2019-2021) MESA and EISA extensive and Detailed surveys in the surrounding/adjoining areas, including extensive Targeted searches for flora of conservation significance (high level of contextual information). Furthermore, the Additional EISA survey was detailed in that the full extent of the Addendum Survey Area was traversed and searched for significant flora and other flora not previously recorded.
Disturbance that may have affected the results of survey such as fire, flood or clearing	Not considered a limitation. There were no significant disturbance events that may have affected the results of the survey. It should be noted that for the 2019/2020 surveys, the survey areas had been unburnt for a long time (estimated at more than 14 years). This would reduce the chances of finding some species that germinate after fire. This is discussed with regard to particular species in the results section.
Use of 2011 Phase 1 quadrat data	Not considered a limitation. The 2011 quadrats were marked at the four corners and the exact same area was able to be resampled (Phase 2) in good Spring conditions in early October 2020. There was no significant disturbance observed that could be attributed to the period between 2011 and the resampling time.
Vegetation mapping outside the survey area	Not considered a limitation. Vegetation mapping outside the survey areas was undertaken at a broader scale than the mapping inside the survey areas. The assignment of survey areas' vegetation codes to vegetation outside that area was indicative and made by broad observation, and was not tested by floristic analysis. Some areas of vegetation were assigned very generic labels.
GDE assessment	Unlikely to be a limitation. GDE assessments were made after referral to the literature and some discussions with peers. Detailed survey for determining GDE status were not undertaken, and the GDE determinations developed in this report should be regarded accordingly.
360 Environmental (2021)	
Availability of Data	Not considered a limitation. All data required to complete the scope of works including regional and local contextual information was available.
Access and Survey Intensity	Not considered a limitation. The survey area was able to be accessed by vehicle and on foot. The survey effort is displayed in Figure 16.

Potential Survey Limitation	Impact on Survey
Experience	Not considered a limitation. The flora and vegetation survey was undertaken by a principal botanist with 20 years' experience conducting similar surveys throughout WA and is a specialist in the south west region. Identification of flora collections was completed by experienced taxonomists at the WAH. Relevant WA Herbarium specialists were consulted for difficult specimens, and any specimens with novel characteristics were submitted to the WA Herbarium for formal identification.
Timing, weather, season	Unlikely to be a limitation. The survey was undertaken during the recommended primary survey period for the region as per the EPA Technical Guidance is Spring (September – November) in which this survey was undertaken. In the three months prior to the survey (June 2020 to August 2020), 114.9 mm of rainfall was recorded, which is 168.4 mm below the long-term average of 283.3 mm for the same time period. It is likely that additional annual and ephemeral species may have been recorded with higher rainfall volumes preceding the survey. Additionally, at the time of the survey there was no fruiting or flowering material available for many species, as a result many of the specimens collected were sterile and could not be confidently identified to species. Significant flora species identified by the likelihood of occurrence assessment with a high or medium likelihood of occurrence that are annual, ephemeral, or short-lived perennial species could occur within the survey area but have been indetectable at the time of the survey.
Life forms sampled	Unlikely to be considered a limitation. The survey area was well traversed and representative sites were sampled in all remnant vegetation types. All flora species encountered within the survey area were recorded. Of the 152 flora species collected, 11 (7.2%) were unable to be identified to species level due to the absence of required identification features such as fruits and flowers.
Completeness	Not considered a limitation. The survey was considered complete for a Detailed flora and vegetation survey, all vegetation types were surveyed and delineated within the survey area.

Dieback Assessment

The assessment was conducted by a DBCA-registered dieback Interpreter in accordance with the *FEM047 Phytophthora dieback Interpreter's Manual for lands managed by the Department produced by the Forest and Ecosystem Management Division* (FEMD, 2015).

5.3.5 FLORA

Desktop Assessment

MESA and EISA

A search of the DBCA rare flora databases was undertaken in November 2011 for an area centred on a point in the MESA, with a 10 km radius (360 Environmental, 2012b). DBCA records showed that four Threatened flora species and 23 Priority flora species had been previously recorded within the search area. A similar search of the DBCA's and WAH databases for Threatened and Priority flora (10 km radius search centred around the MESA) was undertaken in October 2019 and was further updated by a second database search in 2021 (including an area north of Bibby Road). The recent search found five Threatened flora species and 34 Priority flora species had been previously recorded within the search area (Morgan, 2022).

360 Environmental (2021) conducted searches of the DBCA Threatened and Priority Ecological Communities and Priority Flora Species custom database search tools in September 2020 with a 15 km search radius centred on the BBSA. Further searches conducted in August 2020 included the NatureMap area search with a 10 km search buffer and the PMST area search with a 10 km

search radius. The search found 23 Threatened species and 72 Priority species had previously recorded within the search area (360 Environmental, 2021) or had the potential to occur.

General Flora

A total of 575 native plant species have been recorded within the survey areas, consisting of 494 species of native flowering plants, one native cycad (the Zamia Palm, *Macrozamia fraseri*) and one native conifer (the Swamp Cypress, *Callitris pyramidalis*). In addition, 92 non-native species (weed species) were recorded in the survey areas. A total of 422 native species were recorded in the MESA, 354 native species were recorded in the EISA, and 58 native species were recorded in the BBSA.

The number of native species in flowering plant families that had the most native species in the Atlas survey areas were:

- 62 *Myrtaceae* (*Eucalyptus* family) species (including fourteen *Melaleuca* species);
- 54 *Proteaceae* (*Banksia* family) species;
- 41 *Cyperaceae* (sedge family) species (including eighteen *Schoenus* species);
- 37 *Fabaceae* (pea and *Acacia* family) species;
- 28 *Asteraceae* (daisy family) species;
- 25 *Orchidaceae* species;
- 24 *Stylidiaceae* (trigger plant family) species, (including twenty-one *Stylidium* species);
- 23 *Haemodoraceae* species;
- 21 *Asparagaceae* species;
- 19 *Restionaceae* species;
- 18 *Goodeniaceae* species;
- 17 *Ericaceae* species;
- 16 *Droseraceae* (sundew family) species; and
- 14 *Poaceae* (grass family) species.

Morgan (2022) recorded 401 native species in the MESA, which was considerably more than that recorded in the 360 Environmental (2012b) survey. This was largely due to a considerable increase in the number of quadrats recorded in the area, a second phase survey of all quadrats in good Spring season, and the addition of the survey areas south of Wongonderrah Road and the access corridor on the western side.

Of the 422 native species recorded in the MESA, approximately 415 were recorded in the southern bushland area (south of the cleared farmland). This is likely a moderate to large number for the size of that area (928 ha), reflecting the presence of the species-rich *Banksia* woodlands in the MESA and the diverse habitats and consequently, vegetation found.

Significant Flora

No Threatened Flora listed under the EPBC Act or BC Act were recorded in the survey areas.

A total of 32 Priority species were recorded, with 21 Priority species recorded in the MESA, 13 Priority species in the EISA, and nine Priority species in the BBSA (Table 11).

The results of three searches of Threatened species listed under the Australian Government's EPBC Act using the online 'Protected Matters Search Tool' (360 Environmental, 2012b; 360 Environmental 2021; Morgan, 2022) are also shown in Table 11.

Table 11: Threatened and Priority Flora potentially occurring within the survey areas (CE = Critically Endangered, E = Endangered, V = Vulnerable)

Taxon	Status:		MESA & EISA		BBSA
	BC Act	EPBC act	360 Environmental (2012b)	Morgan (2022)	360 Environmental (2021)
Andersonia gracilis	T	T (E)	Moderate to high	Moderate to high	Low
Angianthus micropodioides	P3		Recorded	Recorded	Low
Anigozanthos humilis subsp. *Chrysanthus*	P4		*Not listed*	Recorded	*Not listed*
Anigozanthos viridis subsp. *Terraspectans*	T	T (V)	Moderate to high	Moderate to high	Low
Arnocrinum gracillimum	P3		*Not listed*	*Not listed*	Recorded
Babingtonia urbana	P3		High	Recorded	Recorded
Banksia chamaephyton	P4		*Low*	*Low*	Recorded
Banksia nana	P3		*Not listed*	*Not listed*	Recorded
Beaufortia bicolor	P3		Moderate	Moderate	Recorded
Biblis gigantea	P3		Moderate	Moderate	*Not listed*
Calectasia palustris	P2		High	Recorded	Low
Chordifex reseminans	P2		High	Recorded	Low
Comesperma rhadinocarpum	P3		*Not listed*	*Not listed*	Medium
Conospermum scaposum	P3		Recorded	Recorded	Low
Conostylis pauciflora subsp. *Euryrhipis*	P4		*Not listed*	Recorded	*Not listed*
Desmocladus elongatus	P4		*Not listed*	*Not listed*	Recorded
Desmocladus nodatus (Formerly *Onychosepalum nodatum)*	P3		Recorded	Recorded	Low
Drosera leioblastus	P1		*Not listed*	*Not listed*	Medium
Drosera prophylla	P3		*Not listed*	*Not listed*	Medium
Eremophila glabra subsp. *chlorella*	T		Moderate	Moderate	*Not listed*

Taxon	Status:		MESA & EISA		BBSA
	BC Act	EPBC act	360 Environmental (2012b)	Morgan (2022)	360 Environmental (2021)
Eryngium pinnatifidum subsp. *palustre*	P3		High	Recorded	*Not listed*
Grevillea rudis	P4		*Not listed*	*Not listed*	Recorded
Grevillea thelemanniana subsp. Cooljarloo (BJ Keighery 28B)	P1		Recorded	Recorded	*Not listed*
Hensmania stoniella	P3		Recorded	Recorded	Low
Hypocalymma serrulatum	P2		*Not listed*	*Not listed*	Recorded
Isopogon panduratus subsp. *palustris*	P3		Recorded	Recorded	Low
Jacksonia carduacea	P3		Moderate to High	Recorded	Low
Lepyrodia curvescens	P2		*Not listed*	Recorded	Low
Leucopogon sp. Yanchep (M. Hislop 1986)	P3		High	Recorded	*Not listed*
Levenhookia preissii	P1		Recorded	Recorded	Low
Macarthuria keigheryi	T	T (E)	Moderate to high	Moderate to high	Low
Myriophyllum muelleri	P1		High	High	*Not listed*
Phlebocarya polpsissima subsp. *pilosissima*	P3		*Not listed*	*Not listed*	High
Phlebocarya pilosissima subsp. *teretifolia*	P2		Moderate	Moderate	*Not listed*
Scheonus badius	P2		Recorded	Recorded	*Not listed*
Schoenus griffinianus	P4		High	Recorded	*Not listed*
Schoenus pennisetis	P3		Moderate to high	Recorded	Low
Stylidium aceratum	P3		Recorded	Recorded	Low
Stylidium aeoniodes	P4		*Not listed*	*Not listed*	Medium
Stylidium hymenocraspedum	P3		Moderate	Recorded	Low
Stylidium longitubum	P4		Recorded	Recorded	*Not listed*

Taxon	Status:		MESA & EISA		BBSA
	BC Act	EPBC act	360 Environmental (2012b)	Morgan (2022)	360 Environmental (2021)
Synaphea endothrix	P3		*Not listed*	*Not listed*	Recorded
Thelymitra apiculata	P4		*Not listed*	*Not listed*	High
Thelymitra pulcherrima	P2		*Not listed*	*Not listed*	Medium
Thelymitra stellata	T	T (E)	Low	Low	Medium
Thysanotus glaucus	P4		Moderate	Recorded	Medium
Verticordia lindleyi subsp. *lindleyi*	P4		Moderate to high	Moderate to high	Low

The distribution and counts of the significant flora in the survey areas are shown in Table 12 and Figure 17 to Figure 21.

Table 12: Counts of significant flora in the survey areas and number of count locations

Species	Conservation Status	BBSA	MESA	EISA
		Number of plants	Number of plants	Number of plants
Grevillea sp. Cooljarloo (B.J. Keighery 28 B)	P1		2,405	165
Levenhookia preissii	P1		30	
Acacia benthamii	P2			1
Calectasia palustris	P2			3
Chordifex reseminans	P2		151	202
Hypocalymma serrulatum	P2	515		
Lepyrodia curvescens	P2		1	
Schoenus badius	P2		1	
Angianthus micropodioides	P3		387,300	5,911
Arnocrinum gracillimum	P3	5		
Babingtonia urbana	P3	4	832	10
Banksia nana	P3	14		
Beaufortia bicolor	P3	1		
Conospermum scaposum	P3		1,981	206
Desmocladus nodatus	P3		164	8
Eryngium pinnatifidum subsp. Palustre (G. J. Keighery 13459)	P3		1,262	104
Hensmania stoniella	P3		9	9
Isopogon panduratus subsp. *palustris*	P3		2,664	86
Jacksonia carduacea	P3		1	3
Leucopogon sp. Yanchep (M. Hislop 1986)	P3		1	
Schoenus pennisetis	P3		14	
Stylidium aceratum	P3		1,164	
Stylidium hymenocraspedum	P3		23	
Synaphea endothrix	P3	3		
Anigozanthos humilis subsp. *chrysanthus*	P4		4	2
Bansia chamaephton	P4	4		
Conostylis pauciflora subsp. *euryrhipis*	P4		1	
Desmocladus elongatus	P4	17		
Grevilea rudis	P4	100		
Schoenus griffinianus	P4		21	
Stylidium longitubum	P4		6,068	
Thysanotus glaucus	P4		11	

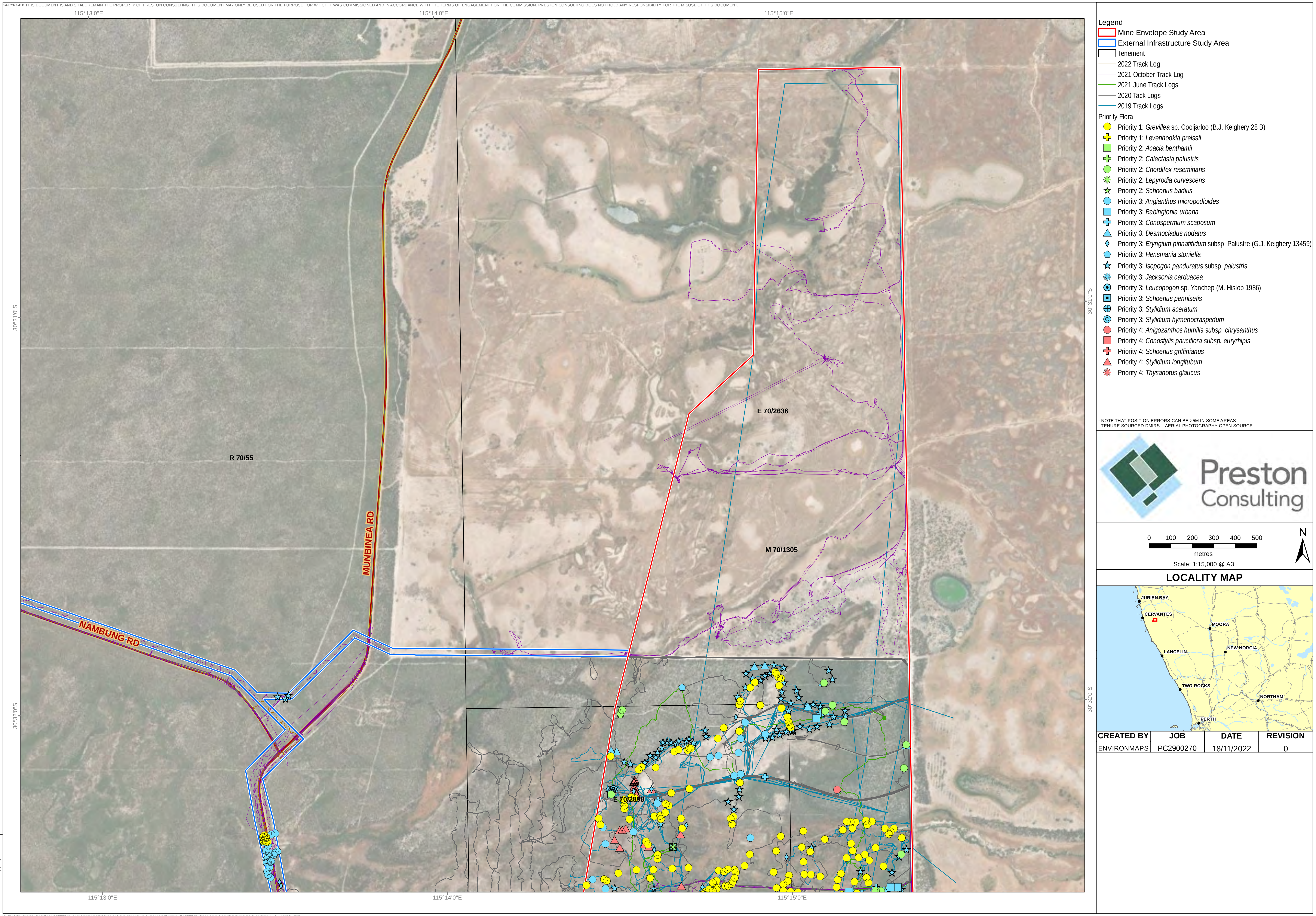


Figure 17: Significant flora records MESA & EISA (1/4)

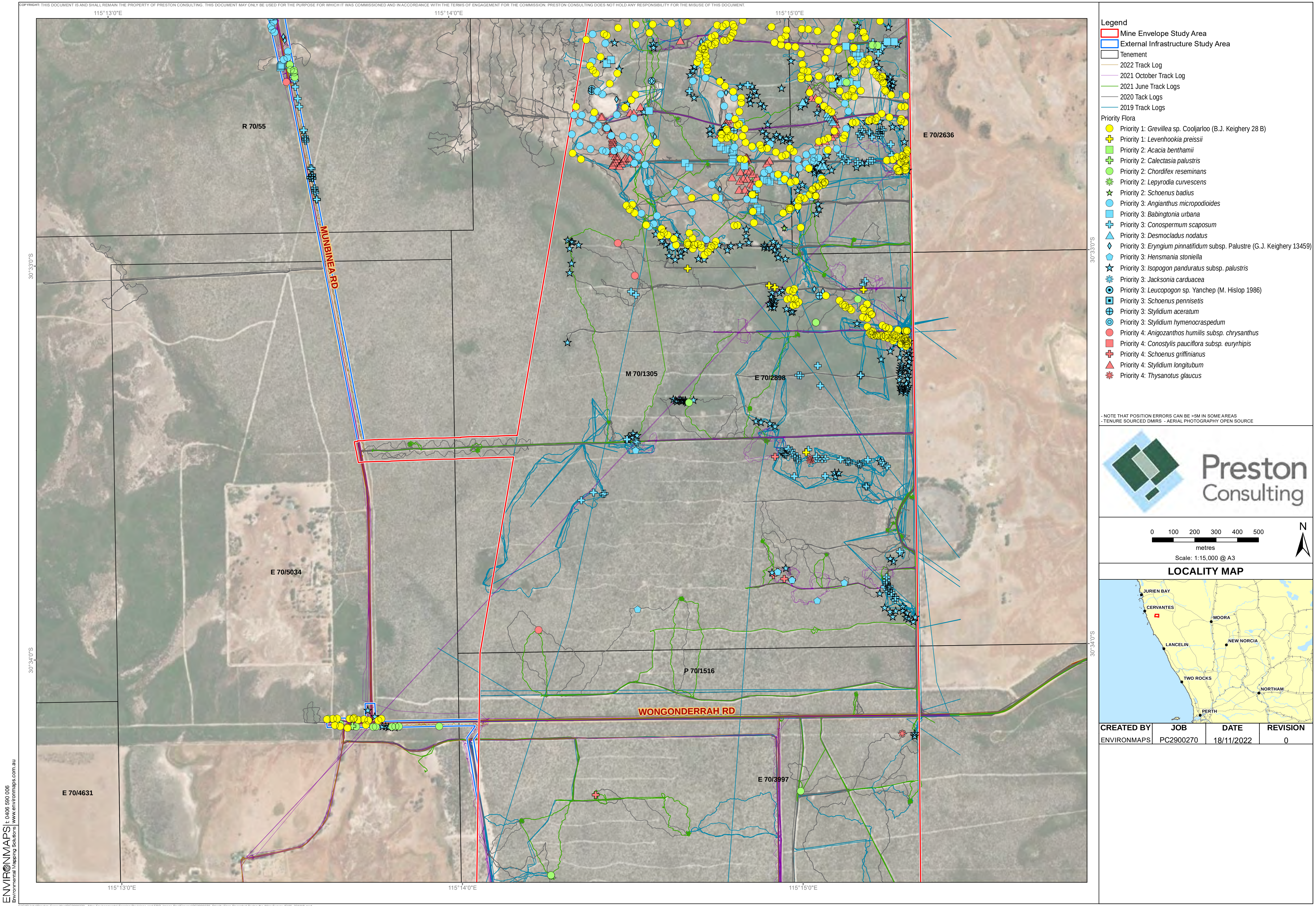


Figure 18: Significant flora records MESA & EISA (2/4)

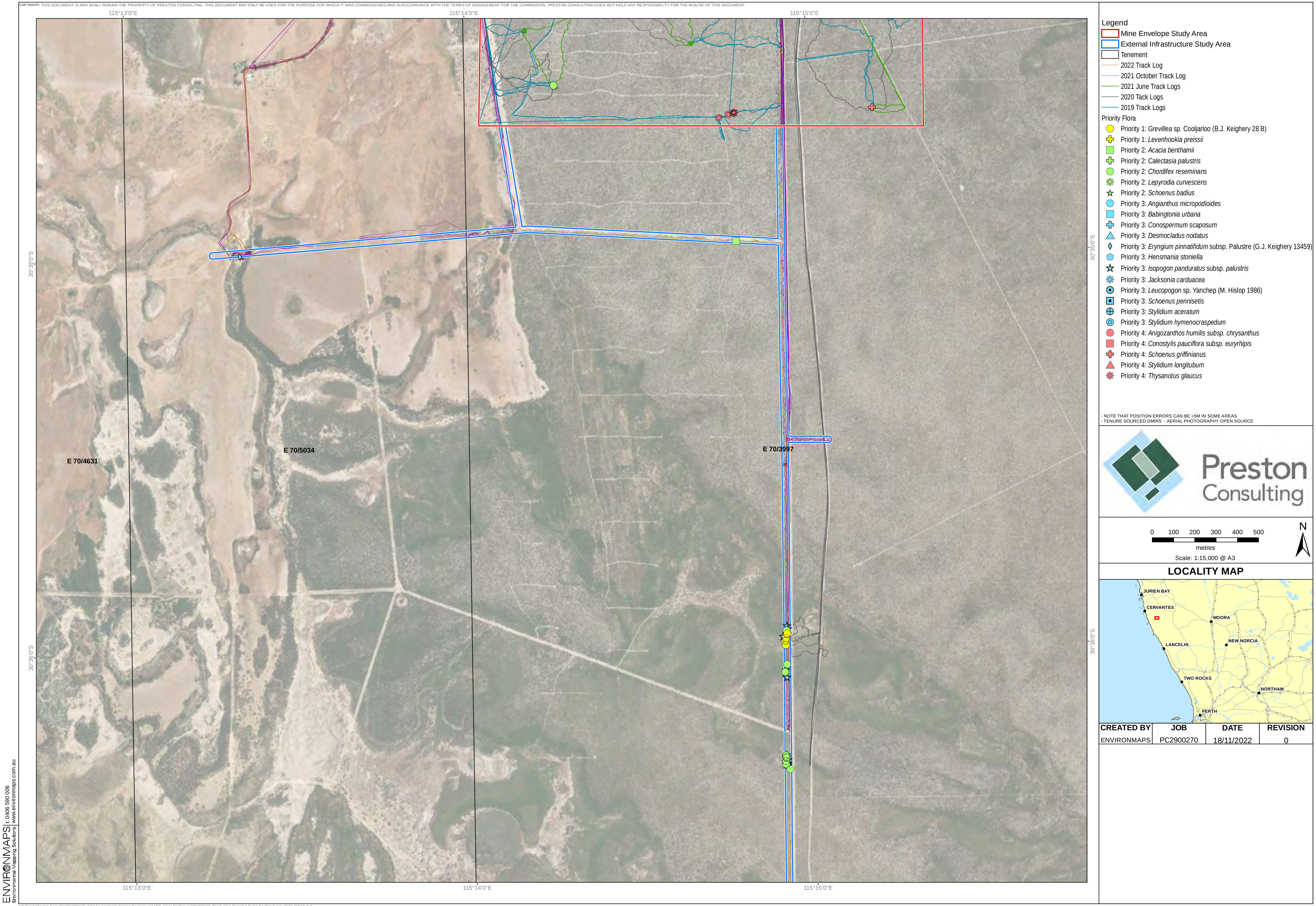


Figure 19: Significant flora records MESA & EISA (3/4)

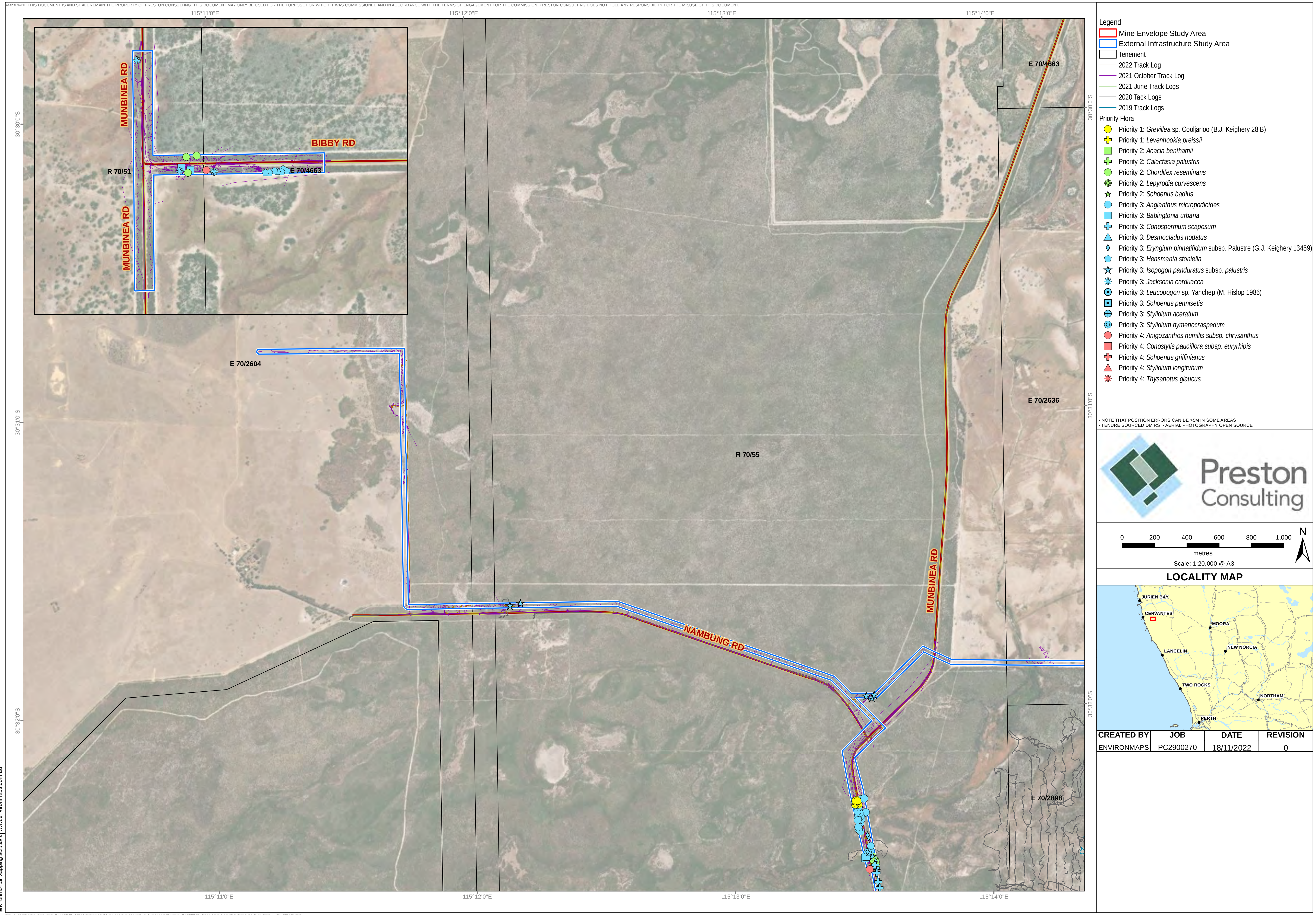


Figure 20: Significant flora records MESA & EISA (2022) (4/4)

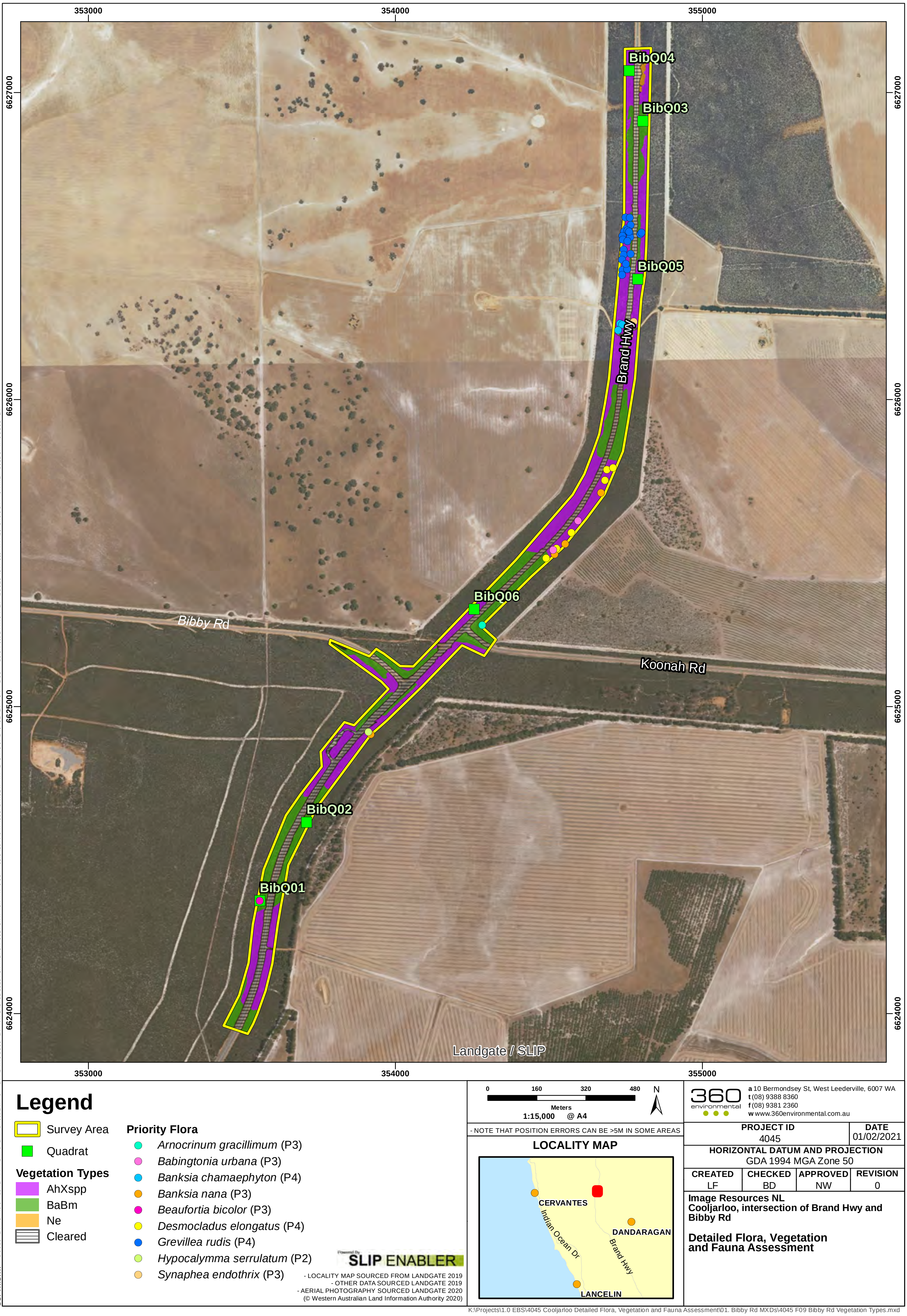


Figure 21: Significant flora records within the BBSA

Grevillea sp. Cooljarloo (B.J. Keighery 28 B) (Priority 1)

Grevillea sp. Cooljarloo (B.J. Keighery 28 B) is a low shrub generally growing to 50 - 60 cm, with dissected leaves. The identification of a number of *Grevillea* sp. Cooljarloo (B.J. Keighery 28 B) specimen collections from the survey area were confirmed by the WA HIS.

This species occurs in the MESA along the convoluted margins of the samphire floodplain and is mostly associated with *Melaleuca brevifolia* open shrublands that occur along those margins. It also occurred along the flow areas on the floodplain. It was recorded at 396 locations within the MESA and 2,405 plants were counted at those locations. These locations included some vegetation sampling sites (quadrats, relevés and mapping notes), but are mostly records from extensive targeted searches in 2019 and 2020. Consequently, the total number of plants recorded would be expected to give a reasonable indication of the absolute numbers that might occur in the MESA.

This species was also recorded at 28 locations in the EISA corridors in similar habitat to those where it was recorded in the MESA (Figure 17 - Figure 20).

Levenhookia preissii (Priority 1)

Levenhookia preissii is an annual herb with pink flowers that grows on grey or black, peaty sand in swampy areas (Paczkowska and Chapman, 2000). It occurs in two discrete areas on the SCP: around the Perth area and around the Wongonderrah Road area (FloraBase, WAH, 2021).

In 2011 *Levenhookia preissii* was recorded at five locations in the MESA, in the heaths on the margins of the floodplain, with at least three of those records being from tracks or track verges (360 Environmental, 2012b). Ten plants were recorded at one site and 16 plants at another (Appendix 3). A number of these locations were revisited in mid-October 2020, but *Levenhookia preissii* plants were not sighted at that time. However, on 7 November 2020, several plants were observed flowering in *Melaleuca seriata* heath on the margins of the floodplain. This was a new location for *Levenhookia preissii* in the MESA. The plants were small (less than 10 cm) and underneath thick heath cover and not easily observed. Several plants were also observed flowering on 21 November 2020 on the margins of *Banksia telmatiaea* heath on the south side of Wongonderrah Road, outside the MESA. The targeted searches of 2019 and 2020 were not successful in better defining the distribution of *Levenhookia preissii* in the survey area, likely as the result of the cryptic nature of this species making observation and identification difficult outside of the spring flowering season.

Acacia benthamii (Priority 2)

One *Acacia benthamii* (Priority 2) plant was recorded in the EISA East-West corridor south of Wongonderrah Rd. It was 140 cm high and was growing along an old fence line. *Acacia benthamii* has been mostly recorded between Mandurah and Guilderton, with the previous most northerly location being north-east of Cataby (DBCA Florabase website). The *Acacia benthamii* plant observed in the EISA corridor would be the most northerly location and the specimen will be lodged at the WA Herbarium.

Calectasia palustris (Priority 2)

Calectasia palustris (Priority 2) is a stilt-rooted herb with stems to 70 cm high that grows on white or grey sands in seasonally inundated swamplands (Barrett and Dixon, 2001). It is known from a small number of locations between Cervantes and Coorow.

Three plants were recorded at two locations in the EISA, on the Wongonderrah Road verge near the intersection with Munbinea Road. This species was not recorded in the MESA.

Chordifex reseminans (Priority 2)

Chordifex reseminans is a tufted, erect plant (growing in a clump) with many densely packed, upright culms, or stems, and belongs to the *Restionaceae* family (sedge-like plants). It was growing to about 60 cm in the survey area. It was recorded in the *Banksia telmatiaea* heaths and related heath vegetation growing in dampland areas and on the gentle slopes around the floodplain.

It co-occurred in the survey areas with the 'similar' looking and more common rush, *Chordifex sinuosus*. *Chordifex reseminans* can be differentiated from *Chordifex sinuosus* by having much denser clumps (short rhizomes), possessing more spikelets per culm and having purple-brown culm sheaths (less reliable) (Meney and Pate, 1999; M Hislop, WAH, pers. comm.). A selection of specimens was submitted to the WA HIS and were confirmed as *Chordifex reseminans.*

A total of 151 plants were recorded at 20 locations in the MESA and about 202 plants at 28 locations in the EISA. *Chordifex reseminans* is not a species that is readily or easily observed in the field, as it is a fairly non-descript rush growing under fairly dense heaths. While the numbers recorded in the EISA are likely to be a good estimate of the numbers in that survey area, *Chordifex reseminans* is likely to be far more abundant in the MESA survey area than the records reported here would suggest.

Hypocalymma serrulatum (Priority 2)

Hypocalymma serrulatum is an erect shrub, 0.45 - 1.7 m high that flowers in April to May. It typically grows in grey or white sand along drainage lines. The WAH has 16 specimens lodged, with records spanning between the Swan Coastal Plain and the Geraldton Sandplains regions (WAH, 2021). A total of 515 plants were recorded during Targeted flora searches by 360 Environmental (2021).

Lepyrodia curvescens (Priority 2)

Lepyrodia curvescens is a rush that has separate male and female plants and grows in dense 'tufts' or clumps, with very short rhizomes. It grows to about 40 cm height and is has been found to occur in 'seasonally inundated swampland' (WAH, 2021). It has been recorded at a number of locations extending from south of Perth on the SCP to as far north as Enneaba.

One *Lepyrodia curvescens* plant was recorded in *Callitris pyramidalis*, *Banksia telmatiaea* closed heath in the MESA. A search around the quadrat failed to find any other *Lepyrodia curvescens* plants, and they were not observed elsewhere in the heaths.

Schoenus badius (Priority 2)

Schoenus badius is a slender, annual, grass-like sedge that grows to a height of between 5 - 12 cm, and is known to grow in grey sand in moist areas (Paczkowska and Chapman, 2000). It is known from the Geraldton Sandplains biogeographic region.

Schoenus badius was recorded during the 2011 survey from one location in the MESA area in *Banksia telmatiaea* heath (quadrat CQ12; 360 Environmental, 2012b). However, in the 2019/2020 surveys, *Schoenus badius* was not collected from any of the sites and it was not observed during the Phase 2 resample of quadrat CQ12. *Schoenis pennisetus* was collected at four sites in that survey area during the 2019/2020 survey, and looks very similar to *Schoenus badius* however is microscopically differentiated by its nut having a smooth surface (with numerous rows of tiny cells) and a rounded summit (Rye, 1997), when compared to the small projections on the surface of the *Schoenus badius* nut (Mike Hislop, WA HIs, pers. comm.). It is most likely that the *Schoenus badius* recorded in the 2011 survey was a misidentification of a *Schoenus pennisetus* (P3) specimen, however this has not been established. It is noted that a similar consideration seems to have occurred regarding a *Schoenus badius* record in the Cooljarloo surveys (Woodman Environmental Consulting, 2014).

Angianthus micropodioides (Priority 3)

Angianthus micropodioides is a small, erect, annual daisy that grows to a height of 3 - 15 cm (WAH, 2021). It has been recorded on saline sandy soils on river edges, saline depressions and claypans. The identification of *Angianthus micropodioides* specimens from the survey area was confirmed by the WA HIS in 2012 and 2020.

Angianthus micropodioides occurred in large numbers over large parts of the samphire floodplain in the MESA. It grew where there was slightly elevated sand cover on the floodplain and generally did not occur in areas with high weed cover. *Angianthus micropodioides* stands were opportunistically recorded at 103 locations in the MESA with an estimated 387,300 plants. It was also recorded in the EISA in stands along the Munbinea Road verge at the Nambung River crossing.

Arnocrinum gracillimum (Priority 3)

Arnocrinum gracillimum is a rhizomatous, perennial herb, 0.2 - 0.4 m high that flowers October to November. *A. gracillimum* grows in white, grey, yellow, or lateritic sand. The WAH has 21 specimens lodged, with records spanning between the Swan Coastal Plain and the Geraldton Sandplains regions (WAH, 2020). During 360 Environmental's survey (2021), five plants of *Arnocrinum gracillimum* were recorded during targeted flora searches.

Babingtonia urbana (Priority 3)

Babingtonia urbana grew to between 40 – 80 cm in the survey area and its surrounds. It is associated with wetlands on the Swan Coastal Plain and has been recorded between Cataby and Nambung and around the Perth region (Rye, 2015; WAH, 2021). It is differentiated from *Babingtonia delicata*, that grows in the Cataby area, by its continuous circle of stamens and its larger hypanthium, fruit, and flowers. Sterile specimens are more difficult to differentiate as the two species have similar leaves and leaf length. *Babingtonia urbana* occurred in some parts of the heaths that surrounded the floodplain in the MESA. Larger stands were found associated with areas of *Melaleuca seriata* heaths near the margins of the floodplain. It did not seem to occur in large parts of the dense *Banksia telmatiaea* heaths. *Babingtonia* sp. was identified from a sterile specimen after the 2019 survey and its determination as *Babingtonia urbana* followed collection of flowering specimens in late December 2020. Some targeted and opportunistic searches for *Babingtonia urbana* in the MESA during the Spring of 2020 resulted in 47 stands being recorded and an estimated 832 plants counted. More stands of this species are likely to be present in the MESA than the records presented suggest. Ten plants were recorded in the EISA at six locations located along the Munbinea Road verge near the Nambung River crossing, and on the Bibby Road verge near the Munbinea Road intersection. Four plants were recorded during targeted flora searches of the BBSA.

Banksia nana (Priority 3)

Banksia nana is a dwarf, prostrate, lignotuberous shrub, 0.1 - 0.5 m high that flowers in October. *B. nana* typically grows on white/grey sand and/or gravel over laterite on hills. The WAH has 23 specimens lodged, with distribution spanning between the Swan Coastal Plan and Geraldton Sandplains regions.

During targeted flora searches of the BBSA, 14 plants of *Banksia nana* were recorded(360 Environmental, 2021).

Beaufortia bicolor (Priority 3)

Beaufortia bicolor is a dense shrub, 0.3 – 1.0 m high that flowers from November to December. It typically grows in white sand over laterite on sandplains. The WAH has 31 specimens lodged, with records spanning between the Swan Coastal Plain, Avon Wheatbelt and Geraldton Sandplains regions (WAH, 2020). During the survey, *Beaufortia bicolor* was recorded in quadrat BIBQ01. The specimen height was 55 cm, and it was recorded as having low cover (0.5%). The specimen grew in grey silty sand on an eastern-facing mid-slope. Laterite rocks were present on site.

Conospermum scaposum (Priority 3)

Conospermum scaposum is an erect shrub growing to approximately 50 - 60 cm, with upright basal leaves with a linear, flat blade on a long petiole. It has small compound heads of small blue flowers. It occurs on the northern Swan Coastal Plain and further inland. It was recorded in the survey areas on the margins of *Banksia* woodlands adjacent to the heaths and in some parts of the heaths. It was often recorded growing in small patches of many plants. It appeared to respond to disturbance, growing in numerous locations along old drill line tracks. A total of 1,981 *Conospermum scaposum* plants were counted at 100 locations in the MESA. *Conospermum scaposum* was also recorded at 24 locations in the EISA, totalling approximately 188 plants.

Desmocladus nodatus (Priority 3) (formerly Onychosepalum nodatum)

Desmocladus nodatus is a rush that grows in a dense tussock, generally under shrubs. It appeared to grow to approximately 20 cm in the survey area. It is restricted to an area north and north-west of Cataby (Meney and Pate, 1999; WAH, 2021).

Desmocladus nodatus was found in some parts of the *Banksia telmatiaea* heaths in the northern half of the MESA. It was usually well hidden under and at the base of shrubs and given the extent of the *Banksia telmatiaea* heaths in the survey area, it is likely to be more abundant and more widely spread than the search results suggest. It was recorded at 27 locations in the MESA, where 164 plants were recorded at sampling sites and during targeted searches. It was also recorded at five locations in the EISA.

Eryngium pinnatifidum subsp. Palustre (G. J. Keighery 13459) (Priority 3)

Eryngium pinnatifidum subsp. Palustre (G. J. Keighery 13459) is a herb that grows to 50 cm in winter wet areas and clay pans. It has been recorded between Cervantes and Mandurah.

Specimens from the EISA were identified by Mr Greg Keighery as *Eryngium pinnatifidum* subsp. Palustre (G. J. Keighery 13459). A total of 104 plants were counted at five locations in the EISA and 1,262 plants were recorded in the MESA, but due to confusion over the taxon's determination, this is expected to be a significant underestimate. This species was scattered over the MESA floodplain and was most abundant in the wetter parts of the floodplain.

Specimens from the MESA were initially identified as *Eryngium pinnatifidum* subsp. *pinnatifidum* by the WA HIS, and consequently records in the MESA, other than at quadrat and relevé sites, were limited. Following Greg Keighery's identification in 2021, the HIS was consulted again and subsequently amended their earlier identifications to *Eryngium pinnatifidum* subsp. Palustre (G. J. Keighery 13459), to make them consistent with Greg Keighery's. No formal description of *Eryngium pinnatifidum* subsp. Palustre (G. J. Keighery 13459) has been published.

Hensmania stoniella (Priority 3)

Hensmania stoniella is a small herb growing to about 20 cm. It has small basal flowers and was flowering at the time of the surveys in 2011 and 2019. *Hensmania stoniella* was recorded in *Banksia attenuata*, *Banksia menziesii* woodlands north of Wongonderrah Road in the MESA, and is most likely sparsely scattered around the margins of the *Banksia* woodlands and damplands in the survey area. Nine specimens were found at eight locations in the MESA and nine plants were also recorded in the EISA.

Isopogon panduratus subsp. palustris (Priority 3)

Isopogon panduratus subsp. *palustris* (Priority 3) (formerly *Ispopogon* sp. Badgingarra (A.S. George 14200)) is an erect shrub that grows to between 60 - 180 cm. It has olive-green leaves that are incurved with a short, spiny tip (mucro), with flowers borne in the leaf axils. It is restricted to the coastal plain from the Cooljarloo area, north-west of Cataby, to north-east of Cervantes (Hislop and Rye, 2010). It grows in winter-wet areas in heathland communities. In the survey area, this species was conspicuous in the *Banksia telmatiaea* heaths that occurred in small dampland flats and on the extensive gentle slopes on the margins of the floodplain. A total of 2,664 plants were counted at 318 locations in the MESA. Most of these were recorded during extensive targeted searches in 2019 and the total number gives a reasonable indication of the absolute numbers that might occur in the MESA. 86 plants were recorded at 29 locations in the EISA.

Jacksonia carduacea (Priority 3)

Jacksonia carduacea is an erect shrub growing to about 50 cm. It occurs along the eastern margin of the northern end of the Swan Coastal Plain and further north, on the Geraldton Sand Plain (WAH, 2021). One plant was recorded at one site in the MESA, at quadrat CNQ19, located in *Melaleuca seriata* heath. While more plants may be present in the MESA, *Jacksonia carduacea* would not be expected to be more than sparsely scattered in the MESA. Three plants were recorded in the EISA.

Leucopogon sp. Yanchep (M. Hislop 1986) (Priority 3)

Leucopogon sp. Yanchep (M. Hislop 1986) is an erect shrub that grows to 50 - 100 cm high. It occurs on the Swan Coastal Plain north of Perth. The area around Nambung would be at the northern end of its distribution. One plant was recorded at one location, in a small swale within a large area of *Banksia* woodland.

Schoenus pennisetis (Priority 3)

Schoenus pennisetis is a small annual sedge that grows to between 5 - 15 cm and is generally found in seasonally damp habitats (WAH, 2021). It was found at four different quadrats in the MESA during the 2019/2020 surveys; at two sites in *Callitris pyramidalis* tall open shrubland and at two sites in *Melaleuca seriata* heath, on the margins of the floodplain. Fourteen plants were observed in total.

Schoenus pennisetis is very similar to *Schoenus badius* and specimens were identified by the WA HIS. It is also a difficult plant to observe in the field as it was typically growing in small numbers. It is very slight and small and was found to be generally less than 10 cm tall in the survey area. *Schoenus pennisetis* may therefore be considerably more abundant than numbers recorded in the survey area to date would suggest.

Stylidium aceratum (Priority 3)

Stylidium aceratum is an annual herb that grows to a height of 5 - 9 cm and occurs on sandy soils in swamp heathland (Paczkowska and Chapman, 2000).

Stylidium aceratum was recorded at 14 dampland locations in the MESA where estimates were made of 1,164 plants (Table 12). These counts may be less accurate to the extent that specimens for verification were not collected at all stands of *S. aceratum,* leaving open the possibility of confusion with *Stylidium ecorne*.

Stylidium hymenocraspedum (Priority 3)

Stylidium hymenocraspedum is a rosetted, perennial herb to 30 - 70 cm high (FloraBase, WAH, 2021). It grows on sand in heath, shrubland or *Banksia* and/or *Eucalyptus* woodland. It was recorded near the north-west boundary of the bushland area of the MESA at quadrat CNQ10 and on and around the track nearby. Twenty three plants were recorded in *Caliitris pyramidalis* open scrub and in the nearby *Banksia prionotes* woodland.

Synaphea endothrix (Priority 3)

Synaphea endothrix is an erect clumped shrub to 0.6 m high that flowers from August to September. *S. endothrix* is associated with gravelly loam and sand, and typically grows on lateritic rises. The WAH has 16 specimens lodged with distribution restricted to the Geraldton Sandplains region. Survey of the BBSA identified a total of three plants of *Synaphea endothrix* during targeted flora searches.

Range Extensions

Many of the native plant species recorded in the survey area were at the limits of their respective recorded ranges due to the survey areas residing at the very northern end of the Perth sub-region of the Swan Coastal Plain bioregion, as well as near the southern end of the Geraldton Sandplains bioregion. Of the 32 Priority flora species recorded within the survey areas, 16 were found at or near their range limits. A total of 38 species were identified as occurring at or near their northern range limits (including 12 Priority Flora), and another 15 species were at or near their southern range limits (including 4 Priority Flora). These species are:

Species at northern limit of range:

- *Acacia benthamii* (Priority 1);
- *Anigozanthos chrysanthus* (Priority 4);
- *Anigozanthos viridus* subsp. Cataby (S.D. Hopper 1786);
- *Babingtonia urbana* (Priority 3);
- *Banksia ilicifolia;*
- *Caladenia discoidea;*
- *Comesperma virgatum;*
- *Conospermum scaposum* (Priority 3);
- *Conostylis euryrhipis* (Priority 4);
- *Conostylis festucacea* subsp. *festucacea;*
- *Daviesia incrassata* subsp. *incrassate;*
- *Desmocladus nodatus* (Priority 3);
- *Drosera closterostigma;*
- *Epilobium hirtigerum;*
- *Eryngium pinnatifidum* subsp. Palustre (G.J. Keighery 13459) (Priority 3);
- *Geranium solanderi;*
- *Hibbertia sericosepala;*
- *Hibbertia stellaris;*
- *Hypolaena pubescens;*
- *Kingia australis;*
- *Leucopogon sp.* Yanchep (M. Hislop 1986) (Priority 3);
- *Leucopogon sprengelioides;*
- *Levenhookia preissii* (Priority 1);
- *Lyginia barbata;*
- *Melaleuca cuticularis;*
- *Microtis alboviridis;*
- *Schoenus elegans;*
- *Schoenus laevigatus;*
- *Stylidium aceratum* (Priority 3);
- *Stylidium hymenocraspedum* (Priority 3);
- *Stylidium longitubum* (Priority 4);
- *Stylidium schoenoides;*
- *Styphelia propinqua;*
- *Tecticornia moniliformis;*
- *Thysanotus multiflorus;*
- *Thysanotus tenellus;*
- *Tricostularia neesii;* and
- *Triglochin minutissima*.

Species at southern limit of range:

- *Acacia dilatata;*

- *Acacia spathulifolia;*
- *Calectasia palustris* (Priority 2);
- *Conostylis aculeata* subsp. *breviflora;*
- *Drosera humilis;*
- *Drosera minutiflora;*
- *Eremaea beaufortioides var. beaufortioides;*
- *Hensmania stoniella* (Priority 3);
- *Jacksonia carduacea* (Priority 3);
- *Jacksonia hakeoides;*
- *Schoenus badius* (Priority 2);
- *Scholtzia umbellifera;*
- *Stenopetalum pedicellare;*
- *Stylidium kalbarriense;* and
- *Thysanotus teretifolius.*

Introduced Flora

None of the 92 weed species recorded in the survey areas are listed as Weeds of National Significance (WONS) (Weeds Australia, 2021). A search of the WA Organism List database (DPIRD, 2021) found one Declared Pest under the *Biosecurity and Agriculture Management Act 2007* (WA) (BAM Act) - one leaf Cape Tulip (**Moraea flaccida*). Legal Status: Declared Pest S22(2). Keeping Category: Exempt. **Moraea flaccida* was recorded on the farmland in the northern part of the MESA and in dampland areas in the EISA corridors, including at the Nambung River crossing.

5.3.6 Vegetation

The survey areas are predominantly located within the Drummond Botanical Sub-District (more or less equivalent to the Swan Coastal Plain and part of the Dandaragan Plateau) in the Darling Botanical District of the South West Botanical Province of WA (Beard, 1981). The BBSA is approximately 23 km north east of the MESA and is located within the Geraldton Sandplains bioregion and the Lesueur Sandplain (GES02) subregion.

The survey areas lie within an area of the Drummond Botanical Sub-District mapped as "*Banksia attenuata*, *Banksia menziezii* low woodland on coastal plain white sand" with "numerous patches of heath in swamps" (Beard, 1979). Beard noted that the "heath of the swampy patches varies locally", with abundant species including *Banksia sphaerocarpa*, *Calytrix aurea*, *Calytrix flavescens*, *Verticordia densiflora* and *Verticordia drummondii*, with *Frankenia* and samphire occurring in salty patches, and the whole forming a 'mosaic requiring further study'. Almost all the areas surveyed are located in the vegetation system association unit 'Bassendean 1030: Low woodland or open low woodland'. The western most end of the EISA (Nambung Road corridor) intersects vegetation system association unit 'Jurien 1029: Scrub heath – mixed heath with scattered tall shrubs *Acacia* spp.' and the BBSA intersects Lesueur 1031: Mosaic shrublands - hakea scrub-heath/Shrublands; dryandra heath.

More recently, the vegetation of WA has been assigned to bioregions and subregions under the IBRA, with the survey areas intersecting the very northern part of the Swan Coastal Plain biogeographic region and the Perth biogeographic subregion, near the southern boundary of the Geraldton Sandplains biogeographic region (Lesueur Sandplain biogeographic subregion) (IBRA V7; DCCEEW, 2021) (Figure 22).

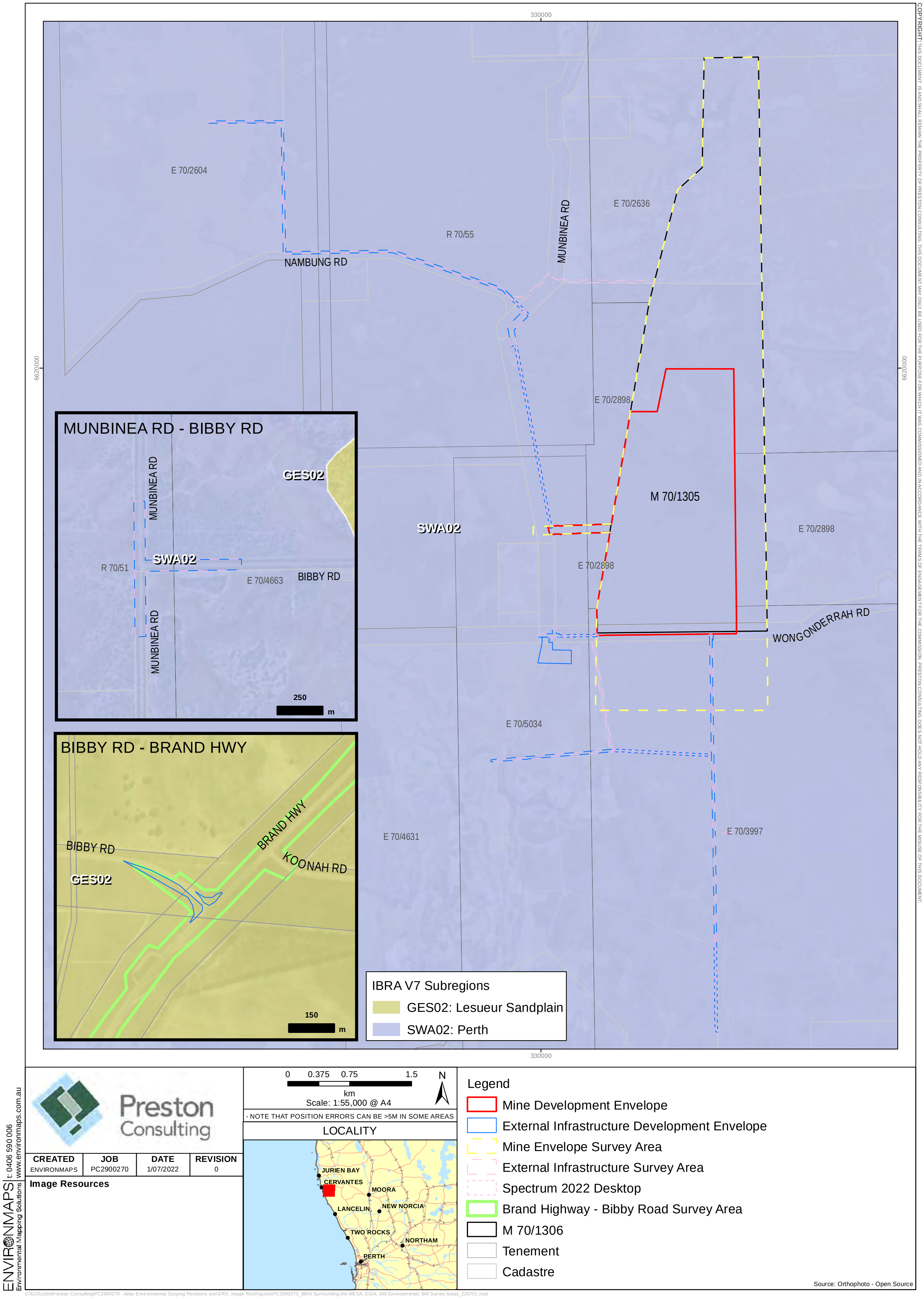


Figure 22: IBRA bioregions at the MESA, EISA and BBSA (Morgan, 2022, 360 Environmental, 2021)

Geomorphology

The MESA and EISA lie at the northern most extent of the Swan Coastal Plain, which extends from Dunsborough to just north of Jurien Bay, and is defined by inland margins at the Gingin Scarp, Dandaragan Scarp and Darling Scarp (Beard, 1981).

The Swan Coastal Plain consists of a series of geomorphological elements which are sub-parallel to the present coastline (McArthur and Bettenay, 1960; Churchward and McArthur, 1980). Each of these geomorphic elements has distinctive geology, vegetation, topography, and soils. Lowry (1974) mapped two physiographic units on the coastal plain in the Cervantes region: the westward Coastal Belt that consists of Quaternary dune systems (Quindalup Dune System and Spearwood Dune System) and the eastward Bassendean Dune System.

The MESA and EISA both lie on the Bassendean Dune System (Lowry, 1974). The Bassendean Dune System is composed of leached quartz sand and consists of low dunes with numerous inter-dunal swamps (Lowry, 1974; Beard, 1979). It takes the form of a flat plain 'behind' the Coastal Belt, about 60 - 100 m above sea level, sloping gently seaward and drained by small seasonal streams which generally terminate into large swamps or lakes near the coast or, in the case of Nambung River, drains into caves beneath the coastal limestone (Beard, 1979).

The soils of the Morgan (2022) survey areas are shown in Figure 23, with the soils in the southern half of the survey areas being mostly the leached quartz sands of the Bassendean Dune System ('Qe') and the soils in the northern area being mostly alluvium ('Qa'), with several discrete 'swamp deposits' of clayey soils ('Qp'). The western end of the EISA Nambung Road corridor passes through sections of and finishes in Tamala Limestone formation soils (Figure 23).

The BBSA occurs within the Geraldton Sandplains, on the Lesueur Sandplain. The Lesueur Sandplain subregion comprises coastal Aeolian and limestones, Jurassic siltstones, and sandstones (often heavily lateritised) of central Perth Basin. Alluvials are associated with drainage systems. There are extensive yellow sandplains in south-eastern parts, especially where the subregions overlap the western edge of the Pilbara Craton.

The soils of the 360 Environmental (2021) survey areas are shown in Figure 23 with the soils in the majority of the BBSA a ferruginous laterite ('Czl'), with several discrete regions of a leached quartz sand associated with laterite ('Czls') at the Bibby Rd/Brand Highway intersection, and in a small area to the north.

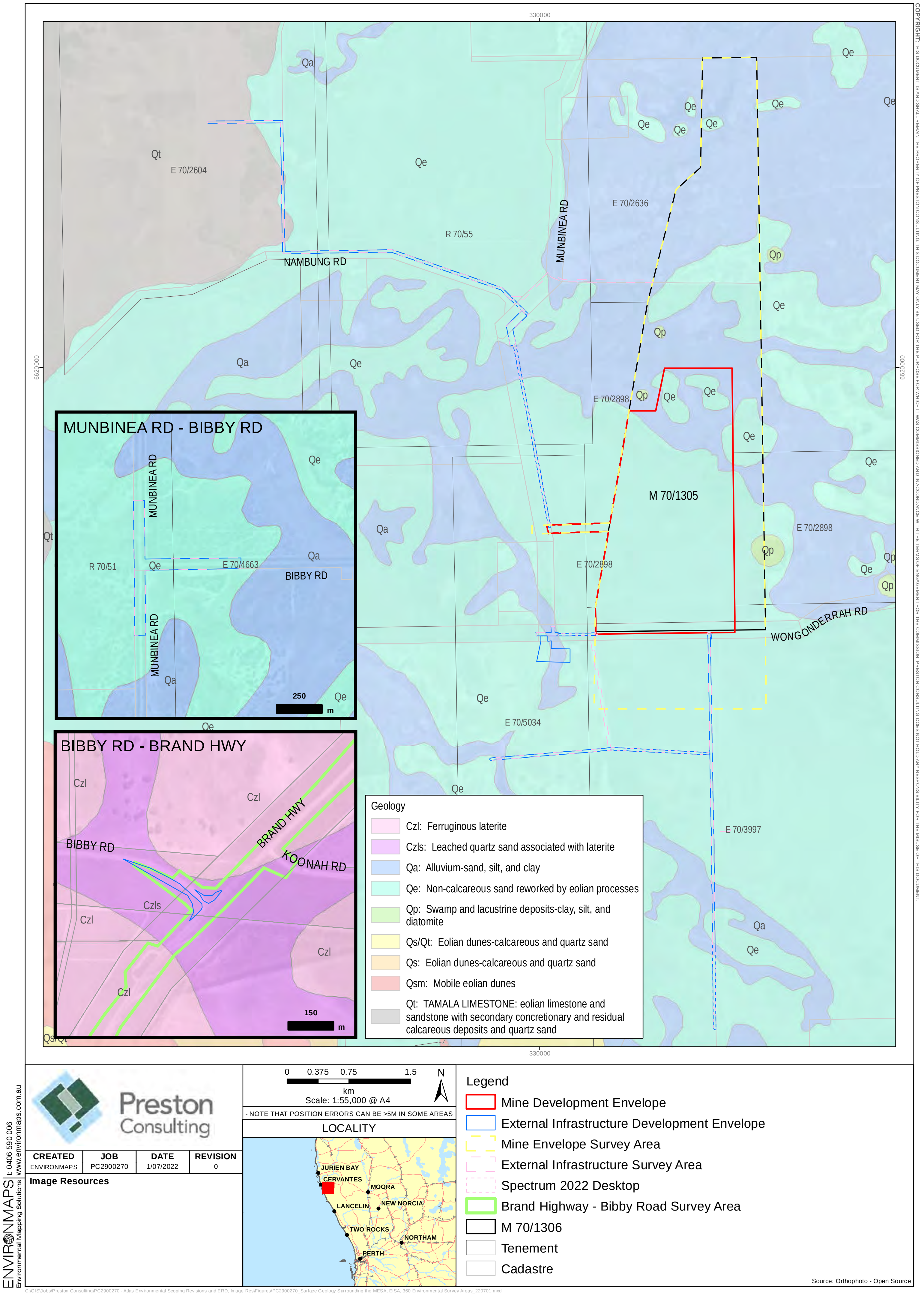


Figure 23: Surface geology surrounding the Atlas Project and 360 Environmental (2021) survey area

Regional Native Vegetation Extent

Native vegetation within 10, 15 and 20 km of the development envelopes was mapped using DPIRDs Native Vegetation Dataset and is shown in Table 13. The extent of native vegetation surrounding the development envelopes is summarised in Figure 24.

Table 13: Native vegetation surrounding the Proposal

Radius (km)	Area of native vegetation remaining (ha)	% of native vegetation remaining
Proposal Development Envelopes	471.50	89.50
10	21,609.85	68.77
15	48,893.01	69.72
20	78,214.98	68.8
25	110,098.04	67.5

Vegetation Associations

All of the MESA and most of the EISA lie within the Bassendean System in the Perth IBRA subregion, in an area mapped as vegetation system association Bassendean 1030 (Table 14; Figure 25). This vegetation association is described as "Low woodland or open low woodland: Other acacia, banksia, peppermint, cypress pine, casuarina, York gum *Acacia* spp., *Banksia* spp., *Agonis flexuosa*, *Callitris* spp., *Allocasuarina* spp., *Eucalyptus loxophleba*." The western-most section of Nambung Road EISA corridor, an area of 1.3 ha, is in vegetation association 'Jurien 1029' and lies entirely in cleared farmland. As none of this area is currently bushland that might be impacted by clearing or other disturbance, the pre-European extent of the Jurien 1029 vegetation system association in the Perth IBRA sub-region is not included in Table 14.

Table 14: Vegetation associations within the MESA and EISA

Pre-European System	Vegetation Association	State-wide pre-European extent (ha)	State-wide extent remaining (ha)	State-wide extent protected for conservation (ha)	Survey Areas	
					Area of Intersection (ha)	Proportion of remaining extent (%)
Bassendean	1030	139,013	88,950 (64.0%)	13,432.67 (9.6%)	1,255.2	1.57

69.7% (79,561 ha) of the pre-European extent of the Bassendean 1030 vegetation association in the Perth IBRA sub-region, remains, and 64% state-wide. Of the 'current extent' of Bassendean 1030 vegetation system association in the Perth IBRA subregion, 9.7% is protected for conservation. It should be noted that the vegetation system associations are very broad vegetation units.

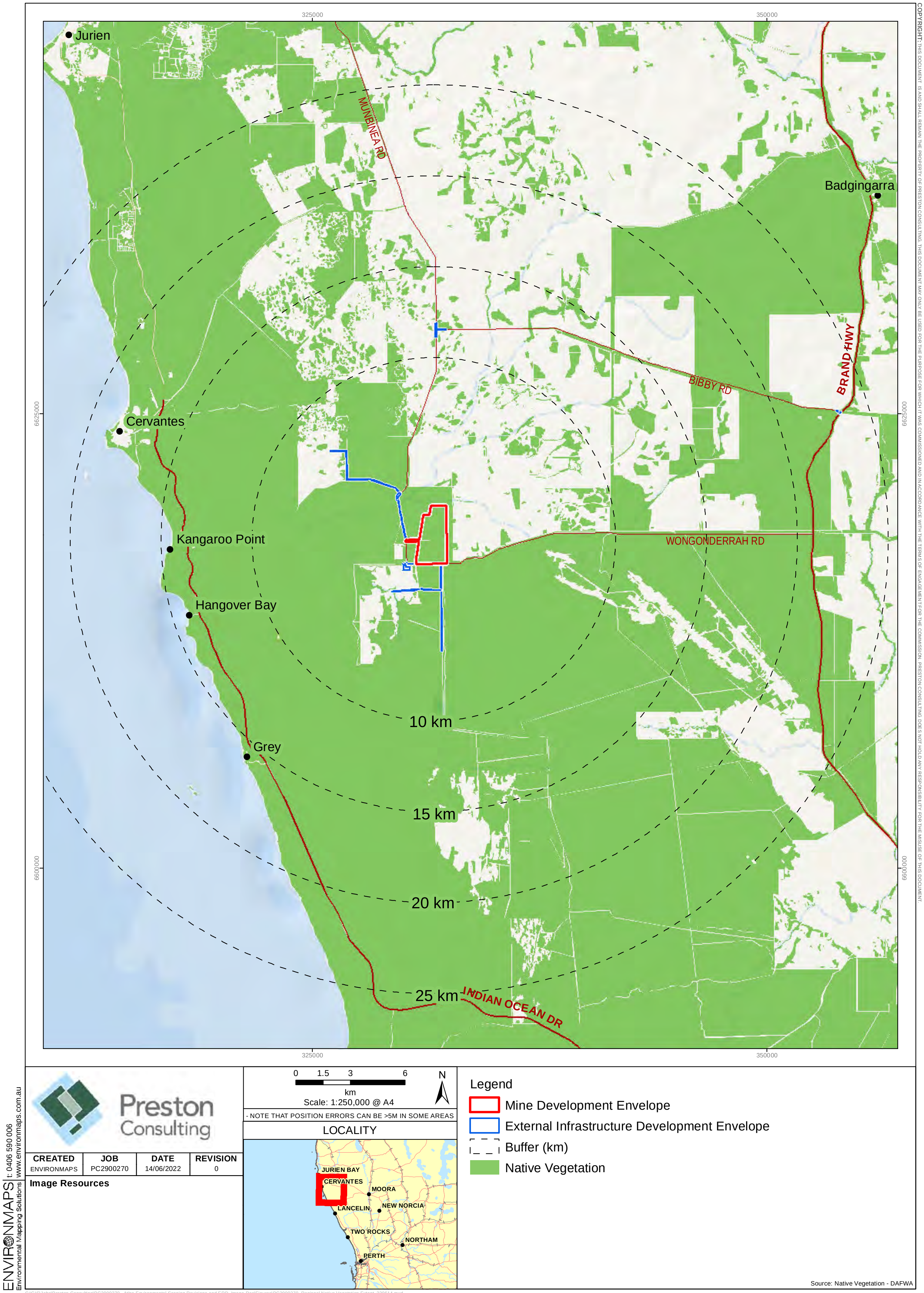
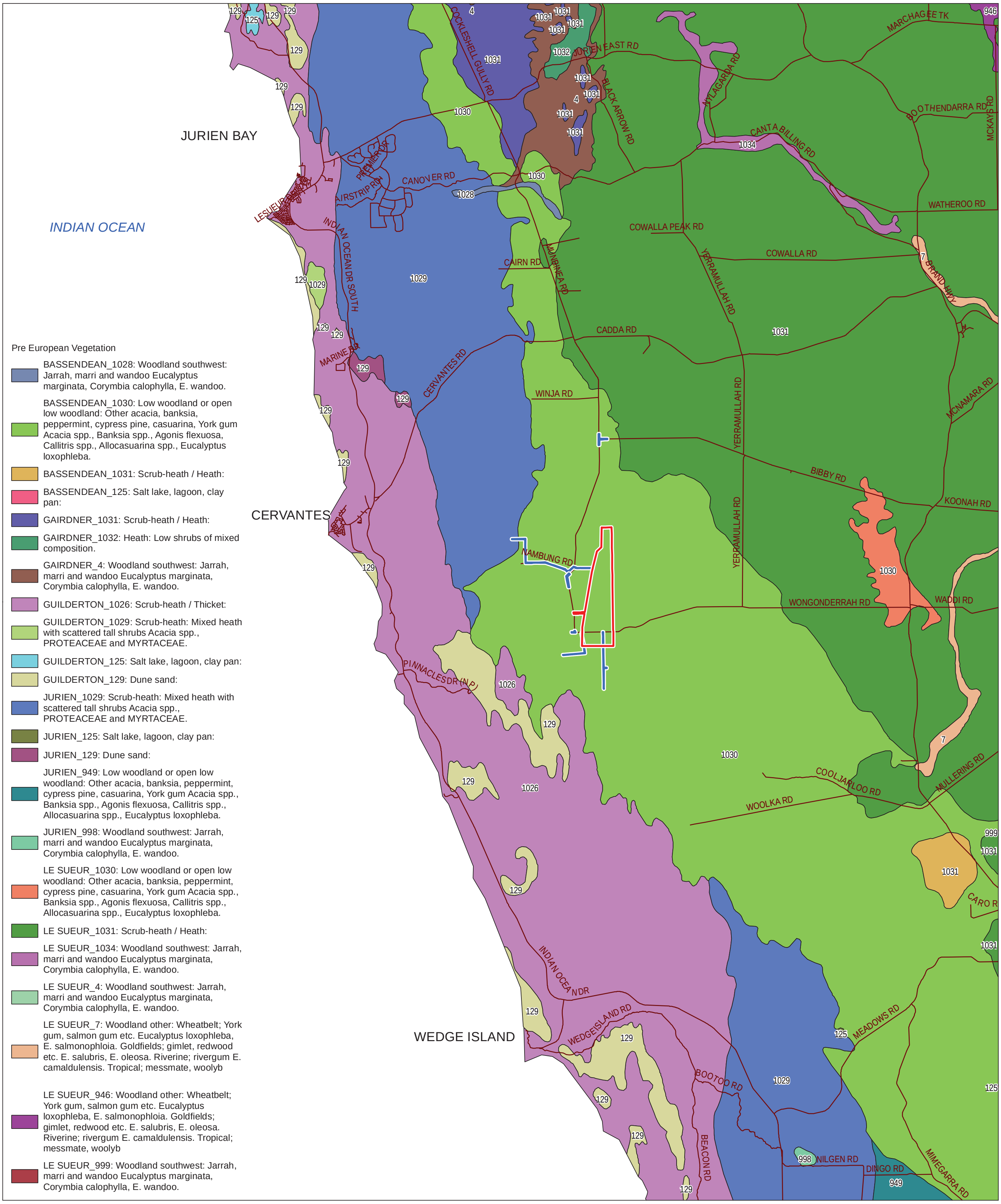


Figure 24: Extent of native vegetation surrounding the Proposal



Legend

Flora and Vegetation Study Areas

- Mine Envelope Study Area
- External Infrastructure Study Area

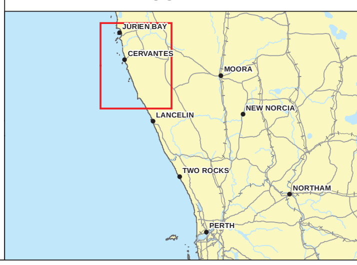
0 2.5 5 10 km

Scale: 1:250,000 @ A3

N

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY



Preston Consulting

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ENVIRONMAPS	ATLASINFRA	8/11/2021	0

ENVIRONMAPS Environmental Mapping Solutions t: 0406 590 006 www.environmaps.com.au

Figure 25: Regional Vegetation System Associations at the Proposal

Source: Pre European Vegetation - DPIRD

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Vegetation Condition

MESA / EISA Surveys

Approximately 69% of the MESA was in 'Excellent' or better condition. Vegetation in 'Excellent' or better condition included most of the *Banksia attenuata, Banksia menziesii* Low Woodlands and *Banksia prionotes* Low Woodlands and most of the areas of *Banksia telmatiaea* heaths and other heath units. These areas had low or very low weed covers. Areas mapped as 'Pristine' had almost no weeds and numerous quadrats in these areas had no weeds recorded.

The vegetation condition of the *Melaleuca* Spp. Tall Shrublands along the main flow lines and their flood banks were mostly in 'Good' to 'Degraded' condition in the MESA, with very high weed cover in the herbland/sedgeland/grassland strata. The high weed cover in these areas could be attributed to a combination of suitable habitat and the introduction of weeds in water flows from adjacent pasture paddocks (east and north of MESA) and by grazing animals (cattle that have found their way into the survey area previously, and large numbers of kangaroos in the locality).

The condition of the *Melaleuca rhaphiophylla, Melaleuca teretifolia* dampland ('MrMt') on the eastern boundary of the MESA, north of Wongonderrah Road, was also 'Good' to 'Degraded' due to high weed cover. This dampland was divided from an adjacent cleared pasture paddock by a fence line. The surrounding *Eucalyptus rudis* subsp. *rudis* open forest also had very high weed cover and significant loss of lower strata species, and was in a 'Degraded' condition.

Large parts of the samphire Low Shrublands on the MESA floodplains were in 'Excellent' condition, with low weed cover and a species-rich herb layer. However, the weed cover was greater and the vegetation condition lower in wetter parts of the floodplain and near the weedy flowlines.

The northern part of the MESA was cleared farmland with pasture paddocks and mostly has a condition in the range of 'Degraded' to 'Completely Degraded' from a native vegetation perspective. Much of the farmland was mapped as Palusplain and some parts had some regrowth sedges and rushes present (mapped 'Degraded' to 'Completely Degraded'). Much of the Nambung Station EISA corridor and the western end of the Nambung Road EISA corridor were on farmland and large parts 'Completely Degraded'.

Summary of vegetation condition identified within the MESA and EISA survey areas is provided in Table 15 and Figure 27 to Figure 32.

Table 15: Area of vegetation condition classes in the survey area

Vegetation Condition Class	MESA		EISA		Total	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Pristine	3.8	0.3	0	0.0	3.8	0.3
Excellent to Pristine	594.6	50.7	0	0.0	594.6	47.9
Excellent	211.9	18.1	33.3	48.8	245.2	19.8
Very Good to Excellent	28.5	2.4	3.5	5.1	32	2.6
Very Good	15.1	1.3	4.6	6.7	19.7	1.6

Vegetation Condition Class	MESA		EISA		Total	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Good to Very Good	7.6	0.6	1.1	1.6	8.7	0.7
Good	13.9	1.2	1.7	2.5	15.6	1.3
Good to Degraded	64.6	5.5	0.5	0.7	65.1	5.2
Degraded	7.5	0.6	1.9	2.8	9.4	0.8
Degraded to Completely Degraded	85.6	7.3	0	0.0	85.6	6.9
Completely Degraded	135	11.5	13.5	19.8	148.5	12.0
Cleared	4	0.3	8.2	12.0	12.2	1.0
Total	**1,172.1**	**100**	**68.30**	**100**	**1,240.4**	**100**

BBSA Survey

Vegetation condition within the Survey Area ranged from Excellent to Degraded, with the majority in Excellent condition (61.4%). Disturbance to the vegetation was minimal with the main sources being roads, tracks, and driveways. Weed presence was minimal and did not impact the condition of the vegetation. It is inevitable that being adjacent to a major highway, litter and rubbish would be present, the occurrences however, were minor and seldom encroached into the vegetation. Vegetation condition within the Survey Area is summarised in Table 16 and illustrated in Figure 34.

Table 16: Vegetation Condition within the Bibby Road and Brand Highway Survey Area

Vegetation Condition	Extent within the Survey Area (ha)	Extent within the Survey Area (%)
Excellent	18.6	61.4
Very Good	0.4	1.3
Very Good to Good	2.1	6.9
Good	0.2	0.7
Degraded	0.5	1.7
Cleared (tracks, roads, and driveways)	8.5	28.1
Total	**30.3**	**100**

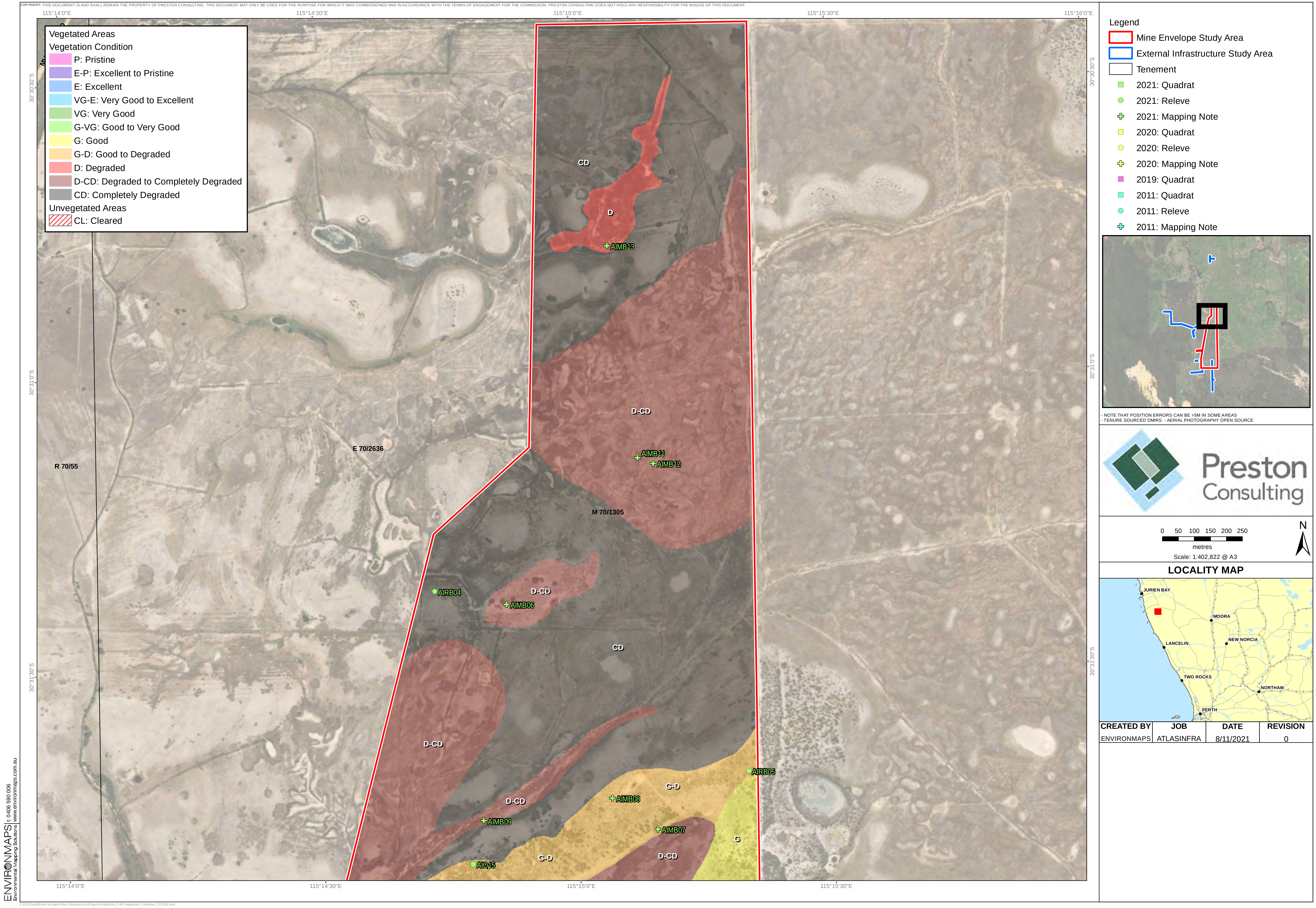

Figure 26: Vegetation condition of the northern section of the MESA

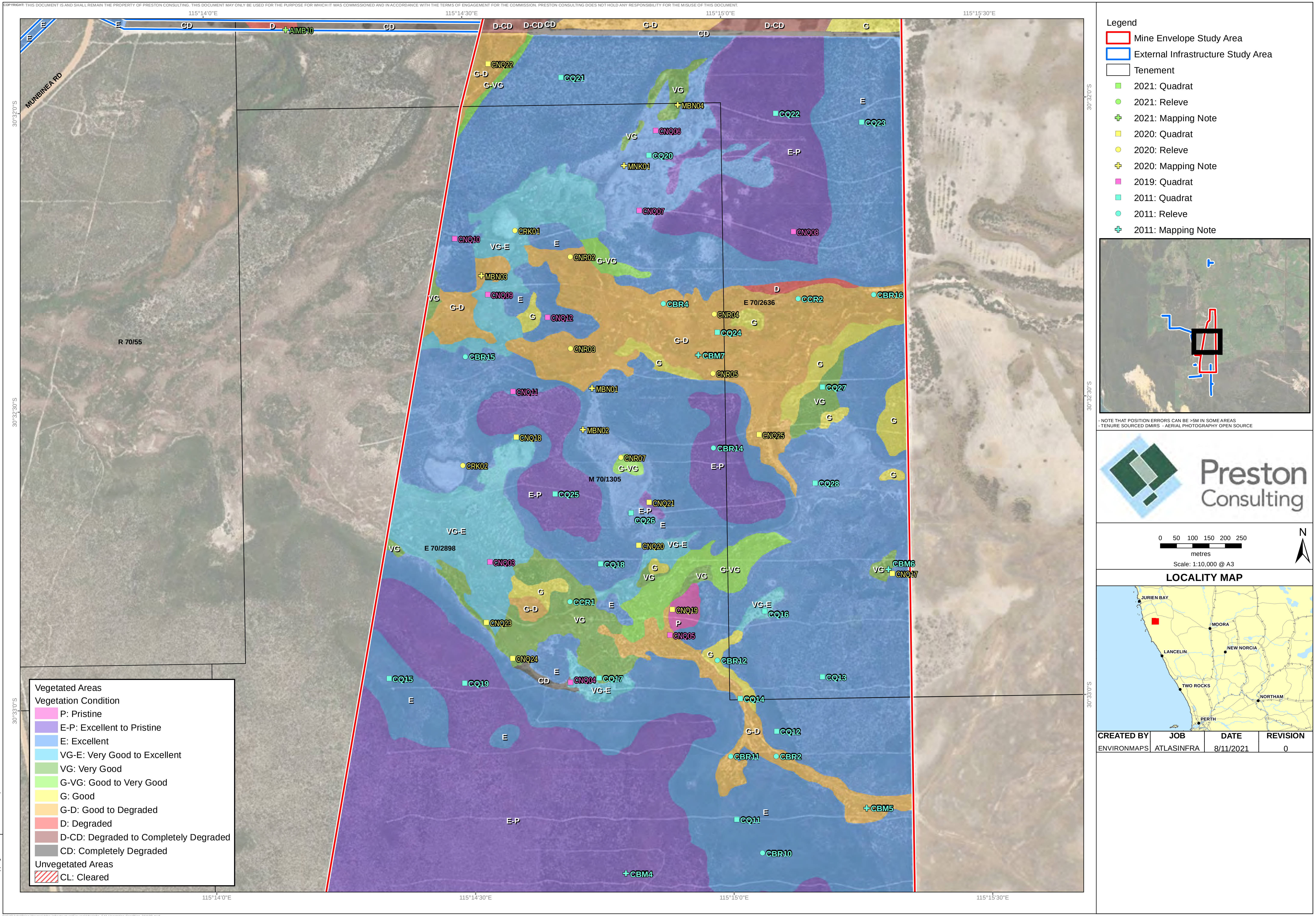

Figure 27: Vegetation condition of the central section of the MESA

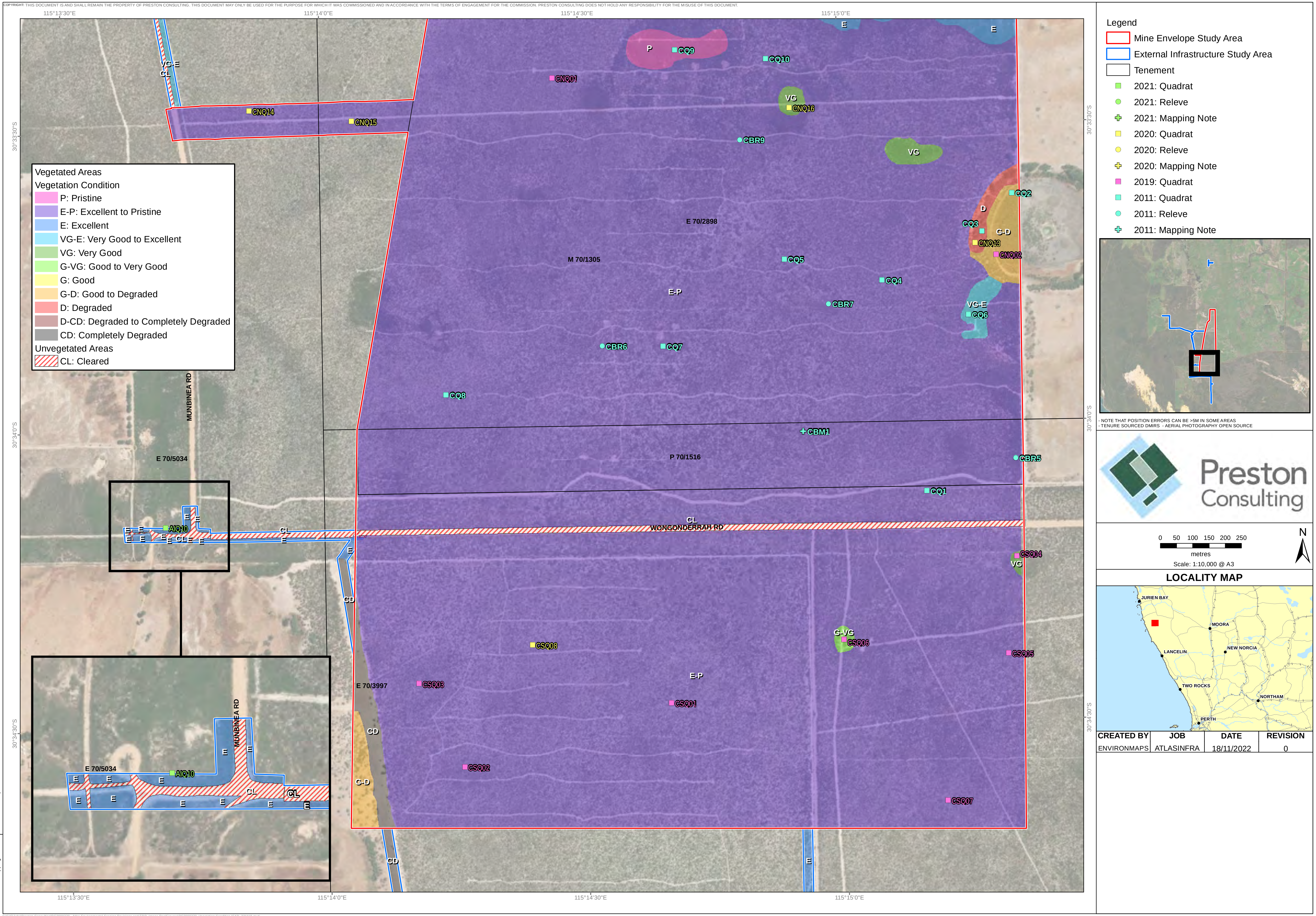

Figure 28: Vegetation condition of the southern section of the MESA

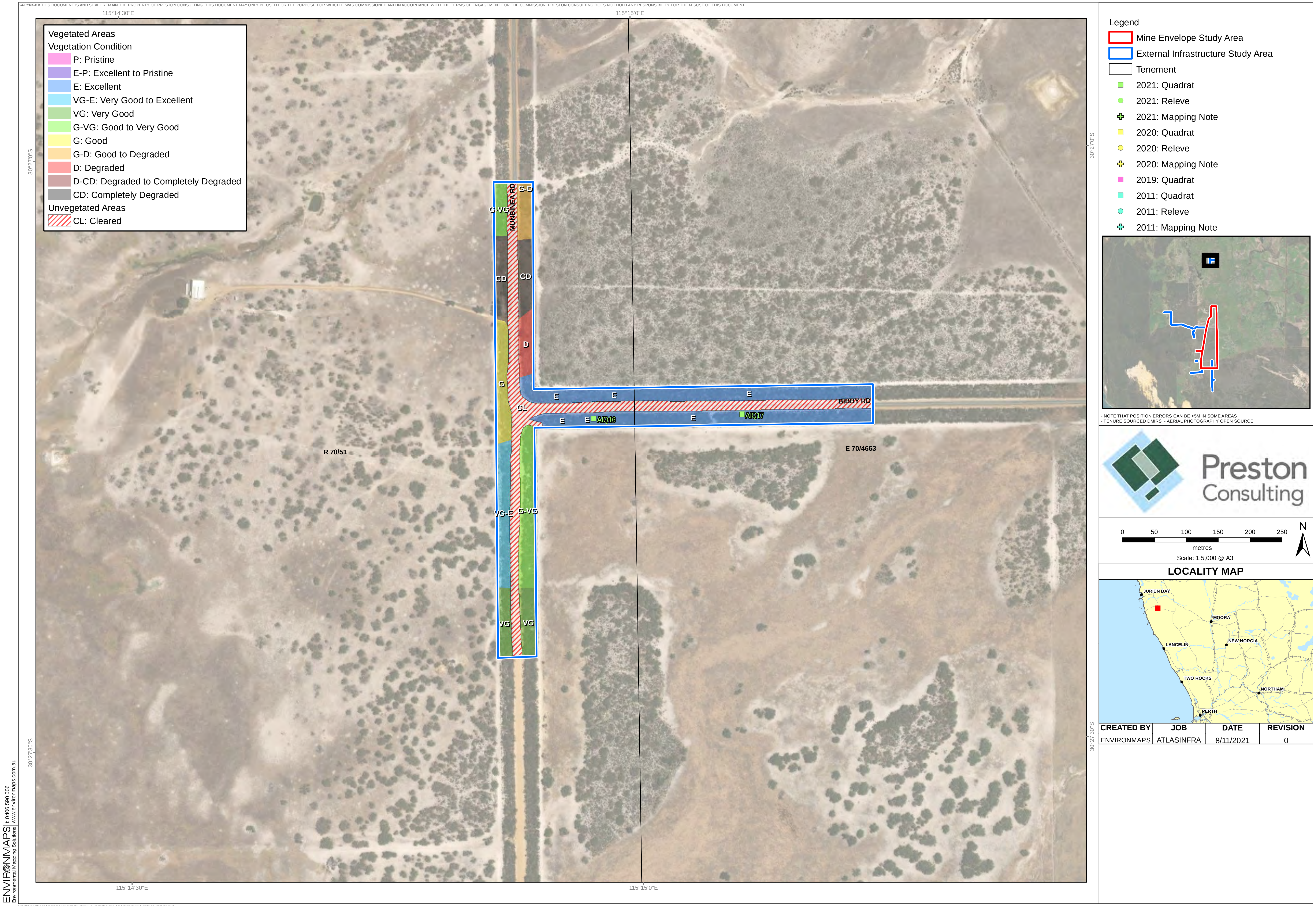

Figure 29: Vegetation condition of the EISA (1/5)

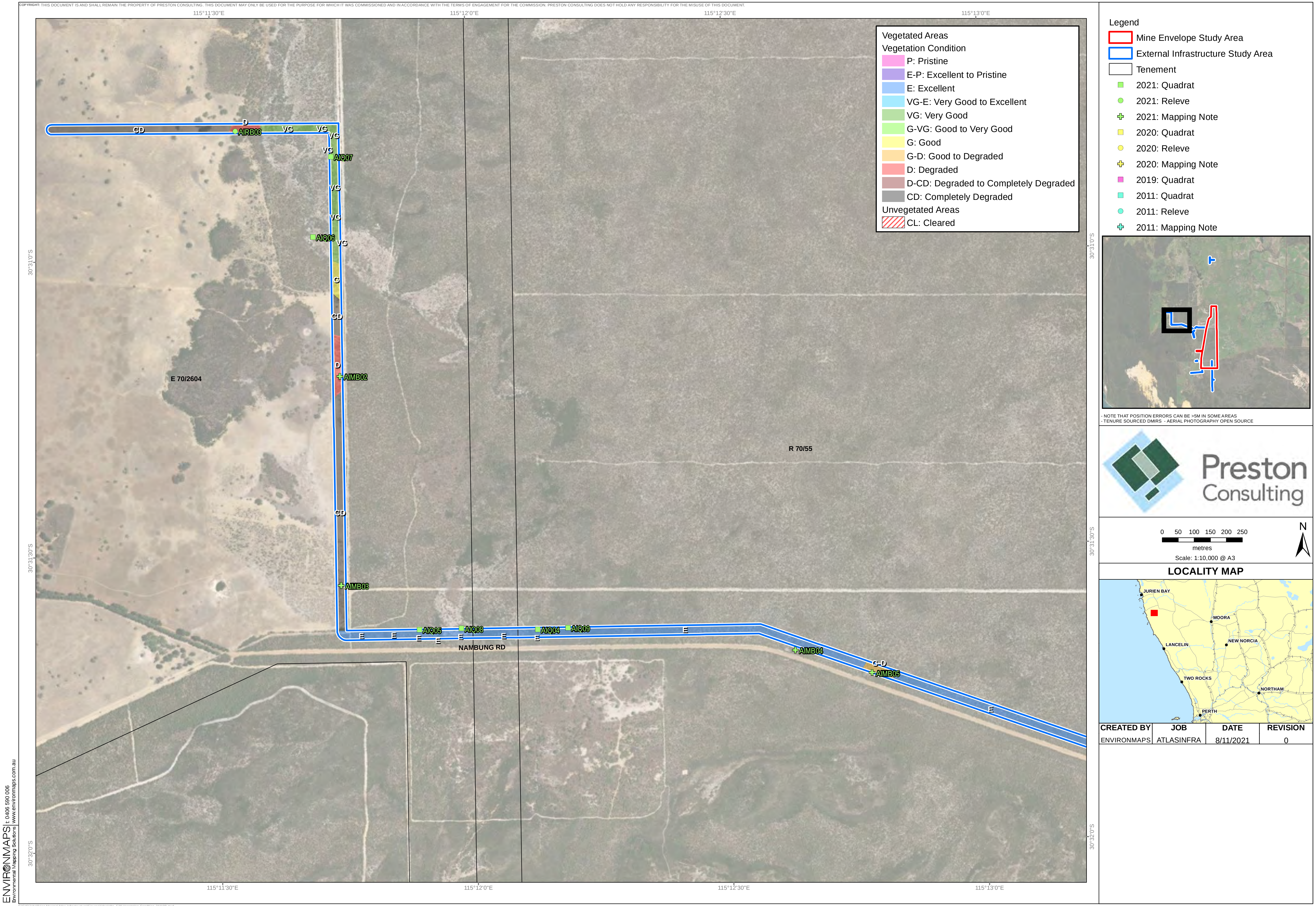

Figure 30: Vegetation condition of the EISA (2/5)

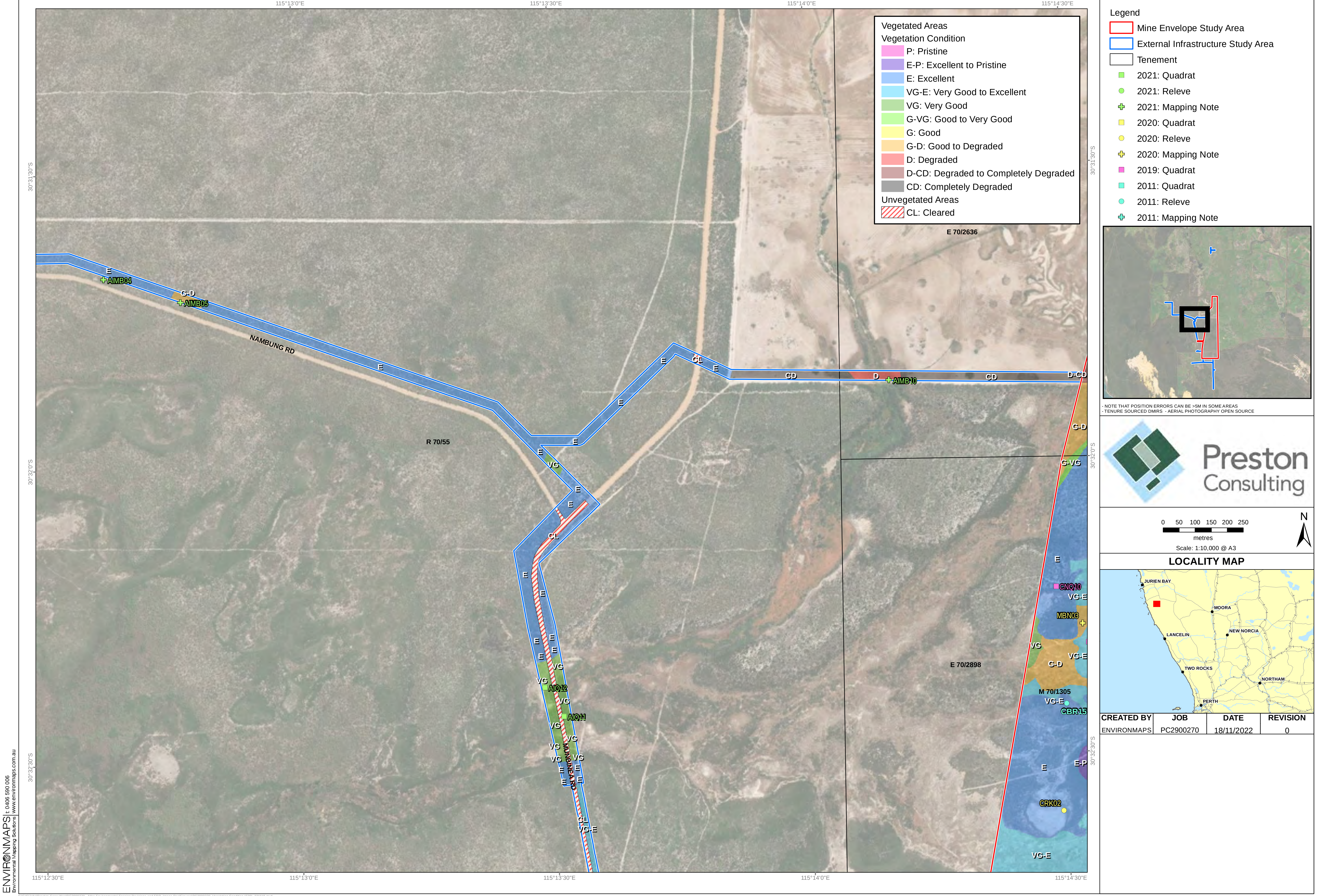

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Figure 31: Vegetation condition of the EISA (3/5)

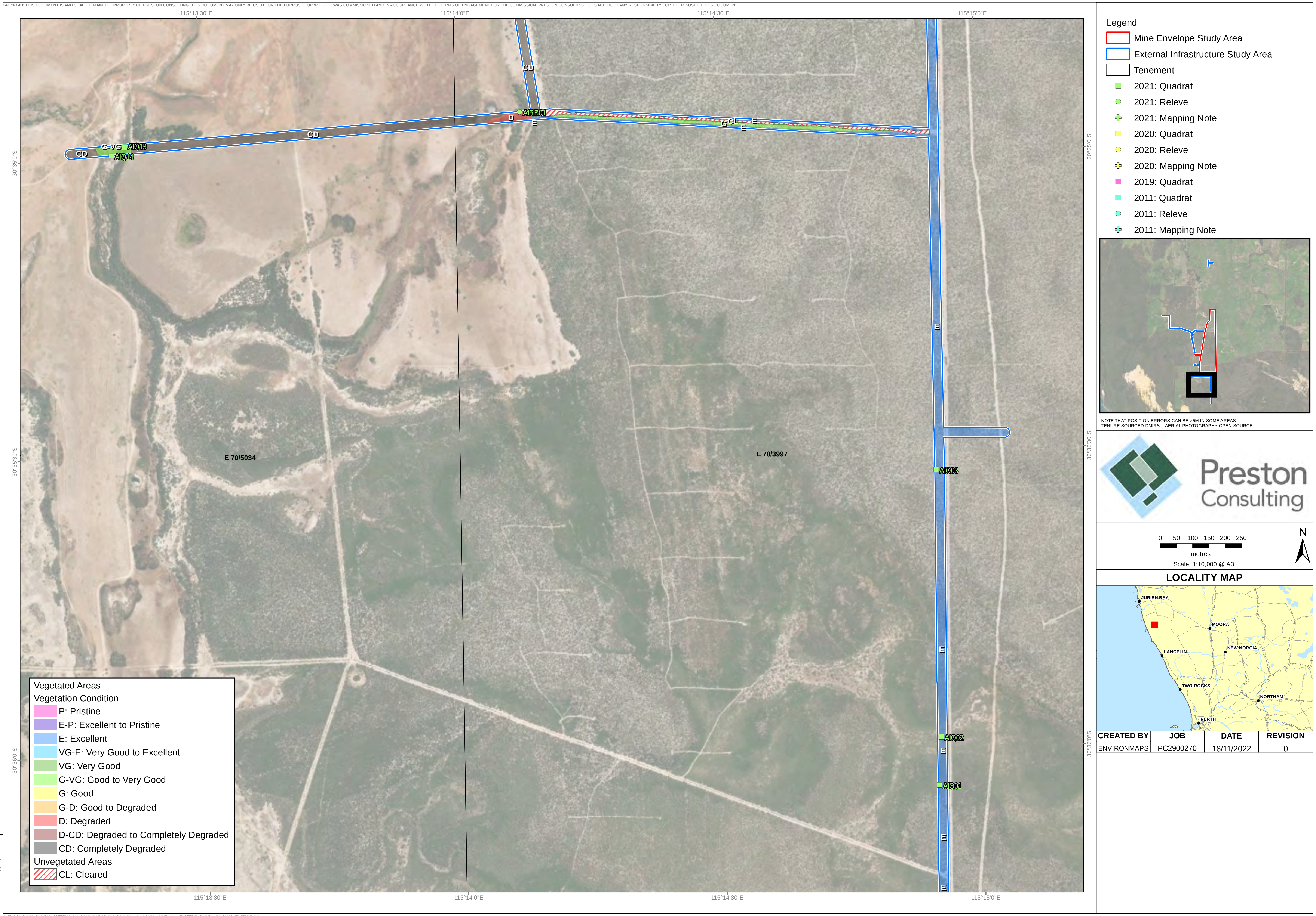


Figure 32: Vegetation condition of the EISA (4/5)

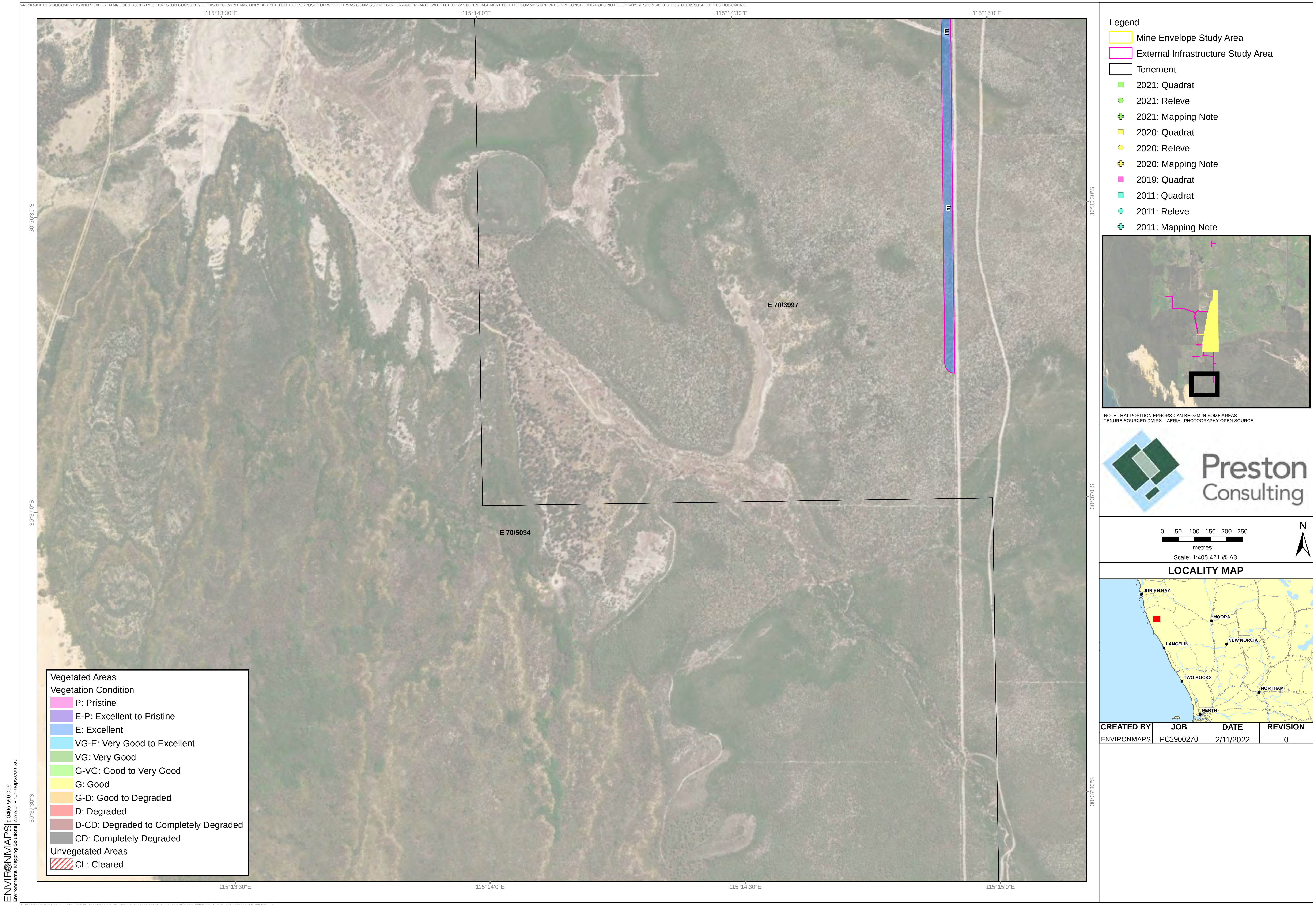


Figure 33: Vegetation condition of the EISA (5/5)

Figure 34: Vegetation Condition within the Bibby Road and Brand Highway Survey Area

Vegetation Units

MESA / EISA Surveys

A total of 28 vegetation units were used to describe the vegetation in the Morgan (2022) survey of the MESA and EISA (Table 17 and Figure 35 - Figure 41). Twenty vegetation units were based on quadrat data and the statistical classification. Four vegetation unit descriptions were based on relevé data because the area of the vegetation unit was too small or too irregular in shape to be able to fit a 100 m^2 quadrat, or because the vegetation condition was too poor (due to high weed covers) to result in meaningful quadrat data. Two vegetation units on farmland (Degraded pasture paddocks with regrowth) were described using mapping notes.

BBSA Survey

Three vegetation units were described and mapped within the BBSA. These included woodlands and shrublands which ranged in condition from Excellent to Degraded. Within the 30.3 ha BBSA; 0.13 ha consisted of a patch of non-endemic eucalypt trees, 8.46 ha was cleared, comprising roads, tracks, and driveways, 8.1 ha was Low woodland and 13.6 ha was mid open shrubland.

Vegetation units within the survey areas are detailed in Table 17 and Figure 35 - Figure 41.

Table 17: Vegetation units within the survey areas

Veg unit	Description	MESA		EISA		BBSA		Total	
		Area (ha)	% of Area	Area (ha)	% of Area	Area (ha)	% of Area	Area (ha)	% of Area
AhAcc	*Allocasuarina humilis*, *Adenanthos cygnorum* subsp. *cygnorum*, *Daviesia incrassate* subsp. *incrassata*, *Melaleuca seriata* Open Shrubland over *Hibbertia hypericoides*, *Hakea incrassata*, *Xanthorrhoea preissii*, *Stirlingia latifolia*, *Conospermum stoechadis* subsp. *stoechadis*, *Daviesia nudiflora* subsp. *nudiflora*, *Daviesia triflora* Low Open Shrubland over *Mesomelaena pseudostygia*, *Chordifex sinuosus*, *Mesomelaena tetragona* Open Sedgeland/Rushland with *Neurachne alopecuroidea* Low Sparse Grassland. **Habitat and soil:** Sand plain. Grey clayey sand with localised clay pockets.			0.4	0.6			0.4	0.03
AhXssp	*Lambertia multiflora* var. *multiflora, Allocasuarina humilis, Xanthorrhoea drummondii* and *Adenanthos cygnorum* over low sparse shrubland of *Bossiaea eriocarpa, Hibbertia hypericoides* and *Stirlingia latifolia* over low isolated clumps of sedges of *Mesomelaena tetragona, M. pseudostygia* and *Dasypogon obliquifolius.* Mid opem shrubland					13.6	45.0	13.6	1.1
Ar	*Acacia rostellifera* Tall Shrubland. **Habitat and soil:** Plain at base of dune. Yellow sand.			0.5	0.7			0.5	0.04
BaBm	*Banksia attenuata, Banksia menziesii*, (*Eucalyptus todtiana*) Low Woodland over *Adenanthos cygnorum* subsp. *cygnorum* Isolated Tall Clumps of Shrubs to Sparse Tall Shrubland (in some parts) over *Xanthorrhoea preissii* Sparse Shrubland over *Melaleuca clavifolia*, *Hibbertia hypericoides*, *Eremaea pauciflora* var. *lonchophylla*, *Eremaea asterocarpa* subsp. *asterocarpa*, *Melaleuca systena, Bossiaea eriocarpa*, *Petrophile rigida* mixed Low Shrubland over *Mesomelaena pseudostygia* Isolated Sedges to Sparse Sedgeland with *Dasypogon obliquifolius*, *Blancoa canescens*, *Patersonia occidentalis* var. *occidentalis* Low Sparse Forbland. **Habitat and soil:** Plains and low rises. Grey sand.	599.7	51.2	23.3	34.1	8.1	26.7	631.1	49.7
Bp	*Banksia prionotes* Low Woodland over *Calothamnus quadrifidus* subsp. *quadrifidus*, *Scholtzia umbellifera* Tall Open Shrubland over *Hibbertia hypericoides*, *Conospermum stoechadis* subsp. *stoechadis*, *Melaleuca systena* Low Open Shrubland over *Lepidobolus preissianus* Sparse Sedges. **Habitat and soil:** Flat plain and low rises. Yellow sand.	41.4	3.5	10.8	15.8			52.2	4.1
BtRc	*Banksia telmatiaea*, *Hakea obliqua* subsp. *parviflora*, *Regelia ciliata* Heathland to Closed Heathland over *Melaleuca seriata* Low Sparse Shrubland to Low Open Shrubland over *Conostylis festucacea* subsp. *festucacea* Low Open Forbland. **Habitat and soil:** Very gentle slopes and elevated areas adjacent to floodplains and in depression areas on the sand plain. Grey sands.	151.3	12.9	5.1	7.5			156.4	12.3
CgMj	*Cyperus gymnocaulos*, *Machaerina juncea* Sparse to Open Low Sedgeland/Rushland (regrowth) with **Cyperus tenellus*, *Isolepis marginata*, **Juncus bufonius* Low Sparse Sedgeland with **Lotus subiflorus*, **Arcotheca calendula*, **Romulea* sp, *Crassula decumbens* var. *decumbens* Low Forbland. **Habitat and soil:** Low plain (flood plain). Grey sand.	76.3	6.5					76.3	6.0

Veg unit	Description	MESA		EISA		BBSA		Total	
		Area (ha)	% of Area	Area (ha)	% of Area	Area (ha)	% of Area	Area (ha)	% of Area
CpBt	*Callitris pyramidalis* Tall Shrubland over *Banksia telmatiaea*, *Regelia seriata*, *Melaleuca seriata* Open Heathland over *Jacksonia hakeoides* Low Isolated Shrubs *Conostylis aculeata* subsp. *breviflora* Low Sparse Forbland. **Habitat and soil:** Very gentle slope on edge of floodplain; pale grey-brown sand.	12.2	1.0	1.2	1.7			13.4	1.1
EdMp	*Eucalyptus decipiens*, *Melaleuca preissiana* Low Woodland over *Spyridium globulosum*, *Acacia cyclops* Isolated Clumps of Tall Shrubs over *Gahnia trifida* Mid Isolated Sedges and *Lepidosperma longitudinale* Sedgeland (patches) and **Ehrharta longiflora* Grassland. **Habitat and soil:** Depression on plain. Dark brown loamy sand.			0.3	0.5			0.3	0.03
Er	*Eucalyptus rudis* subsp*. rudis* Open Forest over *Rhagodia baccata subsp. baccata* Open Shrubland over **Ehrharta longiflora, *Brassica tournefortii, *Trifolium campestre* var. *campestre, *Stellaria media* annual Open Grassland/Forbland of exotics with *Clematis linearifolia Sparse Lianes.* **Habitat and soil:** Very gentle, east-facing slope on margin of wetland. Grey sand.	1.4	0.1					1.4	0.1
MaMcu	*Melaleuca acutifolia* Tall Closed Shrubland over *Melaleuca cuticularis*, *Melaleuca viminea* subsp. *viminea*, *Melaleuca rhaphiophylla*, *Rhagodia baccata* subsp. *Baccata* Sparse Shrubland over *Gahnia trifida* Sparse to Open Sedgeland and **Vulpia myuros* forma *myuros*, **Ehrharta longiflora* Sparse Grassland with *Samolus repens* var. *paucifolius*, *Angianthus micropodioides* (Priority 3), *Podotheca gnaphalioides*, *Cotula cotuloides* Low Sparse Forbland. **Habitat and soil:** Narrow linear unit along edge of the floodplain, at the base of a very gentle slope of a broad low rise. Yellow-brown sand	0.8	0.1					0.8	0.1
MbGcVp	*Melaleuca brevifolia* Open Shrubland over *Grevillea* sp. Coojarloo (B.J. Keighery 28 B) (Priority 1), *Verticordia plumosa var. brachyphylla*, *Frankenia pauciflora* Low Open Shrubland over *Gahnia Trifida* Sparse sedges with *Conostylis aculeata* subsp. *breviflora*, *Brachyscome iberidifolia*, *Angianthus micropodioides* (Priority 3), *Drosera thysanosepala*, *Centrolepis aristata*, *Isolepis marginata*, *Apium prostratum* subsp. *prostratum var. filiforme* Low Sparse to Open Forbland. **Habitat and soil:** Margins of the floodplain. Grey-brown sand.	13.0	1.1					13	1.0
MbTi	*Melaleuca brevifolia* Open Shrubland over *Tecticornia indica* subsp. *bidens* Open Samphire Shrubland with **Polypogon monspeliensis*, **Hordeum geniculatum* Sparse Grassland and **Crassula natans* var. minor, **Cotula coronopifolia*, **Lotus subbiflorus*, **Arctotheca calendula Forbland*. **Habitat and soil:** Floodplain. Pale yellow-grey sand.	2.9	0.2					2.9	0.2
McuMvSb	*Melaleuca cuticularis*, *Melaleuca viminea* subsp. *viminea*, *Melaleuca brevifolia* (higher on sumpland banks) Open Shrubland over *Salicornia blackiana*, (*Tecticornia indica* subsp. *bidens*) Low Samphire Shrubland to Closed Shrubland and **Crassula natans* var. minor Sparse Forbland to Open Forbland. **Habitat and soil:** Gently sloping banks of brackish sumpland. The soil profile was not investigated.	1.2	0.1					1.2	0.1

Veg unit	Description	MESA		EISA		BBSA		Total	
		Area (ha)	% of Area	Area (ha)	% of Area	Area (ha)	% of Area	Area (ha)	% of Area
MrHtBt	*Melaleuca rhaphiophylla*, *Banksia telmatiaea*, *Hakea trifurcata* mixed Open to Closed Shrubland over *Melaleuca seriata*, *Jacksonia hakeoides*, *Banksia dallanneyi* subsp. *dallanneyi* Low Sparse Shrubland over *Conostylis festucacea* subsp. *Festucacea* Isolated Forbs to Low Open Forbland and *Lepidosperma longitudinale*, *Schoenus subfascicularis* Sparse Sedgeland. **Habitat and soil:** Small, very shallow, depression areas on plain. Brown-grey sand.	0.6	0.1					0.6	0.05
MrMt	*Melaleuca raphiophylla* Tall Shrubland over Melaleuca *teretifolia*, *Rhagodia baccata* subsp. *baccata* Sparse Shrubland over *Conostylis festucacea* subsp. *festucacea*, **Trifolium campestre* var. *campestre*, **Trifolium arvense* var. *arvense* Forbland and *Lepidosperma longitudinale*, *Schoenus subfascicularis*, *Leptocarpus coangustatus* mixed Open Sedgeland/Rushland to Sedgeland/Rushland and **Polypogon monspeliensis, *Vulpia myuros forma myuros, *Ehrharta longiflora* Open Grassland with *Comesperma integerrimum, Clematis linearifolia Sparse Lianes.* **Habitat and soil:** Low lying depression on plain (wetland). Brown clayey sand.	3.9	0.3	0.6	0.8			4.5	0.4
MrMtSl	*Melaleuca raphiophylla* Tall Shrubland over *Melaleuca teretifolia* Sparse Shrubland over *Schoenus laevigatus, Lepidosperma longitudinale* Open Sedgeland. **Habitat and soil:** Depression on plain – dampland, broad flow area (spring-fed, surface water present). Dark grey sand.			1.0	1.5			1.0	0.1
MrMv	*Melaleuca viminea* subsp. *viminea*, *Melaleuca rhaphiophylla* Shrubland to Closed Shrubland over *Leptocarpus coangustatus*, *Leptocarpus canus* Rushland Open Sedgeland/Rushland with *Samolus junceus*, **Cotula coronopifolia*, *Crassula colorata* var. *acuminata*, *Centrolepis polygyna*, *Brachyscome iberidifolia* Sparse Forbland and **Vulpia myuros forma myuros* Sparse Grassland. **Habitat and soil:** Small areas on some sumpland banks and small patches on wetter margins of floodplain.	0.2	0.0					0.2	0.02
MrMvBc	*Melaleuca rhaphiophylla*, *Melaleuca viminea* subsp. *viminea*, *Melaleuca brevifolia* Tall Shrubland to Tall Closed Shrubland (patches) over *Bolboschoenus caldwellii*, *Baumea juncea*, *Cyperus gymnocaulos* Mid-Sedgeland with **Ehrharta longiflora*, **Hordeum geniculatum*, **Lolium multiflorum* Sparse Grassland of exotics and **Cotulacoronopifolia*, **Lotus subbiflorus* Low Sparse Forbland of exotics. **Habitat and soil:** Broad, shallow flow line (Bibby Creek). Grey-brown sandy clay loam.	7.0	0.6					7.0	0.6
MrMvMco	*Melaleuca rhaphiophylla*, *Melaleuca concreta*, (*Melaleuca viminea subsp. viminea*) Tall Open to Closed Shrubland (patchy) over *Melaleuca brevifolia* Sparse Shrubland over *Grevillea* sp. Cooljarloo (B.J. Keighery 28 B) Sparse Low Shrubs over *Cyperus gymnocaulos*, *Lepidosperma longitudinale* Sedgeland (along floor of drain) and **Lotus subbiflorus, *Polypogon monspeliensis, *Hordeum geniculatum Closed Herbland/Grassland.* **Habitat and soil:** Flow line bed and flood banks (the eastern part of which was historically excavated to enhance drainage). Light brown sand.	8.2	0.7	1.1	1.6			9.3	0.7

Veg unit	Description	MESA		EISA		BBSA		Total	
		Area (ha)	% of Area	Area (ha)	% of Area	Area (ha)	% of Area	Area (ha)	% of Area
Ms	*Melaleuca seriata*, *Verticordia densiflora* var. *densiflora*, *Grevillea* sp. Cooljarloo (B.J. Keighery 28 B) (Priority 1), *Petrophile seminuda*, *Regelia ciliata* mixed Low Shrubland over *Conostylis aculeata* subsp. *breviflora* Low Open Forbland. **Habitat and soil:** Very gentle slopes and slightly elevated flats on the edge of the floodplain. Pale grey sand.	4.1	0.4					4.1	0.3
MsVdCaf	*Verticordia densiflora* var. *densiflora*, *Babingtonia urbana* (Priority 3), *Regelia ciliate* Sparse Shrubland over *Melaleuca seriata*, *Calytrix aff. flavescens*, *Jacksonia hakeoides*, *Acacia dilatata* Low Heathland to Low Closed Heathland. **Habitat and soil:** Very gentle slopes on the edge of the floodplain. Pale grey sand.	2.4	0.2					2.4	0.2
MvMb	*Melaleuca viminea* subsp. *viminea* Tall Shrubland over *Melaleuca brevifolia* Sparse Shrubland over *Grevillea thelemanniana* subsp. Cooljarloo (B.J. Keighery 28 B) (Priority 1), *Melaleuca seriata* Low Sparse Shrubland and *Tecticornia indica* subsp. *bidens* Sparse Low Samphire Shrubland over **Lotus subbiflorus*, **Crassula natans* var. *minor*, **Cotula coronopifolia*, *Cotula cotuloides*, **Ornithopus pinnatus*, **Crassula glomerata*, **Stellaria media* Low Open Forbland and **Vulpia myuros* forma *myuros*, **Vulpia bromioides*, **Polypogon monspeliensis* Low Open Grassland. **Habitat and soil:** Minor flowline banks and bed. Pale grey-brown sand.	16.3	1.4					16.3	1.3
Ne	Isolated mature non-endemic eucalypt trees					0.1	0.5	0.1	0.01
TCg	*Typha* sp. Tall Rushland with *Ficinia nodosa*, *Lepidosperma longitudinale*, **Juncus acutus* subsp. *acutus*, *Cyperus gymnocaulos* Sedgeland and **Lotus subifolius*, **Cotula coronopifolia* Low Forbland. **Habitat and soil:** Drainage line. Yellow sand.	5.3	0.5	0.5	0.7			5.8	0.5
Ti	*Tecticornia indica* subsp. *bidens*, (*Lawrencia squamata*) Low Open Shrublands over *Angianthus micropodioides* (Priority 3), *Apium prostratum* subsp. *prostratum* var. *filiforme*, *Hydrocotyle diantha*, *Cotula cotuloides*, **Juncus bufonius*, *Quinetia urvillei*, *Drosera menziesii* subsp. *thysanosepala*, *Brachyscome iberidifolia*, *Triglochin* sp. A Flora of Australia (G.J. Keighery 2477), *Triglochin mucronata* Low Open Forbland/Sedgeland/Grassland. **Habitat and soil:** Floodplain. Light brown-grey sand.	42.4	3.6	1.1	1.6			43.5	3.4
TmThTs	*Tecticornia moniliformis*, *Tecticornia halocnemoides*, *Tecticornia syncarpa*, *Frankenia pauciflora*, *Lawrencia squamata* Low Open Shrubland over *Angianthus micropodioides* (Priority 3), *Centrolepis humillima*, *Triglochin minutissima*, *Triglochin mucronata*, *Triglochin centrocarpa* Low Sparse Forbland. **Habitat and soil:** Floodplain with microrelief (included very slightly raised areas). Grey clayey sand with a surface crust.	22.7	1.9					22.7	1.8
TsTi	*Tecticornia syncarpa*, *Tecticornia halocnemoides*, (*Tecticornia indica* subsp. *bidens*) Low Open Samphire Shrubland over **Crassula natans* var. minor (aquatic), (**Cotula coronopifolia*) Closed Herbland. **Habitat and soil:** Banks of saline claypan.	1.3	0.1					1.3	0.1

Veg unit	Description	MESA		EISA		BBSA		Total	
		Area (ha)	% of Area	Area (ha)	% of Area	Area (ha)	% of Area	Area (ha)	% of Area
BtRc/AhAcc	Combination of vegetation units described above			0.9	1.4			0.9	0.1
BtRc/BaBm	Combination of vegetation units described above	2.3	0.2					2.3	0.2
BtRc/Bp	Combination of vegetation units described above	6.8	0.6					6.8	0.5
BtRc/MvMb	Combination of vegetation units described above	0.5	0.0					0.5	0.04
MbTi/BtRc	Combination of vegetation units described above	2.0	0.2					2.0	0.2
MbTi/MbGcVp	Combination of vegetation units described above	0.3	0.0					0.3	0.02
MbTi/MbGcVp/BtRc	Combination of vegetation units described above	3.9	0.3					3.9	0.3
MrMvBc/MbGcVb	Combination of vegetation units described above			0.3	0.5			0.3	0.03
TmThTs/MvMb	Combination of vegetation units described above	0.6	0.1					0.6	0.05
TsTi/MrMv	Combination of vegetation units described above	2.2	0.2					2.2	0.2
Cleared	N/A	5.8	0.5	8.2	12.0	8.5	27.9	22.5	1.8
Pasture Paddock (CD)	N/A	132.7	11.3	13.0	19.0			145.6	11.5
Total		**1,172.1**	**100**	**68.3**	**100**	**30.3**	**100**	**1,270.2**	**100**

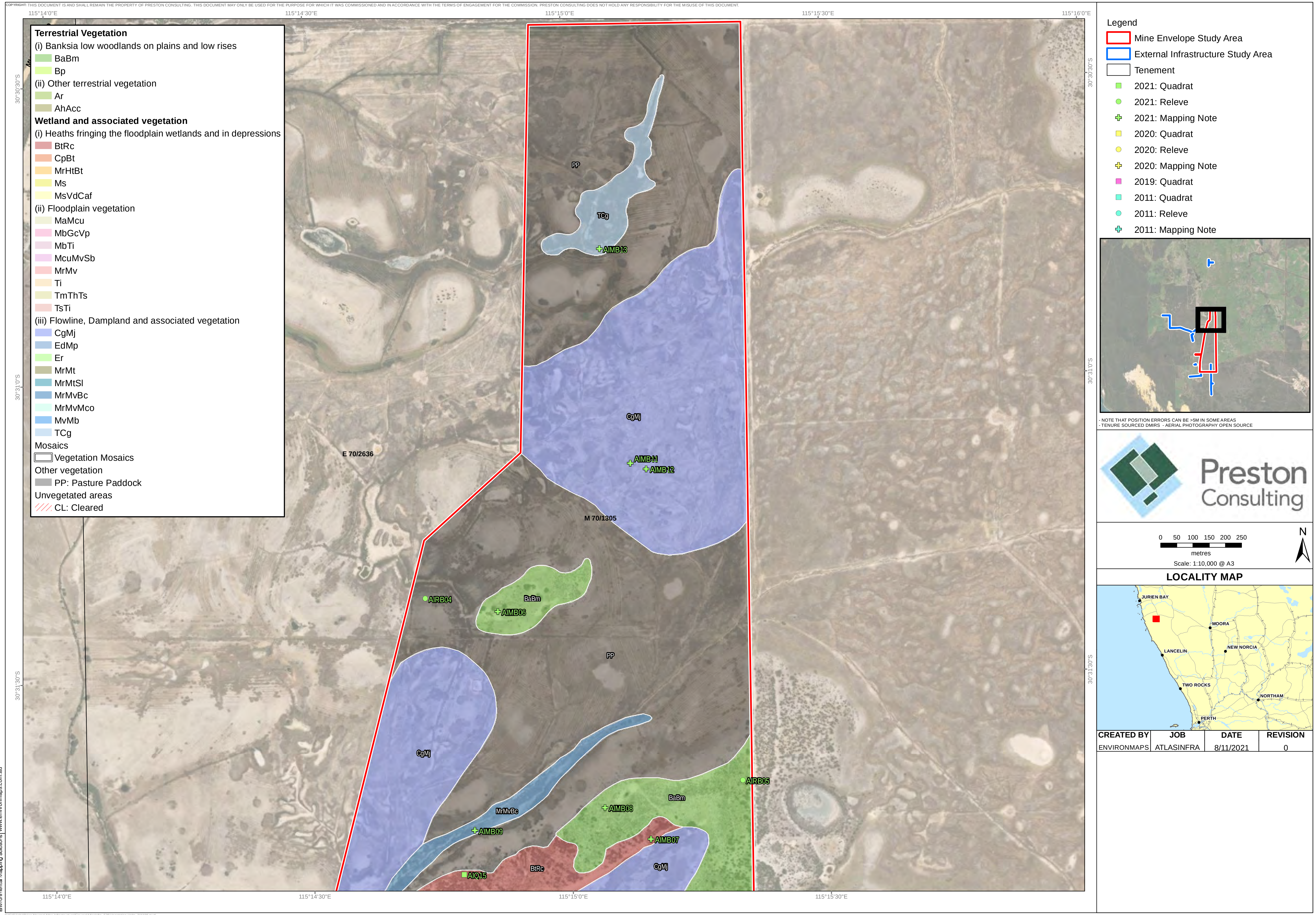


Figure 35: Vegetation units of the northern section of the MESA (Morgan, 2022)

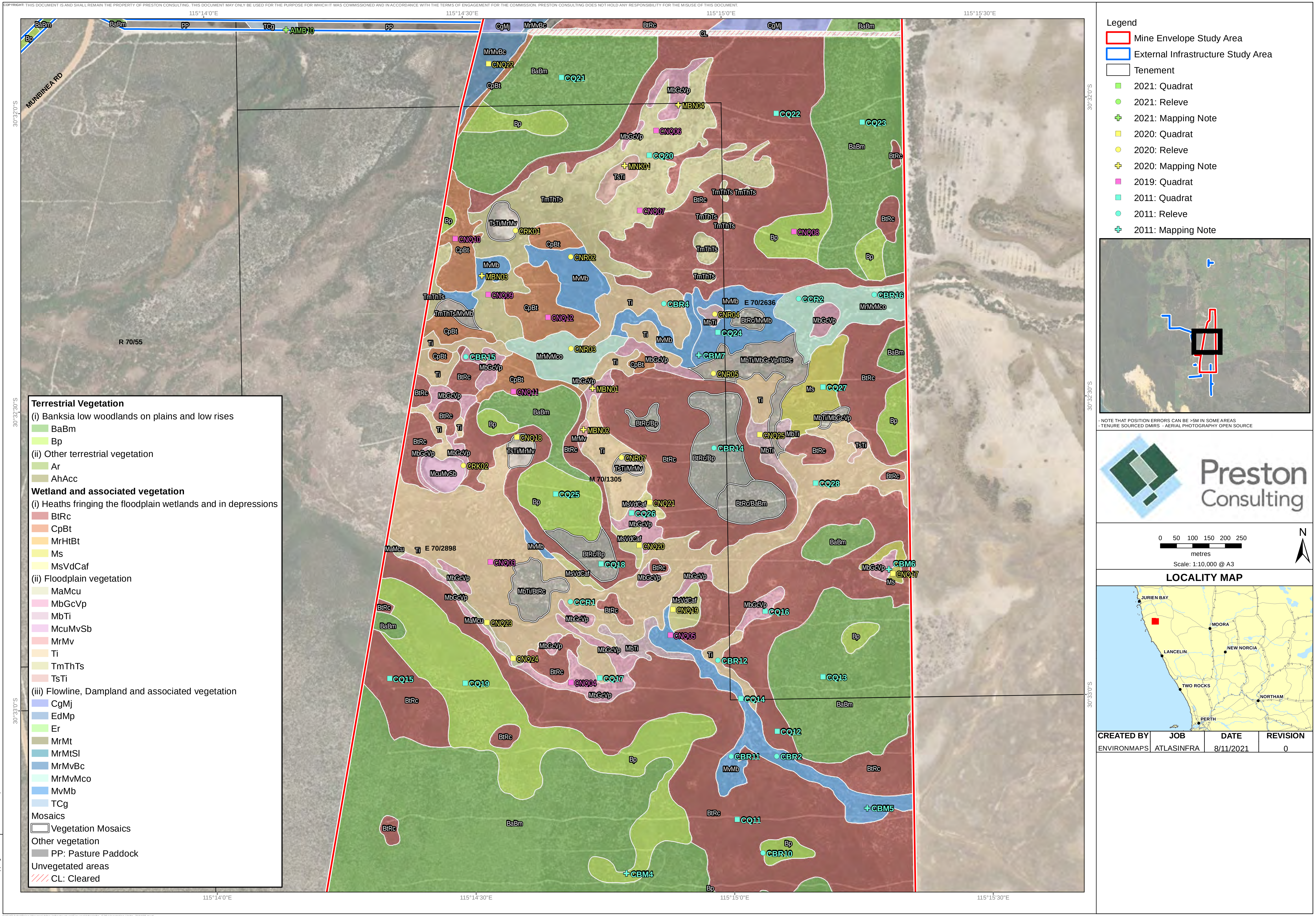


Figure 36: Vegetation units of the central section of the MESA (Morgan, 2022)

Figure 37: Vegetation units of the southern section of the MESA (Morgan, 2022)

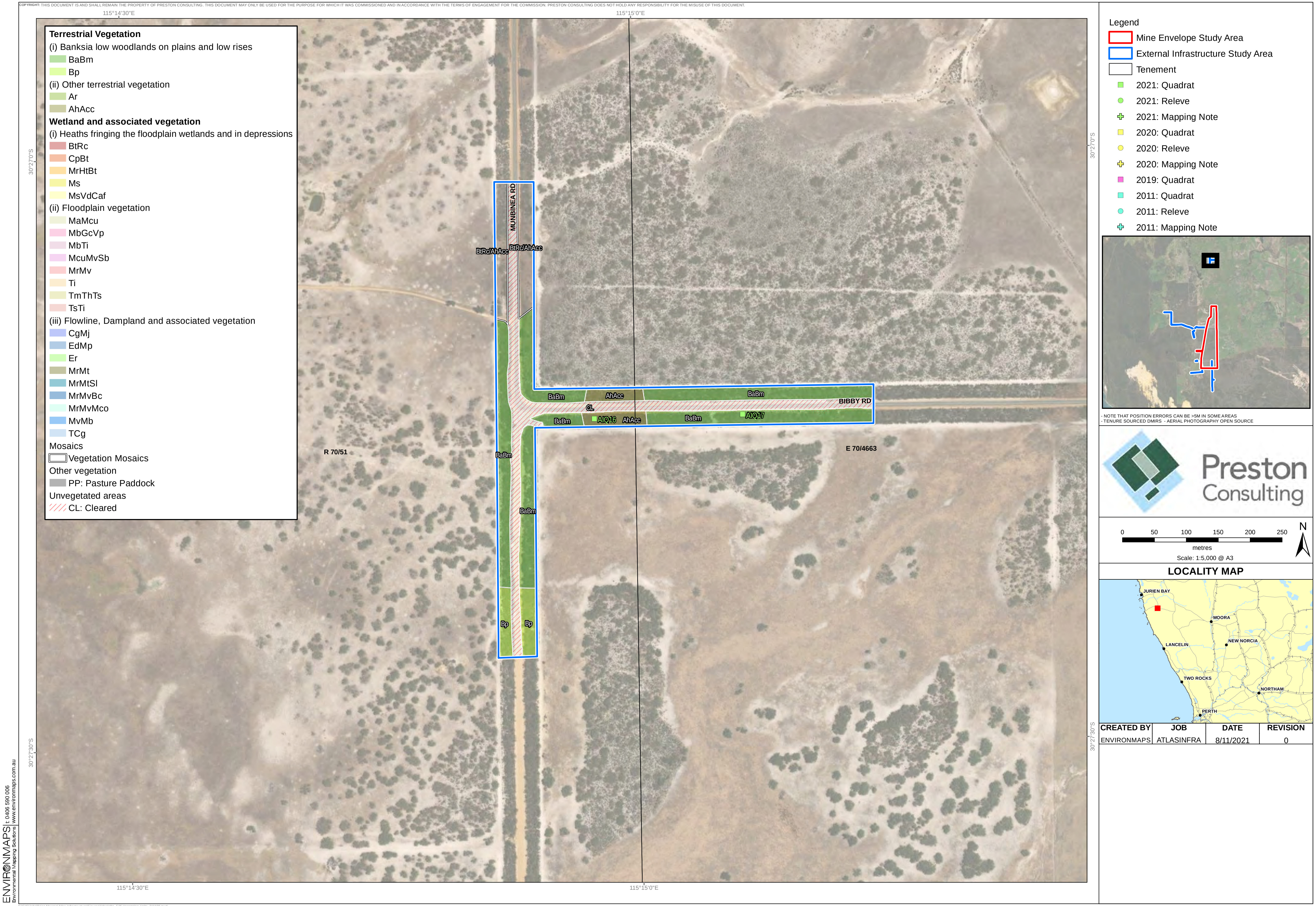
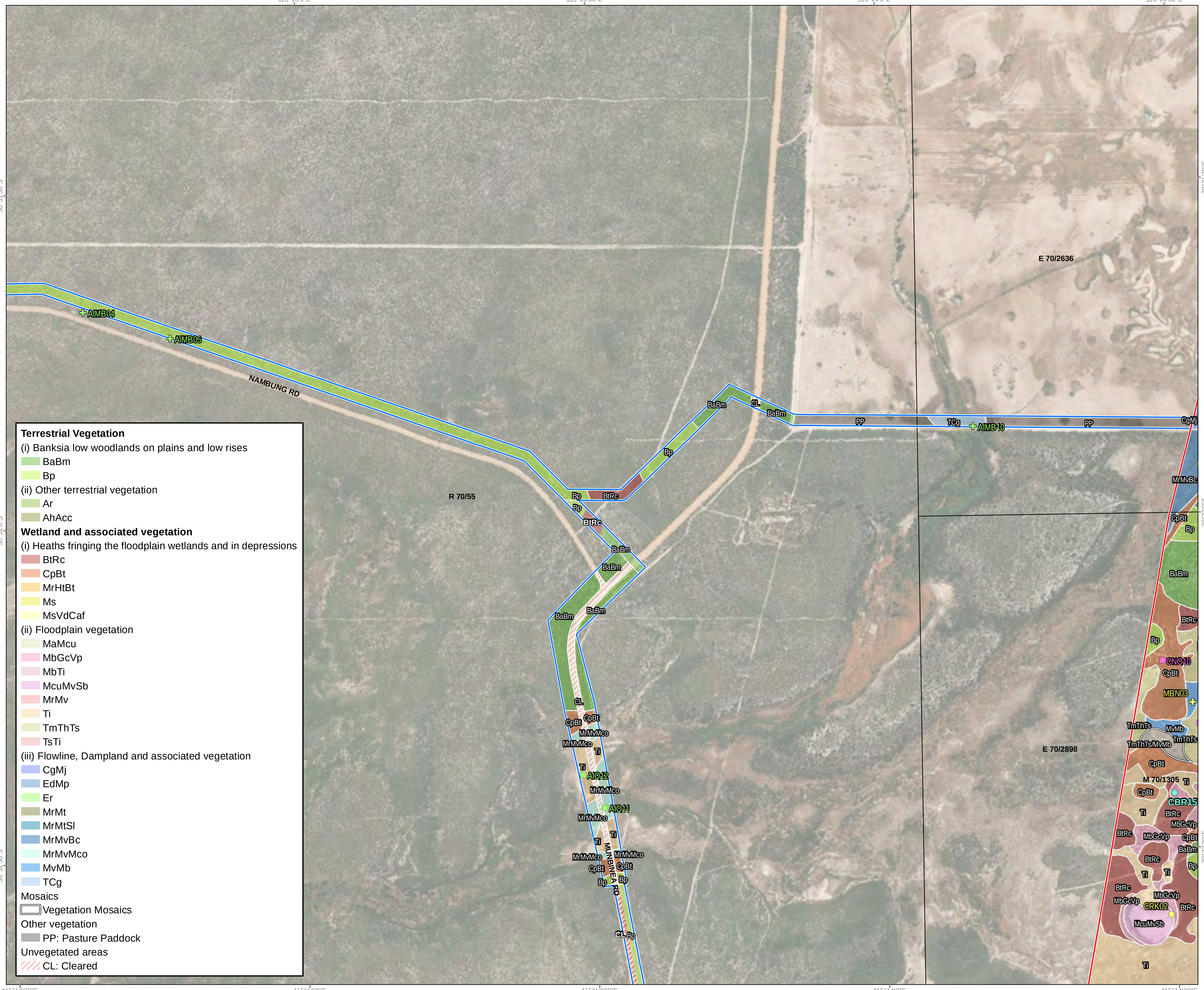
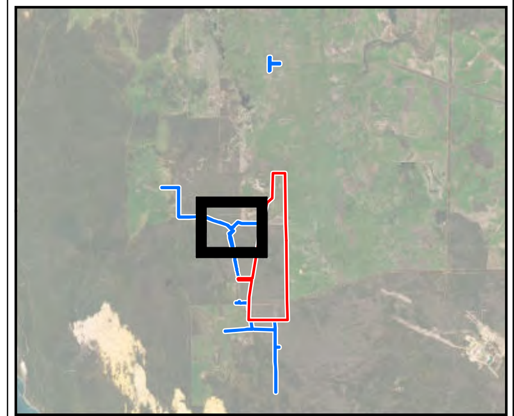


Figure 38: Vegetation units of the EISA (Morgan, 2022) (1/5)



Legend

- Mine Envelope Study Area
- External Infrastructure Study Area
- Tenement
- 2021: Quadrat
- 2021: Releve
- 2021: Mapping Note
- 2020: Quadrat
- 2020: Releve
- 2020: Mapping Note
- 2019: Quadrat
- 2011: Quadrat
- 2011: Releve
- 2011: Mapping Note



- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
- TENURE SOURCED DMIRS - AERIAL PHOTOGRAPHY OPEN SOURCE

Preston Consulting

0 50 100 150 200 250
metres
Scale: 1:10,000 @ A3
N

LOCALITY MAP

CREATED BY	JOB	DATE	REVISION
ENVIRONMAPS	PC2900270	18/11/2022	0

ENVIRONMAPS Environmental Mapping Solutions t: 0406 590 006 www.environmaps.com.au

Figure 39: Vegetation units of the EISA (Morgan, 2022) (2/5)

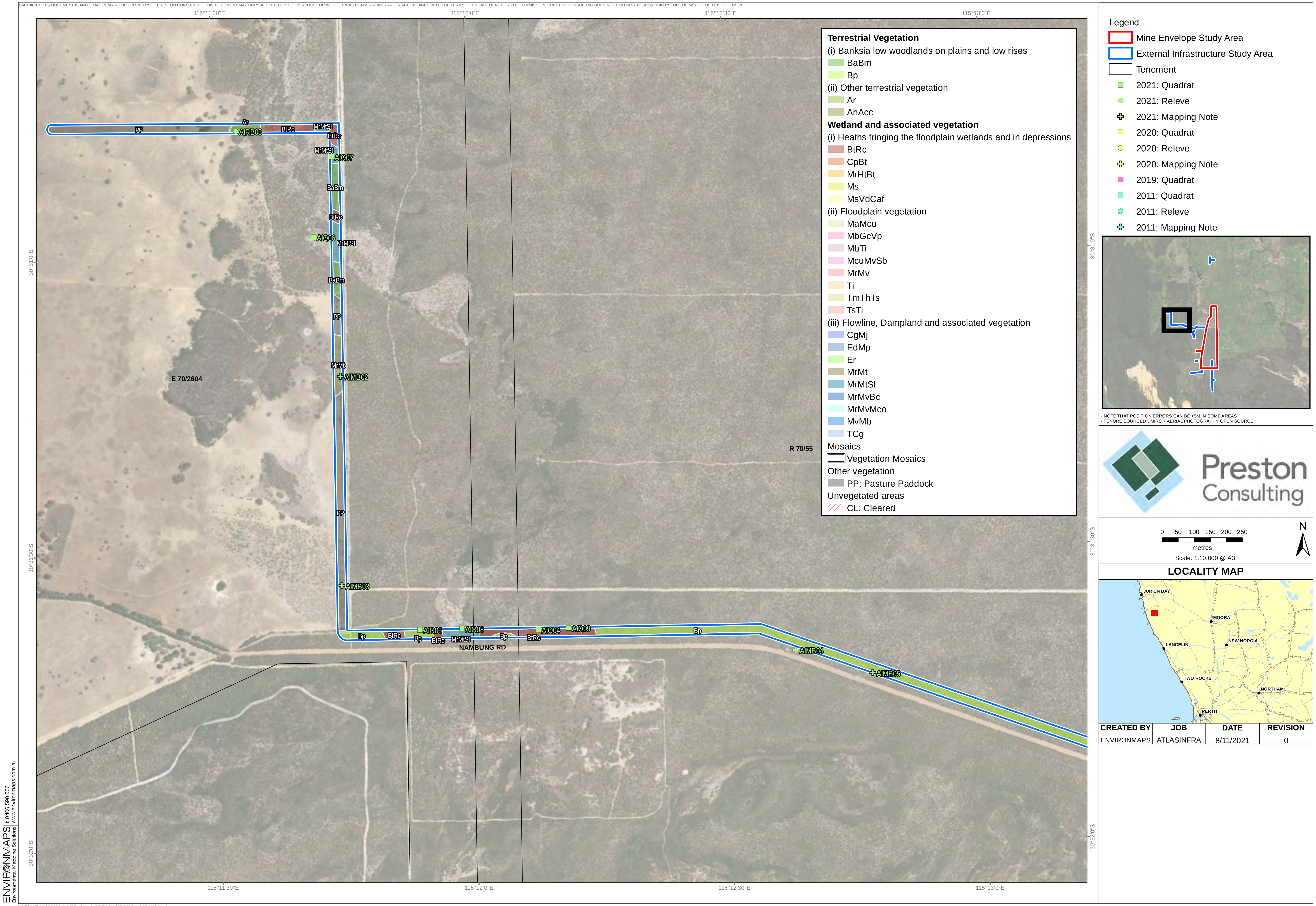


Figure 40: Vegetation units of the EISA (Morgan, 2022) (3/5)

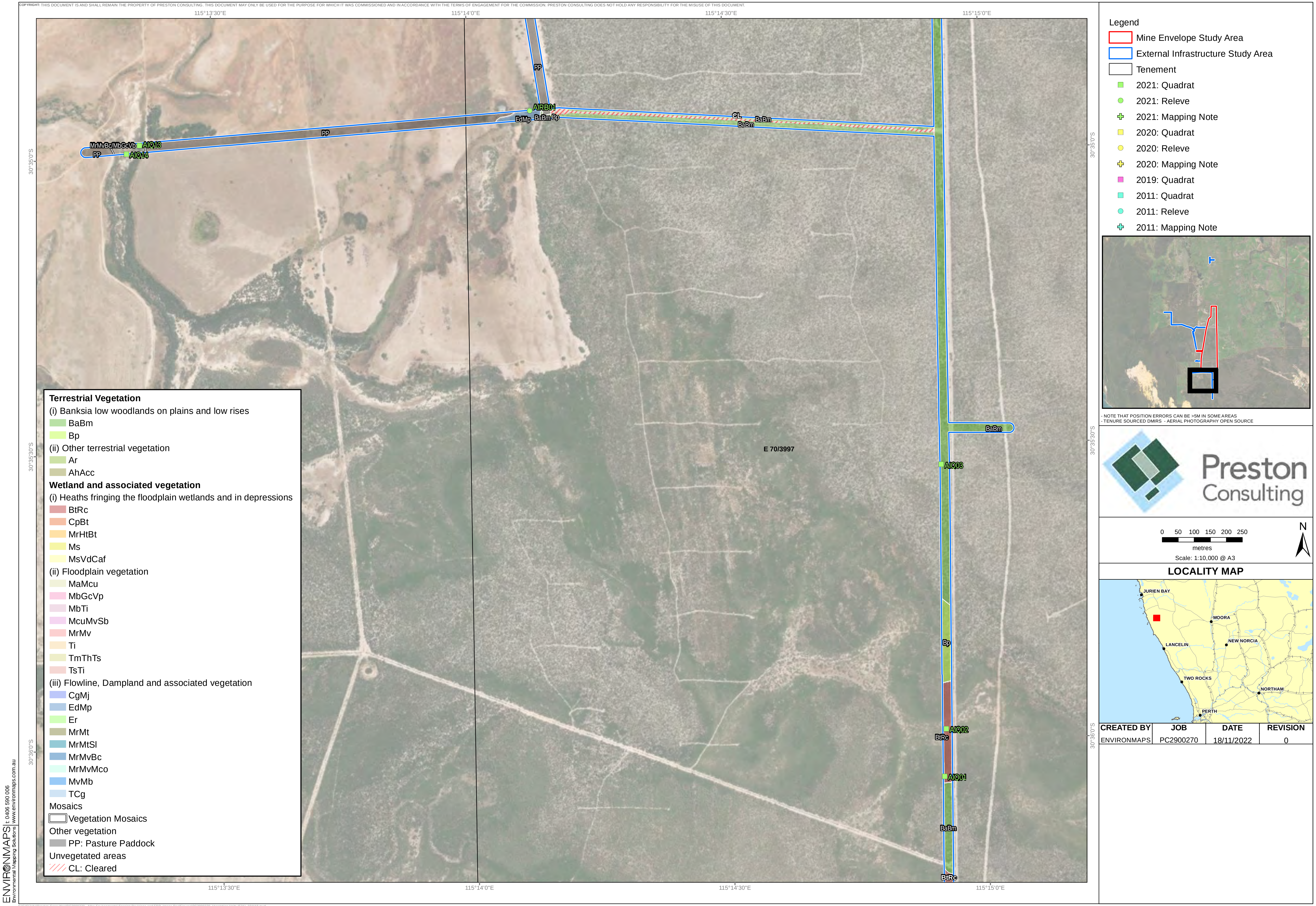


Figure 41: Vegetation units of the EISA (Morgan, 2022) (4/5)

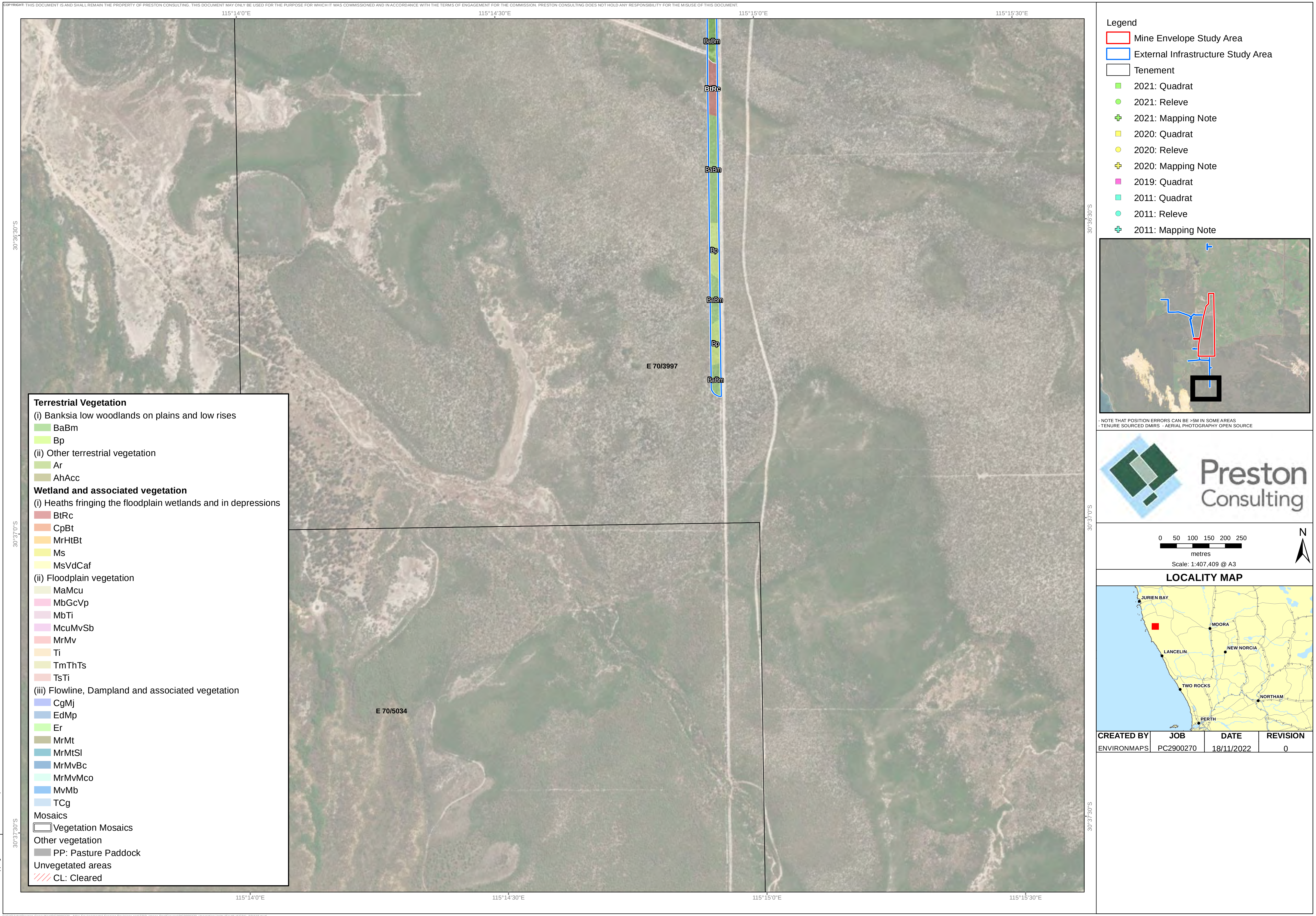


Figure 42: Vegetation units of the EISA (Morgan, 2022) (5/5)

Figure 43: Vegetation units of the BBSA (360 Environmental, 2021)

Regional Analysis of Vegetation Types

Morgan (2022) initially undertook an analysis of all of the 78 quadrat sites against the 2005 SCP dataset (1098 sites) and then compared most of the sites (61 of the 78 quadrats) individually against the 2005 SCP dataset (using 'single site insertion' (SSI)). The following section summarises the more detailed analysis provided in Appendix 2.

At a 35 group level, the analysis of all 78 Atlas sites with the 2005 SCP dataset resulted in the Atlas sites clustering in seven different groups in the dendrogram:

1. The Atlas Banksia woodland and associated sites (26 sites; 'BaBm' and 'Bp') formed an exclusive group that did not include any 2005 SCP sites. Quadrat AIQ17 was part of this group;
2. The Atlas heath sites (20 sites; predominantly 'BtRc', 'CpBt' and *Melaleuca seriata* dominated heath sites) formed an exclusive group with the exception of one SCP FCT23c site;
3. The broad grouping of Atlas floodplain sites (19 sites, including the samphire sites, fringing 'MbGcVp' sites, 'MvMb' creek sites and others) formed an exclusive group that didn't include any SCP sites;
4. Quadrat AIQ16 ('AhAcc') was a single site that grouped at a fairly high dissimilarity level with SCP FCT28 sites;
5. The three 'MrMtSl' wetland sites (AIQ6-8) grouped with a mix of 2005 SCP dataset sites;
6. Five Melaleuca tall shrubland sites grouped at high dissimilarity with 2005 SCP dataset sites; and
7. Four 'Degraded' dampland Melaleuca tall shrubland and a *Eucalyptus rudis* Woodland site grouped with another group of 2005 SCP sites.

The SSI analysis results are summarised as follows:

- Many of the Atlas sites had little similarity with SCP FCTs, indicated by their clustering with SCP sites at relatively high dissimilarity values (Table 14) and often clustering with SCP sites from a mix of various SCP FCTs. The high dissimilarity index values between the Atlas quadrats and their SCP dataset nearest neighbours, suggests substantial differences in floristics between the two datasets;
- Some *Banksia attenuata*, *B. menziesii* Low Woodland sites ('BaBm') were similar to FCT23b, but most 'BaBm' sites clustered with a mix of SCP FCT sites, namely FCTs 23b, 23a and 28. The four 'BaBm' sites south of Wongonderrah Rd (CSQ01, 05, 07, 08) were similar to FCT23b and two 'BaBm' sites from the MESA north of Wongonderrah Rd had similarity with FCT23b (CNQ01 and CNQ15). Site AIQ17 (on the Bibby Rd verge near the Bibby Rd-Munbinea Rd intersection and close to the SCP boundary with the Geraldton Sandplain bioregion) had inconsistent results, fusing at high dissimilarity with FCT20c sites, but having mostly FCT23a nearest neighbours (21 of 30 nearest neighbours were FCT23a SCP sites);
- *Banksia prionotes* Low Woodland sites ('Bp') fused with SCP sites at high dissimilarities. They had some similarity with sites assigned to SCP FCTs 28, S09 and 23c.
- The EISA 'MrMtSl' wetland vegetation site analysis had a high ordination stress value, but had similarity with FCTs 17/S19;
- The *Banksia telmatiaea, Melaleuca seriata* and *Callitris pyramidalis* dominated heaths on the gentle slopes around the floodplain in the MESA (units 'BtRc', 'CpBt', 'Ms, and 'MsVdCaf') mostly had no notable similarities with FCTs, fusing at high dissimilarities with

SCP sites assigned to various FCTs. Site CQ27 ('Ms') was an exception, clustering with some FCT7 sites;
- Two of the three sites in *Melaleuca brevifolia* shrublands, that occurred around the margins of the MESA floodplain (unit 'MbGcVp', sites CQ16 and CQ26) and site AIQ14 that was on the flood banks of the Frederick-Smith Crk, together with *Tecticornia indica* subsp. *bidens* low samphire shrubland sites on the MESA floodplain (CQ17, CQ28, CNQ03) and CQ20) clustered with some FCT7 sites at relatively high dissimilarity levels (>0.7); and
- One Atlas site, CNQ18, had some similarity with FCT7 as it fused with several SCP FCT7 sites at dissimilarity levels between 0.61 and 0.64. A similar result was found when CNQ18 was run against the smaller Gibson *et al.* (1994) dataset. Site CNQ18 was in a small patch of *Melaleuca viminea* subsp. *viminea*, (*Melaleuca rhaphiophylla*) Closed Shrubland on the margins of a small clay pan.

Some sites listed above, showed some clustering with 2005 SCP dataset FCT 7 sites, albeit fusing at relatively high dissimilarity levels. As FCT 7 is classified as 'Herb rich saline shrublands in clay pans' (TEC Vulnerable) by the WA State Government forms part of the 'Clay Pans of the SCP' (TEC Critically Endangered) under the EPBC Act, Morgan (2022) investigated the relationship further.

Claypans of the Swan Coastal Plain"/Herb rich saline shrublands in clay pans TEC (FCT7)

Morgan (2022) conducted a detailed analysis of 14 floodplain and related sites that clustered with some FCT7 sites at high dissimilarity in the PATN analysis (Appendix 2). This analysis showed that the Atlas sites, both as a group of 14 sites and as subsets of sites aligned with Atlas vegetation units, consistently formed their own cluster that was significantly different from the SCP FCT7 site clusters.

Given that the 2005 SCP regional dataset used in the analysis does not include vegetation data for the SCP north of Moore River and hence a classification of that vegetation, the following findings of analyses suggests that it is possible that the 14 Atlas sites may belong to a distinct northern wetland SCP FCT:
- The clustering of these Atlas sites with 2005 SCP FCT7 sites at relatively high dissimilarity values;
- SSI shows that these sites are mostly significantly different from clusters of 2005 SCP sites (SIMPROF test);
- These Atlas sites group together in clusters that are significantly different from 2005 SCP site clusters (including FCT7 clusters); and
- The dissimilarity of Atlas sites with 2005 SCP sites generally increases with the removal of weed species from the data and often significantly so.

The results of these analyses show that the 14 Atlas floodplain and related sites have relatively low similarity with SCP FCT7 sites and, both individually and as a group (subgroups), form significantly different clusters from the SCP FCT7 sites. One of those sites, CNQ18, was considered to have some similarity with SCP FCT7 sites.

Site CNQ18 was assigned to a single quadrat vegetation unit 'MrMv' in a small patch of *Melaleuca viminea* subsp. *viminea*, (*Melaleuca rhaphiophylla*) Closed Shrubland on the margins of a small sumpland in the MESA. This vegetation unit had limited occurrence (0.2 ha;0.02%) in the survey areas. It was included in the vegetation unit 'MrMv'. The 'MrMv' vegetation unit was broadly defined to describe small, scattered patches of *Melaleuca rhaphiophylla, Melaleuca viminea* subsp.

viminea shrublands that were observed occasionally on the margins of some of the small sumplands/claypans on the floodplain and in a few locations on the wetter margins of the MESA floodplain (Figure 36). It should be noted that the overall sumpland/claypan vegetation was also described in vegetation units 'McuMvSb' and 'TsTi'. 'Herb rich saline shrublands in clay pans' (FCT 7) was described by Gibson *et al*. (1994) as being generally 'dominated by either *Melaleuca viminnamom uncinata*, *M. cuticularis* or *Casuarina obesa* or a mixture of these species' and as occurring 'on heavy clay soils that are generally inundated from winter to mid-summer' (DSEWPC, 2012). This description does not appear to closely match the habitat mapped in CNQ18.

Locally Significant Vegetation

The two *Banksia* woodland units (*Banksia attenuata*-*Banksia menziesii* Low Woodland and *Banksia prionotes* Low Woodland) that were described in the survey area were considered locally significant:

- Vegetation unit 'BaBm' occupied most of the southern half of the survey area and was by far the largest vegetation unit in the survey area, occupying 598 ha (51.2%) in the MESA. BaBm was found on sand plains and low sandy rises and, in a few places, 'low dunes.' They occurred on grey siliceous sands over most of the southern half of the MESA and in the EISA corridor south of the MESA and Wongonderrah Rd, with small areas in other EISA corridors. *Eucalyptus todtiana* was typically scattered through the unit. *Banksia ilicifolia* was sparsely scattered in lower parts of the unit. This vegetation was quite species rich, with an average of 56.9 native species per quadrat. Vegetation condition was generally 'Excellent' to 'Pristine' in the MESA and EISA, with very low numbers of weed species and very low weed cover, with no weeds recorded in some quadrats; and
- Vegetation unit 'Bp' occurred on areas of yellow sand on the plains and low rises in the MESA and included other calcareous soil-loving species such as *Calothamnus quadrifidus*. The *Banksia prionotes* trees in the survey area grew to approximately 3 - 4 m, and were in dense stands in places. 'Bp' vegetation was significantly less species rich than the 'BaBm' low woodlands, with approximately 40 - 55 native species in a 100 m^2 quadrat. Vegetation condition was generally found to be 'Excellent to Pristine', with very low numbers of weed species and very low weed cover. There were numerous broad low rises on the floodplain that demonstrated vegetation that was transitional or ecotonal between unit 'Bp' and the *Banksia telmatiaea* heaths, and were mapped as mosaics.

The *Banksia attenuata*, *Banksia menziesii* Low Woodlands ('BaBm') and the *Banksia prionotes* Low Woodlands ('Bp') in the Atlas survey area meet the criteria to be characterised as the EPBC Act-listed TEC '*Banksia* woodlands of the Swan Coastal Plain' (Endangered) (DAWE, 2021a). These *Banksia* woodlands are classified as '*Banksia* dominated woodlands of the Swan Coastal Plain IBRA region' (PEC Priority 3) by the WA State Government. The *Banksia* woodlands were mostly continuous over a large area of sand plain but occurred in smaller 'patches' amongst and around the floodplain area.

Four locally significant heathland units ('BtRc', 'CpBt', 'MsVdCaf', 'Ms') were identified fringing the floodplain and in depressions. These heathlands are thought to be floristically distinctive, and are associated with a high number of significant flora taxa:

- Vegetation Unit 'BtRc' was recorded at floristically similar quadrats on the gentle slopes around the floodplain and in small depression areas on the sandplain, and occupied 151.3 ha of the MESA. There was a consistent transition in the 'BtRc' vegetation fringing the floodplain, from the taller areas of this unit in dryer parts with high covers of *Banksia* *telmatiaea* to lower heaths lower on the slopes and nearer the margins of the floodplain, where *Regelia ciliata* and *Melaleuca seriata* had higher covers and where *Callitris pyramidalis* and *Banksia nivea* were typically present, along with some dampland herb species (such as *Drosera gigantea*). *Isopogon panduratus* subsp. *palustris* (Priority 3) was common in this vegetation unit. 'BtRc' was moderately species rich with an average of 32.8 native species per MESA quadrat;

- Vegetation Unit 'CpBt' was similar floristically to 'BtRc', however different structurally. It mostly occurred on the gentle slopes around the floodplain in the northern part of the survey area (12.2 ha of the MESA). *Callitris pyramidalis* typically formed Tall Shrublands to 4 m in height in areas of this unit, but in some areas it formed a dense Closed Heath to about 1.9 - 2 m height;
- Vegetation Unit 'MsVdCaf' was dominated by *Melaleuca seriata*, and occurred at five or six small patches (2.4 ha of the MESA) on the margins on the southern-central part of the floodplain. It was differentiated from other heaths by the occurrence of *Babingtonia urbana* (Priority 3) as a co-dominant. *Desmocladus nodatus* (Priority 3) was also associated with this unit. 'MsVdCaf' vegetation was moderately species rich (31.7 native species per quadrat; and
- Vegetation Unit 'Ms' was recorded in two areas, each described with one quadrat, and could best be described as *Melaleuca seriata* miscellaneous heaths. At one quadrat, 'Ms' likely represents an area ecotonal between 'MsVdCaf' and 'BtRc.' The other quadrat was identified in in a small area of *Melaleuca seriata* heath, and was differentiated by having a *Desmocladus lateriflorus* Open Rushland and *Neurachne alopecuroidea* Low Sparse grassland, suggesting the influence of nearby ironstone.

Threatened and Priority Ecological Communities

<u>MESA / EISA Survey Areas</u>

A search of the DBCA TEC/PEC database in October 2019 identified 'Banksia dominated woodlands of the Swan Coastal Plain IBRA region' (State Priority 3; Federal TEC (Endangered)) mapped in the survey area and its surrounds. Figure 44 shows the local area mapped by DBCA as 'Banksia Woodlands of the Swan Coastal Plain'.

The *Banksia attenuata, Banksia menziesii* Low Woodlands ('BaBm') and the *Banksia prionotes* Low Woodlands ('Bp') in the survey areas (excepting one small area in 'Good' condition) meet the criteria to be characterised as the EPBC Act-listed 'Banksia woodlands of the Swan Coastal Plain' TEC (Endangered) (DEE, 2016; DAWE, 2021a). The *Banksia* woodlands are also classified as 'Banksia dominated woodlands of the Swan Coastal Plain IBRA region' (Priority 3 Ecological Community) by DBCA.

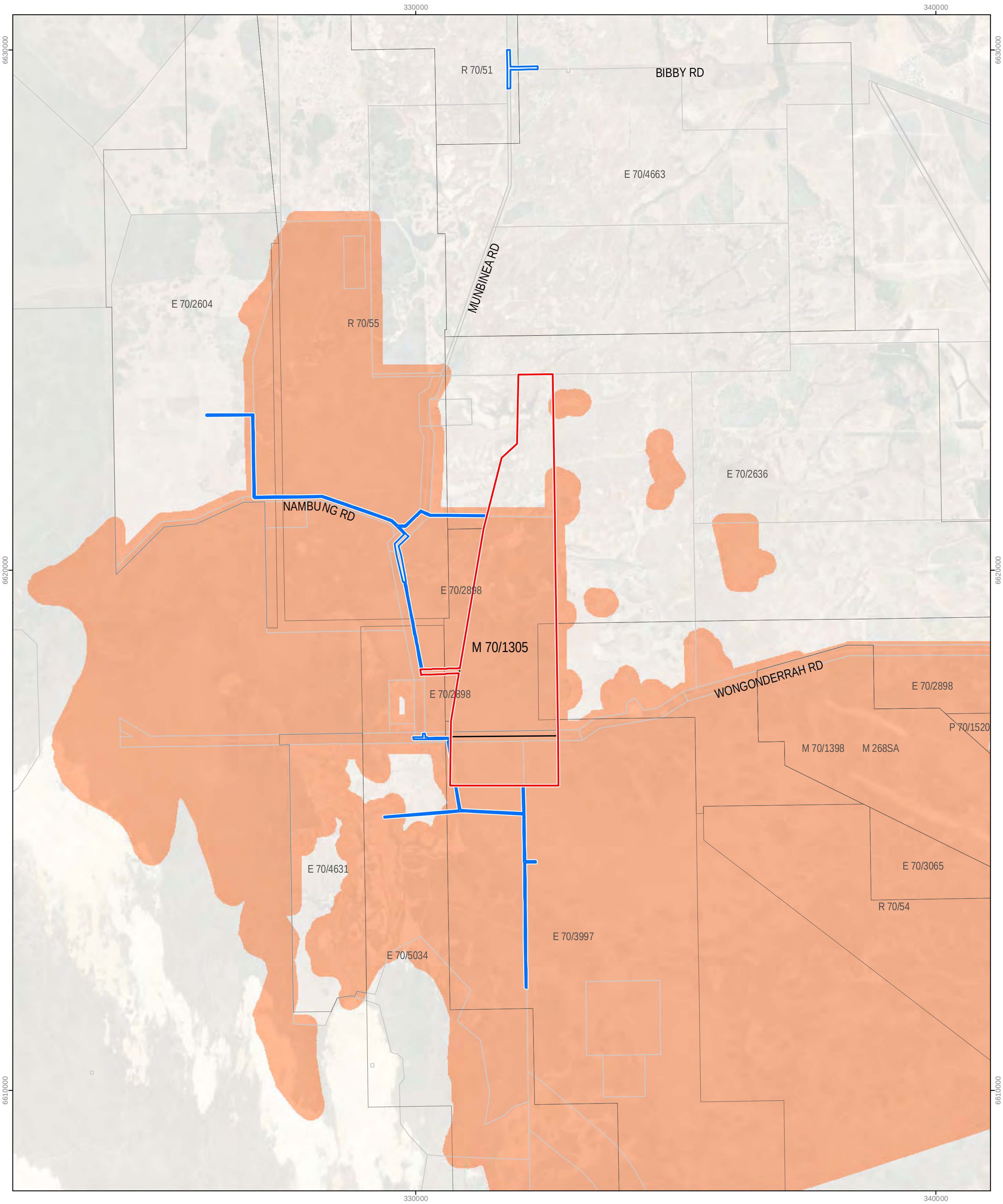
Condition thresholds for minimum 'patch' size apply in assessing if an area of *Banksia* woodland qualifies as the 'Banksia woodlands of the Swan Coastal Plain' TEC (DCCEEW, 2022a; DEE, 2019). The *Banksia attenuata, Banksia menziesii* Low Woodland and *Banksia prionotes* Low Woodland covered 54.8% (675.1 ha) of the combined MESA and EISA (Figure 45), including 67.5% of the bushland portion of the MESA (south of farmland). The vegetation condition of the *Banksia* woodlands varied, but was mostly in the range 'Excellent' to 'Pristine'. The exceptions were areas mapped as *Banksia* woodland on the farm in the northern part of the MESA and to a lesser extent, in parts of the EISA corridor on farmland at the western end of Nambung Road. The *Banksia* woodlands were mostly continuous over a large area of sand plain but occurred in smaller 'patches' amongst and around the floodplain area.

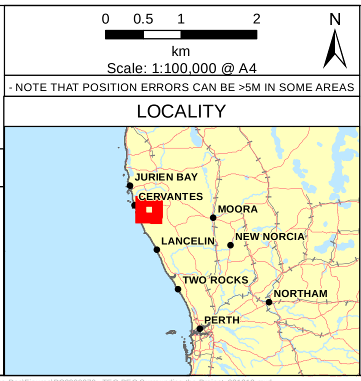
Only one area of *Banksia* woodland in the MESA bushland area (southern part) did not meet the patch size for the condition criteria. It was a 1.7 ha area of unit 'Bp' on the eastern boundary, which was assessed as being in 'Good' condition (2 ha area is the threshold). Two areas of remnant *Banksia* woodland on farmland in the MESA were assessed as not meeting the minimum condition criteria ('Good'). Therefore, 625.7 ha of *Banksia* woodlands in MESA were assessed to be 'Banksia woodlands of the Swan Coastal Plain' TEC / PEC.

There was 34.1 ha of *Banksia* woodland ('BaBm' and 'Bp') in the EISA corridors. This was all assessed as TEC, even when the discrete areas in the corridors were small, because all corridor patches were assessed as being continuous with or part of larger adjacent or surrounding *Banksia* woodland patches. Therefore, a total area of 659.8 ha of the total area of 675.1 ha of *Banksia* woodlands across the MESA and EISA was assessed to be 'Banksia woodlands of the Swan Coastal Plain' TEC / PEC.

BBSA Survey

Two of the Floristic Community Types (FCT) identified as occurring in the BBSA from the statistical analysis; FCT SCP23b - Northern *Banksia attenuata* – *Banksia menziesii* woodlands and FCT SCP S09 – *Banksia attenuata* woodlands over dense low shrublands are listed as sub-communities of the *Banksia* woodlands of the Swan Coastal Plain TEC / PEC.





Legend
- Mine Envelope Study Area
- External Infrastructure Study Area
- M 70/1306
- Tenement
- Cadastre

Threatened and Priority Ecological Communities
- Priority 3, Endangered, Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region

Source: Orthophoto - Open Source

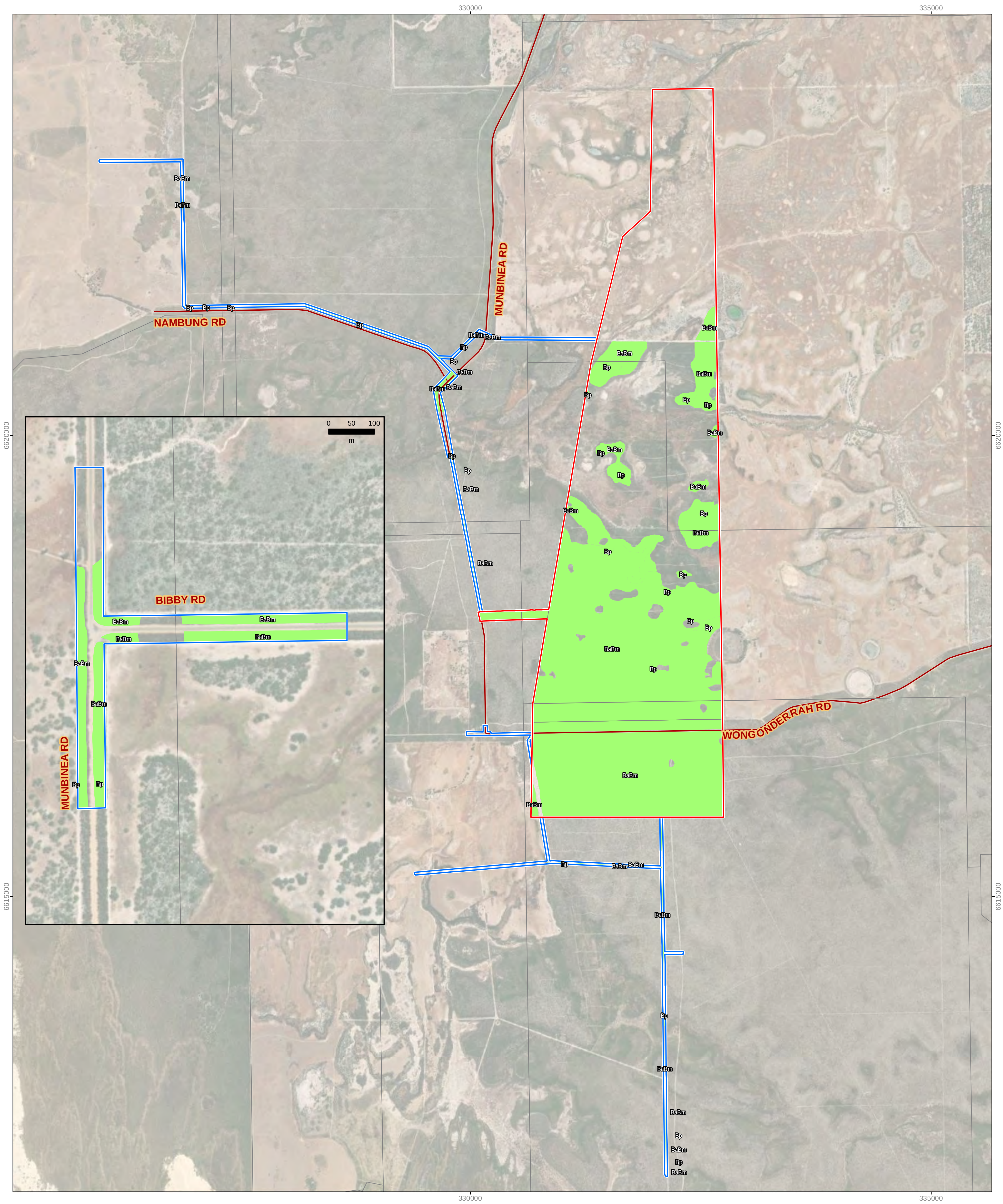
CREATED	JOB	DATE	REVISION
ENVIRONMAPS	PC2900270	13/12/2022	0

Image Resources

ENVIRONMAPS | t: 0406 590 006 | www.environmaps.com.au
Environmental Mapping Solutions

C:\GIS\Jobs\Preston Consulting\PC2900270 - Atlas Environmental Scoping Revisions and ERD, Image Res\Figures\PC2900270_TEC-PEC Surrounding the Project_221213.mxd

Figure 44: Local DBCA mapped TEC/PEC



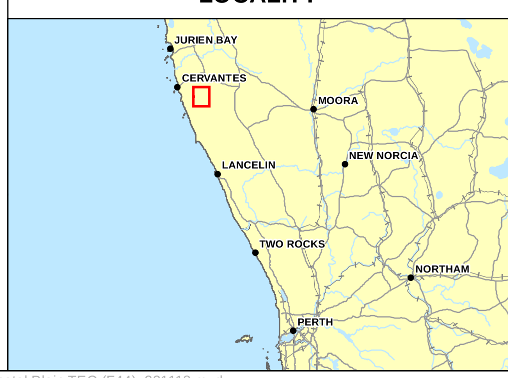
Legend

- Mine Envelope Study Area
- External Infrastructure Study Area
- Tenement
- Banksia Woodlands of the Swan Coastal Plain (Federal TEC (Endangered)) (State PEC (Priority 3))

0 0.5 1 2
km
N
Scale: 1:40,000 @ A3

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY



Preston Consulting

CREATED BY	JOB	DATE	REVISION
ENVIRONMAPS	PC2900270	18/11/2022	0

Figure 45: 'Banksia woodlands of the Swan Coastal Plain' mapped within the MESA and EISA (Morgan, 2022)

Source: Orthophoto - Open Source Imagery

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Preston Consulting

CREATED	JOB	DATE	REVISION
ENVIRONMAPS	PC2900270	20/06/2022	0

Image Resources

0 75 150 300
m
Scale: 1:15,000 @ A4
N

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY

Legend

- External Infrastructure Development Envelope
- 360 Environmental 2021 Survey Area
- Cadastre
- Banksia Woodlands of the Swan Coastal Plain (Federal TEC (Endangered)) (State PEC (Priority 3))

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C:\GIS\Jobs\Brian Morgan\Atlas Infrastructure\Figures\PC2900270_Banksia Woodlands of the Swan Coastal Plain TEC 360 Environmental (2021) Survey Area_220620.mxd

Source: Orthophoto - Open Source

Figure 46: 'Banksia woodlands of the Swan CoastalPlain' mapped within the BBSA (360 Environmental, 2021)

Groundwater Dependant Ecosystems

There are a number of groundwater attributes which influence the relationship with GDEs, depth to groundwater generally being the most important attribute for GDEs that rely primarily on groundwater, while depth and frequency of inundation are most important for GDEs that rely on both surface expressions of groundwater and overland flow of surface water (e.g., floodplains and wetlands) (Froend and Loomes, 2006).

In the survey area, a recent hydrology study (MWES Consulting, 2021) formed a conceptual hydrological model of the study area that was comprised of two aquifer systems, the Superficial/Tamala Limestone aquifer and the deeper Mesozoic aquifer system. The superficial formations are considered to be a single unconfined aquifer system that is generally thin near the Atlas deposit and thickens to the north and south. Recharge to the Superficial Aquifer from rainfall and associated runoff is widespread over the project area.

MWES Consulting (2021) found that depth to the water table increases from less than 2 m in the northern part of the MESA to 8 - 10 m in the south-east (refer to Section 7.3.5, Figure 83).

Terrestrial Vegetation

Terrestrial vegetation in the survey area comprised of *Banksia attenuata*, *Banksia menziesii* Low Woodlands and *Banksia prionotes* Low Woodlands. *Banksia attenuata*, *Banksia menziesii* and *Banksia prionotes* are facultative phreatophytes (use groundwater if it is accessible) (Thomas, 2014; Syrinx Environmental, 2013). *Eucalyptus todtiana*, which was a co-dominant scattered throughout the *Banksia* woodland, is also a facultative phreatophyte (Syrinx Environmental, 2013). *Banksia ilicifolia*, which was sparsely scattered in the lower parts of the *Banksia* woodlands in the study area, is considered an obligate phreatophyte. Several terrestrial shrub species present in the *Banksia* woodlands, are also known to be facultative groundwater users: *Eremaea pauciflora*, *Jacksonia floribunda* and *Stirlingia latifolia* (Thomas, 2014; Syrinx Environmental, 2013).

Most of the *Banksia* woodlands in the MESA have a depth to water table of between 4 - 8 m (refer to Section 7.3.5). Given that studies of *Banksia* woodlands on the Swan Coastal Plain have shown that if they are within 10 m of water table, *Banksia* spp. are phreatophytic and derive some of their water from groundwater (Froend and Loomes, 2006); it can be concluded that the *Banksia* woodlands in the MESA can be considered to be a potential terrestrial GDE.

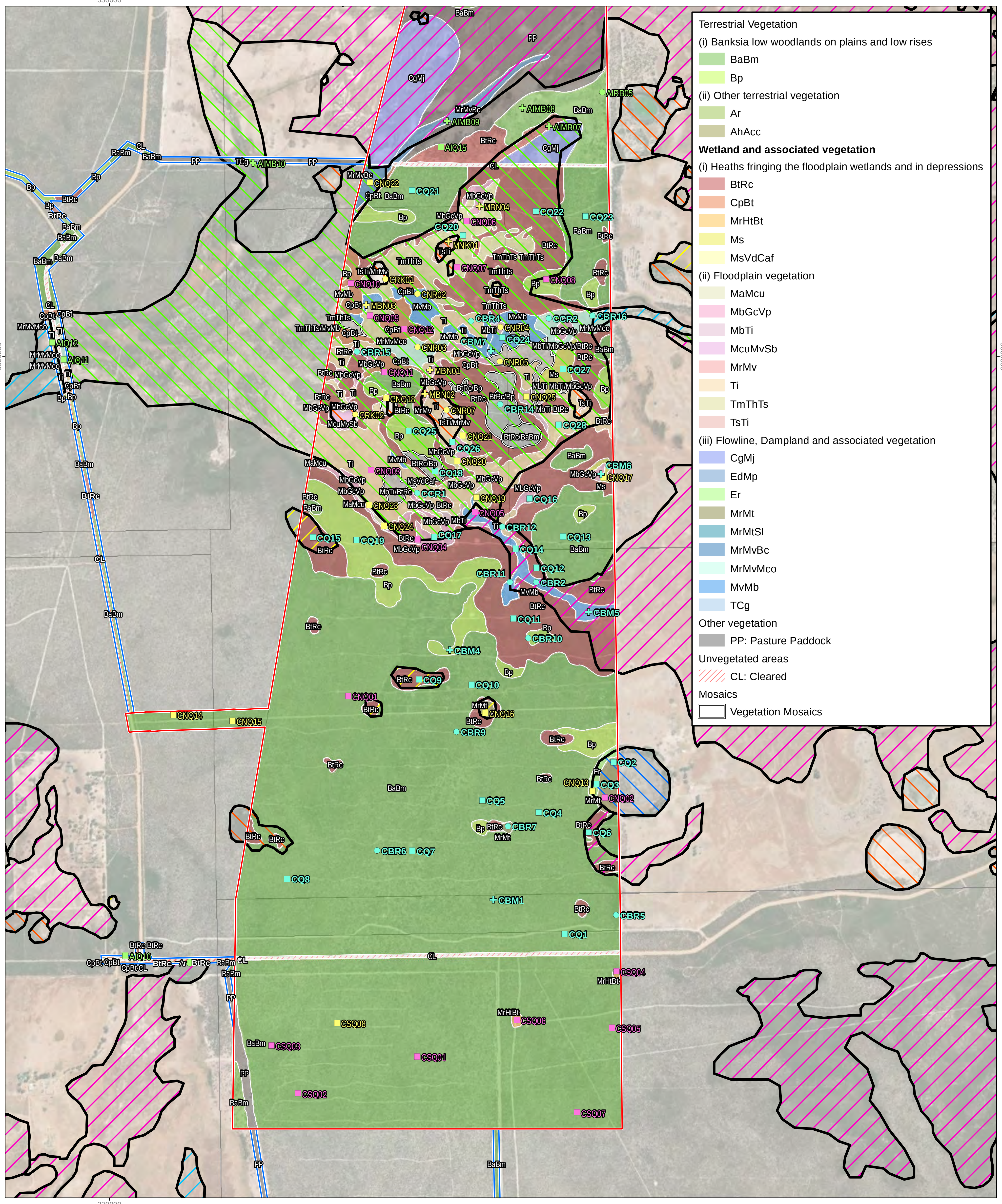
Wetland and Associated Vegetation

Froend *et al*. (2004) noted that the groundwater dependence of many wetland ecosystems has been largely inferred from their position in the landscape and the occurrence of plant species associated with shallow groundwater. The *Melaleuca* shrubland units in damplands and along flowlines and their flood banks and on some other parts of the floodplain, include dominant species that are considered obligate wetland species (*Melaleuca brevifolia*, *M. rhaphiophylla*, *M. teretifolia*) and which through association are considered potential wetland GDE.

The *Tecticornia* unit 'TmThTs', which occurred in the northern part of the MESA where there is a shallower water table (<2 m), includes waterlogging-tolerant species and it would be reasonable to assert that this unit may be 'wetland GDE'. This is also true for the sumpland vegetation units.

The southern and western part of the floodplain area had a depth to groundwater of 2 - 4 m (Refer to Section 7.3.5) and *Tecticornia indica* subsp. *bidens* Low Shrublands occurred in these parts. *Tecticornia indica* subsp. *bidens* is known to occur in 'well drained, saline soils' (Datson, 2002). Equinox Environmental (2013) reported the findings of a modelling study which suggested that the ecological water requirements of the fringing samphire communities (including *Tecticornia indica* subsp. *bidens*) are wholly or predominantly met by surface inputs. However, samphire root excavations have found that the fine roots can extend up to 2.5 m (Equinox Environmental, 2013). In conclusion, the GDE status of *Tecticornia indica* subsp. *bidens* in the MESA is not known, but its occurrence in a floodplain area in association with a water table that may be accessible to its roots leads to a conservative assessment for this report that it may be potential GDE. The *Banksia telmatiaea* heaths that occurred in depressions on the sandplain and that, together with other heaths, fringed the floodplains in the MESA, were in areas with relatively low depths to groundwater table of 2 - 4 metres (Figure 47) and are therefore likely to be potential GDE. The general association of *Banksia telmatiaea* heaths with wetlands suggests it is facultative GDE. Finally, *Eucalyptus rudis* subsp. *rudis* is considered an obligate wetland taxon (ENV Australia, 2010) and the *Eucalyptus rudis* subsp. *rudis* Open Forest that fringes a dampland in the survey area would be considered GDE.

In summary, the entire MESA native vegetation can be considered either a potential wetland GDE or a potential terrestrial GDE.



Preston Consulting

CREATED BY	JOB	DATE	REVISION
ENVIRONMAPS	PC2900270	22/11/2022	0

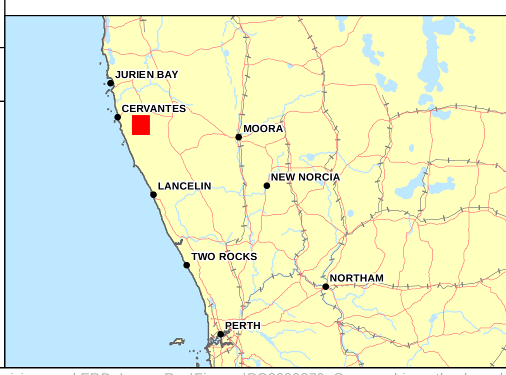
Image Resources

Figure 47: Geomorphic wetlands and associated vegetation at the Proposal

0 200 400 800
metres
Scale: 1:20,000 @ A3
N

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY



Legend
- Mine Envelope Study Area
- External Infrastructure Study Area

APFVSOCT20_Samples_210303
- 2021: Quadrat
- 2021: Releve
- 2021: Mapping Note
- 2020: Quadrat
- 2020: Releve
- 2020: Mapping Note
- 2019: Quadrat
- 2011: Quadrat
- 2011: Releve
- 2011: Mapping Note

Geomorphic Wetlands
- Palusplain
- Sumpland
- Dampland
- Floodplain
- Creek
- Lake

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Source: Orthophoto - Open Source

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Dieback

Phytophthora dieback (or dieback) is a disease caused by the introduced soil-borne pathogen *P. cinnamomi*. While some plant species are resistant, others are susceptible to the disease caused by the pathogen, which can result in chlorosis, dieback and usually death (Wills and Keighery, 1994).

Disease expression caused by *Phytophthora* species occurs in native vegetation when the following variables and environmental conditions are present:

- Host – plant species are present that are susceptible to *Phytophthora* spp.;
- Pathogen – a *Phytophthora* spp. Pathogen must be present, either residing in susceptible or resistant species; and
- Environment – soil temperatures of 15-30°C and pH 5-6 (acidic) are required for *P. cinnamomi* survival and activity. Some *Phytophthora* species, including *P. multivora*, can survive in alkaline soils (pH 7+).

In WA, dieback is a significant environmental issue for projects between Geraldton in the Midwest and Esperance on the South Coast, and it is widespread in the Southwest region. Dieback has a range of hosts in Southwest WA, predominantly from the *Ericaceae*, *Fabaceae*, *Myrtaceae*, *Proteaceae*, and *Xanthorrhoeaceae* plant families.

Desktop Assessment

A desktop assessment conducted by Terratree (2020) identified no previous *Phytophthora* samples had been taken within the Dieback Assessment Area. The DIDMS database indicated that the southern and central portions of the Assessment Area were considered to be Uninfested with a 'moderate' level of confidence, while northern areas were considered to be Uninfested with a 'low' level of confidence. The 'moderate' to 'low' confidence classifications of the Dieback Assessment Area was considered the result of a lack of recorded samples as well as the age of any dieback mapping which may have previously occurred within the MDE.

The DIDMS database did indicate an area of infested vegetation occurring along a watercourse on the western side of Munbinea Road, which was outside and down-gradient of the Dieback Assessment Area. The occurrence of this infested vegetation was therefore not considered to affect the protectability of the vegetation which occur upstream along the water course.

Field Assessments

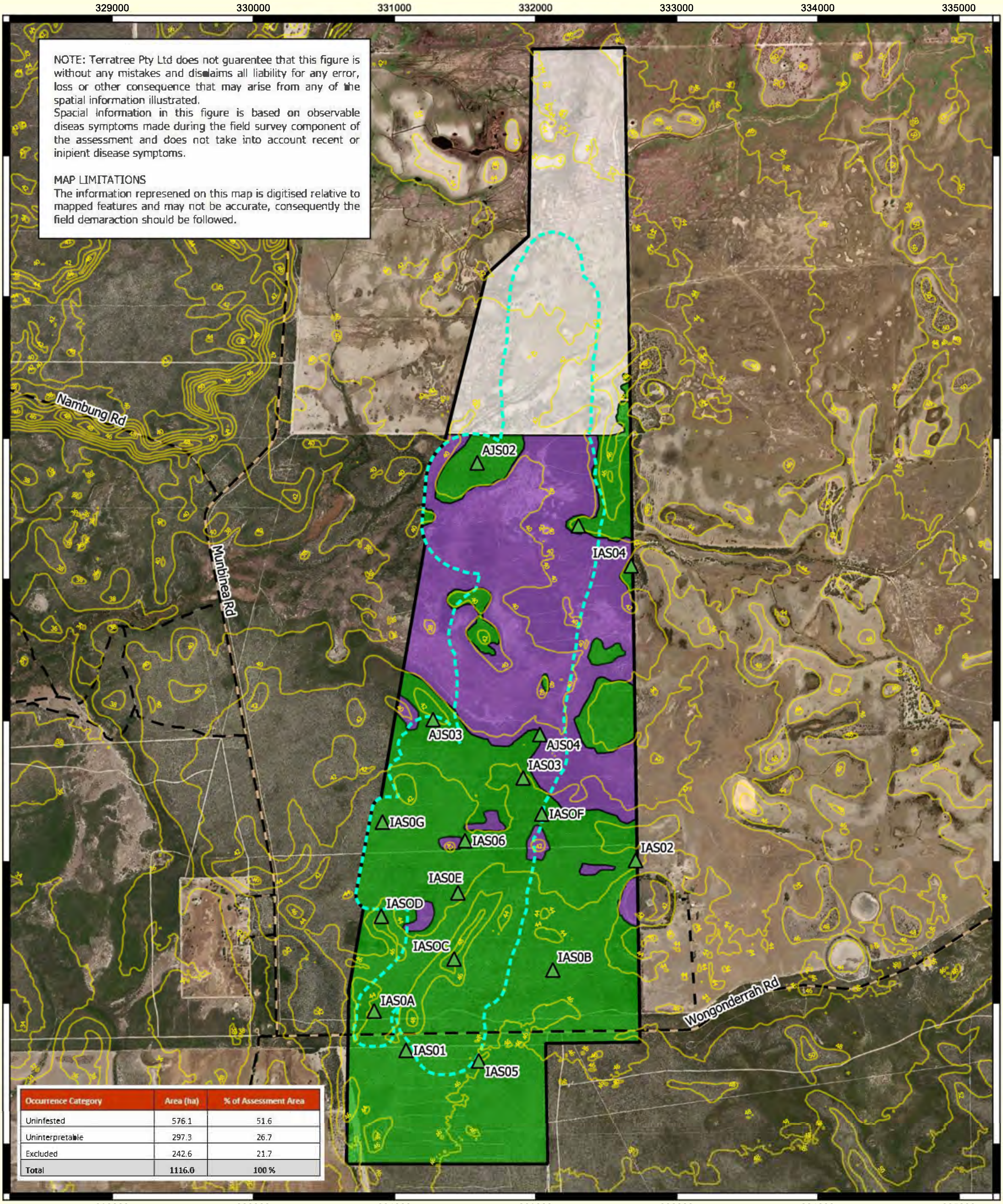
Dieback occurrence within the Dieback Assessment Area is detailed in Figure 48. A total of 576.1 ha (51.6%) of the assessed area was mapped as Uninfested and 297.3 ha (26.7%) was categorised as Uninterpretable. The remaining 242.6 ha (21.7%) had to be excluded from the assessment due to the vegetation condition in this area which has degraded over time as a result of being extensively grazed. Areas mapped as Uninfested vegetation generally dominated the southern third of the Dieback Assessment Area, excluding some low-lying areas. Uninfested vegetation was also present to a lesser degree in the middle third of the Dieback Assessment Area, generally in areas of higher topography. There was also a small patch of Uninfested vegetation within the northern third of the Dieback Assessment Area, which ran for approximately 375 m along the eastern boundary. Uninfested vegetation contained sufficient numbers of primary indicator species (mainly *Banksia attenuate*, *B. menziesii* and *B. prionotes*) for the vegetation to be interpretable. These communities also contained a number of secondary indicators which assisted with the interpretation of the vegetation.

Uninterpretable vegetation dominated the central third of the Assessment Area, with the exception of areas of higher topography. The low-lying areas in the southern third did contain a Banksia species (*Banksia telmatiaea*) which are generally considered to be primary disease indicator species, however *B. telmatiaea* alone was not considered to be sufficient to make this vegetation interpretable. *B. telmatiaea's* significantly shallower root system is not considered to be able penetrate the soil deeply enough to reach the high concentration of *Phytophthora* inoculum when compared with other *Banksia* species (*B. attenuata*, *B. menziesii* and *B. prionotes*) (McCredie *et al*., 1985). *B. telmatiaea* was the only disease indicator species identified in the central third of the Dieback Assessment Area, which was otherwise dominated by dieback-resistant species including *Regelia ciliata* making it very difficult to map dieback if it were present.

Small patches of uninterpretable vegetation were also identified in the southern third of the Dieback Assessment Area. None of the communities with uninterpretable vegetation, contained any primary disease indicator species on the health of which the presence of dieback could be determined.

Most of the northern third of the Dieback Assessment Area had to be excluded from this dieback assessment, approximately 242.6 ha (21.7%) of the Assessment Area. This is due to the vegetation condition in this area which has degraded over time as a result of being extensively grazed. This community was defined as 'completely degraded' pasture paddock in the Level 2 Flora Survey conducted in 2012 (360 Environmental, 2012b). There are some small patches of Community 1 vegetation present in the south east of the northern portion, however, apart from some small patches along the eastern boundary most of the vegetation was classified as 'degraded' (Keighery, 1994).

Seventeen soil and tissue samples were taken during the dieback assessment, all of which returned negative results. Retesting was not considered to be required as these were expected results.



Occurrence Category	Area (ha)	% of Assessment Area
Uninfested	576.1	51.6
Uninterpretable	297.3	26.7
Excluded	242.6	21.7
Total	**1116.0**	**100 %**

Legend

- Assessment Area
- Roads and Tracks
- Contours (2m)
- Comprehensive Assessmnet Area

Sample Locations

- Negative

Dieback Occurence

- Excluded
- Uninfested
- Uninterpretable

Figure 48: Dieback occurrence within the Dieback Assessment Area

Project Location

Dieback Occurence Map

2020 Image Resources Ltd Atlas Mine Site Dieback Assessment

0 | 0.5 | 1 | 1.5 km

N

Datum: GDA 1994
Projection: MGA Zone 50

Scale: 1: 25000 at A3

Date: 7/12/2020	Prepared: A. Caubo	Project No: T20035
Expiry: 7/12/2021	Checked: J. Grehan	
	Revision:	
	Review:	

Terratree

5.3.7 Environmental Values

Based on the information provided in Section 5.3, the following environmental values were determined to require assessment for this factor:

- General native flora and vegetation, which covers:
    - All vegetation types listed in 360 Environmental (2021) and Morgan (2022) in order to assess broad local and regional impacts;
    - Locally significant heathland vegetation;
    - Linkage values of survey area vegetation (links Nambung National Park bushland to the bushland south of Wongonderrah Road); and
    - Functioning geomorphic wetland system of floodplain, palusplain, sumplands and flow channels that drain water from the area to the east and distribute it across a continuation of the floodplains to the west and ultimately to the Nambung River;
- Priority flora species recorded within the development envelopes;
- Range extensions flora;
- The 'Banksia woodlands of the Swan Coastal Plain' TEC / PEC; and
- Locally significant vegetation.

5.4 Potential Impacts

Table 18 defines the potential impacts (direct, indirect and cumulative) on the environmental values listed above in a local and regional context.

Table 18: Potential impacts on flora and vegetation

Environmental value	Current Extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
General native flora and vegetation	The pre-European vegetation associations within the survey area are partially cleared with a minimum of 63.75% of each type remaining.	Up to 318 ha of native vegetation clearing (292 ha within the MDE, and 26 ha in the EIDE). 126 ha of native vegetation cleared for the mine pit will be progressively rehabilitated during operations, and the remaining 192 ha is to be rehabilitated post-closure.	Reduction in vegetation health as a result of: • Alterations to fire regimes • Establishment or spread of weed species / populations • Reduction of groundwater depth • Hydrocarbon spills • Introduction or spread of dieback • Dust deposition affecting photosynthesis and transpiration rates of flora and vegetation	Impacts to general native flora and vegetation from the Cooljarloo West Titanium Minerals Project approximately 20 km to the south east. Impacts to regional vegetation from agriculture, resources and road infrastructure.	Up to 292 ha of native vegetation clearing within the MDE, and 26 ha in the EIDE in addition to historic disturbance and disturbance associated with other proposals. Reduction in vegetation health due to indirect impacts.
Priority Flora	32 Priority Flora species were recorded within	Clearing of known individuals of 21 Priority Flora species.	Reduction in flora health as a result of:	Impacts to Priority Flora from the nearby Cooljarloo West	Clearing of known individuals of 21

Environmental value	Current Extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
	the MESA, EISA and BBSA.	Clearing of up to 318 ha of potential habitat, with 126 ha progressively rehabilitated during operations, and the remaining 192 ha rehabilitated post-closure.	• Alterations to fire regimes • Establishment or spread of weed species / populations • Reduction of groundwater depth • Hydrocarbon spills • Introduction or spread of dieback • Dust deposition affecting photosynthesis and transpiration rates of flora	Titanium Minerals Project. Impacts to local vegetation from agriculture, resources and road infrastructure.	different Priority Flora. Clearing of up to 318 ha of potential habitat, with 126 ha progressively rehabilitated during operations, and the remaining 192 ha rehabilitated post-closure. Reduction in habitat health due to indirect impacts.
Range Extensions Flora	38 species were identified as occurring at or near their northern range limits (including 12 Priority Flora) 15 species were at or near their southern range limits (including 4 Priority Flora)	Clearing of known individuals of 13 different Range Extensions Flora. Clearing of up to 318 ha of potential habitat, with 126 ha progressively rehabilitated during operations, and the remaining 192 ha rehabilitated post-closure.	Reduction in flora health as a result of: • Alterations to fire regimes • Establishment or spread of weed species / populations • Reduction of groundwater depth • Hydrocarbon spills • Introduction or spread of dieback • Dust deposition affecting photosynthesis and transpiration rates of flora	Impacts to Range Extensions Flora from the nearby Cooljarloo West Titanium Minerals Project. Impacts to local vegetation from agriculture, resources and road infrastructure.	Clearing of known individuals of 13 different Range Extensions Flora. Clearing of up to 318 ha of potential habitat, with 126 ha progressively rehabilitated during operations, and the remaining 192 ha rehabilitated post-closure. Reduction in habitat health due to indirect impacts.
Banksia woodlands of the Swan Coastal Plain TEC / PEC	683.3 ha recorded within the combined survey areas	Up to 236.2 ha of clearing (210 ha within the MDE, and 26.0 ha in the EIDE). 75.6 ha cleared for the mine pit will be progressively rehabilitated during operations, 0.6 ha will remain cleared permanently and the remainder is to be rehabilitated post-closure.	Reduction in health as a result of: • Alterations to fire regimes • Establishment or spread of weed species / populations • Reduction of groundwater depth • Hydrocarbon spills • Introduction or spread of dieback • Dust deposition affecting photosynthesis and transpiration	Impacts from the Cooljarloo West Titanium Minerals Project approximately 20 km to the south east (1,532 ha). Impacts to regional extent from agriculture, resources and road infrastructure.	Up to 210 ha of clearing within the MDE, and 26 ha in the EIDE in addition to historic disturbance and disturbance associated with other proposals. Reduction in vegetation health due to indirect impacts.

Environmental value	Current Extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
			rates of vegetation		
Locally significant vegetation	Vegetation units BaBm, Bp, BtRc, CpBt, MsVdCaf, Ms were identified as being of local significance	Clearing of: • 192 ha of BaBm • 27 ha of Bp • 45 of BtRc • 6 ha of BtRc / Bp • 2 ha of MsVdCaf • 2 ha of MbTi / BtRc • 2 ha of BtRc / BaBm • 0.05 ha of MbTi / MbGcVp / BtRc	Reduction in health as a result of: • Alterations to fire regimes • Establishment or spread of weed species / populations • Reduction of groundwater depth • Hydrocarbon spills • Introduction or spread of dieback • Dust deposition affecting photosynthesis and transpiration rates of vegetation	Impacts to regional extent from agriculture, resources and road infrastructure.	Clearing within 4 locally significant vegetation types in addition to historic disturbance and disturbance associated with other proposals. Reduction in vegetation health due to indirect impacts.

5.5 Assessment of Impacts

The following sections assess the potential impacts on each environmental values identified in Section 5.3.

5.5.1 General Native Flora and Vegetation

Table 19 summarises the extent of the potential direct and indirect impacts on general native flora and vegetation. Additional assessment is provided in the following sections.

Table 19: Potential impacts on general flora and vegetation

Flora / Vegetation / Feature	Regional extent (ha / numbers)	Extent in Survey Areas (ha)	Extent in DEs (ha)	Extent in Indicative Disturbance Footprint (ha)	Indirect Impacts	Cumulative impacts (ha)
Regional Native Vegetation						
Extent within 10 km of MDE	21,610 remaining (69%)	N/A	471.50	318 (1.5% of extent)	Negligible	10,132 (32.5% of extent disturbed)
Extent within 15 km of MDE	48,893 remaining (70%)	N/A	471.50	318 (0.7%)	Negligible	21,553 (30.7% of extent disturbed)
Extent within 20 km of MDE	78,215 remaining (69%)	N/A	471.50	318 (0.4%)	Negligible	35,788 (31.4% of extent disturbed)

Flora / Vegetation / Feature	Regional extent (ha / numbers)	Extent in Survey Areas (ha)	Extent in DEs (ha)	Extent in Indicative Disturbance Footprint (ha)	Indirect Impacts	Cumulative impacts (ha)
Extent within 25 km of MDE	110,098 remaining (67%)	N/A	471.50	318 (0.3%)	Negligible	53,328 (33.3% of extent disturbed)
Vegetation associations						
1030	88,950 remaining (64%)	1,255.2	526	318 (0.4%)	Negligible	50,381 (35.8% of pre-European extent disturbed)
Vegetation communities (Morgan, 2022 and 360 Environmental, 2021) *indicates locally significant vegetation						
BaBm*	N/A	631.1	320.97	209.47	Negligible	209.47 (33.2% of Mapped Extent)
BtRc*	N/A	156.4	74.3	45.47	Negligible	45.47 (29.1%)
Bp*	N/A	52.2	38.26	35.16	Negligible	35.26 (67.5%)
Ti	N/A	43.5	25.13	19.57	Negligible	19.57 (45.0%)
MbGcVp	N/A	13	7.76	6.49	Negligible	6.49 (49.9%)
BtRc*/Bp*	N/A	6.8	6.83	6.35	Negligible	6.35 (93.4%)
MvMb	N/A	16.3	4.18	2.55	Negligible	2.55 (15.6%)
MsVdCaf*	N/A	2.4	2.39	2.39	Negligible	2.39 (99.6%)
MbTi/BtRc*	N/A	2.04	2.04	2.04	Negligible	2.04 (100.0%)
BtRc*/BaBm*	N/A	2.3	2.26	1.78	Negligible	1.78 (77.4%)
MbTi	N/A	2.9	2.48	1.2	Negligible	1.2 (41.4%)
MaMcu	N/A	0.8	0.83	0.64	Negligible	0.64 (80.0%)
MrMt	N/A	4.5	1.46	0.59	Negligible	0.59 (13.1%)
TsTi/MrMv	N/A	2.2	1.18	0.48	Negligible	0.48 (21.8%)
Ar	N/A	0.5	0.47	0.18	Negligible	0.18 (36%)
MbTi/MbGcVp/BtRc*	N/A	3.9	1.7	0.05	Negligible	0.05 (1.3%)
MrMv	N/A	0.2	0.21	0.01	Negligible	0.01 (5.0%)
AhAcc	N/A	0.4	0.43	0	Negligible	0
AhXspp	N/A	13.6	0.15	0	Negligible	0
BtRc*/AhAcc	N/A	0.9	0.94	0	Negligible	0
BtRc*/MvMb	N/A	0.5	0	0	Negligible	0
CgMj	N/A	76.3	0	0	Negligible	0
CpBt*	N/A	13.4	1.47	0	Negligible	0
EdMp	N/A	0.3	0.34	0	Negligible	0
Er	N/A	1.4	0	0	Negligible	0
MbTi/MbGcVp	N/A	0.3	0	0	Negligible	0
McuMvSb	N/A	1.2	0	0	Negligible	0
MrHtBt	N/A	0.6	0	0	Negligible	0
MrMtSl	N/A	1	1.02	0	Negligible	0
MrMvBc	N/A	7	0	0	Negligible	0

Flora / Vegetation / Feature	Regional extent (ha / numbers)	Extent in Survey Areas (ha)	Extent in DEs (ha)	Extent in Indicative Disturbance Footprint (ha)	Indirect Impacts	Cumulative impacts (ha)
MrMvBc/MbGcVb	N/A	0.3	0.32	0	Negligible	0
MrMvMco	N/A	9.3	1.11	0	Negligible	0
Ms*	N/A	4.1	0.34	0	Negligible	0
Ne	N/A	0.1	0	0	Negligible	0
TCg	N/A	5.8	0	0	Negligible	0
TmThTs	N/A	22.7	0	0	Negligible	0
TmThTs/MvMb	N/A	0.6	0	0	Negligible	0
TsTi	N/A	1.3	0	0	Negligible	0
Cleared	N/A	22.5	7.37	2.59	Negligible	2.59
Pasture Land	N/A	145.6	8	0	Negligible	0
'Banksia woodlands of the Swan Coastal Plain' TEC / PEC						
BaBm	**> 335,000 ha** ***	631.1	320.97	192.07	Negligible	192.07 ha
Bp		52.2	38.26	26.76		26.76 ha
Total		**683.3**	**359.23**	**218.83**		**218.83 ha (0.06% of SCP Extent)**
Priority Flora recorded within the DEs						
Grevillea thelemanniana subsp. Cooljarloo (BJ Keighery 28B) (P1)	12 records all within 30 km of the Proposal	5,467 individuals	1,295 individuals	831 individuals	None predicted	831 individuals (15.2% of local records)
Levenhookia preissii (P1)	38 records, from Wongonderrah Rd area to Northcliffe	34 individuals	31 individuals	14 individuals	None predicted	14 individuals (41.2% of local records)
Acacia benthamii (P2)	25 records from south of Mandurah to Guilderton	1 Individual	1 Individual	1 Individual	None predicted	1 individual (100% of local records)
Calectasia palustris (P2)	14 records from south of Coorow to northeast of Cataby	23 individuals	3 individuals	3 individuals	None predicted	3 individuals (13.0% of local records)
Chordifex reseminans (P2)	45 records from south of Eneabba to Cataby. 1 record located at Mount Annan in NSW	1,711 individuals	192individual s	186 individual	None predicted	186 individuals (10.9% of local records)
Schoenus badius (P2)	10 Records from Northampton to southeast of Cervantes	1 Individual	1 Individual	1 Individual	None predicted	1 individual (100% of local records)

Flora / Vegetation / Feature	Regional extent (ha / numbers)	Extent in Survey Areas (ha)	Extent in DEs (ha)	Extent in Indicative Disturbance Footprint (ha)	Indirect Impacts	Cumulative impacts (ha)
Angianthus micropodioides (P3)	124 records from Mullewa to south of Beverly	1,201,022 individuals	180,006 individuals	90,405 individuals	None predicted	90,405 individuals (7.5% of local records)
Babingtonia urbana (P3)	35 records from the Proposal to Baldivis	7,512 individuals	709 individuals	698 individuals	None predicted	698 individuals (9.3% of local records)
Conospermum scaposum (P3)	57 records from east of Green Head to southeast of Wickepin	2,242 individuals	1079 individuals	521 individuals	None predicted	521 individuals (23.2% of local records)
*Desmocladus nodatus (*Formerly *Onychosepalum nodatum)* (P3)	28 records within 25 km of the Proposal	6,817 individuals	103 individuals	12 individuals	None predicted	12 individuals (0.2% of local records)
Eryngium pinnatifidum subsp. Palustre (G. J. Keighery 13459) (P3)	11 records from Badgingarra to south of Pinjarra	1,356 individuals	907 individuals	577 individuals	None predicted	577 individuals (42.6% of local records)
Hensmania stoniella (P3)	47 records south east of Port Denison to Regans Ford	18 individuals	16 individuals	11 individuals	None predicted	11 individuals (61.1% of local records)
Isopogon panduratus subsp. *palustris* (P3)	30 records all located within 15 km of the Proposal	7,643 individuals	1,110 individuals	986 individuals	None predicted	986 individuals (12.9% of local records)
Jacksonia carduacea (P3)	51 records all located within 50 km of the Proposal	13 individuals	13 individuals	13 individuals	None predicted	13 individual (100% of local records)
Schoenus pennisetis (P3)	54 records from east of Geraldton to west of Mount Barker	14 individuals	2 individuals	2 individuals	None predicted	2 individuals (14.3% of local records)
Stylidium aceratum (P3)	30 records from northeast of Cervantes to Yarloop	1,167 individuals	1,013 individuals	711 individuals	None predicted	711 individuals (60.9% of local records)
Anigozanthos humilis subsp. *chrysanthus* (P4)	79 records from Dandaragan to as far south as the Twin Peaks Conservation Reserve	6 individuals	4 individuals	3 individual	None predicted	3 individuals (50% of local records)
Conostylis pauciflora subsp. *euryrhipis* (P4)	34 records, from Moore River National Park to Perth metropolitan region	1 individual	1 individual	1 individual	None predicted	1 individual (100% of local records)

Flora / Vegetation / Feature	Regional extent (ha / numbers)	Extent in Survey Areas (ha)	Extent in DEs (ha)	Extent in Indicative Disturbance Footprint (ha)	Indirect Impacts	Cumulative impacts (ha)
Schoenus griffinianus (P4)	58 records from north of Kalbarri to Perth metropolitan area	22 individuals	19 individuals	2 individuals	None predicted	2 individuals (9.1% of local records)
Stylidium longitubum (P4)	100 records from north of Eneabba to east of Cowaramup.	6,072 individuals	4,116 individuals	3,223 individuals	None predicted	3,223 individuals (53.1% of local records)
Thysanotus glaucus (P4)	34 records from south of Eneabba to Two Peoples Bay Nature Reserve.	11 individuals	3 individuals	0	None predicted	None predicted

*** The Threatened Species Scientific Committee (TSSC) provides information on the estimated extent of Banksia Woodland TEC / PEC within the SCP Bioregion.

Direct Disturbance

The Proposal will result in the progressive clearing of up to 318 ha of native vegetation (292 ha within the MDE, and 26 ha in the EIDE). 126.2 ha of native vegetation cleared for the mine pit will be progressively rehabilitated during operations, 0.6 ha that will remain cleared permanently for the Bibby Road / Brand Highway intersection and the remaining 191.2 ha will be rehabilitated post-closure.

As part of the assessment of the regional significance of the clearing, the extent of the proposed clearing has been compared with the mapped regional extent of native vegetation within a 10, 15, 20 and 25 km radius of the Proposal. In contrast to other areas of the Swan Coastal Plain region, the extent of remaining native vegetation remains relatively high in the vicinity of the Proposal. 21,610 ha of native vegetation remains within 10 km of the Proposal (68.8% of original extent), 48,893 ha of native vegetation remains within 15 km of the Proposal (69.7% of the original extent), 78,215 ha of native vegetation remains within 20 km of the Proposal (68.8% of the original extent), and 110,098 ha remains within 25 km of the Proposal (67.5% of original extent).

The proposed clearing represents a reduction of 1.47% of the regional extent of native vegetation within 10 km of the Proposal, 0.65% within 15 km, 0.40% within 20 km and 0.28% within 25 km. The cumulative impacts of the proposed and existing clearing will therefore not be significantly increased, and significant areas of native vegetation will remain after implementation of the Proposal, including large areas within conservation estate. This clearing is assessed further from an ecological context in the sections below.

At a regional scale, the 318 ha of native vegetation clearing required for the Proposal will occur across a single vegetation association (1030; Figure 25). Vegetation association 1030 has 64.0% of its pre-European extent remaining and the Proposal will disturb only 0.35% of the remaining vegetation association, or 0.23% of the pre-European extent. This minor reduction is unlikely to be significant as there will be 63.75% of the pre-European extent remaining after the implementation of the Proposal.

An estimated 13,433 ha of vegetation association 1030 is noted as being in conservation estate and the Southern Beekeepers Nature Reserve and Nambung National Park also lie in proximity to the Proposal.

The development envelopes contain several vegetation and flora values that are considered significant. An assessment of the direct disturbance of those values is provided in Section 5.5.2-5.5.5.

Altered Fire Regimes

Fire is a known disturbance mechanism within the Swan Coastal Plan, however survey areas at the Proposal were characterised as being long unburnt with no fire thought to have occurred in the area for more than 12 years.

Mining activities have the potential to ignite bushfires through hot work and other activities, however with appropriate firefighting and prevention management measures in place (Section 5.6), the development of the Proposal will improve the ability to immediately fight fire outbreaks and prevent them from spreading. The potential for increased fire risk is therefore expected to not be significant.

Weeds

Weeds have the potential to outcompete and displace native vegetation if introduced or conditions are altered to favour their growth. Proposal activities have the potential to spread existing weeds and to introduce new weed species into previously weed free areas. Weeds can impact the ecology and biodiversity of natural systems by out-competing native species for habitat, nutrients and water. Once established, weeds can also alter the composition and structure of vegetation communities. Weeds can have a significant impact on natural values by:

- Successfully out-competing native species for available nutrients, water, space and sunlight;
- Reducing the natural diversity by smothering native plants or preventing them from growing back after clearing, fire or other disturbance;
- Replacing the native plants that animals use for shelter, food and nesting; and
- Altering fire regimes, often making fires hotter and more destructive.

Weeds may be spread and/or introduced by vehicles and equipment, resulting in soil and weed vegetative material being transported around site and being present on equipment entering and exiting site.

A total of 92 introduced species were identified during flora / vegetation surveys for the Proposal. None of these species are listed as WONS, however one is listed as a Declared Pest under the BAM Act (the one leaf Cape Tulip (**Moraea flaccida*). *Moraea flaccida* was recorded on the farmland in the northern part of the MESA and in dampland areas in the EISA corridors, including at the Nambung River crossing.

Given the presence of these weed species, weed management measures will be implemented to prevent or minimise the spread of weeds and any increased competition with native species (Section 5.6).

Reduction of Groundwater Depth

Dewatering of the mine pit will be required to allow the safe 'dry' mining of the resource. Much of the vegetation in the area was considered to be potentially groundwater-dependant, therefore significant investigations have been undertaken to identify suitable drawdown mitigation measures. These are discussed in detail in Section 7.5, however in general terms a series of short trenches will be installed around the edge of the mine disturbance footprint and water will be pumped into these pits to keep the aquifer in the surrounding vegetation at background levels. Impacts from groundwater drawdown are therefore predicted to not extend outside the proposed disturbance areas.

Groundwater abstraction for water supply is proposed to occur within one or more borefields. The focus of this abstraction is to target aquifers that have little to no connection to the superficial aquifer, such that there would be a negligible reduction in the level of groundwater that may currently be accessed by vegetation. Hydrogeological investigations are well-progressed but are yet to be finalised, however a water supply source will not be developed unless the parameters above are able to be met.

Hydrocarbon Spills

Considering the small scale of operations planned for the Proposal, large-scale hydrocarbon spills are considered unlikely. Small hydrocarbon spills associated with hydraulics failures on machinery and refuelling spills may occur on occasion in operational areas. Spills generally result in a defined area of hydrocarbon-contaminated soil that can be remediated via passive means such as bioremediation. Proposed control measures are identified in Section 5.6 and are designed to further reduce the risk of vegetation impacts from hydrocarbon spillage.

Dieback

Dieback disease caused by *Phytophthora cinnamomi* continues to be a significant environmental issue within the southwest region of WA, affecting the distribution and abundance of many native plant species. Potential impacts on biodiversity as a result of the spread of Dieback include the following:

- A significant decline in species richness;
- Altered vegetation structure with the loss of keystone species such as Banksia;
- Temporary or permanent decline in vegetation cover which can lead to erosion and loss of nutrients;
- Loss of fauna foraging habitat, particularly Proteaceous genera including Banksia, Hakea, Isopogon and Petrophile;
- The potential loss of Priority flora species if they occur within the affected areas and areas susceptible to Dieback.

Water-gaining sites are at a higher risk of being infested with *Phytophthora cinnamomi* as flagellated zoospores can travel through water or moist substrate. It is possible, however, for the pathogen to survive as stromata (thick-walled chlamydospores) in resistant plant species in upland areas during summer, and reproduce when conditions become more favourable for survival (Crone et al. 2012).

Non-autonomous spread of Dieback can occur if the disease occurrence has not been managed appropriately. Without hygiene control measures, there is a high risk of Dieback being spread into Uninfested areas of native vegetation during ground disturbing activities. If Dieback is spread into Uninfested areas, the pathogen will have a significant impact on biodiversity. Susceptible species will become infected and die, with flow-on effects impacting ecosystem function and resilience.

The risk of transporting infected soil increases significantly during wet conditions when soil and vegetative material can easily adhere to vehicles and machinery. In dry conditions, the risk of transporting infected soil is reduced but not eliminated.

In addition to spreading the pathogen within disturbance areas, there is potential to introduce the pathogen into adjacent and down-gradient receiving areas. This down-gradient spread can occur if drainage lines within or adjacent to the Proposal become contaminated with the pathogen, or infected soil is transported off-site into Uninfested areas.

Assessment of Dieback occurrence at the Proposal identified 297.3 ha of Uninterpretable vegetation, in which dieback may be present (in very low levels as an endemic or incipient disease) without showing signs of its presence or the determination of the presence of the pathogen is not possible using interpretation methods. Given the high risk and significant potential impacts of dieback, hygiene management measures will be implemented to prevent the introduction or spread of dieback (Section 5.6).

Vegetation and Dust

The construction and operation of the Proposal will result in the generation of dust. Dust generation is discussed further in Section 9.5. There is the potential deposited dust to affect the health of susceptible vegetation by adversely affecting photosynthesis and transpiration rates. As the Proposal is in an area of high biodiversity, the potential for deposited dust to have an effect upon the health of vegetation has been considered.

There are no specific assessment guidelines available for impacts on vegetation from dust deposition, however, several studies on impacts on vegetation from particulate deposition have been completed in Australia and globally. Most studies of the effects of mineral dusts on vegetation have focussed on dusts that have chemical effects (e.g., cement dust) or where dust loads exceed 7 g/m^2. Relatively inert mineral dust, such as those generated in the mining process or from unsealed haul roads principally influence light and temperature relations of leaves.

A study by Doley and Rossato (2010) used published data to assess the impacts of particulate deposition on photosynthesis in cotton leaves and canopies. The study indicated that many plant species have similar ranges of values for the photosynthetic parameters used in assessing the impacts on cotton and it is possible to use the cotton estimates as a general estimate to model the impacts of particulate deposition and thereby the environmental risks associated with dust generating activities. The results of the study indicated that at deposition levels of approximately 9 g/m^2/month, the estimated reductions in canopy photosynthesis of cotton plants would be less than 7% with a <1% decrease in productivity (Doley & Rossato, 2010).

The dust assessment in Section 9.5.3 determined that dust deposition levels were unlikely to be significant in surrounding areas. The separation distance between the Proposal and the closest conservation reserves (Nambung National Park, over 1.5 km away from mining areas) exceeds the recommended generic buffer distance (discussed further in Section 9.5) established for protection of amenity (EPA, 2005), considered in the context of this Proposal to be a suitable proxy for the assessment of potential effects upon vegetation from dust deposition.

More generally, native vegetation in the region is expected to be reasonably tolerant to dust deposition and at minimal risk of physiological impacts (Eco Logical Australia, 2016), being adapted to high dust levels that occur naturally in summer under the combination of high winds and low rainfall. Dust deposition will be mitigated to some extent by periodic high rainfall events, which would remove built-up materials on foliage.

Based on the above, dust emissions from the Proposal are not expected to have a significant impact on flora or vegetation health.

Radiation

Radiation is not considered to be a likely potential impact for flora and vegetation. The only material on site which could be classified as a radioactive material is the HMC which is temporarily stockpiled on cleared areas, and not adjacent to vegetation. Radiation levels in vegetated areas before, during and after mining will be similar to background levels. In addition, mitigation measures to protect human health impacts (see Section 9.6) will also subsequently minimise impacts to the natural environment.

Summary

The Proposal will result in progressive clearing of up to 318 ha of native vegetation, 126.2 ha of native vegetation cleared for the mine pit will be progressively rehabilitated during operations, and the remaining 191.8 ha will be rehabilitated post-closure.

Management and monitoring is proposed during the operational phase to further minimise indirect impacts to general native flora and vegetation (refer to Section 5.6)

The assessment above identified that the Proposal was unlikely to result in significant impacts to general flora and vegetation, however there are potential impacts to specific flora values that require further assessment in the following sections.

5.5.2 PRIORITY FLORA

Direct Disturbance

Image has made a considerable effort to avoid Priority Flora identified through the 360 Environmental (2012c & 2021) and Morgan (2022) flora and vegetation surveys at the Proposal. The 524 ha reduction to the original extent of the MDE (from 981 ha to 457 ha) approved under S43A of the EP Act will avoid large concentrations of the following species:

- *Grevillea sp. Cooljarloo* (B.J. Keighery 28 B) (P1) (1,284 individuals);
- *Chordifex reseminans* (P2) (127 individuals);
- *Angianthus micropodioides* (P3) (213,211 individuals);
- *Babingtonia urbana* (P3) (133 individuals);
- *Conospermum scaposum* (P3) (1,107 individuals);
- *Desmocladus nodatus* (P3) (69 individuals);
- *Eryngium pinnatifidum* subsp. Palustre (G.J. Keighery 13459) (P3) (459 individuals);
- *Isopogon panduratus* subsp. *palustris* (P3) (1,643 individuals);
- *Stylidium aceratum* (P3) (150 individuals); and
- *Stylidium longitubum* (P4) (1,955 individuals).

Smaller concentrations of *Levenhookia preissii* (P1), *Lepyrodia curvescens* (P2), *Hensmania stoniella* (P3), *Schoenus pennisetis* (P3), *Stylidium hymenocraspedum* (P3), *Anigozanthos humilis* subsp. *chrysanthus* (P4), *Schoenus griffinianus* (P4) and *Thysanotus glaucus* (P4) will also be avoided.

20 Priority Flora species were recorded within the Proposal development envelopes (Table 19). Of these, nine had a large proportion of their local records (those recorded during the 360 Environmental (2012c & 2021) and / or Morgan (2022) flora and vegetation surveys) that were located outside the development envelopes:

1. 76% of *Grevillea thelemanniana* subsp. Cooljarloo (BJ Keighery 28B) (P1);
2. 87% of *Calectasia palustris* (P2);
3. 89% of *Chordifex reseminans* (P2);
4. 85% of *Angianthus micropodioides* (P3);
5. 91% of *Babingtonia urbana* (P3);
6. 98% of *Desmocladus nodatus* (formerly *Onychosepalum nodatum)* (P3);
7. 85% of *Isopogon panduratus* subsp. *palustris* (P3);
8. 86% of *Schoenus pennisetis* (P3); and
9. 73% of *Thysanotus glaucus* (P4).

Given the large proportion of local records that will not be impacted by the Proposal the species listed above are considered unlikely to be significantly impacted by the Proposal.

The distribution of the remaining 12 Priority Flora species within the MDE is shown in Figure 49 - Figure 51. Four of these species, returned a relatively low number of records within the development envelopes when compared to the number of regional records (noting that regional records do not indicate the number of individuals at each record location):

1. *Acacia benthamii* (P2) – only one individual within the development envelopes, and only one likely to be disturbed, with 25 regional records;
2. *Anigozanthos humilis* subsp. *chrysanthus* (P4) - only four individuals within the development envelopes, and only three likely to be disturbed, with 79 regional records;
3. *Conostylis pauciflora subsp. euryrhipis* (P4) - only one individual within the development envelopes, which is likely to be disturbed, with 34 regional records; and
4. *Schoenus griffinianus* (P4) - only 19 individuals within the development envelopes, and only two likely to be disturbed, with 58 regional records.

The remaining eight Priority Flora species were deemed to require further assessment:

1. *Levenhookia preissii* (P1);
2. *Schoenus badius* (P2);
3. *Conospermum scaposum* (P3);
4. *Hensmania stoniella* (P3);
5. *Jacksonia carduacea* (P3);
6. *Eryngium pinnatifidum* subsp. Palustre (G. J. Keighery 13459) (P3);
7. *Stylidium aceratum* (P3); and
8. *Stylidium longitubum* (P4).

Levenhookia preissii (P1)

Levenhookia preissii (P1) is an annual herb, growing from 3 – 17 mm high in the heaths found on the margins of the Proposal floodplain. 34 individuals of *L. preissii* were recorded within the survey areas, of which 31 individuals were located within the initial disturbance footprint. This species was noted during flora surveys as being difficult to observe and identify outside of the spring flowering season, which likely contributed to an underestimated true number of *L. preissii* individuals in the survey areas (Morgan, 2022).

Image is proposing to avoid impacts to a cluster of *L. preissii* (17 individuals) to the east of the mine pit (Figure 49). The final locations of Proposal infrastructure will be selected and detailed in a Final Infrastructure Design Plan which demonstrates avoidance of this cluster. The cluster lies within the groundwater drawdown zone, however given the physiological characteristics (small size and shallow roots) of *L. preissii*, this species is unlikely to be accessing groundwater and therefore it is likely that no impacts would be associated with groundwater drawdown. Image will also seek advice from DBCA regarding whether this species could be included in the seed mix for rehabilitation.

The Proposal is therefore predicted to disturb 14 individuals or 41.2% of the 34 *L. preissii* records within the survey areas. *L. preissii* has also been recorded in another 38 locations in WA, ranging over 400 km from the Proposal at Cooljarloo to Northcliffe (south of Pemberton). While individual counts are not available for each of those 38 locations, these records demonstrate that impacts to 14 individuals of *L. preissii* are unlikely be significant in a regional context.

Based on the above the Proposal is unlikely to significantly impact the local or regional extent of this species.

Schoenus badius (P2)

Schoenus badius is a slender, annual, grass-like sedge that grows to a height of between 5 - 12 cm, and is known to grow in grey sand in moist areas. One individual was recorded during the 2011 survey from one location in the MESA area (quadrat CQ12) in *Banksia telmatiaea* heath (Figure 49).

No *S. badius* individuals were recorded during the 2019/2020 surveys, including the Phase 2 resample of quadrat CQ12. *Schoenis pennisetus* was however collected at four sites in that survey area during the 2019/2020 survey and is noted as looking very similar to *Schoenus badius*, requiring differentiation at a microscopic level (its nut having a smooth surface with numerous rows of tiny cells and a rounded summit when compared to the small projections on the surface of the *Schoenus badius* nut) (Morgan, 2022). It is most likely that the *Schoenus badius* recorded in the 2011 survey was a misidentification of a *Schoenus pennisetus* specimen, although this has not been established. However it is noted that a similar consideration seems to have occurred regarding a *Schoenus badius* record in the Cooljarloo surveys (Woodman Environmental Consulting, 2014). Differentiation of *S. badius* from *S. pennisetis* is difficult, and *S. pennisetis* has previously been recorded in five locations around the Proposal region and was recorded at another three locations (totalling 14 individuals) in the MESA.

If the 2011 record was in fact *S. badius*, the record no longer exists in that location. *Schoenus badius* has also been recorded in another ten locations in WA, from areas surrounding Northampton to southeast of Cervantes.

Based on the above the Proposal is unlikely to significantly impact the local or regional extent of this species.

Conospermum scaposum (P3)

A total of 1079 individuals of *Conospermum scaposum* (P3) are located within the development envelopes and 521 individuals of *C. scaposum* (P3) are predicted to be disturbed, equating to only 23.2% of the 2,242 individuals recorded within the survey areas. As far as practical, the Final Infrastructure Design Plan will avoid any of the individuals in the predicted disturbance area. Image will also seek advice from DBCA regarding whether this species could be included in the seed mix for rehabilitation.

Another 57 records of *C. scaposum* have been identified in WA, ranging from the South Eneabba Nature Reserve (northeast of Jurien Bay) to Wickepin, near Narrogin. Individual counts for these 57 records are unknown however given the wide range of these records (spread out over approximately 380 km), the likelihood that the number of individuals of *C. scaposum* impacted by the Proposal resulting in significant impacts at a regional context is unlikely.

Based on the above the Proposal is unlikely to significantly impact the local or regional extent of this species.

<u>*Hensmania stoniella (P3)*</u>

A total of 16 individuals of *Hensmania stoniella* (P3) are located within the development envelopes of which 11 individuals are located within the initial disturbance footprint. However, the majority of these individuals were recorded in a cluster along the boundary of the Bibby Rd/Munbinea Rd intersection. Image is proposing to avoid impacts to this cluster of *H. stoniella* (9 individuals) as the proposed intersection upgrade is unlikely to require disturbance of these records (Figure 50). The final locations of Proposal infrastructure will be selected and detailed in a Final Infrastructure Design Plan which demonstrates avoidance of this cluster. Image will also seek advice from DBCA regarding whether this species could be included in the seed mix for rehabilitation.

The Proposal is therefore predicted to disturb 2 individuals or 11.1% of the 18 *H. stoniella* records within the survey areas. *H. stoniella* has also been recorded in another 47 locations in WA, ranging over 250 km from the south east of Port Denison to Regans Ford. While individual counts are not available for each of those 47 locations, these records demonstrate that impacts to 2 individuals of *H.stoniella* are unlikely be significant in a regional context.

Based on the above the Proposal is unlikely to significantly impact the local or regional extent of this species.

<u>*Jacksonia carduacea (P3)*</u>

A total of 13 individuals of *Jacksonia carduacea* (P3) are located within the development envelopes of which 13 individuals are located within the initial disturbance footprint. However, the majority of these individuals were recorded in in the EIDE on the boundaries of the Bibby Rd/Munbinea Rd intersection. Image is proposing to avoid impacts to *J. carduacea* (12 individuals) in these locations as the proposed intersection upgrade is unlikely to require disturbance of these records (Figure 50). The final locations of Proposal infrastructure will be selected and detailed in a Final Infrastructure Design Plan which demonstrates avoidance of *J. carduacea* records at Bibby Rd/Munbinea Rd intersection. Image will also seek advice from DBCA regarding whether this species could be included in the seed mix for rehabilitation.

The Proposal is therefore predicted to disturb one individual or 7.7% of the 13 *J. carduacea* records within the survey areas. *J. carduacea* has also been recorded in another 51 records all located within 50 km of the Proposal. While individual counts are not available for each of those 51 locations, these records demonstrate that impacts to one individual of *J. carduacea* is unlikely be significant in a regional context.

Based on the above the Proposal is unlikely to significantly impact the local or regional extent of this species.

Eryngium pinnatifidum subsp. Palustre (G. J. Keighery 13459) (P3)

A total of 907 individuals of *Eryngium pinnatifidum* subsp. Palustre (G. J. Keighery 13459) (P3) are located within the development envelopes however only 577 individuals are predicted to be disturbed at the Proposal. This equates to 42.6% of the 1,356 individuals recorded within the survey areas. A formal description for this species has not been published, and confusion over the identification of this species (which were initially identified as *Eryngium pinnatifidum* subsp. *pinnatifidum* by WA HIS) means that individual counts in the MESA to be a likely significant underestimate (Morgan, 2022).

As far as practical, the Final Infrastructure Design Plan will avoid any of the individuals in the predicted disturbance area. Image will also seek advice from DBCA regarding whether this species could be included in the seed mix for rehabilitation.

This species has also been recorded in another 11 locations in WA, from Badgingarra to south of Pinjarra. As above, individual counts are not available for each of those 11 locations however underestimates of individuals at the Proposal and the wide-ranging distribution of *S. longitubum* (approximately 250 km) demonstrates that the number of impacted individuals is unlikely to be significant in a local or regional context.

Based on the above, localised impacts are high, however the Proposal is unlikely to significantly impact the regional extent of this species.

Stylidium aceratum (P3)

A total of 1,013 individuals of *Stylidium aceratum* (P3) are located within the development envelopes however only 711 individuals are found within the disturbance footprint, equating to 60.9% of the 1,167 individuals recorded in the survey areas.

As far as practical, the Final Infrastructure Design Plan will avoid any of the individuals in the predicted disturbance area. Image will also seek advice from DBCA regarding whether this species could be included in the seed mix for rehabilitation.

This species has also been recorded in another 30 locations in WA, ranging from northeast of Cervantes to Yarloop (north of Harvey). As above, individual counts are not available for each of those 30 locations however these records demonstrate that there are a number of *S. aceratum* populations across the region.

Based on the above the Proposal localised impacts are high however the Proposal is unlikely to significantly impact the regional extent of this species.

Stylidium longitubum (P4)

A total of 4,116 individuals of *Stylidium longitubum* (P4) are located within the development envelopes, and 3,223 individuals are predicted to be disturbed at the Proposal, equating to 53.1% of the 6,072 individuals recorded within the survey areas.

Image will also seek advice from DBCA regarding whether this species could be included in the seed mix for rehabilitation.

S. longitubum has also been recorded in another 100 locations in WA, ranging over 400 km (from north of Eneabba to east of Cowaramup). The wide-ranging distribution of *S. longitubum* in conjunction with underestimated counts at the Proposal demonstrates that the number of impacted individuals is unlikely to be significant in a local or regional context.

Based on the above the Proposal localised impacts are high however the Proposal is unlikely to significantly impact the regional extent of this species.

Indirect Impacts

Section 5.5.1 provides a detailed assessment of indirect impacts on native flora and vegetation, which showed that indirect impacts would be minimal outside the area of direct disturbance if managed correctly. This assessment is suitable for this value also, with the Proposal considered unlikely to indirectly impact any known Priority Flora records if the mitigation measures listed in Section 5.6 are implemented.

5.5.3 Range Extensions Flora

A total of 12 Range Extensions Flora lie within the Proposal development envelopes, however all of these species are also listed as Priority Flora and therefore have been assessed in detail in Section 5.5.2. All remaining Range Extensions Flora lie outside the development envelopes and are considered unlikely to be directly impacted by the Proposal (Figure 52 and Figure 53).

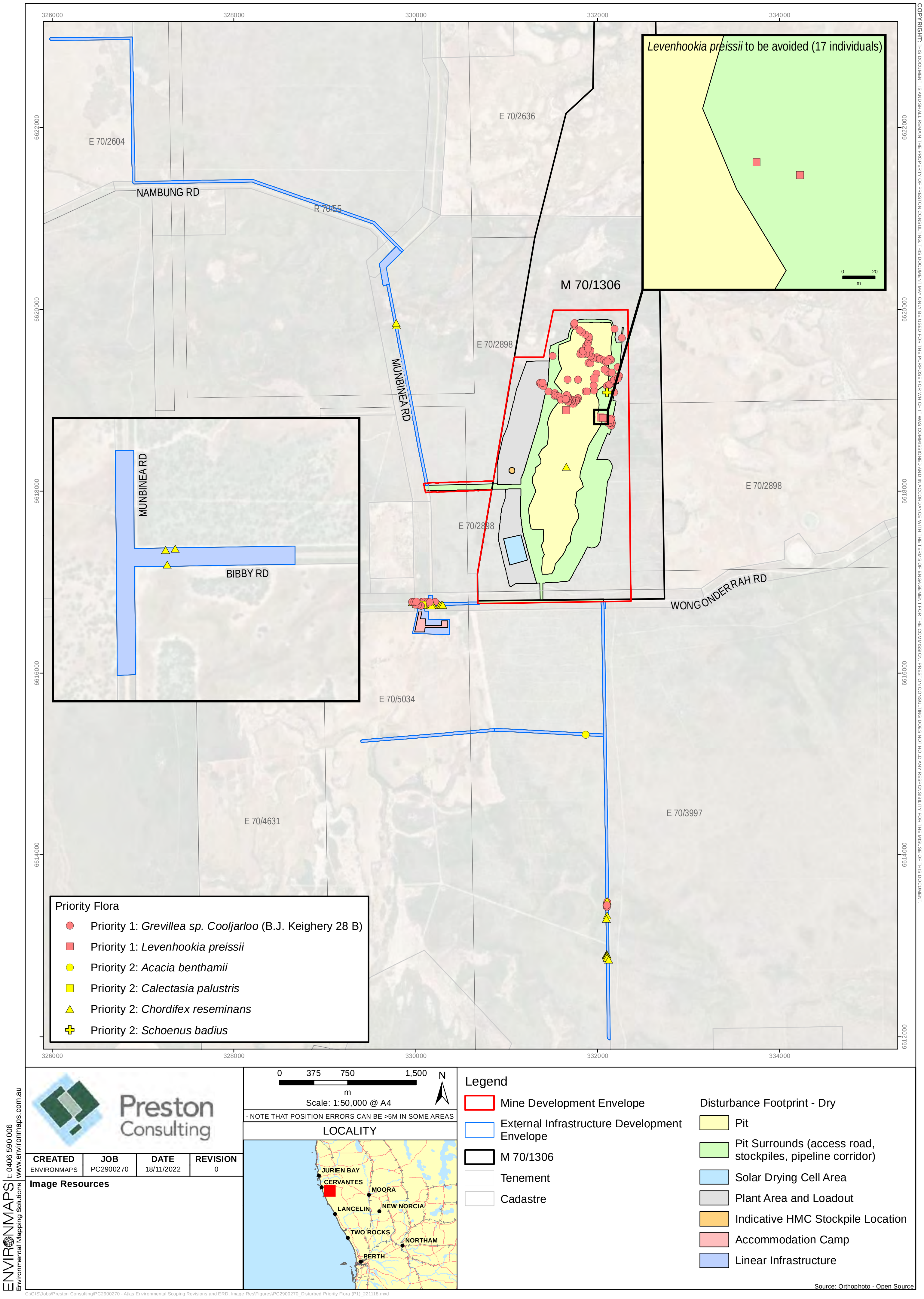


Figure 49: Priority 1 and 2 Flora records predicted to be disturbed by the Proposal

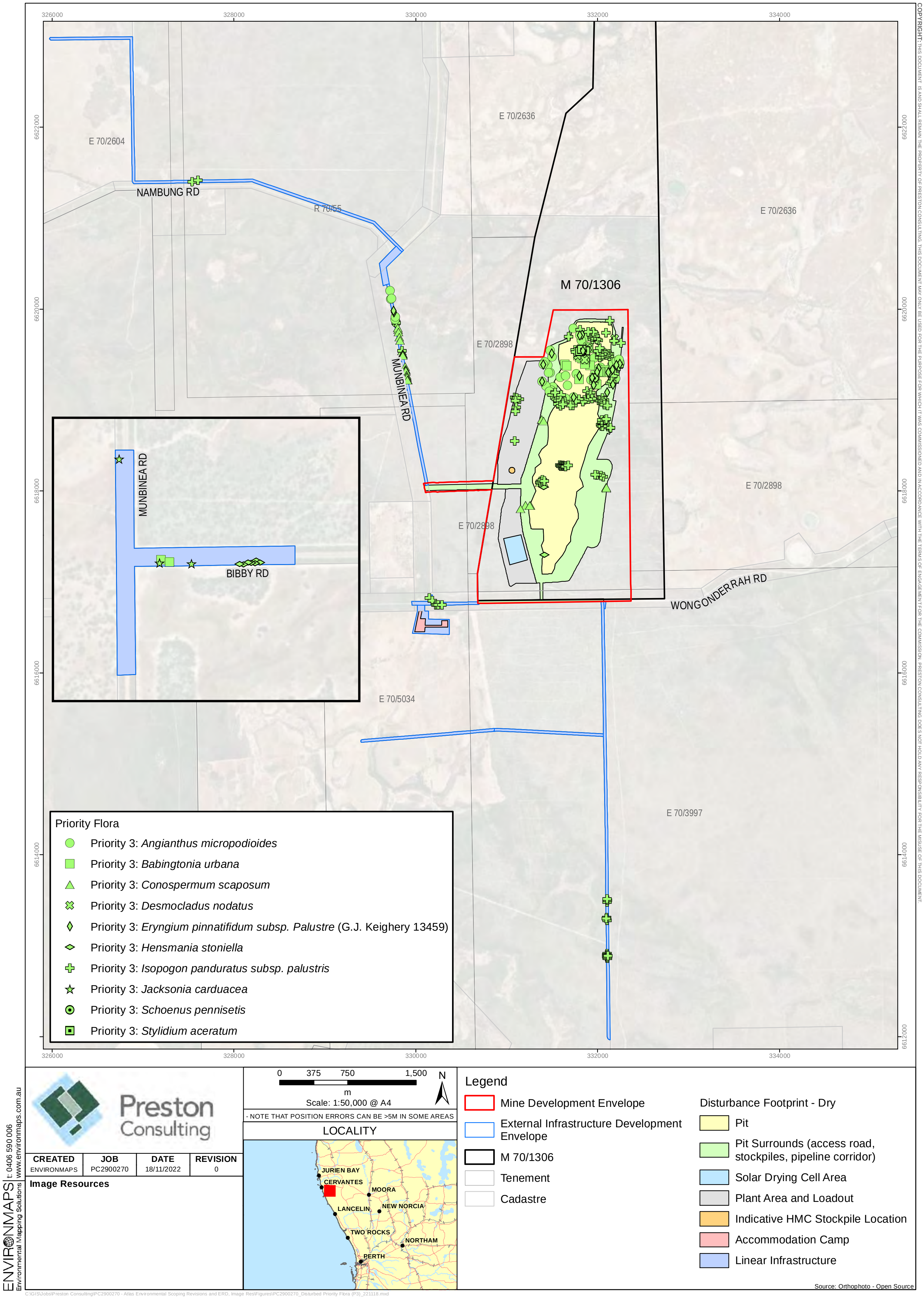


Figure 50: Priority 3 Flora records predicted to be disturbed by the Proposal

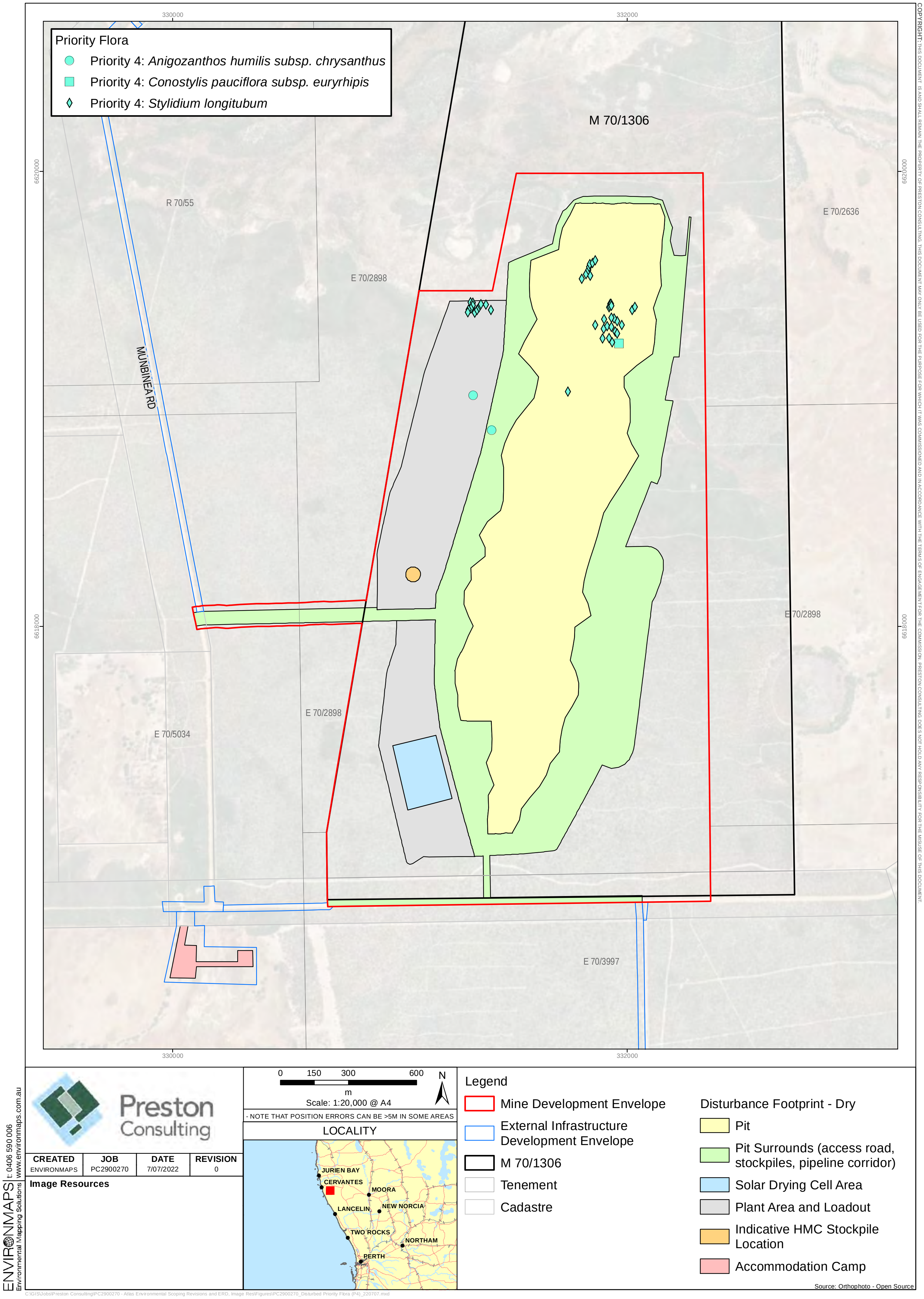


Figure 51: Priority 4 Flora records predicted to be disturbed by the Proposal

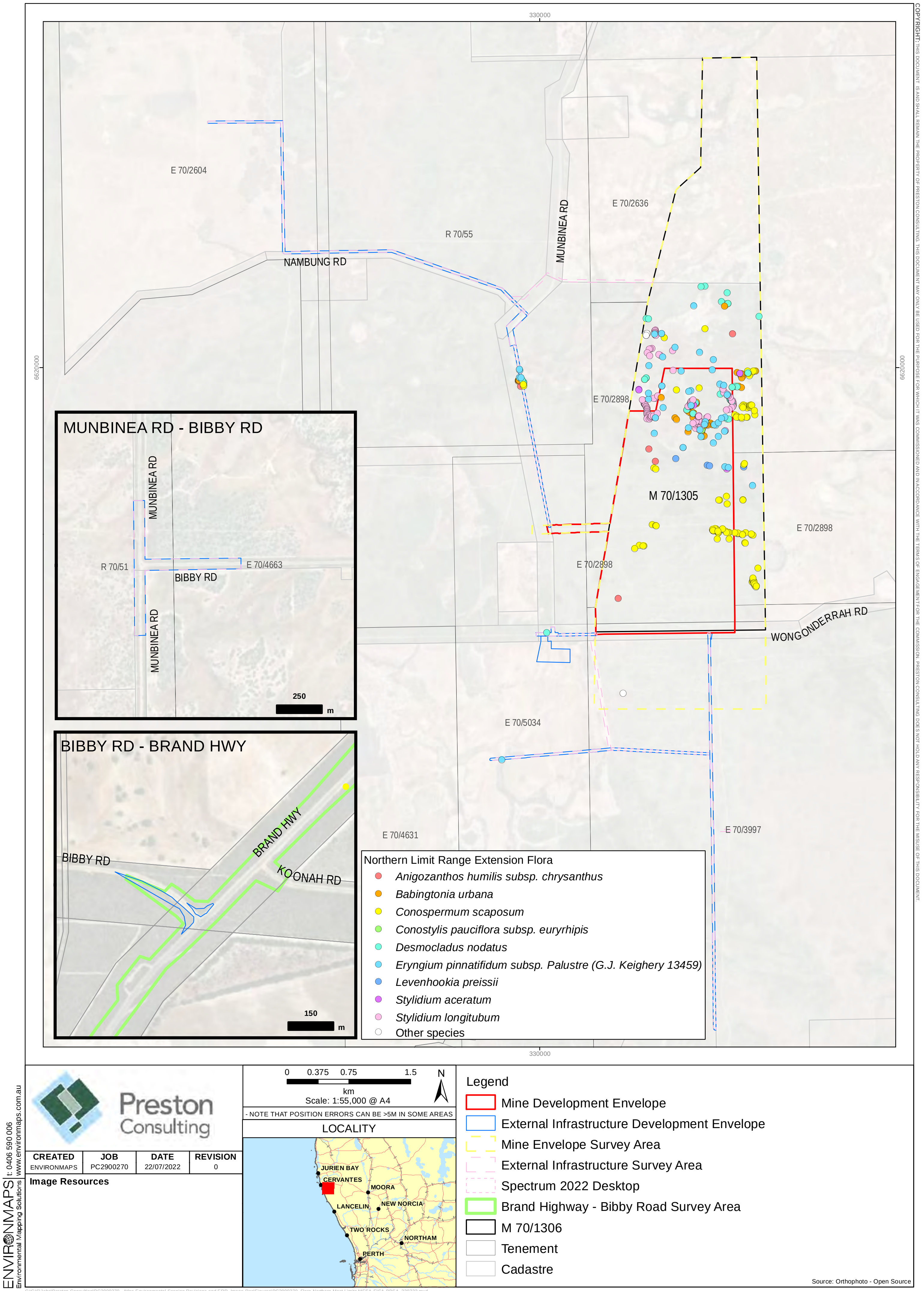


Figure 52: Location of Range Extensions Flora within the development envelopes (northern extent)

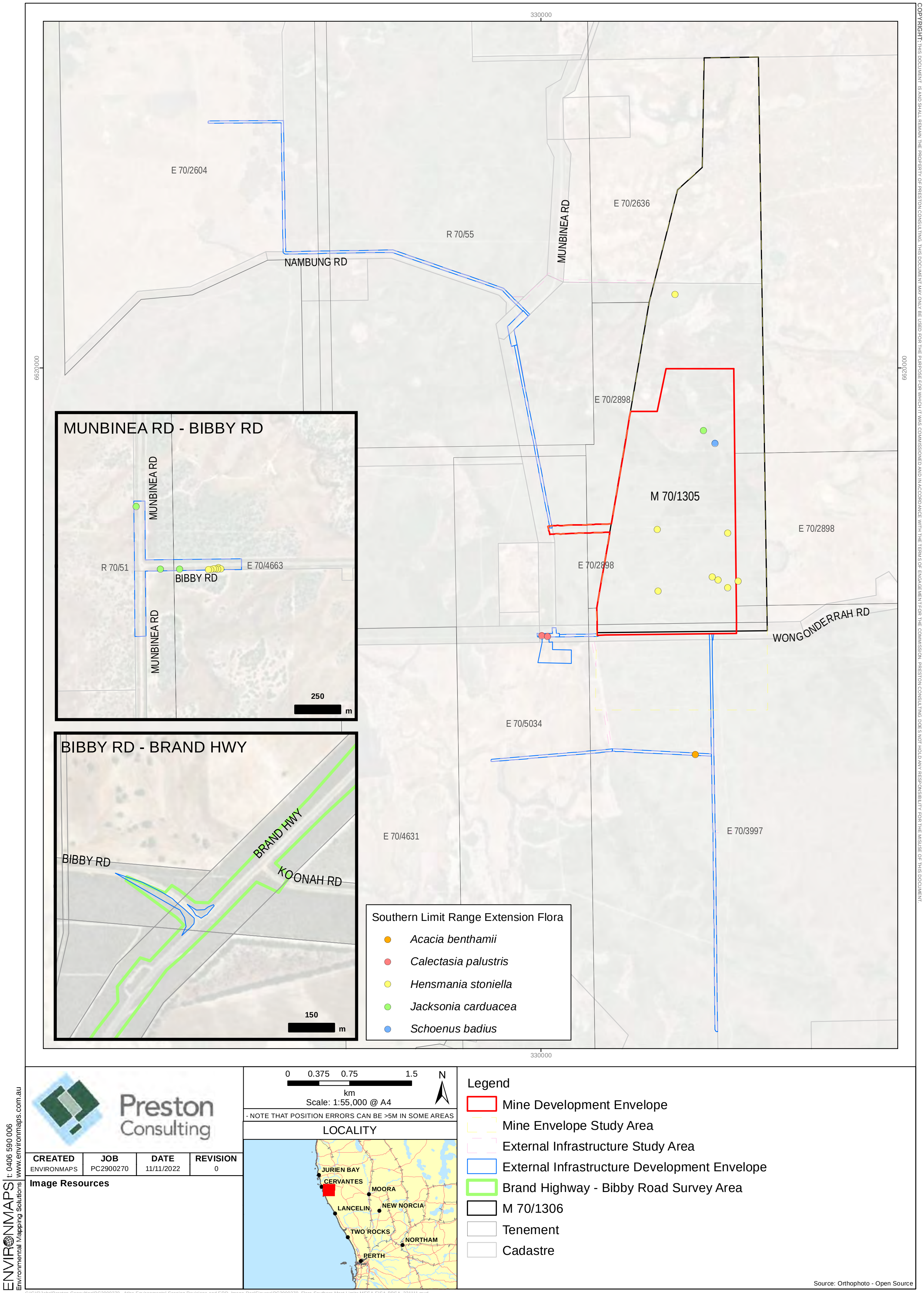


Figure 53: Location of Range Extensions Flora within the development envelopes (southern extent)

5.5.4 Banksia Woodlands of the Swan Coastal Plain TEC / PEC

Direct Disturbance

As previously noted, two vegetation units identified during flora surveys at the Proposal meet the criteria to be characterised as the EPBC Act-listed 'Banksia woodlands of the Swan Coastal Plain' TEC (Endangered) / 'Banksia dominated woodlands of the Swan Coastal Plain IBRA region' PEC (P3) by the DBCA (Banksia Woodlands TEC / PEC). The *Banksia* woodlands were mostly continuous over a large area of sand plain but occurred in smaller 'patches' amongst and around the floodplain area.

Up to 210.2 ha of Excellent to Pristine quality Banksia Woodlands TEC / PEC is predicted to be disturbed within the MDE, and 26.0 ha within the EIDE (majority is Excellent condition – 22.5 ha). State-wide, the Banksia Woodlands TEC / PEC covers over 335,000 ha and as such 0.06% is predicted to be disturbed and rehabilitated by the Proposal.

Banksia Woodlands of the Swan Coastal Plain: a nationally protected ecological community (DotEE, 2016b) provides some context of the importance of this TEC / PEC. The following text has been summarised from that advice.

The Banksia Woodlands TEC / PEC only occurs on or adjacent to the Swan Coastal Plain of WA, which stretches to the north and south of Perth. The TEC / PEC provides habitat for many native plants and animals that rely on Banksia Woodlands for their homes and food. Remaining patches of the ecological community provide important wildlife corridors and refuges in a mostly fragmented landscape.

Since the 19th century, the region has been heavily cleared for agriculture, housing and associated infrastructure. In total, about 60% of the original extent of the TEC / PEC has been cleared. When native vegetation is cleared, habitat which was once continuous becomes divided into smaller separate fragments. This makes it harder for animals to roam or migrate and for plants to disperse. Many fragments of the TEC / PEC are small islands; isolated from each other by roads, houses and other developments. The remaining patches of the TEC / PEC are typically small over much of its range (more than 80% are less than 10 ha in size).

The rehabilitation of the Proposal will seek to reinstate this ecological community, using best-practice rehabilitation methods for Banksia woodlands. Banksia Woodlands: A restoration guide for the Swan Coastal Plain by Stevens *et al.* (2016) provides relevant information about the rehabilitation of Banksia woodlands and the information provided below has been based on recommendations in that document.

Reference sites will be used to determine the 'benchmark' for rehabilitation and enables an assessment of rehabilitation success. The rehabilitation of the Banksia Woodlands TEC / PEC will be carefully monitored to ensure success. The following parameters will be monitored within the rehabilitation sites and compared against the reference sites:

- **Stem density** – number of individuals per sample unit;
- **Species richness** – number of species per sample unit;
- **Species frequency** – proportion of samples that contain a species;
- **Species composition** – the makeup of each sample in terms of the relevant abundance of each species;
- **Species diversity** – the variety of species in a sample unit by taking into account species richness and the evenness of the relative abundance of species;

- **Similarity** – the extent by which sample units differ in their composition;
- **Plant cover** – the horizontal projection of live plant material over the ground.

Annual performance criteria will be established for the rehabilitation sites, which allows any rehabilitation underperformance to be determined from as early as Year 1 (Stevens *et al.,* 2016). It will also determine whether annual planting is required to encapsulate a range of climate conditions and assist in achieving the performance criteria.

A consolidation of approximately 15 years of monitoring data at Hanson rehabilitation sites (encompassing a range of topsoil qualities and climate conditions) revealed that data for stem density and species richness falls into three groups:

1. Good restoration requires good quality topsoil and favourable climatic conditions;
2. Good restoration occurs with:
   a) Good quality topsoil and unfavourable climatic conditions; or
   b) Poor quality topsoil and favourable climatic conditions;
3. Poor restoration occurs with poor quality topsoil and unfavourable climatic conditions.

In areas of good restoration the stem density at Year 1 at the Hanson sites was more than 25 plants and more than 20 species per m^2. These numbers reduce to more than five plants and more than nine species per m^2 at Year 5 as the community becomes more established.

The topsoil gathered at the Proposal and to be used for rehabilitation of the Banksia Woodlands TEC / PEC is predicted to be of good quality due to the limited time that it will be stockpiled (maximum three years) and the management measures proposed to ensure it is gathered and stockpiled in accordance with best-practice methods.

Ultimately Image will be targeting to meet the 'Attributes of Restored Ecosystems' defined by Stevens *et al.* (2016) in the Banksia Woodlands TEC / PEC rehabilitation areas:

1. The restored ecosystem contains a characteristic assemblage of species that occur in the reference ecosystem and that provide appropriate community structure;
2. The restored ecosystem consists of indigenous species to the greatest practical extent;
3. All functional groups necessary for the continued development and / or stability of the restored ecosystem are represented, or if they are not, the missing groups have the potential to colonise by natural means;
4. The physical environment of the restored ecosystem is capable of sustaining reproducing populations of the species necessary for its continued stability or development along the desired trajectory;
5. The restored ecosystem apparently functions normally for its ecological stage of development, and there are no signs of dysfunction;
6. The restored ecosystem is suitable integrated into a larger ecological matrix or landscape, with which it interacts through abiotic and biotic flows and exchanges;
7. Potential threats to the health and integrity of the restored ecosystem from the surrounding landscape have been eliminated or reduced as much as practicable;
8. The restored ecosystem is sufficiently resilient to endure the normal periodic stress events in the local environment that serve to maintain the integrity of the ecosystem; and
9. The restored ecosystem is self-sustaining to the same degree as its reference ecosystem and has the potential to persist indefinitely under existing environmental conditions.

Rehabilitation methods are relatively well-established for Banksia woodlands, however Image acknowledges the effort and complexity involved with achieving the desired outcomes of re-establishing a functional and sustainable ecological community, and that success cannot be guaranteed. The conservative position is therefore that the residual impacts associated with the disturbance to the Banksia Woodlands TEC / PEC is considered to be significant given the conservation status of this ecological community, and the cumulative losses of this TEC / PEC throughout the SCP.

Indirect Impacts

Section 5.5.1 provides a detailed assessment of indirect impacts on native flora and vegetation, which showed that indirect impacts would be minimal outside the area of direct disturbance if managed correctly. This assessment is suitable for this value also, with the Proposal considered unlikely to indirectly impact ‘Banksia Woodlands of the Swan Coastal Plain’ TEC/PEC if the mitigation measures listed in Section 5.6 are implemented.

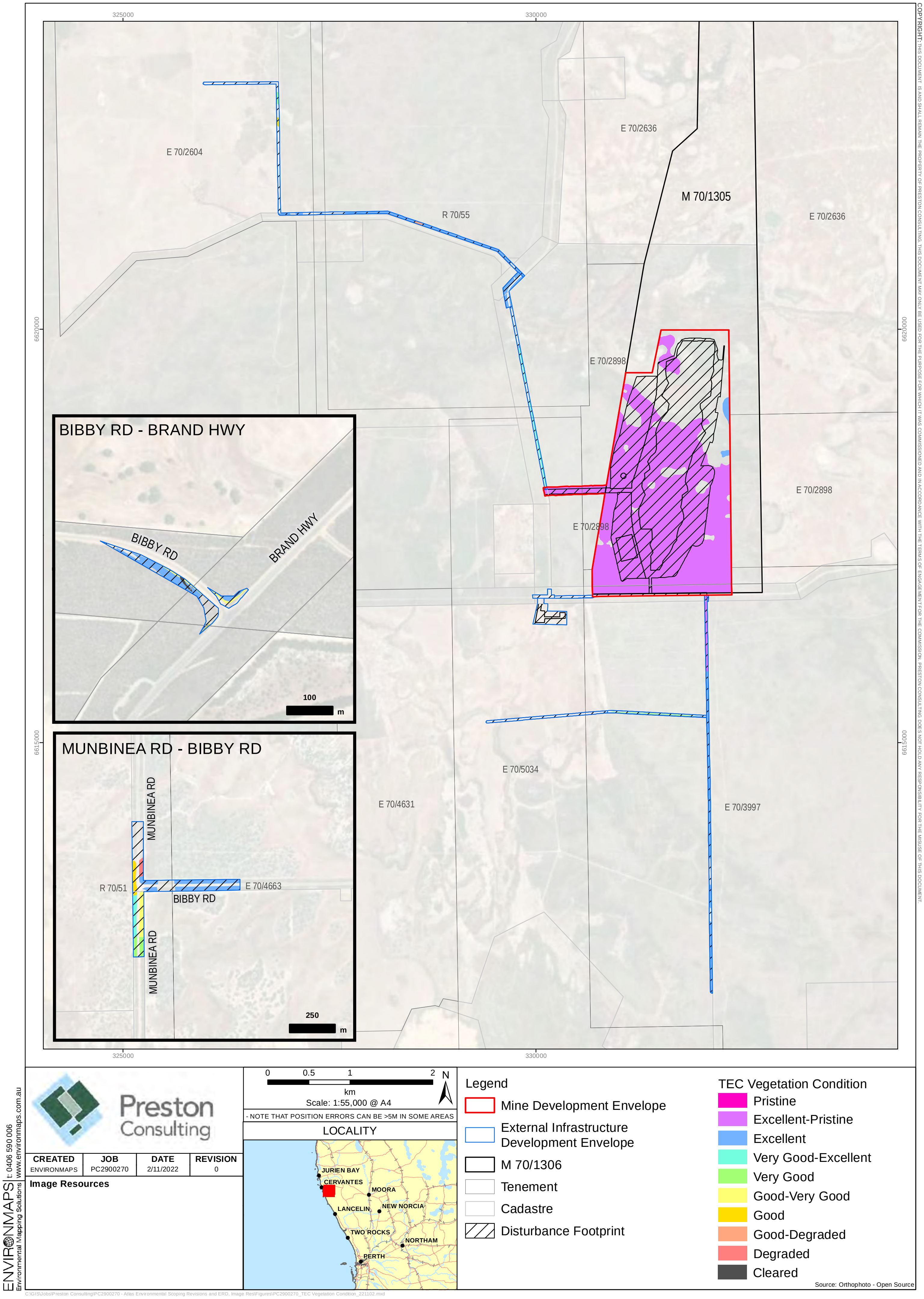


Figure 54: Indicative disturbance within Banksia Woodlands TEC / PEC

5.5.5 Locally Significant Vegetation

At a local scale, six vegetation communities were identified as locally significant at the Proposal. Of these, two Banksia woodland units were identified as being locally significant as they meet the criteria to be characterised as '*Banksia* woodlands of the Swan Coastal Plain' TEC/PEC. Impacts to these vegetation communities are detailed in the section above. Four locally significant heathland units ('BtRc', 'CpBt', 'MsVdCaf', 'Ms') were identified fringing the floodplain and in depressions. These heathlands are thought to be floristically distinctive, and are associated with a high number of significant flora taxa.

Figure 55 shows the location of the locally significant vegetation in proximity to the development envelopes and indicative disturbance footprint.

Direct Disturbance

A total of 156.4 ha of vegetation unit 'BtRc' and another 16.4 ha of transitional vegetation containing BtRc was recorded in the survey areas. 74.3 ha of BtRc occurs within the development envelopes (47.5%) as does 13.77 ha of transitional vegetation containing BtRc. Of this however only 45.47 ha of BtRc is predicted to be disturbed equating to 29.1% of the mapped extent. Another 10.22 ha of transitional vegetation containing BtRc is predicted to be disturbed.

A total of 2.4 ha of vegetation unit 'MsVdCaf'' was recorded in the survey areas and almost all is predicted to be disturbed (2.39 ha). Vegetation Unit 'MsVdCaf' was dominated by *Melaleuca seriata*, and occurred at five or six small patches (2.4 ha of the MESA) on the margins on the southern-central part of the floodplain. MsVdCaf vegetation was moderately species rich (31.7 native species per quadrat).

BtRc and MsVdCaf are considered to align with vegetation type VT5 by Woodman Environmental Consulting's (Woodman) study of the Cooljarloo West survey area (2014) (Morgan, 2022). Woodman's VT5 unit covered an area of 1,887 hectares, and another 119.2 ha of VT5 was identified as occurring within local reserves. Given the extent of VT5 is the local area the disturbance of BtRc and MsVdCaf at the Proposal is considered unlikely to be significant.

The remaining two locally significant wet heathlands ('CpBt' and 'Ms') only have minimal area within the development envelopes (11% and 8% of the areas mapped within the Survey Area respectively) and are not expected to be disturbed based on the current Proposal indicative disturbance footprint.

Indirect Impacts

Section 5.5 provides a detailed assessment of indirect impacts on native flora and vegetation, which showed that indirect impacts would be minimal outside the area of direct disturbance if managed correctly. This assessment is suitable for this value also, with the Proposal considered unlikely to indirectly impact locally significant vegetation if the mitigation measures listed in Section 5.6 are implemented.

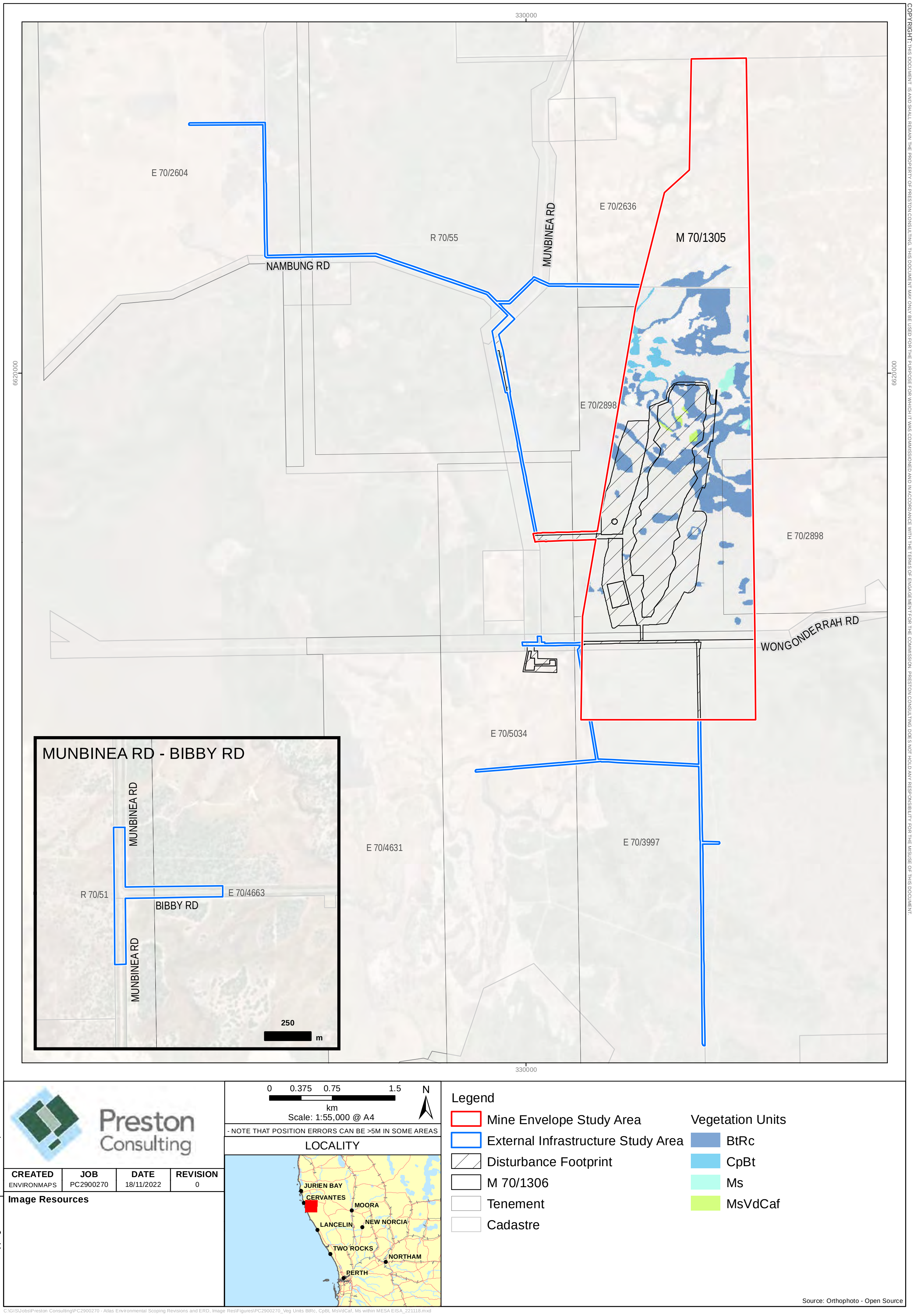


Figure 55: Locally significant vegetation potentially impacted by the Proposal

5.6 Mitigation

Image has mitigated the potential impacts to this factor according to the mitigation hierarchy; avoid, minimise, rehabilitate, offset.

5.6.1 Avoid

Image conducted extensive flora and vegetation surveys of the areas within and surrounding the development envelopes, and have utilised this information to conduct multiple mine planning, infrastructure and access road design revisions. This avoidance process resulted in the final boundaries of the development envelopes and disturbance footprint presented in this ERD, specifically modifications made to reduce the overall scale of the Proposal to avoid large concentrations of numerous Priority Flora (refer to Section 5.5.2).

The development envelopes now avoid the following values identified during the surveys:

1. Eight of the 21 Priority Flora species recorded within the MESA, EISA and BBSA (refer to Section 5.5.2);
2. Direct and indirect impacts to native vegetation including Groundwater Dependant Ecosystems; and
3. The Mt Jetty and Bibby Creeks and wetland and associated vegetation.

In addition to the measures above, an exclusion zone will be implemented around the location of 17 recorded *Levenhookia preissii* (P1) individuals (Figure 49) to ensure the location is avoided. The exclusion zone will be demarcated (physically marked on-ground and on GIS) to ensure the individuals are not disturbed.

5.6.2 Minimise

The following mitigation measures are proposed to ensure that direct and indirect impacts to flora and vegetation are minimised:

1. **Implement industry best practice management measures for flora and vegetation:**
    a. Vegetation clearing will be managed through internal ground disturbance procedures;
    b. Boundaries of areas to be cleared or disturbed will be identified by GPS coordinates and maps of boundaries will be provided to the dozer operator to minimise clearing;
    c. Progressive clearing and rehabilitation will be undertaken;
    d. The disturbance footprint will be developed to the minimum required to ensure safe and adequate construction and operation;
    e. Water or dust suppressants will be applied to disturbed areas, mining areas and product transfer/storage areas as required to minimise dust generation;
    f. Emergency and fire response capabilities will be maintained to respond to fire outbreaks where possible;
    g. Weed and dieback hygiene and management measures / procedures will be implemented to prevent spread of weeds and dieback and the introduction of new weed species as a result of construction and operation;
2. **Obtain and comply with the following approvals (to be obtained):**
    a. Ministerial Statement to be issued under Part IV of the EP Act;
    b. Approval under the EPBC Act;

   c. Works Approval(s) and Licence to be issued under Part V of the EP Act; and
   d. Mining Proposal to be approved under the Mining Act.
3. **Prepare a Final Infrastructure Design Plan** prior to ground disturbance, which will provide further detail that demonstrates that the final locations of all Proposal infrastructure and related disturbance has been selected to avoid Priority Flora and the Banksia Woodlands TEC / PEC wherever practicable;
4. **Ensure groundwater abstraction (mine pit and water supply) and recharge is managed in accordance with the measures described in Section 7.6 to minimise drawdown impacts to vegetation**;
5. **Implement the following measures to minimise the risk and impact of hydrocarbon spills:**
   a. Hydrocarbons will be stored either within a bunded area or within self-bunded tanks;
   b. All spills will be controlled, contained and cleaned up as soon as practicable;
   c. Service vehicles will be fitted with spill kits;
   d. Spill kits will be located at all workshop and fuel storage areas;
   e. Environmental incident recording, investigation and reporting system;
6. **Comply with Water Quality Protection Guidelines and guidance notes**, particularly in relation to the storage and use of hydrocarbons and other harmful chemicals, the design and operation of vehicle maintenance areas and facilities, and the handling and storage of other waste materials, including contaminated soils.
7. **Implement Dieback Management Plan (DMP; Appendix 7)** to mitigate dieback risks and impacts. Dieback surveys will be revised regularly to maintain the currency of comprehensive occurrence information in accordance with relevant guidance throughout the life of the Proposal. The DMP will be reviewed prior to commencement of the Proposal and annually for the life of the Proposal. The DMP will be revised as required on the basis of survey results, change in dieback occurrence and changes to the Proposal.

5.6.3 Rehabilitate

During and after the mining stage of the Proposal the site will be rehabilitated to reinstate the flora and vegetation of areas that were disturbed. The mining pits will be progressively filled and rehabilitated to the pre-mining profile with the pre-existing land use reinstated as mining advances and actioned in accordance with the MCP.

An interim MCP has been prepared to accompany this ERD (Appendix 2) which was developed according to DMIRS Guidelines (2020a; 2020b). Key rehabilitation measures captured within the MCP are summarised below:

1. All infrastructure will be removed from site;
2. All long-term disturbance areas will be respread with topsoil (or ripped and seeded if topsoil is no longer viable) and rehabilitated;
3. All earthmoving equipment will be cleaned free of any soil material to minimise the risk of weed or dieback introduction;
4. Rehabilitation specific to Banksia woodlands will be conducted in areas previously vegetated by this vegetation type, utilising best-practice methods;
5. Rehabilitation specific to geomorphic wetlands will be conducted in areas where these landforms are re-established; and
6. Impacted Priority Flora will be included in the rehabilitation seed mix.

Image also proposes to develop a specific Banksia Woodland Rehabilitation Management Plan which will be developed and implemented prior to the disturbance of any Banksia Woodland TEC / PEC. This Plan will be an appendix to the final MCP and will draw on current rehabilitation practices for Banksia woodlands and is intended to be developed in consultation with DBCA and relevant rehabilitation experts. The Plan will include rehabilitation and revegetation of proposed offset sites.

The MCP will be submitted to DMIRS for assessment and approval prior to the construction of the Proposal and will be reviewed and revised at least every three years, or prior to closure, whichever is the earliest.

5.6.4 Offset

After the implementation of the mitigation measures described above, it is predicted that the Proposal will have unavoidable significant residual impacts on the Banksia Woodlands TEC / PEC.

Proposed offsets for the unavoidable residual impacts on these flora and vegetation values are discussed in Section 12.

5.7 Predicted Outcome

The EPA's environmental objective for this factor is "to protect flora and vegetation so that biological diversity and ecological integrity are maintained". In the context of this objective: "ecological integrity" is listed as the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements (EPA, 2016a).

Image conducted extensive flora and vegetation surveys of the areas within and surrounding the development envelopes. Targeted significant flora surveys were also conducted over the development envelopes and in surrounding areas.

Image has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes, however direct impacts to flora and vegetation are unavoidable. The Proposal will result in the clearing of up to 318 ha of native vegetation, which will be progressively rehabilitated during operations and following mine closure.

With the implementation of controls, the Proposal will not result in significant residual impacts to regional vegetation associations, locally significant vegetation communities, or significant flora.

Management and monitoring is proposed during the operational phase to further minimise indirect impacts to general native flora and vegetation, locally significant vegetation and Banksia Woodlands TEC / PEC (refer to Section 5.6). Management will include:

- Drawdown mitigation measures (discussed in detail in Section 7.5) designed to maintain the aquifer in the surrounding vegetation at background levels. This will be managed by the implementation of the Groundwater Operating Strategy and 5C licensing under the RIWI Act;
- Dust management and monitoring as described in the Dust Management Plan. This plan will be regulated under the Mining Act via a Mining Proposal, and Part V of the EP Act as part of the Works Approval and Licence for the Proposal;
- Dieback management will be as described in the Dieback Management Plan, which is likely to be a commitment and linked to a required outcome (therefore becomes a legal requirement) in the Mining Proposal;

- Weeds, fire risks and hydrocarbon spills will require clear outcomes in the Mining Proposal, with the latter also regulated under Part V of the EP Act (Works Approval and Licence).

The residual impacts to Banksia Woodlands TEC / PEC are however considered to remain significant, despite the avoidance, minimisation and rehabilitation measures proposed. Rehabilitation methods are relatively well-established for Banksia woodlands, however Image acknowledges the effort and complexity involved with achieving the desired outcomes of re-establishing a functional and sustainable ecological community, and that success cannot be guaranteed. The conservative position is therefore that the residual impacts associated with the disturbance to the Banksia Woodlands TEC / PEC is considered to be significant given the conservation status of this ecological community, and the cumulative losses of this TEC / PEC throughout the SCP.

Up to 218.83 ha of Proposal Banksia Woodlands TEC / PEC disturbance will be rehabilitated as the mining front progresses, or at the completion of the Proposal. The Proposal will therefore result in a loss of 218.83 ha of this ecological community for up to an estimated 15 years, until rehabilitated areas have qualities that align with this TEC / PEC (i.e., up to five years of construction and operations, and an estimated ten years of rehabilitation). After this period the community will not be of the same quality, however the quality is predicted to improve gradually over time.

A small area (0.05 ha) is likely to remain cleared permanently as it will form part of the Bibby Road / Brand Highway intersection.

The residual impacts are therefore predicted to be:

- A loss of 218.83 ha of predominantly Excellent - Pristine quality Banksia Woodlands TEC / PEC for a period of 11 - 15 years;
- A permanent loss of 0.05 ha of Good to Excellent quality Banksia Woodlands TEC / PEC; and
- A reduction in the quality of 218.83 ha of the Banksia Woodlands TEC / PEC after rehabilitation (in comparison to pre-mining quality).

Offsets have been proposed to counterbalance these residual impacts. These offsets are described in detail in Section 12, including an assessment of the benefits of the offset to this environmental value.

If the Proposal is approved, the Ministerial Statement is likely to contain a condition requiring the development and implementation of an Offset Strategy. The offset measures will be reviewed and refined in the Offset Strategy and will be informed by discussions with DMIRS, DBCA, DCCEEW and EPA Services to ensure they adequately counterbalance the residual impacts.

Based on the above, Image considers that the Proposal can be implemented such that the EPA objective can be met.

6 TERRESTRIAL FAUNA

6.1 EPA Objective

The EPA Objective for this key environmental factor is to protect terrestrial fauna so that biological diversity and ecological integrity are maintained.

6.2 Policy and Guidance

Relevant EPA and Commonwealth Government guidance documents for Terrestrial Fauna are summarised in Table 20.

Table 20: Policy and guidance relevant to the Terrestrial Fauna key environmental factor

Policy and Guidance	How guidance has been considered
WA Government	
Key EPA documents	
Statement of Environmental Principles, Factors and Objectives 2021 (EPA, 2021b)	This document was considered in the preparation of this ERD and to inform EIA. It was used identify the Key Environmental Factors likely to be impacted by the Proposal and the EPA's objective for each factor.
Statutory Guidelines for MCPs (DMIRS, 2020b)	This document has been considered in the design and planning of the Proposal, it has also been considered in the preparation of mitigation measures for the Proposal, including the preparation of the Interim MCP (Appendix 2).
EIA (Part IV Divisions 1 and 2) Administrative Procedures (EPA, 2021e)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
EIA (Part IV Divisions 1 and 2) Procedures Manual (EPA, 2021a)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
Instructions on how to prepare *EP Act* Part IV Environmental Management Plans (EPA, 2021f).	This document was considered, although not deemed to be relevant to this ERD (no environmental management plans have been prepared to support this ERD).
Relevant EPA Factor Guidelines	
Environmental Factor Guideline – Terrestrial Fauna (EPA, 2016d);	This document was considered in the preparation of this section (Section 6) of the ERD.
Relevant EPA Technical Guidance	
Technical Guidance – Sampling methods for terrestrial vertebrate fauna (EPA, 2016e)	This document was used to inform the survey effort required to undertake EIA for early survey work for the Proposal and is referenced throughout the terrestrial vertebrate fauna reports for the Proposal.
Technical Guidance – Terrestrial fauna surveys (EPA, 2016f)	This document was used to inform the survey effort required to undertake EIA for early survey work for the Proposal and is referenced throughout the terrestrial fauna reports for the Proposal.
Technical Guidance – Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA, 2020a)	This document was used to inform the survey effort required to undertake recent surveys for the Proposal and is referenced throughout the terrestrial vertebrate fauna reports for the Proposal.
Technical Guidance – Sampling of short range endemic (SRE) invertebrate fauna (EPA, 2016g)	This document was used to inform the survey effort required to undertake EIA for the Proposal and is referenced throughout the SRE invertebrate fauna reports for the Proposal.

Policy and Guidance	How guidance has been considered
Technical Guidance – Subterranean fauna surveys for EIA (EPA, 2021g)	This document was used to inform the survey effort required to undertake EIA for the Proposal and referenced throughout the subterranean fauna report.
Other Policy and Guidance	
WA Environmental Offsets Policy (EPA, 2011)	This document was considered during EIA for Terrestrial Fauna to determine suitable offsets.
WA Environmental Offsets Guidelines (EPA, 2014a)	This document was considered during EIA for Terrestrial Fauna to determine suitable offsets.
WA Environmental Offsets Template (EPA, 2014b)	This document was considered during EIA for Terrestrial Fauna to determine suitable offsets.
Commonwealth Government	
Key Documents	
Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act, 1999) (DotEE, 2016a)	This document was considered in the preparation of this ERD and while undertaking EIA.
EPBC Act Environmental Offsets Policy (Department of Sustainability, Environment, Water, Population and Communities; DSEWPaC, 2012a) – including the Offset Assessment guide	This document was considered during EIA for Terrestrial Fauna to determine suitable offsets.
Environmental Management Plan Guidelines (DotE, 2014a)	No management plans were deemed to be required for this factor as part of the EIA process.
EPBC Act Condition Setting Policy (DAWE, 2020a); an	This document was used as guidance for the potential regulation of the Proposal.
EPBC Act Outcomes-based conditions policy (DotE, 2016a)	This document was used as guidance for the potential regulation of the Proposal.
Relevant Technical Guidance	
Relevant EPBC Act listed species specific survey guidelines and protocols.	These documents were used as guidance when undertaking surveys of EPBC listed species and addressing potential survey limitations.
Relevant EPBC Act listed species specific Recovery plans, Threat Abatement Plans, Approved Conservation Advices and other documents.	These documents were used as guidance to assess and manage EPBC listed species that may be impacted by the Proposal.

6.3 RECEIVING ENVIRONMENT

Information in this section has been sourced from the following reports:

- Spring Biological Assessment (360 Environmental, 2021; Appendix 5);
- Atlas Tenement Level 2 Vertebrate Fauna Survey (Single Phase) (360 Environmental, 2012c; Appendix 8);
- Atlas Tenement Graceful Sun-moth Survey and Site Based (*Lomandra*) Habitat Assessment (360 Environmental, 2012a; Appendix 9);
- Atlas Project Detailed Fauna Assessment (Spectrum Ecology & Spatial Pty Ltd; Spectrum, 2022a; Appendix 10);
- Atlas Project Subterranean Fauna Desktop Report and Stygofauna Survey (Bennelongia Environmental Consultants; Bennelongia, 2021; Appendix 11);
- Baseline Stygofauna Survey at the Image Resources Atlas Project Borefield (Bennelongia Environmental Consultants; Bennelongia, 2022; Appendix 12); and

- Atlas Project Regional SRE Survey (Spectrum, 2022b; Appendix 13).

6.3.1 Survey Effort

The survey effort at the Proposal can be summarised as follows:

- Detailed fauna surveys of the Mine Envelope Survey Area (MESA) completed by 360 Environmental (2012c) and Spectrum (2022a), including a targeted Black Cockatoo assessment;
- Basic fauna survey of the External Infrastructure Survey Area (EISA) completed by Spectrum (2022a);
- Basic fauna survey of the Brand Highway-Bibby Road Survey Area (BBSA) completed by 360 Environmental (2021), including a Black Cockatoo assessment; and
- Targeted surveys for:
  - Subterranean fauna (Bennelongia, 2021);
  - Baseline Stygofauna survey (Bennelongia, 2022);
  - Graceful Sun Moth (360 Environmental, 2012a); and
  - Regional SRE extents (Spectrum, 2022b).

Figure 56 - Figure 59 show the boundaries of each of these survey areas. A summary of the field survey effort undertaken for the Proposal is detailed in Table 21.

Table 21: Field survey effort completed for the Proposal

Survey	Survey Timing	Trap Nights					No. Sites		Survey Effort (hrs)			Bat Recordings	Motion Cameras
		Person Days	Pit	Funnel	Elliott	Cages	SRE Wet Pitfall	Leaf Litter	Diurnal Searches	Bird Surveys	Nocturnal		
Detailed Fauna Assessment – MESA (360 Environmental, 2012c)	15 - 24 Nov 2011	40*	161	175	560	112	-	-	18.3	≥80	4	48	-
Basic Fauna Assessment – MESA (Spectrum, 2022a)	22 - 24 Jan 2020	6	-	-	-	-	-	4	7	7	-	8	10
Detailed Fauna Assessment – MESA (Spectrum, 2022a)	14 - 24 Oct 2020	52	280	560	280	112	8	8	43	16.6	6	60	1,200
Basic Fauna Assessment – BBSA (360 Environmental, 2021)	20-24 Sep 2021	4	-	-	-	-	-	Undertaken but no. of sites not recorded	14	14	-	-	-
Basic Fauna Assessment – EISA (Spectrum, 2022a)	28 Jul 2022	2	-	-	-	-	-	-	6	6	-	-	-
Total		**102**	**441**	**735**	**840**	**224**	**8**	**At least 12**	**88.3**	**123.6**	**10**	**116**	**1,210**

*Not included in report, conservative estimate

In addition to the above, the following field surveys were also completed:

- Regional SRE field survey:
  - SRE wet pitfall trapping (16 sites; four traps per site; 2648 trap nights);
  - Leaf litter collection (eight sites, three samples per site); and
  - Foraging (16 sites; two foraging events).
- Graceful Sun Moth field survey:
  - Survey of 200 quadrats (2 x 2 m) to assess Graceful Sun Moth habitat; and

    - Survey of five 10.94 km transects across a range of landscape features.
- Subterranean (stygofauna) pilot survey, including:
    - Sampling for stygofauna at six bores using weighted plankton nets (six hauls per site: three using 50 µm mesh net and three using 150 µm mesh net); and
    - Water quality measurements at four bores.
- Baseline Stygofauna survey, including:
    - Sampling for stygofauna at 12 bores using weighted plankton nets (six hauls per site: three using 50 µm mesh net and three using 150 µm mesh net); and
    - Water quality measurements at five bores (seven bores were not measured as they were too narrow to sample).

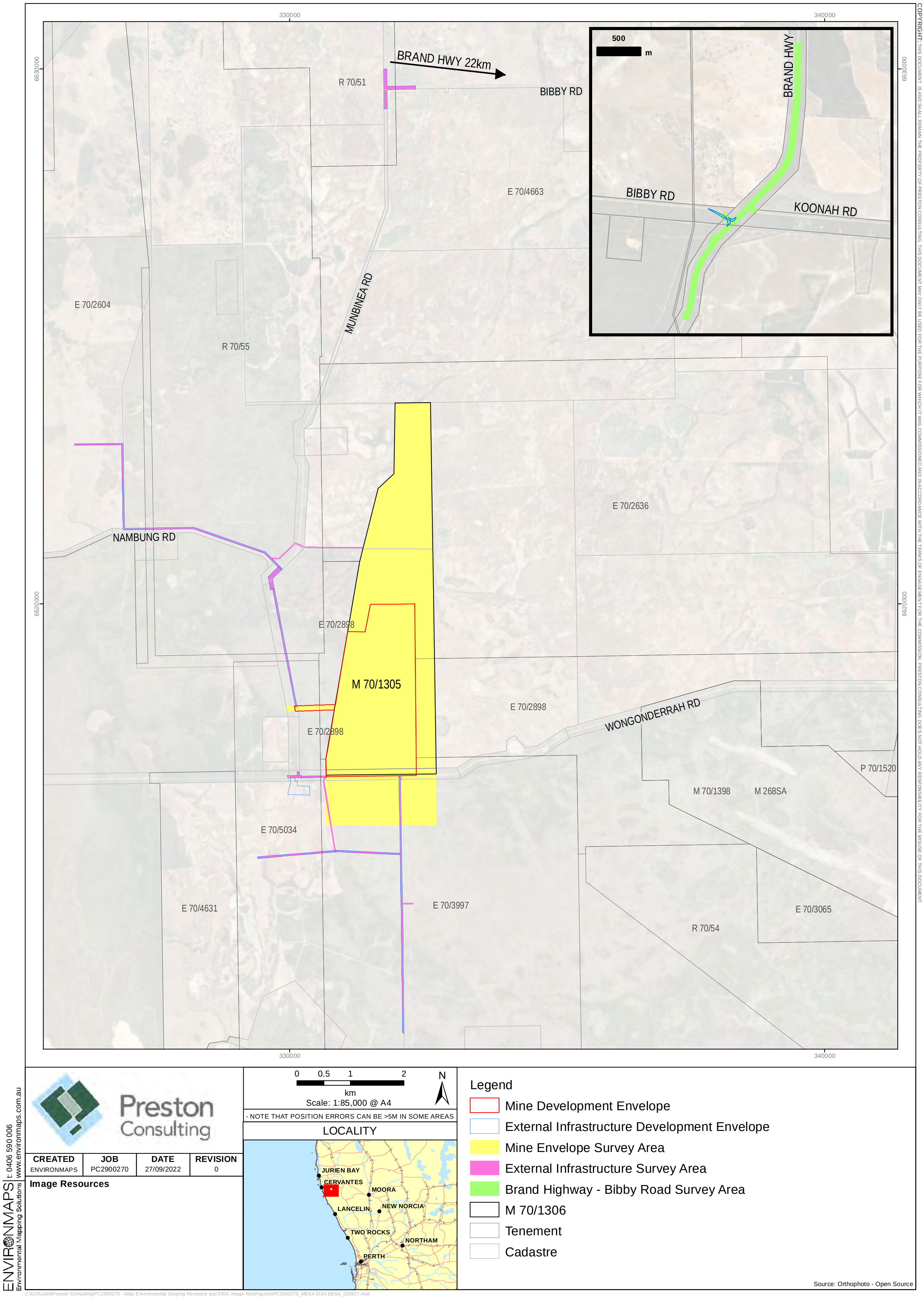


Figure 56: MESA, EISA and BBSA survey areas

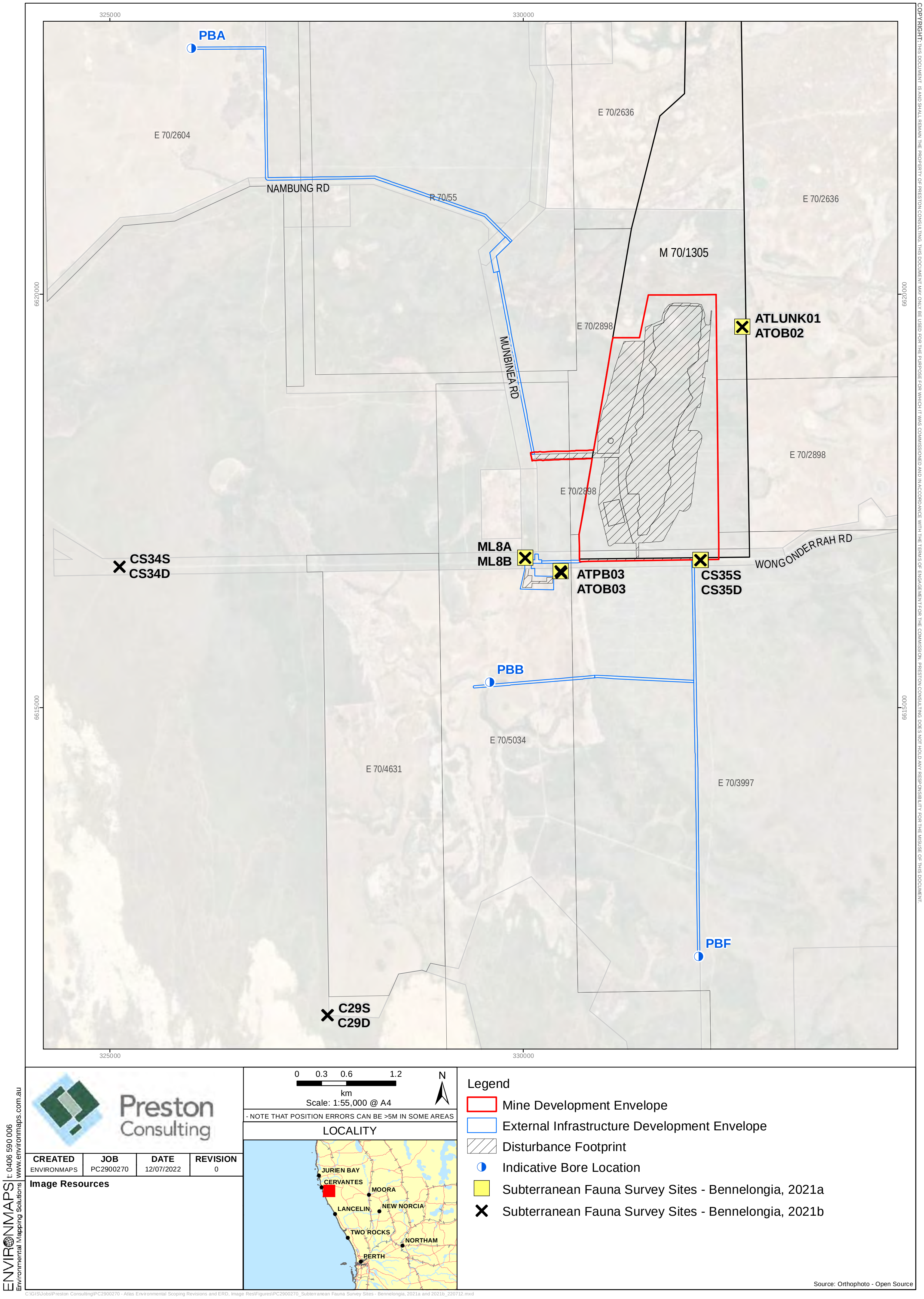


Figure 57: Subterranean Fauna mine and borefield survey sites (Bennelongia, 2021a & 2021b)

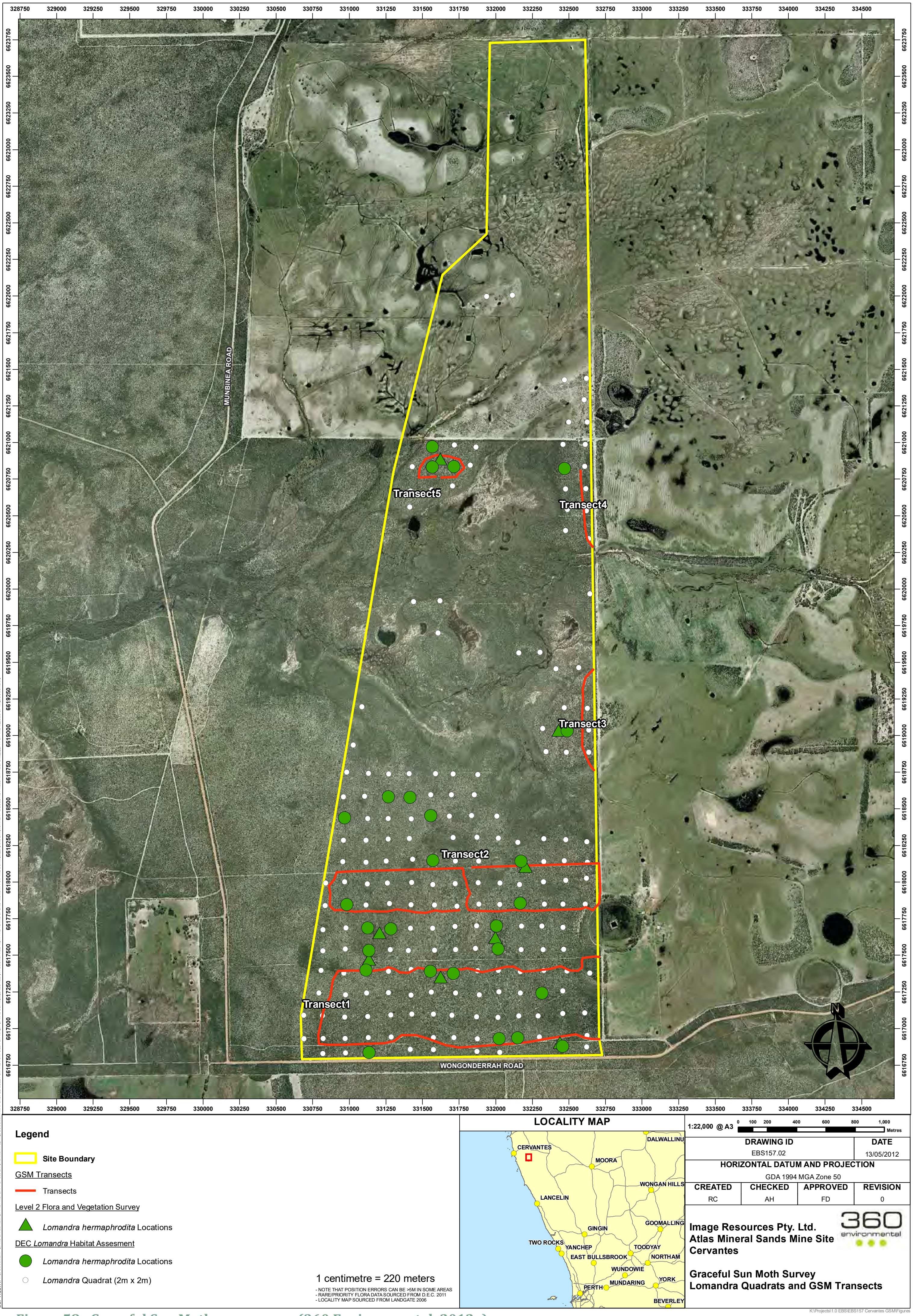
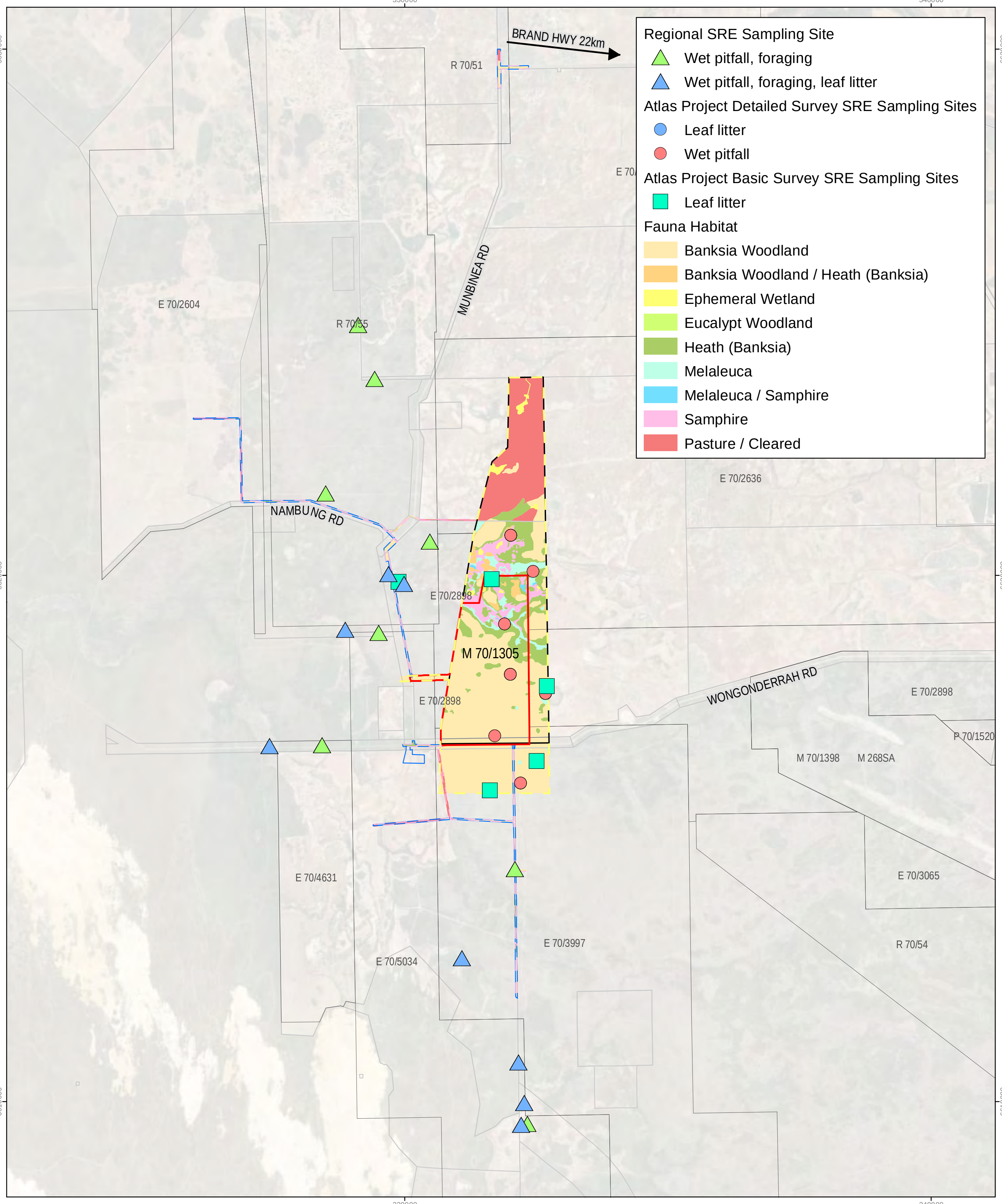


Figure 58: Graceful Sun Moth survey area (360 Environmental, 2012a)



Preston Consulting

CREATED	JOB	DATE	REVISION
ENVIRONMAPS	PC2900270	18/11/2022	0

Image Resources

0 0.5 1 2
km
Scale: 1:100,000 @ A4
- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY

Legend
- Mine Development Envelope
- External Infrastructure Development Envelope
- Mine Envelope Survey Area
- External Infrastructure Survey Area
- Brand Highway - Bibby Road Survey Area
- M 70/1306
- Tenement
- Cadastre

Source: Orthophoto - Open Source

ENVIRONMAPS Environmental Mapping Solutions t: 0406 590 006 www.environmaps.com.au

C:\GIS\Jobs\Preston Consulting\PC2900270 - Atlas Environmental Scoping Revisions and ERD, Image Res\Figures\PC2900270_SRE Sample Sites - Regional_221118.mxd

Figure 59: Regional SRE survey sites (Spectrum, 2022b)

6.3.2 Mine Envelope Survey Area

Level 2 (first phase) Fauna Survey (2011)

360 Environmental undertook a single season Detailed Vertebrate Fauna Survey of portion of the MESA (Figure 56) to the north of Wongonderrah Road and including all of the area of Mine Development Envelope.

The objectives of the Detailed Vertebrate Fauna Survey were to:

- Provide an inventory of the fauna habitats and assemblage of the 2011 Survey Area;
- Identify significant constraints associated with the faunal values within the Fauna Survey Area;
- Assist with the evaluation of potential impacts on vertebrate fauna and/ or habitat of conservation significance; and
- Provide recommendations to mitigate fauna impacts.

The scope of works for the fauna survey included a desktop study followed by a detailed site visit which included fauna trapping. The purpose of the desktop study was to gather background information relevant to the MESA by searching literature, data sources and map-based information. This desktop study has been superseded by a recent desktop study completed by Spectrum (2022a) in 2020, therefore the findings of the 360 Environmental desktop study have not been included in this ERD.

The reconnaissance and trapping survey (15 – 24 November 2011) aimed to verify the accuracy of the desktop study, delineate and characterise fauna and faunal assemblages present within the MESA and identify potential impacts. The survey comprised ten systematic survey sites. The standard trapping arrangement at each site survey comprised of three pit-traps, three funnel pairs, five large Elliots, five small Elliots and two cages. Systematic survey sites were positioned such that they sampled all major habitats available within the MESA.

Basic Fauna Survey and SRE Reconnaissance Survey (2020)

Spectrum undertook a single season Basic Fauna Survey and Targeted Fauna Assessment (Spectrum, 2022a) of the MESA that included areas to the south of Wongonderrah Road.

The assessment included:

- Desktop review and updates to the findings of the 360 Environmental (2012c) survey report;
- Details of any significant fauna and / or habitat identified as occurring within the MESA; and
- A reconnaissance level SRE survey.

Spectrum conducted an initial desktop review of all relevant and available terrestrial fauna data sources undertaken prior to the field assessment. Table 22 shows the data sources Spectrum searched to assess the terrestrial fauna species likely to occur in the MESA.

Table 22: Fauna database searches (Spectrum, 2022a)

Data Source	Custodian	Details
Commonwealth Protected Matters Search Tool (PMST)	DCCEEW	Date: 24/11/20 Radius: 40 km

Data Source	Custodian	Details
NatureMap	DBCA /West Australian Museum (WAM)	Date:24/11/20 Radius:40 km Centre Point: 115° 15' 51'' E,30° 34' 22'' S
DBCA Threatened Database Search	DBCA	Date: 15/01/20 Details: Polygon plus 40 km Ref #: 6232
Arachnida & Myriapoda, Crustacea, Mollusca Database	WAM	Search Area: NW corner -29.5° 114.9° SE corner -31.5° 116.9° Date: 7/01/20
Index of Biodiversity Surveys of Assessments (IBSA) database.	DWER	Date: 30/11/2019, Buffer: 100 km

The field survey was completed between 22 – 24 January 2020 and conducted in accordance with the EPA's *Technical Guidance: Sampling Methods for Terrestrial Vertebrate Fauna* (EPA, 2016e). Selective low intensity sampling of fauna and fauna habitats were utilised to verify the accuracy of the desktop assessment. Habitat assessments were completed to describe and define major fauna habitat types within the MESA, particularly those that may be utilised by significant fauna. Active searches were also completed to identify broad fauna assemblages with attention given to habitat that may host significant fauna species. Survey sites established within the MESA and surrounding region included:

- 21 habitat assessment, active search/ foraging sites;
- Five Motion Camera sites;
- Three bat recorder sites; and
- Four leaf litter collection sites.

The SRE status of taxa collected during the surveys was based on categories developed by the West Australian Museum (WAM). The categories were used by taxonomists and consultants in order to describe the SRE status of taxa collected from the MESA. The classifications listed in Table 23 are based on known information of the species group such as distribution, representation of records in collections, and distinct morphological features. Information gaps lead to classing taxa as potential SREs which is a requirement under the precautionary principle.

Table 23: WAM SRE categories (WAM, 2013)

Distribution	Taxonomic Certainty	Taxonomic Uncertainty
Distribution <10,000km^2	**Confirmed SRE** Known distribution of <10,000 km^2. Taxonomy is well known. Group is well represented in collections and /or via comprehensive sampling.	**Potential SRE** Patchy sampling has resulted in incomplete knowledge of the geographic distribution of the group. There is incomplete taxonomic knowledge. The group is not well represented in collections. This category is most applicable to situations where there are gaps in knowledge of the taxon.
Distribution >10,000 km^2	**Widespread (not SRE)** Represented in collections and /or via comprehensive sampling.	

Detailed Fauna Survey (2020)

Spectrum (2022a) undertook a Detailed fauna assessment of the MESA, including both vertebrate and SRE invertebrate fauna. The assessment included:

- A desktop assessment review addressing any updated records or revised conservation status;
- Field Surveys including;
  - Detailed terrestrial vertebrate fauna survey; and
  - Detailed SRE invertebrate survey.

Four public databases were accessed as part of the desktop assessment. Details of the completed database searches are listed in Table 24.

Table 24: Database Searches (Spectrum, 2022a)

Custodian	Database	Species Group	Details
DCCEEW	Protected Matters Search	EPBC listed vertebrate and invertebrate fauna species	Date: 24/11/20 Radius: 40 km
DBCA	NatureMap	Vertebrate Fauna species	Date: 24/11/20 Radius: 40 km Centre Point: 115° 15' 51'' E,30° 34' 22'' S
	Threatened Fauna Database Search	Threatened and Priority Vertebrate and Invertebrate Fauna species	Date: 15/01/20 Details: Polygon +40 km Reference: #6232
WAM	Arachnida & Myriapoda Database	SRE invertebrate fauna species	Search Area; NW corner – 29.5° 114.9 SE corner -31.5° 116.9 Date: 07/01/20
	Crustacea Database		
	Mollusc Database		

Three survey reports from previous surveys completed within the MESA and three additional surveys associated with the local region (Cooljarloo West and Yandin Wind Farm Project) were reviewed as part of the literature review. Details of these surveys are listed in Table 25.

Table 25: Reviewed survey reports (Spectrum, 2022a)

Reference	Location	Details
Atlas Tenement Level 2 Vertebrate Fauna Survey (Single Phase) – North Perth Mineral Sands Project (360 Environmental, 2012c)	Within MESA	Single phase Level 2 vertebrate fauna survey
Atlas Tenement Graceful Sun-moth Survey & Site Based (*Lomandra*) Habitat Assessment (360 Environmental, 2012a)	Within MESA	Targeted Sun Moth survey
Cooljarloo West Proposal: Short Range Endemic Fauna, Pilot and Targeted Surveys (Bennelongia, 2013)	Cooljarloo	SRE targeted invertebrate survey
Cooljarloo West Development Envelope Fauna Assessment (Bamford, Bancroft and Turpin, 2015)	Cooljarloo	Two phase Level 2 vertebrate fauna survey
Yandin Wind Farm – Flora, Vegetation and Avifauna Assessment (Ecologia, 2017)	Cataby	Avifauna survey

Reference	Location	Details
Bibby Road, Cooljarloo. Spring Biological Assessment (360 Environmental, 2021)	Within Survey Area	Basic vertebrate fauna and targeted black cockatoo habitat assessment.

Based on the results of the desktop review, Spectrum completed a single-phase Detailed fauna survey to complement the first phase of surveying in 2011 (360 Environmental, 2012c) and a Basic / Targeted fauna survey completed by Spectrum in 2020. The Detailed field survey was completed from 14 - 24 October 2020. SRE wet pitfall traps were installed on 14 - 15 September, four weeks prior to the Detailed survey. Cameras were also installed at this time and were collected at the completion of the Detailed survey. The MESA and survey sites are shown in Figure 60.

During the first phase of the Detailed (previously known as Level 2) survey (360 Environmental, 2012c), eight systematic trapping sites were installed for seven nights. For consistency, Spectrum (2022a) installed eight systematic trapping sites during the second phase survey as close as possible to the original first phase site locations. The survey methods used directly aligned with the methods used during the first phase of surveying in 2012. Detailed descriptions for each sampling method are described below.

Vertebrate Fauna Systematic Sampling

Fauna trapping sites include a suite of trapping techniques designed to detect the local terrestrial fauna assemblage. The trapping grids used during the field survey included the following:

- **20 L bucket and 50 cm PVC pipe pitfall traps**: a trapping grid comprised of five alternating buckets and PVC pipes, dug into the ground to act as pitfall traps. A 10 m long, 30 cm high fence was also installed, passing across the top of each pit to direct fauna into it;
- **Fraser-type funnel traps**: similar to Yabbie traps, these were placed at the ends of each fence to capture fauna that are not readily caught in pitfall traps (ten per trapping grid);
- **Elliott traps**: aluminium box traps were baited with 'universal bait' to attract and capture smaller mammals (five per trapping grid) and re-baited as required; and
- **Cage traps**: larger wire-frame box traps, also baited with 'universal bait', to capture medium-sized mammals (two per trapping grid) and re-baited as required.

Trapping grids were set up in each major fauna habitat type where possible, with each trapping grid surveyed over a seven-night period.

Bird Surveys: Area searches (30 minute set-time searches of 2 ha areas) were used to document the bird assemblage present at each of the systematic fauna trapping sites. During each area search an ornithologist recorded the number of individuals of each species observed while actively searching similar habitat within a 2 ha area surrounding the trapping site. Survey effort was concentrated within three hours of dawn or dusk, as these times are considered optimal for recording most bird species. A minimum of 2 hours of survey were completed at each systematic site.

Bat Surveys: Bat echolocation calls were recorded from each fauna trapping site using Wildlife Acoustics SM4Bat ultrasonic recorders. The SM4Bat device records the full spectrum of calls allowing greater accuracy and sensitivity when identifying bat species. Each SM4Bat device was programmed to record from 30 minutes pre-dusk to 30 minutes post-dawn for each night surveyed. All sites were surveyed for 1 - 3 nights to identify the bat assemblage present.

SRE Invertebrate Fauna Systematic Sampling

SRE invertebrate fauna species were sampled using the below methods:

- **Wet pitfall trapping**: Wet pitfall traps consisted of a 1 L plastic jar containing 500 - 700 ml of mixed preserving solution (active ingredients; Propylene-Glycol and Ethanol). All wet pitfall traps were covered with a bucket lid, situated approximately 1 - 2 cm above the surface of the ground to prohibit vertebrate species from being trapped. Each wet pitfall site comprised four wet pitfalls which were established in suitable microhabitat and left in-situ for six weeks;
- **Leaf litter collection**: Three 1 m^2 quadrats were collected from each site containing suitable leaf litter or soil. The samples were initially processed using a leaf litter reducer, with the smaller leaf litter components placed into plastic zip-lock bags and transported back to Perth where they were placed under Tullgren funnels to extract the invertebrates; and
- **Dry pitfall trapping**: Dry pitfalls used at systematic trapping sites for vertebrate fauna species (listed above) were concurrently utilised to collect SRE invertebrate species. The pitfalls were left open for seven nights and checked each morning.

Opportunistic Sampling

One limitation of systematic sampling sites is that some species and taxa are difficult to detect due to cryptic behaviours or other ecological considerations, such as fossorial or arboreal species. Systematic survey techniques were therefore supplemented with a suite of opportunistic sampling techniques that target specific species and habitats not normally covered by systematic trapping sites. These active survey techniques are listed below:

- **Reptiles and Amphibians**: Minimum 20-minute searches of 1 ha areas by an experienced herpetologist. Microhabitats favoured by reptiles and amphibians were searched using various techniques including the raking of leaf litter and soil under shrubs, searching amongst rock piles and searching under and inside fallen timber. Nocturnal species searches were also performed (when safe access was available) using spotlights and recordings of frog calls, if present;
- **Birds**: Area searches (20-minute set-time searches of 2 ha areas) were used to document the bird assemblage present at bird-specific habitats, or habitats not already surveyed at systematic trapping sites. Bird species opportunistically observed inside the MESA that were not typically recorded during set time searches were also recorded, such as raptors, water birds and nocturnal species;
- **Mammals**: Mammals observed opportunistically within the MESA were also recorded. Tracks, scats and other traces of mammals were recorded and identified where possible. Suitable areas were targeted using additional SM4BAT acoustic devices to record the potential presence of bat species;
- **SRE Invertebrate Fauna**: Suitable microhabitats were foraged for invertebrates that potentially represent SRE species. Leaf litter and the underside of rocks and logs were closely searched for molluscs, millipedes, isopods, pseudoscorpions and arachnids. If encountered, live snails were also collected from vegetation and trapdoor spider burrows were excavated; and
- **Motion Cameras**: Motion sensitive cameras capable of recording both normal (day) and infra-red (night) images were set up in areas of high fauna interest, such as permanent water features, to record cryptic species not typically observed during field surveys.

Listed Fauna Targeted Searches

A number of species listed under the EPBC Act and/ or BC Act were identified by the literature review as having a medium to high likelihood of occurrence in the MESA. The following species were specifically targeted using the field survey techniques listed below, whilst all other species were targeted using the methods listed above:

- **Quenda (*Isoodon fusciventer*) and Western Brush Wallaby (*Notamacropus irma*) -** baited (non-food) long-term Motion Cameras (Reconyx HF2X & HP2X) were installed within suitable habitat across the MESA. Cameras were deployed four weeks prior to the Detailed survey. Any opportunistic sightings of these species were recorded including tracks, scats and other traces;
- **Carnaby's Cockatoo (*Zanda latirostric*) and Fork-tailed Swift (*Apus pacificus*) -** area searches were used to document the bird assemblage present at each systematic fauna trapping sites. All bird species were targeted during all surveys and any opportunistic sightings or secondary evidence were recorded;
- **Malleefowl (*Leiopa ocellata*)** All bird species were targeted during all surveys and any opportunistic sightings or secondary evidence were recorded. Suitable habitat within the MESA is limited to Heath (Banksia) and is also leaf litter dependent;
- **Common Greenshank (*Tringa nebularia*)** All migratory bird species present were targeted during all surveys and any opportunistic sightings were recorded. Area searches (20-minute set-time searches of 2 ha areas) were used to document the species within suitable habitat including wetland areas and dams; and
- **Black-striped Burrowing Snake (*Neelaps calonotos*) and Jewelled Southwest Ctenotus (*Ctenotus gemmula)*** These species were targeted through systematic vertebrate sampling sites and opportunistic sampling searches within suitable habitat. Opportunistic sampling involves searching and raking leaf litter and soil under shrubs, searching amongst rock piles, and searching under and inside fallen timber, within suitable habitat.

Site Selection

Prior to the selection of survey sites, all previous fauna assessments and habitat mapping within the MESA were consolidated to allow the identification of survey gaps. Previous survey information, pre-European vegetation mapping and aerial imagery were then utilised to identify fauna habitats expected to occur within the MESA. The number of previous survey sites located in each habitat type was also determined to allow further identification of survey gaps. Both systematic and opportunistic survey sites were established across all representative habitat types. Survey site locations are shown in Figure 60.

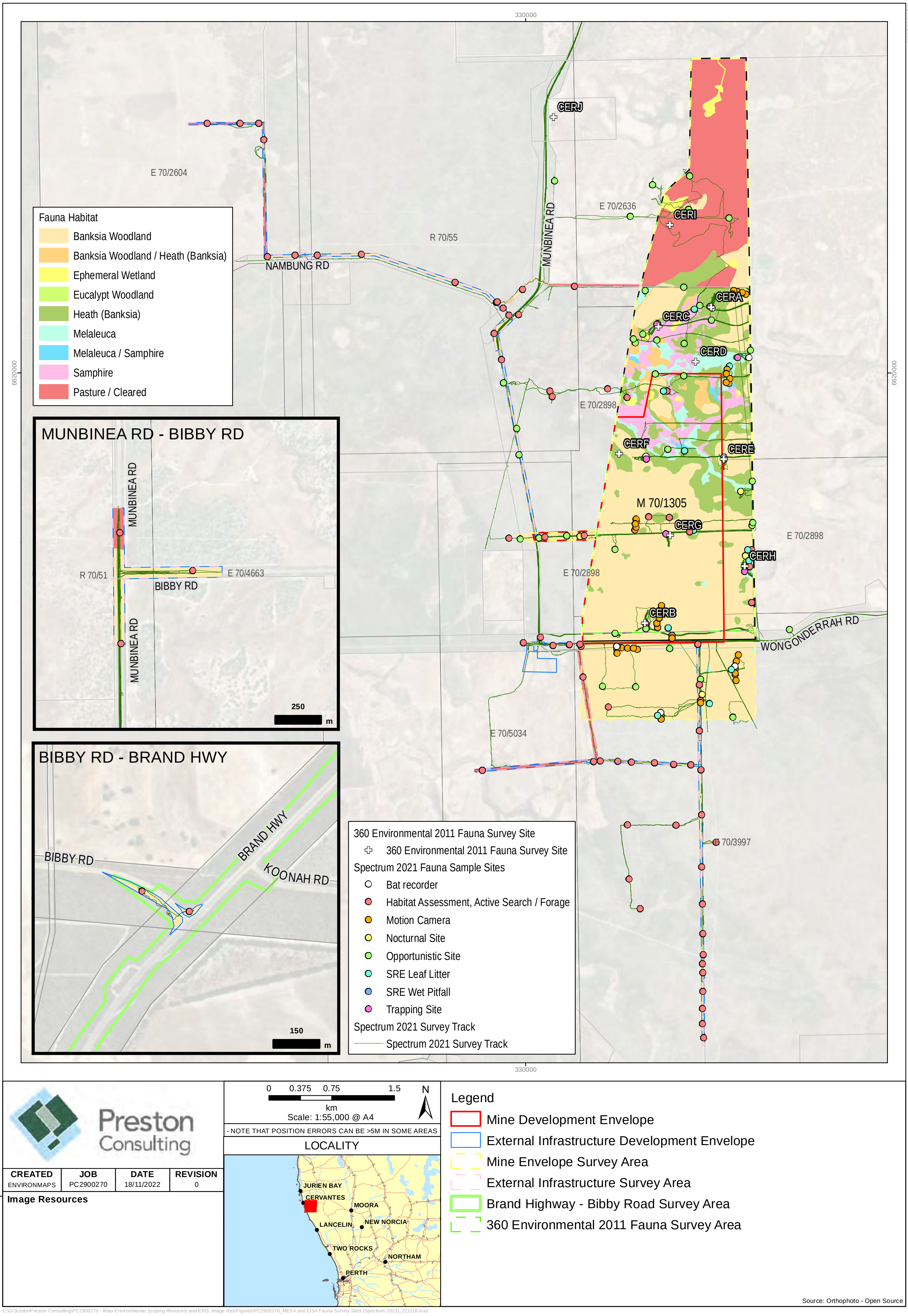


Figure 60: MESA, EISA and survey sites

Targeted Black Cockatoo Assessment

A Black Cockatoo Targeted assessment was conducted by Spectrum (2022a) to determine if the MESA contained quality Black Cockatoo foraging habitat. Information on the following was collected:

- The presence of all plant species that provide foraging, including non-native food sources used by Black Cockatoos;
- The presence of tree species used for breeding;
- Use as a roosting site;
- The vegetation present in the surrounding area, i.e. at least 12 km from the MESA, including proximity to any breeding habitat, roosting sites and watering points;
- Breeding habitat, such as an estimate of the number of trees with a diameter of ≥500 mm or 300 mm for salmon gum or wandoo at breast height (1.3 m from the ground);
- Numbers of any known nesting trees; and
- Presence of disease, such as *Phytophthora cinnamomi* or marri canker (*Quambalaria coyrecup*).

Each potential breeding tree was also scored for suitability for breeding and the presence or absence of suitable tree hollows was noted.

This assessment followed the *Black Cockatoo referral guidelines* (DSEWPaC, 2012b) and the *Revised draft referral guideline for three threatened black cockatoo species* (DotEE, 2017a), and utilised a scoring tool included in these documents.

Graceful Sun-moth Survey (2012)

Following an identified presence of potential Graceful Sun-moth (*Synemon gratiosa;* GSM; Endangered under the EPBC Act) habitat (*Lomandra* sp.) in the previous flora and vegetation survey (360 Environmental, 2012b), a Targeted fauna assessment (360 Environmental, 2012c) for the GSM was conducted.

The Targeted GSM assessment included:

- Desktop searches of the DSEWPaC Protected Matters Database, NatureMap and DEC Fauna Search databases for records of GSM or GSM habitat;
- Review of the 2011 flora and vegetation study (360 Environmental, 2012b) for presence or observed locations of *Lomandra* sp.;
- Site-based habitat assessment specifically targeting *Lomandra* sp.; and
- Intensive GSM surveys informed by the site-based habitat assessment.

The Targeted assessment was undertaken in accordance with the Department of Environment and Conservation's (DEC) (2010) *Graceful Sun Moth Information Kit and Survey Methods Version 1.2*. The purpose of the desktop searches was to assess the presence or observed presence of GSM and GSM habitat to assist in planning for both the habitat-based assessment and intensive surveys of the site.

The site-based habitat assessment aimed to determine the fine-scale *Lomandra* sp. presence and density, and the dominant plant species at each site. DEC's *Graceful Sun Moth Information Kit and Survey Methods Version 1.2* (2010) dictate the even disbursement of 2 x 2 m quadrats evenly across a survey site, however the size of the Survey Area (approximately 957 ha) meant this was not feasible and liaison with DEC staff allowed for the use of 200 quadrats (Figure 58).

The GSM survey used information taken from the site-based habitat assessment completed in conjunction with previously observed locations of *Lomandra* sp. and aerial photos. Landscape features such as tracks, firebreaks, major vegetation types, landforms etc. were incorporated into a series of transects, producing a total transect length of 10.94 km (Figure 58). The survey's findings suggested sufficient and appropriate survey techniques were used, however no GSM were recorded.

6.3.3 External Infrastructure Survey Area

Basic Fauna Survey

Spectrum (2022a) undertook a Basic fauna survey of the EISA between 20 - 24 September 2021 and on 28 July 2022. This Survey included 39 habitat assessment sites with active searches completed at each site, and opportunistic observations made whilst walking through the infrastructure corridors.

6.3.4 Brand Highway-Bibby Road Survey Area

360 Environmental (2021) undertook a Basic fauna survey and Black Cockatoo Habitat Assessment of the BBSA on 16-17 September 2020. The fauna survey locations within the BBSA are shown in Figure 61.

Desktop Study

360 Environmental (2021) completed an initial desktop reviewed of all relevant and available fauna data sources, prior to the field assessment. Database searches were undertaken to identify potential significant fauna taxa, ecological communities and MNES within or surrounding the BBSA. Table 26 lists the data sources 360 Environmental searched to assess the terrestrial fauna species likely to occur in the BBSA. Significant fauna species identified from the desktop assessment were assessed to determine a likelihood of occurrence both prior to and post field survey.

Table 26: Database searches of the BBSA

Database name	Search Target	Details
DBCA Threatened and Priority Fauna List, plus Black Cockatoo specific custom database search (DBCA, 2020a)	Threatened and Priority Fauna and Black Cockatoos	Date: 02/09/20 Radius: 12 km search buffer of the BBSA (general fauna); 30 km buffer (black cockatoos)
NatureMap area search (DBCA, 2020b)	Threatened and Priority Fauna, and inventory of potential fauna	Date: 26/08/20 Radius: 10 km search buffer of the BBSA
PMST area search (DAWE, 2020b)	Commonwealth listed Threatened fauna	Date: 26/08/2020 Radius: 10 km search buffer of the BBSA

Vertebrate Fauna Survey

A Basic vertebrate fauna field survey was undertaken from 16 - 17 September 2020 to verify the accuracy of the desktop assessment and further delineate and characterise the fauna assemblages and fauna habitat in the BBSA. The field survey consisted primarily of fauna habitat assessments, systematic bird searches and opportunistic fauna observations.

Fauna habitat assessments were undertaken throughout the BBSA to identify fauna habitat values. Fauna habitat mapping was based on a combination of field observations, fauna habitat assessment data and vegetation mapping undertaken by 360 Environmental (2021).

Unbounded bird surveys were undertaken at each habitat assessment location for a duration of 10 minutes. Opportunistic observations of fauna were recorded through the BBSA. Additional active searches were undertaken in microhabitats likely to contain fauna.

Black Cockatoo Habitat Assessment

The Black Cockatoo habitat assessment was undertaken alongside the vertebrate fauna survey and involved traversing the BBSA on foot to determine the presence of potential breeding, foraging and roosting habitat (360 Environmental, 2021). The survey was conducted in accordance with the EPBC Act Referral Guidelines for three threatened Black Cockatoo Species (DSEWPaC, 2012).

6.3.5 Regional Short-Range Endemic Survey

Spectrum (2022b) undertook additional regional SRE surveys to provide information on the distribution of potential SRE taxa recorded from the MESA, with particular focus on taxa that had not been recorded outside the MESA (Figure 59). The regional survey was to target taxa from three main groups: Pseudoscorpions, Isopods and Snails with proposed techniques also targeting the jumping spider *Maratus* 'BAR130' (Spectrum, 2022b).

The field survey was completed in Spring 2021, with field survey dates as follows:

- SRE wet pitfall trap installation, foraging and leaf litter collection: 20 - 24 September 2021; and
- SRE wet pitfall trap collection and foraging: 2 - 4 November 2021.

Sites were pre-selected based on information from previous surveys, including the habitats target SRE groups collected from within the MESA (Spectrum, 2022a) and satellite imagery. Pre-selected sites were ground-truthed and adjusted during the survey to best represent target habitats. The SRE sampling was conducted in three habitat types recorded from the MESA – Banksia Woodland, Melaleuca and Samphire (Spectrum, 2022a).

Sixteen SRE invertebrate sampling sites were established. Wet pitfall traps were installed at all sites (four traps per site; 2,648 trap nights), leaf litter was collected from eight sites (three samples per site) and foraging was conducted at all sites, using sifting trays where appropriate. Alacran Environmental Science (Alacran) taxonomists assisted with identification of invertebrate fauna specimens (Alacran, 2022).

Figure 61: Fauna assessment locations within the BBSA

6.3.6 Subterranean Fauna Desktop Review and Stygofauna Survey (2020)

Bennelongia (2021) undertook a desktop review and pilot stygofauna study to assess the knowledge of subterranean fauna values at the Proposal with a view to determine the significance of any species and communities present and to determine whether a more detailed field survey was warranted (Figure 57). Previous records of subterranean fauna species in the vicinity of the Proposal were collated and evaluated to clarify the likelihood of subterranean fauna species occurring in and around the Proposal. Records were obtained from the WAM and Bennelongia databases, with a search area of approximately 100 km x 100 km, centred on the Proposal (Bennelongia, 2021). However, the extent of subterranean occurrence on the northern Swan Coastal Plain and Mid-West coast is still being evaluated, with limited survey effort conducted in the area. As a result, areas that were geologically and hydrologically analogous to the Proposal were assessed as a means of establishing the level of subterranean communities that could feasibly be expected around the search area.

Stygofauna sampling was conducted according to the general principles laid out in Technical Guidance – Sampling methods for subterranean fauna (EPA, 2021g) and Technical Guidance – Subterranean fauna survey (EPA, 2016h) and the Environmental Factor Guideline – Subterranean Fauna (EPA, 2016i).

Stygofauna were sampled using weighted plankton nets, with a total of six hauls taken at each site (three using a 50 µm mesh net and three using a 150 µm mesh net). Contents were transferred to a polycarbonate vial, flushed with bore water to reduce sediment, preserved in 100% ethanol and refrigerated at a constant 4°C. In situ water quality parameters (temperature, electrical conductivity (EC) and pH) were measured at each site where possible. Depth to the water table and total depth of hole were also measure at each site.

Nine bores were identified as prospective stygofauna habitat within Proposal bores. Weather and access conditions resulted in only six bores being sampled for stygofauna. Water quality was only measured at four of the bores, as the other two bores were too narrow to sample.

6.3.7 Subterranean Fauna Desktop Review and Stygofauna Baseline Survey (2021)

Bennelongia (2022) undertook a desktop review and baseline stygofauna study to assess the knowledge of subterranean fauna values for the Proposal's borefield options with a view to determine the significance of any species and communities present (Figure 57). Previous records of subterranean fauna species in the vicinity of the Proposal were collated and evaluated to clarify the likelihood of subterranean fauna species occurring at the Proposal's borefield. Records were obtained from the WAM and Bennelongia databases, with a search area of approximately 100 km x 100 km, centred on the Proposal (Bennelongia, 2022). However, the extent of subterranean occurrence on the northern Swan Coastal Plain and Mid-West coast is still being evaluated, with limited survey effort conducted in the area. As a result, areas that were geologically and hydrologically analogous to the Proposal were assessed as a means of establishing the level of subterranean communities that could feasibly be expected around the search area.

Stygofauna sampling was conducted according to the general principles laid out in Technical Guidance – Sampling methods for subterranean fauna (EPA, 2021g) and Technical Guidance – Subterranean fauna survey (EPA, 2016h) and the Environmental Factor Guideline – Subterranean Fauna (EPA, 2016i).

Stygofauna were sampled using weighted plankton nets, with a total of six hauls taken at each site (three using a 50 μm mesh net and three using a 150 μm mesh net). Contents were transferred to a polycarbonate vial, flushed with bore water to reduce sediment, preserved in 100% ethanol and refrigerated at a constant 4°C. In situ water quality parameters (temperature, electrical conductivity (EC) and pH) were measured where possible. Depth to the water table and total depth of hole were also measured.

Twelve bores were identified as prospective stygofauna habitat within Proposal borefield. Water quality was only measured at five of the bores, as the other seven bores were too narrow to sample.

6.3.8 Alignment with Technical Guidance

The terrestrial fauna surveys were developed with reference to guidelines and recommendations set out by the EPA for fauna surveys in 2016 and 2020. The EPA proposes two levels of investigation that differ in the approach to field investigations, Basic being a review of data and a site reconnaissance to place data into the perspective of the area and Detailed being a literature review and intensive field investigations (e.g., trapping and other intensive sampling). The level of survey recommended by the EPA is determined by the size and location of the proposed disturbance, the sensitivity of the surrounding environment in which the disturbance is planned and the availability of pre-existing data. Both Basic and Detailed assessments were completed within the MESA. Spectrum (2022a) completed a Basic assessment, and the Detailed assessment was completed in two phases, initially by 360 Environmental (2012c) and the second phase by Spectrum (2022a). An additional Basic assessment was completed by Spectrum in 2021 within the EISA to assess several infrastructure corridors outside of the area surveyed during the Detailed assessment (the MESA).

Detailed (first phase) Fauna Survey (MESA)

The Detailed Fauna Survey was planned and implemented by 360 Environmental (2012c) in accordance with *Position Statement No. 3 Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA, 2002) and *Guidance Statement No. 56 Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA, 2004b). To ensure adequate data of a high standard the survey was conducted with reference to the *Technical Guidance – Terrestrial Vertebrate Fauna Surveys for EIA* to meet the EPA and DBCA expectations for undertaking a Level 2 Vertebrate Fauna Survey (EPA, 2010).

Basic Fauna Survey (MESA)

The Basic Fauna Assessment was carried out by Spectrum (2022a) in accordance with *Technical Guidance: Terrestrial Fauna Surveys* (EPA, 2016f) and *Technical Guidance: Sampling Methods for Terrestrial Vertebrate Fauna* (EPA, 2016e). The guidance suggests selective low intensity sampling of fauna and fauna habitats to verify the accuracy of the desktop assessment. Habitat assessments were completed to describe and define major fauna habitat types within the MESA, particularly those that may be utilised by significant fauna. Active searches were completed to identify broad fauna assemblages within the MESA with attention given to habitat that may host significant fauna species.

Detailed (second phase) Fauna Survey (MESA)

The terrestrial vertebrate fauna survey was consistent with a Detailed survey as described in *Technical Guidance- Terrestrial vertebrate fauna surveys for environmental impact assessment* (EPA, 2020a). Sampling techniques for SRE invertebrate fauna were consistent with those outlined in 'Technical Guidance- Sampling of SRE invertebrate fauna' (EPA, 2016g).

The MESA is located within the Southwest Botanical Province as described by Beard (1980). The Technical Guidance (EPA, 2016g; EPA, 2020a) recommends terrestrial fauna surveys in this region be completed October – December to coincide with peak reptile, bird and mammal activity. Migratory bird species typically arrive in large number between November and March although early arrivals and juveniles that have over-wintered in Australia may be encountered in October. Peak periods of amphibian activity are highly variable, typically rainfall driven, and can occur at any time of year dependent on the individual species ecology. Although the survey timing fell just outside of the peak period of activity for autumn-winter breeding amphibians the timing allowed for potential records of early migratory bird species. The Technical Guidance also states that some compromise in timing may be required due to generally lower temperatures in spring pushing survey timing into late spring.

Generally, a two-season survey is preferred where possible to coincide with peak fauna activity. Completing both phases of the field survey in October/November was effective due to relatively mild spring temperatures and recent winter rains resulting in moderate species activity with reptiles entering periods of greater activity.

Basic Fauna Survey (EISA)

The additional Basic Fauna Assessment was undertaken by Spectrum (2022a) in accordance with '*Technical Guidance – Terrestrial vertebrate fauna surveys for environmental impact assessment* (EPA, 2020a). Habitat assessment was carried out throughout external infrastructure corridors, with active searches completed at each site and opportunistic observations made whilst walking the transects.

Desktop Fauna Habitat Mapping and Conservation Significant Fauna Assessment (EISA)

The fauna habitat mapping undertaken for the additional external infrastructure corridors was undertaken at a desktop level, referencing previous surveys undertaken within and in the vicinity of the additional external infrastructure corridors.

Basic Fauna Survey and Black Cockatoo Habitat Assessment (BBSA)

The fauna assessment of the BBSA was undertaken by 360 Environmental (2021) in accordance with a Basic Survey as described in *Technical Guidance – Terrestrial vertebrate surveys for environmental impact assessment* (EPA, 2020a).

The Black Cockatoo habitat assessment was undertaken in accordance with the *EPBC Act Referral Guidelines for three threatened Black Cockatoo Species* (DSEWPAC, 2012).

Subterranean Fauna Desktop Review and Pilot Stygofauna Survey

The pilot stygofauna study was undertaken according to the general principles laid out in Technical Guidance – Sampling methods for subterranean fauna (EPA, 2016j) and Technical Guidance – Subterranean fauna survey (EPA, 2016h) and the Environmental Factor Guideline – Subterranean Fauna (EPA, 2016i).

Fauna Desktop Review and Baseline Stygofauna Survey

The baseline stygofauna study was undertaken according to the general principles laid out in Technical Guidance – Sampling methods for subterranean fauna (EPA, 2016j) and Technical Guidance – Subterranean fauna survey (EPA, 2016h) and the Environmental Factor Guideline – Subterranean Fauna (EPA, 2016i).

Regional Short-Range Endemic Invertebrate Survey

The Spectrum (2022b) SRE assessment was conducted in accordance with Commonwealth and State legislation, as well as the EPA's *Technical Guidance – Sampling of Short Range Endemic Invertebrates* (EPA, 2016g).

The survey area is located within the Southwest Botanical Province as described by Beard (1980). The EPA's technical guidance recommends SRE surveys in this region be completed in winter to early spring (May – October) to coincide with the presence of adults for key SRE groups and increased activity in otherwise cryptic groups such as land snails. Heavy rain in the region throughout October prolonged optimal conditions for target species.

Survey Limitations

The EPA technical guidance (EPA, 2020b) outlines a number of limitations that may arise during surveying. Survey limitations are unforeseen events that can limit the effectiveness of field surveys to achieve the required objectives. Overall, no significant limitations were experienced during the field surveys (360 Environmental, 2012a; 2012c & 2021; Spectrum, 2022a & 2022b). Specific potential limitations for each survey are addressed in Table 27. 360 Environmental noted a partial limitation due to only one phase of surveys being conducted within the MESA for the initial Level 2 assessment. This limitation was however addressed by Spectrum (2022a) via the completion of the second phase of the survey.

Table 27: Potential limitations of the Terrestrial Fauna surveys

Possible limitations	MESA			EISA	BBSA	Regional
	Detailed Survey, Phase 1 (360 Environmental, 2012c)	Basic Fauna Survey and SRE Reconnaissance Survey (Spectrum, 2022a)	Detailed Survey, Phase 2 (Spectrum, 2022a)	External Infrastructure Corridors Basic Survey (Spectrum, 2022a)	Brand Highway – Bibby Road Survey Area (360 Environmental, 2020)	Regional SRE Survey (Spectrum, 2022b)
Availability of contextual (e.g., biogeographic) information on the region.	**No Limitation**: staff had adequate access to fauna databases to determine which species were likely to be identified within the MESA.	**No Limitation:** Background information about the region was available and sufficient.	**No Limitation:** Background information about the region was available and sufficient.	**No Limitation:** Background information about the region was available and sufficient.	**No Limitation:** Background information about the region was available and sufficient.	**No Limitation:** Background information about the region was available and sufficient.
Competency and experience of the consultant(s) carrying out the survey	**No Limitation**: The staff members who completed the field work and prepared this report have appropriate training and experience in conducting Detailed Vertebrate Fauna Surveys.	**No Limitation:** Fauna survey staff had relevant experience assessing fauna and fauna of conservation significance in the northern Swan Coastal Plain.	**No Limitation:** The zoologists that completed the field survey were highly experienced conducting terrestrial fauna surveys in the south west region.	**No Limitation:** Fauna survey staff had relevant experience assessing fauna and fauna of conservation significance in the northern Swan Coastal Plain.	**No Limitation:** Fauna survey staff had relevant experience conduction surveys of similar scope throughout WA and the south west region.	**No Limitation:** The zoologists that completed the field survey were highly experienced with conducting short range endemic invertebrate surveys in the south west region.
Completeness	**No Limitation**: The survey was completed in detail, and replication was conducted in most cases throughout the five broad fauna habitat types within the MESA. The EPA guidelines state that it is preferable that Detailed Fauna Surveys conduct a second season phase. Therefore a second seasonal phase was conducted by Spectrum in 2020.	**No Limitation:** All representative habitat types and faunal assemblages were identified.	**No Limitation:** All major fauna habitat types were sampled and defined. Habitat types that may host significant fauna species were adequately surveyed.	**No Limitation:** All representative habitat types and faunal assemblages were identified.	**No Limitation:** The survey was considered complete for a basic vertebrate fauna survey, including number of species recorded and habitat assessment.	**No Limitation:** All major fauna habitat types were sampled.

Possible limitations	MESA			EISA	BBSA	Regional
	Detailed Survey, Phase 1 (360 Environmental, 2012c)	Basic Fauna Survey and SRE Reconnaissance Survey (Spectrum, 2022a)	Detailed Survey, Phase 2 (Spectrum, 2022a)	External Infrastructure Corridors Basic Survey (Spectrum, 2022a)	Brand Highway – Bibby Road Survey Area (360 Environmental, 2020)	Regional SRE Survey (Spectrum, 2022b)
Disturbances (e.g., fire, flood, accidental human intervention) which affected results of survey.	**No Limitation**: Clearing for exploration drill lines has occurred throughout the site. However, this impact was not recent and is limited to a small area.	**No Limitation:** No disturbances were recorded during the survey.	**No Limitation:** No disturbances were recorded during the survey.	**No Limitation:** No disturbances were recorded during the survey.	**No Limitation:** No disturbances were recorded during the survey.	**No Limitation:** no disturbances were recorded during the survey.
Intensity (in retrospect, was the intensity adequate).	**No Limitation**: 5 broad fauna habitats were surveyed, allowing replicated trapping sites within each Banksia woodland, Melaleuca and heath fauna habitat type. Trapping effort within the 2011 Fauna Survey Area consisted of 161 pit trap nights, 175 funnel pair trap nights, 560 Elliot trap nights, 112 cage trap nights, 12 bird survey hours, 15 foraging hours, 240 head torching minutes and 6 Anabat nights. The intensity of the survey effort was sufficient for the area surveyed and as part of a Phase 1 Level 2 Fauna Survey (EPA, 2004b).	**No Limitation:** A Basic survey was adequate to identify faunal assemblages and fauna habitat present within the MESA. Targeted searches to confirm expected significant fauna species were completed across the majority of the subject area, with particular emphasis on suitable habitat types.	**No Limitation:** The completed detailed assessment was adequate to identify the fauna assemblages and habitats present within the MESA. Sufficient targeted searches for significant fauna and SRE species were completed within areas of suitable habitat.	**No Limitation:** A basic survey was adequate to identify faunal assemblages and fauna habitat present within the EISA.	**No Limitation:** A basic survey was adequate to identify faunal assemblages and fauna habitat present within the BBSA.	**No Limitations:** The completed assessment was adequate to identify the SRE invertebrate fauna assemblage within and surrounding the Survey Area. Sufficient targeted searches for SRE species were completed within areas of suitable habitat.
Proportion of fauna identified, recorded and/ or collected	**No Limitation**: A high diversity of fauna species were recorded on the basis of those expected to occur	**No Limitation:** All vertebrate fauna species encountered were identified in the field.	**No Limitation:** All vertebrate fauna species encountered were identified in the field.	**No Limitation:** All vertebrate fauna species encountered were identified in the field.	**No Limitation:** The basic fauna survey and black cockatoo assessment focused on habitat	**No Limitation:** Invertebrate fauna specimens were collected for identification by

Possible limitations	MESA			EISA	BBSA	Regional
	Detailed Survey, Phase 1 (360 Environmental, 2012c)	Basic Fauna Survey and SRE Reconnaissance Survey (Spectrum, 2022a)	Detailed Survey, Phase 2 (Spectrum, 2022a)	External Infrastructure Corridors Basic Survey (Spectrum, 2022a)	Brand Highway – Bibby Road Survey Area (360 Environmental, 2020)	Regional SRE Survey (Spectrum, 2022b)
	and the available habitats It is likely that additional species would be recorded should a seasonal survey phase be completed	Basic survey methods do not require the identification of all fauna species present within the MESA.	Invertebrate fauna specimens were collected for identification by taxonomists at Bennelongia Environmental Consultants.	Basic survey methods do not require the identification of all fauna species present within the survey area.	assessments and opportunistic fauna records, therefore there were no constraints relating to fauna recorded associated with the survey.	Alacran taxonomists. Taxonomic resolution is limited by current knowledge of invertebrate species/taxa.
Remoteness and/ or access problems	**No Limitation**: Suitable access tracks were available throughout the site. Access to and around the site was not considered a limitation.	**No Limitation:** All areas were adequately accessed and sampled.	**No Limitation:** No issues were encountered in accessing the site and suitable access tracks were available throughout.	**No Limitation:** All areas were adequately accessed and sampled.	**No Limitation:** All areas were adequately accessed and sample.	**No Limitation**: No issues were encountered in accessing the site and suitable access tracks were available throughout.
Resources (degree of expertise available in animal identification to taxon level).	**No Limitation**: Adequate resources were available.	**No Limitation:** Resources available were adequate and did not compromise the outcome of the basic survey.	**No Limitation:** The experience level of the zoologists present was sufficient to identify all species accurately. Resources available were adequate and did not compromise the outcome of the survey.	**No Limitation:** Resources available were adequate and did not compromise the outcome of the basic survey.	**No Limitation:** Resources available were adequate and did not compromise the outcome of the basic survey.	**No Limitation:** The experience level of the zoologists present was sufficient to sample all species and Alacran taxonomists were able to identify specimens accurately. Resources available were adequate and did not compromise the outcome of the survey.
Scope (what faunal groups were sampled and were some sampling methods not able to be employed because of	**Partially**: The purpose of a Detailed survey is to compile an inventory of fauna habitats and species and to identify any fauna of elevated conservation	**No Limitation:** Sampling techniques were limited to observations only. No constraints were experienced due to	**No Limitation:** Sampling techniques were designed for a detailed terrestrial fauna assessment. All fauna groups were	**No Limitation:** Sampling techniques were limited to observations only. No constraints were experienced due to	**No Limitation:** Sampling techniques were limited to observations only. No constraints were experienced due to	**No Limitations:** Sampling techniques were designed for a SRE invertebrate fauna survey. No survey constraints were experienced that limited

Possible limitations	MESA			EISA	BBSA	Regional
	Detailed Survey, Phase 1 (360 Environmental, 2012c)	**Basic Fauna Survey and SRE Reconnaissance Survey (Spectrum, 2022a)**	**Detailed Survey, Phase 2 (Spectrum, 2022a)**	**External Infrastructure Corridors Basic Survey (Spectrum, 2022a)**	**Brand Highway – Bibby Road Survey Area (360 Environmental, 2020)**	**Regional SRE Survey (Spectrum, 2022b)**
constraints such as weather conditions).	significance within the MESA. A comprehensive and detailed species list was collated as a result of this survey. This comprised the first phase of a Detailed Fauna Survey. The EPA would likely require a minimum of two Detailed (trapping) Surveys over different seasons to demonstrate spatial and temporal variations in faunal assemblages (according to Guidance Statement 56; EPA, 2004b).	external factors whilst completing the survey.	sampled, and no survey constraints were experienced that limited sampling of specific groups.	external factors whilst completing the survey.	external factors whilst completing the survey.	sampling of specific SRE groups.
Sources of information	**No Limitation**: Vertebrate fauna information was accessed by searching available literature and survey data; web-based mapping tools and map-based information.	**Partially:** A limited number of surveys have previously been completed and are publicly available within the region. The single phase detailed survey (360 Environmental, 2012c) and database searches have identified likely species from the area and provided an adequate level of information for a basic assessment.	**No Limitation:** Database searches and previous survey reports provided a significant level of information, adequate to guide field survey design and effort.	**No Limitation:** Database searches and previous survey reports provided a significant level of information, adequate to guide field survey design and effort.	**No Limitation:** Database searches and previous survey reports provided a significant level of information, adequate to guide field survey design and effort.	**No Limitation:** Database searches and previous survey reports provided a sufficient level of information, adequate to guide field survey design and effort.
The proportion of the task achieved and further	**No Limitation**: The field component fulfils EPA's	**No Limitation:** All components of a basic	**No Limitation:** All components of a	**No Limitation:** All components of a basic	**No Limitation:** All components of a basic	**No Limitation:** All components of a regional

Possible limitations	MESA			EISA	BBSA	Regional
	Detailed Survey, Phase 1 (360 Environmental, 2012c)	Basic Fauna Survey and SRE Reconnaissance Survey (Spectrum, 2022a)	Detailed Survey, Phase 2 (Spectrum, 2022a)	External Infrastructure Corridors Basic Survey (Spectrum, 2022a)	Brand Highway – Bibby Road Survey Area (360 Environmental, 2020)	Regional SRE Survey (Spectrum, 2022b)
work which might be needed.	requirements for a single phase Detailed Fauna Survey.	fauna survey were completed.	detailed vertebrate fauna and SRE assessment were completed during the field survey. The combination of previous and current survey work gives a comprehensive understanding of the fauna values of the MESA.	fauna survey were completed.	fauna survey were completed.	SRE assessment were completed during the field survey. The combination of previous and current survey work gives a comprehensive understanding of the SRE invertebrate assemblage of the Survey Area.
Timing / weather / season / cycle	**No Limitation**: The survey was conducted in late spring after recent rainfall events and following sufficient winter rainfall. The weather for the survey was primarily fine and clear with warm conditions. These were ideal conditions for the survey of reptiles, mammals, birds and amphibians. The proportion of fauna recorded is considered acceptable for a Phase 1 Detailed Fauna Survey.	**No Limitation:** Weather conditions were sunny and warm, and reptile and bird activity suitable. The assessment of fauna habitats and recording of secondary evidence of fauna species was not compromised. All dominant fauna groups and assemblages were recorded.	**No Limitation:** The survey was conducted during suitable seasonal conditions for a detailed survey, and all dominant fauna groups, assemblages and major fauna habitat types were recorded.	**No Limitation:** Weather conditions were sunny and warm, and reptile and bird activity suitable. The assessment of fauna habitats and recording of secondary evidence of fauna species was not compromised. All dominant fauna groups and assemblages were recorded.	**No Limitation:** The timing of the survey was not a limitation for the basic vertebrate fauna survey or black cockatoo habitat assessment.	**No Limitation:** The field survey was conducted during the optimal survey period for SRE taxa in the south west region. Wet pitfall traps were collected just outside the recommended period however above average rainfall in the months preceding the survey is likely to have led to increased invertebrate activity throughout the period of wet pitfall trapping.

6.3.9 Fauna Habitat

Mine Envelope Survey Area

Seven fauna habitat types and two ecotone (mixed habitats) were identified within the MESA and EISA (Table 28; Spectrum, 2022a).

Table 28: Habitat types within the MESA and EISA

Habitat type (associated vegetation units in brackets)	Description	Extent in MESA (ha)	Extent in EISA (ha)	Total extent in MESA & EISA (ha)	% of MESA & EISA
Banksia Woodland (Bp, BaBm)	 Banksia Woodland habitat is the most common habitat type and covers 687.7 ha (55.2%) of the MESA and EISA. This habitat type is mainly located on low rises consisting of deep aeolian white/grey sands located in the southern half of the MESA. Wood and leaf litter is prevalent, leaf litter particularly so beneath mature *Banksia* and *Adenanthos*. Vegetation associated with Banksia Woodland habitat consists of *Banksia attenuata* with *Banksia menziesii* low woodland (Veg Unit: BaBm) over *Adenanthos cygnorum* subsp. *cygnorum* scattered tall shrubs to high open shrubland (in parts) over a mixed low shrubland (Morgan, 2021). Also associated with this habitat type are small discrete areas of *Banksia prionotes* low woodland (Veg Unit: Bp) which is typically associated with the edges of damp heath.	644.5	43.2	**687.7**	**55.2**
Pasture/ Cleared	Pasture habitat covers 231 ha (18.5%) of the MESA and EISA. The Pasture habitat type is located along the northern edge of the MESA and consists of cleared tracks and open farmland typically used to graze livestock. Areas of highly degraded Banksia Woodland also form part of this habitat type due to the loss of important habitat characteristics such as a vegetated understorey and the presence of leaf litter beds.	212.2	18.8	**231**	**18.5**
Heath (Banksia) (BtRc, MbTi/BtRc, MbTi/MbGcVp/BtRc)	 Heath (Banksia) habitat covers 168.3 ha (13.5%) of the MESA and EISA. This habitat type is mainly located in the northern half of the MESA and is associated with damp, low, gentle slopes with white/grey sands. Significant wood litter is scarce though leaf litter beds present beneath Banksia and dense sedges also provide sheltered microhabitats for fauna.	162.1	6.2	**168.3**	**13.5**

Habitat type (associated vegetation units in brackets)	Description	Extent in MESA (ha)	Extent in EISA (ha)	Total extent in MESA & EISA (ha)	% of MESA & EISA
	Vegetation associated with Heath (Banksia) habitat consists of *Banksia telmatiaea*, *Regelia ciliata* dominated heathlands (Veg Unit: BtRc) with a *Melaleuca brevifolia* open shrub layer. This habitat is common in the damper, lower lying areas (Morgan, 2021). This habitat type also forms a transition between dryer areas where *Banksia telmatiaea* is more common to lower damper areas where *Regelia ciliata* and *Melaleuca brevifolia* are more common.				
Samphire (MrMv, TEC, Ti)	Samphire habitat covers 65.6 ha (5.3%) of the MESA and EISA. ha This habitat type is associated with low lying areas, often bordering Ephemeral Wetland habitat. These areas are partially submerged when sufficient rainfall occurs, altering the salinity levels and by extension the fauna species that occupy the area. Both wood and leaf litter are scarce and what is present does not create significant shelter for fauna.  Vegetation associated with Samphire habitat consists of three vegetation types; tall open shrubland dominated by *Melaleuca rhaphiophylla* (Veg Unit: MrMy), *Tecticornia moniliformis*, *Tecticornia halocnemoides*, *Tecticornia syncarpa* low open samphire shrubland (Veg Unit: TEC), and *Tecticornia indica* subsp. *bidens* low open samphire shrubland (Veg Unit: Ti) (Morgan, 2021).	65.3	0.3	**65.6**	**5.3**
Melaleuca (MbGcVp, MaMcu, MsVdCaf, MrMtAl, MrHtBt, MrMco, MrMt, Mb, MvMb, MrMvMb, MvMcoMb, BtRc/MvMb, MrMvMco, Ms.)	Melaleuca habitat covers 51.4 ha (4.1%) of the MESA and EISA. ha This habitat type is associated with the dense clay and clay sand soils that are located along the flow lines and depressions associated with the large drainage system located in the northern half of the 2020 Fauna Survey Area. The drainage system flows seasonally after rain though scattered deeper pools persist after this time providing a water source and moist microhabitats for fauna. Wood and leaf litter is present beneath shrubs and a dense layer of grasses and shrubs also provides shelter for fauna. 	50.2	1.2	**51.4**	**4.1**

Habitat type (associated vegetation units in brackets)	Description	Extent in MESA (ha)	Extent in EISA (ha)	Total extent in MESA & EISA (ha)	% of MESA & EISA
	Although relatively small in areas the vegetation associated with Melaleuca habitat is diverse and consists of 14 vegetation units that are all dominated by either *Melaleuca acutifolia*, *Melaleuca cuticularis*, *Melaleuca brevifolia*, *Melaleuca viminea* subsp. *viminea*, *Melaleuca rhaphiophylla*, *Melaleuca concreta*, and *Melaleuca teretifolia* (Morgan, 2021).				
Banksia Woodland/ Heath (Banksia) (Cr18, CpBt, MNB4, BtRc/Bp, MsGc,)	Banksia Woodland / Heath (Banksia) habitat covers 22.5 ha (1.8%) of the MESA and EISA. This habitat type is mainly located in the northern half of the MESA and is an ecotone of the Banksia Woodland and Heath (Banksia) habitat types. The habitat is also  associated with the damper lower gentle slopes adjacent to Samphire. Significant wood litter is scarce though leaf litter beds present beneath Banksia and dense sedges also provide sheltered microhabitats for fauna. Vegetation associated with Banksia Woodland / Heath (Banksia) habitat consists of a mosaic of *Banksia prionotes* low woodland over *Banksia telmatiaea*, *Regelia ciliata*, *Hakea obliqua* subsp. *parviflora* dominated scrubs and heaths (Veg Unit: BtRc/Bp) with a *Melaleuca seriata* low shrub layer (Veg Unit: MsGc) common in the damper, lower lying areas (Morgan, 2021) and *Callitris pyramidalis* tall shrubland over *Banksia telmatiaea*, *Regelia ciliata* open heathland (Veg Unit: CpBt).	21.2	1.3	**22.5**	**1.8**
Ephemeral Wetland	The Ephemeral Wetland habitat type covers 13.7 ha (1.1%) of the MESA and consists of dry open depressions that fill with water when sufficient rainfall occurs. This habitat type is typically devoid of vegetation due to the high salinity present however some samphire species can occur along the edges of these lakes. 	13.7	0	**13.7**	**1.1**

Habitat type (associated vegetation units in brackets)	Description	Extent in MESA (ha)	Extent in EISA (ha)	Total extent in MESA & EISA (ha)	% of MESA & EISA
Melaleuca/ Samphire (MbTi, TEC/MvMb, MbTi/MbGcVp)	Melaleuca/Samphire habitat covers 3.8 ha (0.3%) of the MESA and EISA. This habitat is an ecotone, hosting flora and fauna species from both the Melaleuca and Samphire habitat types. Wood and leaf litter is sparse though does accumulate in some areas beneath shrubs.  Vegetation associated with Melaluca/Samphire habitat consists of *Melaleuca brevifolia* open shrubland over *Tecticornia indica* subsp. *bidens* low open samphire shrubland (Veg Unit: MbTi), *Tecticornia moniliformis*, *Tecticornia halocnemoides*, *Tecticornia syncarpa* low open samphire shrubland (Veg Unit: TEC), *Melaleuca brevifolia* mid open shrubland over *Grevillea* sp. Cooljarloo (B.J. Keighery 28 B), *Verticordia plumosa* var. *brachyphylla* low open shrubland (Veg Unit: MbGcVp), *Melaleuca viminea* subsp. *viminea* tall shrubland over *Melaleuca brevifolia* mid sparse shrubland (Veg Unit: MvMb) (Morgan, 2021).	3.5	0.3	**3.8**	**0.3**
Eucalypt Woodland (Er)	Eucalypt Woodland habitat covers 1.4 ha (0.1%) of the eastern part of the MESA. It is a small strip of distinct fauna habitat located between Melaleuca and Banksia Woodland habitat. Leaf litter beds are present beneath trees and shrubs and large logs also provide shelter for fauna.  The vegetation associated with this habitat type consists of *Eucalyptus rudis* open woodland to woodland (Veg Unit: ErMr) over *Melaleuca raphiophylla* open scrub over **Ehrarta longiflora*, **Brassica tournefortii* annual grassland/herbland (Morgan, 2021).	1.4	0	**1.4**	**0.1**
Total		**1,174**	**71.3**	**1,245.3**	**100**

*Vegetation codes from (Morgan, 2021)

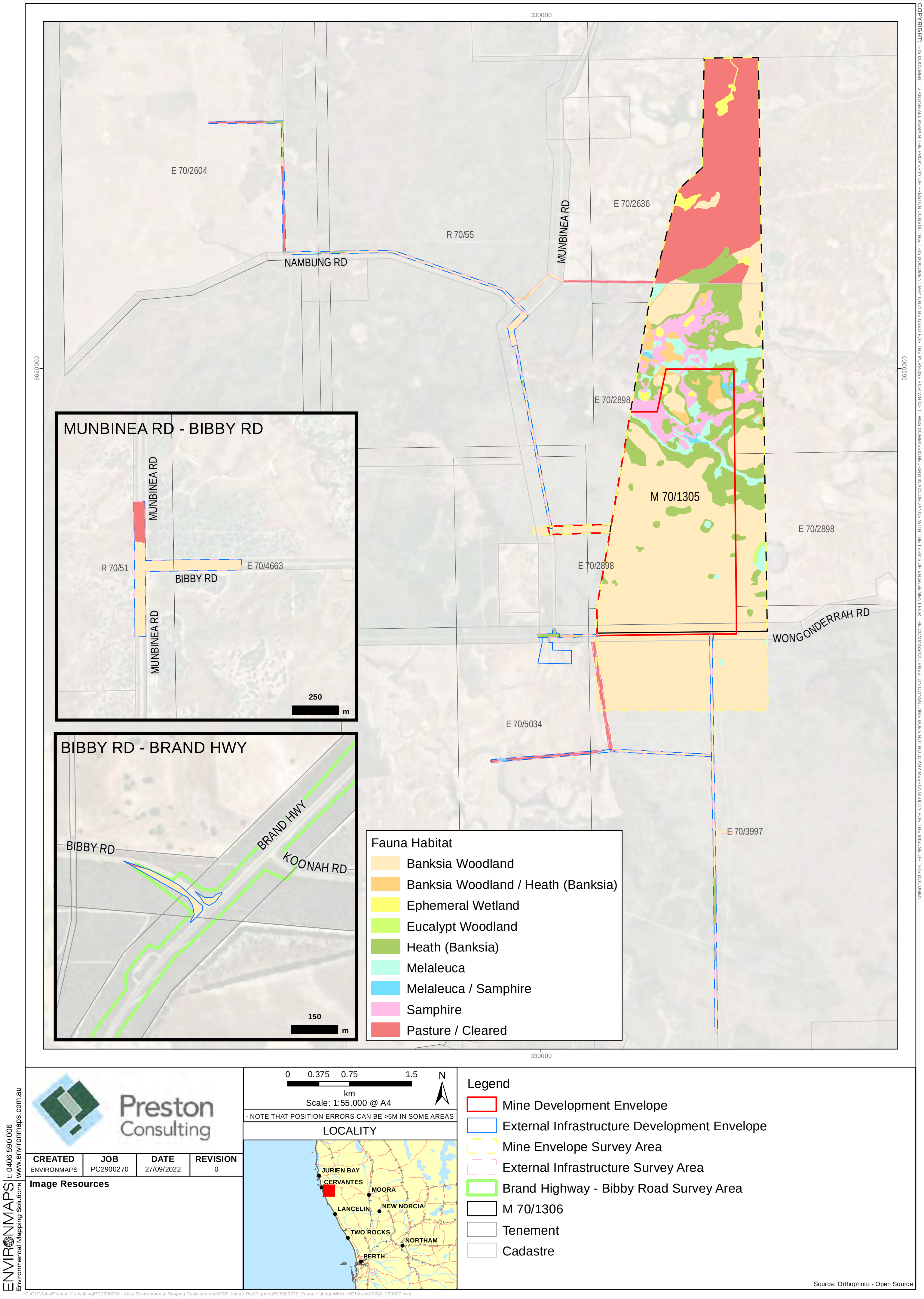


Figure 62: Fauna habitats within the MESA and EISA

Brand Highway-Bibby Road Survey Area

Two broad fauna habitats (excluding cleared areas) were identified by 360 Environmental (2021) and mapped within the BBSA:

- *Banksia* woodland / *Allocasuarina* shrubland (21.7 ha; 71.6% of the BBSA); and
- A small stand of non-endemic trees (0.1 ha; 0.5% of the BBSA).

Cleared areas accounted for the remaining 8.4 ha (27.9%) of the BBSA.

Vegetation within the *Banksia* woodland / *Allocasuarina* shrubland habitat consisted primarily of scattered *Eucalyptus todtiana* trees over open *Banksia attenuata* and *Banksia menziesii* woodlands over mixed heathland / shrublands containing *Allocasuarina humili, Adenanthos cygnorum, Banksia sessilis* and *Xanthorrhoea* sp. over clubs of sedges and forbs occurs in some areas. The dense healthy vegetation provides shelter and refuge for small fauna species. Additionally, important microhabitats were present including woody debris and logs, leaf litter and peeling bark. The majority of the habitat was in very good condition, with litter and weeds impacting the habitat particularly near the road verge (360 Environmental, 2021).

A small stand of non-endemic *Eucalyptus* and *Acacia* trees were planted adjacent to a small roadside rest-stop. This habitat provided limited value to most fauna species, however the trees provide foraging and nesting opportunities, primarily for birds. Magpie-larks were recorded nesting in this habitat. The habitat was disturbed, with large amounts of litter and degraded / absent understorey vegetation (360 Environmental, 2021).

Legend

Survey Area

Fauna Habitat

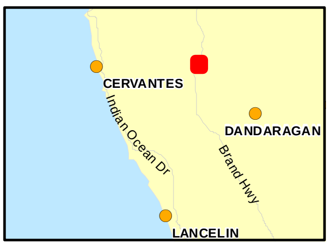
- Banksia woodland / Allocasuarina shrubland
- Non-endemic trees
- Cleared

0 160 320 480 Meters

1:15,000 @ A4

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY MAP



SLIP ENABLER

- LOCALITY MAP SOURCED FROM LANDGATE 2019
- OTHER DATA SOURCED LANDGATE 2019
- AERIAL PHOTOGRAPHY SOURCED LANDGATE 2020
(© Western Australian Land Information Authority 2020)

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PROJECT ID	DATE
4045	15/01/2021

HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

CREATED	CHECKED	APPROVED	REVISION
LF	BD	NW	0

Image Resources NL
Cooljarloo, intersection of Brand Hwy and Bibby Rd

Detailed Flora, Vegetation and Fauna Assessment

Fauna Habitat

K:\Projects\1.0 EBS\4045 Cooljarloo Detailed Flora, Vegetation and Fauna Assessment\01. Bibby Rd MXDs\4045 F12 Bibby Rd Fauna Habitat.mxd

Figure 63: Fauna Habitat within the BBSA

Short Range Endemic Fauna Habitats

The freshwater damplands associated with the Melaleuca fauna habitat type provide microhabitats suitable for SRE invertebrate species. Complex, mesic and often isolated microhabitats in an otherwise dry and well drained environment may support relictual species isolated by aridification or habitat specialists that have adapted to utilised the area. Five potential SRE species were recorded from Melaleuca habitat (Spectrum, 2022a).

Samphire habitat within the MESA did not possess relictual habitat characteristics typically associated with terrestrial SRE species, however five SRE target groups were collected via wet pitfall trapping from this habitat (Spectrum, 2022a).

Spectrum (2022a) identified that the Banksia Woodland habitat and Heath (Banksia) habitat provided limited microhabitats (e.g., deep leaf litter beds) suitable for use by species within SRE target groups. However, the Banksia Woodland habitat was regionally extensive prior to European settlement with a high level of connectivity and as such is unlikely to have provided conditions known to produce SRE species. Nine potential SRE species were captured within Banksia Woodland habitat (Spectrum, 2022a). Heath (Banksia) habitat is well drained and does not provide the habitat isolates and mesic refugia typically associated with SRE fauna. Two potential SRE were captured withing Heath (Banksia) habitat (Spectrum, 2022a).

Similar to Banksia Woodland and Heath (Banksia), limited microhabitats (e.g., deep leaf litter beds) were present within Eucalypt Woodland habitat that may be suitable for use by species within SRE target groups. However, the habitat is well drained and does not provide the mesic refugia typically associated with SRE fauna. No SRE species were recorded from Eucalypt Woodland habitat (Spectrum, 2022a).

Subterranean Fauna

Bennelongia (2021; 2022) undertook an assessment of habitat prospectivity for subterranean fauna within the in and around the Proposal. They identified that many features hosting subterranean fauna in the desktop review area and surrounding sub-region do not occur at the Proposal, including caves (English, Jasinska and Blyth, 2003; Knott, Storey and Chandler, 2007; Knott, Storey and Tang, 2008; Knott, Storey and Tang, 2009), karst (Moulds, 2007) and groundwater environments containing root matt from Tuart trees (Tang and Knott, 2009). However, the geology of the Atlas area is similar to areas yielding subterranean fauna elsewhere on the Swan Coastal Plain, especially stygofauna, for example Bassendean Sands at Kensington (Bennelongia, 2015) and Pt Grey with sand over Tamala Limestone (Bennelongia, 2009).

Water quality parameters at the Proposal were identified to be well within the tolerances of stygofauna and not expected to be a limiting factor on their occurrence. The groundwater is considered to be sufficiently shallow to harbour many stygofauna. Additionally, the underlying geology indicates it is likely that there is porous geology providing spaces such as interstices within the sand that could be utilised by stygofauna. Water courses and drainage lines flow through Atlas (URS, 2013) and could provide habitats for animals as has been demonstrated at other locations (Bagas, Beukenhorst and Hos, 2004; Bennelongia, 2012; Eberhard, Halse and Humphreys, 2005).

Troglofauna habitat is usually considered to extend from the lower layers of loose soil and sand (starting 3-4 m below the ground surface) to the interface with groundwater (Juberthie, 1983).

Given the small depth to water and the propensity that the MESA has to waterlogging during the winter months (URS, 2013), it is considered unlikely that the area contains significant troglofauna habitat.

6.3.10 General Fauna

The Spectrum (2022a) desktop survey identified 296 vertebrate fauna species as potentially occurring in the MESA consisting of 11 amphibians, 190 birds, 19 non-volant native mammals, seven bats, five introduced mammals and 64 reptiles. This is significantly higher than the results of any single vertebrate fauna field survey completed in the region. This is to be expected, as the desktop draws data from a wide range of sources that were collected over different time periods and seasons, as well as more types of fauna habitats than those present within a single survey area. An example of this is the large number of shorebird and other water bird species reported only by NatureMap. These records may also come via museum collection trips, public specimen collections/ observations, DBCA surveys as well as from the DBCA Fauna Survey Returns Database which includes data from private sources.

The data reported by NatureMap, DBCA Threatened Fauna Database, PMST and previous survey reports provide a useful indication of regional vertebrate fauna assemblages. Whilst many species recorded during the desktop assessment have the potential to occur, the fauna assemblage that typically utilises the habitats found within the MESA form a much smaller subset of species. Variations in population distributions and the availability of microhabitats within each area also limit the species that may occur. However, the accumulated data provided by the desktop assessment is invaluable during survey planning to ensure all major fauna assemblages are sampled and any significant species that may occur are targeted appropriately.

A total of 132 vertebrate fauna species (17 mammals, 95 birds, 25 reptiles and eight amphibians) were recorded from the MESA and EISA or close by during both assessment phases. A total of 121 vertebrate fauna species were recorded by Spectrum (2020) consisting of five amphibians, 83 bird species, 14 mammals (including four introduced mammals) and 19 reptiles. In comparison, the single-phase Level 2 (Detailed) vertebrate fauna survey completed by 360 Environmental recorded a total of 97 species (118 species indicated as being recorded in the report, however there were instances of the same species being listed more than once). The overall number of vertebrate fauna species were similar between the two surveys, however 29 species (three mammals, 16 birds, seven reptiles and three amphibians) were unique to the phase 1 survey and 31 species (three mammals, 24 birds and four reptiles) were unique to the phase 2 survey.

The Basic survey of the BBSA by 360 Environmental (2021) recorded 20 terrestrial vertebrate fauna species, comprising 16 birds and four mammals. Three introduced fauna species were recorded within the BBSA; european cattle (*Bos primigenius taurus*), the red fox (*Vulpes vulpes*) and the rabbit (*Oryctolagus cuniculus*).

6.3.11 Significant Fauna – Desktop Assessment Results

For the purposes of this assessment the term 'significant fauna' refers to fauna listed under the EPBC Act or BC Act, DBCA Priority (P) Fauna and some species that occur at the edge of their range.

The results of the literature reviews by Spectrum (2022a) and 360 Environmental (2021) identified fauna species that are listed under current legislative frameworks.

Spectrum (2022a) assessed the likelihood of a listed fauna species being present within the MESA and EISA by examining the following:

- Suitability of fauna habitats known to exist within the area;
- Distribution of previously recorded listed species;
- Frequency of occurrence of listed species records in the region;
- Detectability of listed species based on specific behavioural and ecological characteristics; and
- Temporal distribution of listed species records, taking previous survey effort into consideration.

Each listed fauna species potentially occurring in the MESA and EISA were assigned a likelihood of occurrence based on the categories shown in Table 29. In accordance with the precautionary principle, the level of available information for each species was also taken into consideration so that species are not allocated a low likelihood of occurrence because of insufficient survey information.

Each listed fauna species potentially occurring in the BBSA were assigned a likelihood of occurrence by 360 Environmental based on criteria shown in Table 30. Species identified as Marine under the EPBC Act by 360 Environmental were not included as conservation significant as the Marine listing only applies within Commonwealth marine areas (360 Environmental, 2021).

Table 29: Likelihood of Occurrence Criteria for Listed Species

Likelihood	Fauna Criteria	
	MESA & EISA (Spectrum, 2022a)	BBSA (360 Environmental, 2021)
Recorded	Species recorded within the Survey Area within the previous ten years.	Species previously recorded within the Survey Area.
High	Species recorded within or in proximity to the Survey Area within the previous 20 years. Suitable habitat occurs in the Survey Area.	Preferred habitat is present within the Survey Area, the Survey Area is within the species' known distribution, and the species has been recorded within the database search area in the last 15 years. The Survey Area and surrounding habitat is expected to support individuals or populations of the species.
Medium	Species recorded within or in proximity to the Survey Area more than 20 years ago. Species recorded outside the Survey Area but within 50 km. Suitable habitat occurs in the Survey Area.	The high likelihood of occurrence has not been met, however suitable (not necessarily preferred) habitat occurs within the Survey Area and the Survey Area is within or near the species' known distribution. The Survey Area and surrounding habitat may support individuals or populations of the species.
Low	Species rarely or not recorded within 50 km of the Survey Area. Suitable habitat does not occur within or in proximity to the Survey Area.	No suitable habitat is present within the Survey Area, or the Survey Area is well outside the species known distribution, or the species is considered locally or regionally extinct. The Survey Area and surrounding habitat are unlikely to support individuals or populations of the species, however the individuals may rarely occur as transients or vagrants.
Very Low	Species not recorded within 50 km despite multiple recent surveys. Suitable habitat does not occur within the Survey Area. Species considered locally extinct.	-

A total of 48 significant fauna were identified in Spectrum's (2022a) desktop survey consisting of seven non-volant mammals, one bat, 34 birds and six reptiles (Figure 64). Of these species, Spectrum (2022a) noted that three have been recorded and three species were assessed to have a high likelihood of occurrence within the MESA and EISA, based on previous records and the habitat types present.

Due to the recorded occurrence of Common Greenshank within the MESA, migratory shorebirds could not be excluded from Spectrum's (2022a) assessment. Nineteen migratory shorebird, seabird and wader species were identified by the literature review and database searches as having the potential to occur within the MESA. Suitable habitat for these species within the MESA is dependent on rainfall and season, with suitable conditions generally lasting for very short periods, if at all.

In addition to these migratory species, one mammal, seven birds, one reptile and two invertebrates were also assessed as having a medium likelihood of occurrence across the MESA and EISA.

Twenty additional species of conservation significance were assessed to have a low or very low likelihood of occurrence, based on the criteria listed in Table 29. The PMST and DBCA database records also returned marine listed species which were excluded from the likelihood assessment as no suitable habitat occurs within the MESA and EISA (Spectrum, 2022a).

Database searches identified 22 significant terrestrial vertebrate fauna species potentially occurring within the BBSA, comprising 17 bird species (of which 13 are shorebirds/waders), three mammal species and two reptile species (360 Environmental, 2021). The likelihood of occurrence assessment of these species found that three species have a high likelihood, one has a medium likelihood and 18 species have a low likelihood of occurrence. Due to the lack of coastal or wetland habitat, 360 Environmental did not include shorebirds/waders in the likelihood of occurrence assessment.

The likelihood rankings assigned to each significant fauna species by Spectrum (2022a) and 360 Environmental (2021) have been provided in Table 30.

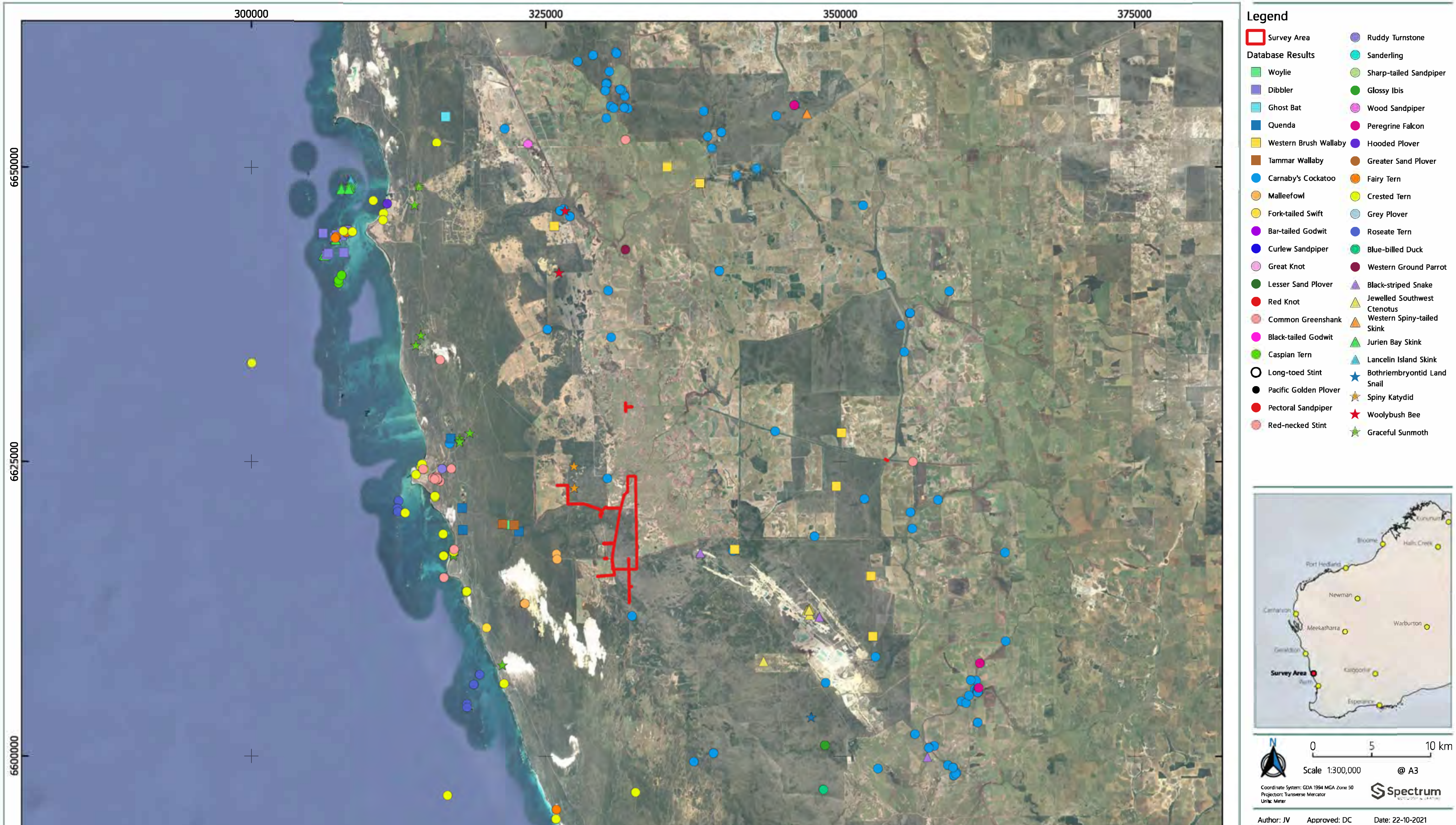


Figure 64: DBCA Threatened Fauna database results (Spectrum, 2022a)

DBCA Threatened Fauna Database Results

Atlas Project

Table 30: Summary of the Likelihood of Occurrence of Significant Fauna Species

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence	
	EPBC Act	BC Act	DBCA			Spectrum (2022a)	360 Environmental (2021)
Mammals							
Woylie *(Bettongia penicillata ogilbyi)*	EN	CR		Woodland and heath with an understorey of dense shrubs (TSSC, 2018).	Records exist from Nambung National Park, 10 km west of the Proposal (DBCA 2004-2005).	**Very Low** The species has not been recorded in the region since a failed translocation attempt in 2004-2005 (TSSC, 2018). Locally extinct.	-
Dibbler *(Parantechinus apicalis)*	EN	EN		Mainland habitat is characterised by long unburnt heaths on sandy substrates (Australian Government & DotEE, 2019a).	All local records are restricted to islands off the coast of Jurien Bay, approximately 31 km north west of the Proposal.	**Very Low** Suitable sandy heath habitat occurs within the MESA and EISA though no mainland populations are known in the region. Locally extinct.	**Low** Mainland population confined to area between Fitzgerald River National Park and Torndirrup National Park.
Ghost Bat *(Macroderma gigas)*	VU	VU		Occupies a wide range of habitats, from the arid ranges of the Pilbara region to the rainforests of Northern Queensland (Van Dyck and Strahan, 2008).	Historical records only, fossilised remains were found at Drover's Cave National Park.	**Very Low** Contemporary WA distribution restricted to the Pilbara and Kimberley regions. Locally extinct.	-
South-western Brush-tailed Phascogale *(Phascogale tapoatafa* subsp. *Wambenger)*	VU	VU		Dry sclerophyll forests and open woodlands that contain hollow-bearing trees with sparse ground cover (Soderquist and Ealey, 1994).	Historical record only, approximately 35km from the Proposal.	**Very Low** Contemporary WA distribution restricted to suitable habitat south of Perth to Albany.	-
Chuditch *(Dasyurus geoffroii)*	VU	VU		Inhabits sclerophyll forest, drier woodlands, heath and mallee shrubland (Van Dyck and Strahan, 2008).	PMST record only.	**Low** Contemporary WA distribution restricted to the south-west of WA.	**Low** BBSA is outside current known distribution Area. No recent DBCA records.
Quenda *(Isoodon fusciventer)*			P4	Woodland, heath and areas with dense vegetation in the lower stratum (Van Dyck & Strahan, 2008).	Multiple records exist in proximity to the Proposal, the nearest from 8 km west (2005).	Medium Suitable woodland and heath habitat recorded from the MESA and EISA	-

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence	
	EPBC Act	BC Act	DBCA			Spectrum (2022a)	360 Environmental (2021)
						though no individuals or secondary evidence was observed.	
Western Brush Wallaby *(Notamacropus Irma)*			P4	Open forest or woodland. Open, seasonally wet flats with low grasses and scrubby thickets. Mallee and heathland occasionally utilised (Van Dyck & Strahan, 2008).	Recorded by 360 Environmental (2012c) within the Proposal and Spectrum (2022a) in banksia woodland adjacent to the Proposal.	**Recorded** One individual was recorded within the MESA and EISA in Banksia Woodland habitat. Extensive habitat exists within the southern part of the MESA and EISA and the local region.	**High** Suitable habitat occurs within the BBSA, one recent DBCA record.
Tammar Wallaby (*Notamacropus eugenii derbianus)*			P4	Coastal scrub, heath, dry sclerophyll forest and thickets in woodland habitat (Van Dyck & Strahan, 2008).	Records from 9 km west of the Proposal in Nambung National Park (DBCA, 2004-2006).	**Low** Suitable woodland and heath habitat occurs within the MESA and EISA. However, the 2004-2006 records from Nambung National Park are the result of a translocation attempt. No records have been made since this time and the result of the translocation attempt in unknown.	-
Birds							
Western Ground Parrot *(Pezoporus flaviventris)*	CR	CR		Long unburnt, near coastal heath (DAWE, 2021).	Historical written record only from 19 km north of the Proposal. No date or location information is associated with the record.	**Very Low** Currently only known from two locations on the south coast of WA, Fitzgerald River National Park and Cape Arid National Park. Locally extinct.	-
Curlew Sandpiper *(Calidris ferruginea)*	CR, MI	CR		Mostly recorded from intertidal mudflats and coastal wetlands. Also recorded from ephemeral and permanent lakes further inland (DAWE, 2021).	Multiple coastal and salt lake (Lake Thetis) records west of the Proposal.	**Medium** Seasonally inundated salt lakes within the MESA and EISA may represent temporary migratory shorebird habitat.	-
Great Knot *(Calidris tenuirostris)*	CR, MI	CR		Mainly coastal, habitat includes intertidal mudflats, sandy beaches, estuaries and shallow	Two records from Lake Thetis, west of the Proposal.	**Medium** Seasonally inundated salt lakes within the MESA and EISA may	-

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence	
	EPBC Act	BC Act	DBCA			Spectrum (2022a)	360 Environmental (2021)
				saline and freshwater wetlands (DAWE, 2021).		represent temporary migratory shorebird habitat.	
Carnaby's Cockatoo *(Zanda latirostris)*	EN	EN	-	Breeding in tree hollows of Wandoo, Tuart, Jarrah, York gum, Karri and Marri. Foraging in proteaceous woodland, forests, riparian vegetation, heath and introduced species (DSEWPaC, 2012).	Many historical and contemporary records from the region, the closest record located less than 2 km from the Proposal (2001).	**Recorded** Multiple individuals recorded within the external infrastructure corridors. Proteaceous woodland and heath within the MESA and EISA represents foraging habitat. No breeding habitat was recorded.	**Recorded** Recorded numerous times within the BBSA, across three sites. Extensive evidence of foraging at additional site. Preferred habitat within BBSA.
Lesser Sand Plover *(Charadrius mongolus)*	EN, MI	EN		Prefers coastal habitats including sheltered sand flats, mudflats, bays and estuaries though may infrequently utilise coastal salt lakes (DAWE, 2021).	Two records from west of the Proposal, Lake Thetis and Kangaroo Point.	**Medium** Seasonally inundated salt lakes within the MESA and EISA may represent temporary migratory shorebird habitat.	-
Red Knot *(Calidris canutus)*	EN, MI	EN		Prefers coastal habitats including sheltered sand flats, mudflats, bays, sandy beaches and estuaries though may infrequently utilise coastal salt lakes (DAWE, 2021).	Two records from west of the Proposal, Lake Thetis and Kangaroo Point.	**Medium** Seasonally inundated salt lakes within the MESA and EISA may represent temporary migratory shorebird habitat.	-
Malleefowl *(Leipoa ocellata)*	VU	VU		Semi-arid and arid mallee, shrubland, mulga and other habitats with dense litter forming vegetation (Benshemesh, 2007).	Two records from Nambung National Park, 8 km west southwest of the Proposal (2012).	**Medium** Suitable shrubland and heath habitat exists in the MESA and EISA though no individuals or secondary evidence in the form of nesting mounds (contemporary or historical) or tracks were observed.	**Low** BBSA lacks abundant leaf litter therefore habitat is not suitable, no recent DBCA records.
Greater Sand Plover *(Charadrius leschenaultia)*	VU, MI	VU		Sandy or shelly beaches, sand spits and intertidal mudflats (DAWE, 2021).	Three coastal records from Nambung and Wedge Island. A single record was also returned from Badgingarra though the coordinate does	**Low** No suitable habitat recorded within the MESA and EISA.	-

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence	
	EPBC Act	BC Act	DBCA			Spectrum (2022a)	360 Environmental (2021)
					not correspond with suitable habitat.		
Fairy Tern *(Sternula nereis)*	VU	VU		Islands, beaches and estuarine systems (DAWE, 2021).	Coastal and island records only.	**Low** No suitable habitat recorded within the MESA and EISA.	-
Bar-tailed Godwit *(Limosa lapponica)*	MI (VU or CR at ssp.)	MI (VU or CR at ssp.)		Prefers coastal habitats including sand flats, mudflats, bays and estuaries though may infrequently utilise coastal salt lakes and marshes (DAWE, 2021).	Multiple coastal and salt lake (Lake Thetis) records west of the Proposal.	**Medium** Seasonally inundated salt lakes within the MESA and EISA may represent temporary migratory shorebird habitat.	-
Fork-tailed Swift *(Apus pacificus)*	MI	MI		Displays almost entirely aerial behaviour while in Australia. Utilises air space over a wide variety of habitat types including open plains, woodlands, salt marsh, rainforest, pasture and urban areas (Australian Government & DAWE, 2020b).	Recorded approximately 12 km west southwest of the Proposal (2013).	**High** May occur infrequently over any part of the MESA and EISA.	**Low** Entirely airborne and will not rely on habitats within the BBSA, no recent DBCA records.
Common Greenshank *(Tringa nebularia)*	MI	MI		Habitat including sheltered sand flats, mudflats, bays, sandy beaches, estuaries and salt lakes (DAWE, 2021).	Numerous coastal records exist. One record occurs inland to the east along Koonah Road. Five records exist to the southwest around Lake Guraga.	**Recorded** Multiple individuals recorded during the Spectrum (2022a) survey. Seasonally inundated salt lakes within the MESA and EISA provides temporary habitat for the species.	-
Black-tailed Godwit *(Limosa limosa)* Caspian Tern *(Sterna caspia)* Common Sandpiper *(Tringa hypoleucos)* Grey Plover	MI	MI		Habitat including sheltered sand flats, mudflats, bays, sandy beaches, estuaries and salt lakes (DAWE, 2021).	Predominantly coastal records from islands, beaches and coastal salt lakes (Lake Thetis in particular).	**Medium** Migratory shorebird and seabird species that may utilise seasonally inundated salt lake habitat for foraging and/ or roosting purposes. With the exception of the Caspian Tern, these birds are non-breeding visitors to Australia. No breeding	-

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence	
	EPBC Act	BC Act	DBCA			Spectrum (2022a)	360 Environmental (2021)
(Pluvialis squatarola) Gull-billed Tern *(Sterna nilotica)* Long-toed Stint *(Calidris subminuta)* Pacific Golden Plover *(Pluvialis fulva)* Pectoral Sandpiper *(Calidris melanotos)* Red-necked Stint *(Calidris ruficollis)* Ruddy Turnstone *(Arenaria interpres)* Sanderling *(Calidris alba)* Sharp-tailed Sandpiper *(Calidris acuminata)*						habitat for Caspian Tern was recorded.	
Glossy Ibis *(Plegadis falcinellus)*	MI	MI		Foraging habitat consists of shallow saline and freshwater lakes, flooded pasture and samphire as well as man made water bodies such as sewerage ponds (DAWE, 2021).	Sporadic visitor to southern parts of WA. A single record was returned during the database searches from approximately 22 km south east of the Proposal.	**Medium** Freshwater wetland, salt lake and samphire habitat occurs within the MESA and EISA.	-
Wood Sandpiper *(Tringa glareola)*	MI	MI		Mainly freshwater river and pool habitat though rarely associated with brackish, salt lake and estuary environments (DAWE, 2021).	A single record from disturbed freshwater wetland habitat north northwest of the Proposal.	**Medium** Freshwater wetland habitat occurs within the MESA and EISA.	-

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence	
	EPBC Act	BC Act	DBCA			Spectrum (2022a)	360 Environmental (2021)
Bridled Tern *(Sterna anaethetus)*	MI	MI		Species occupies islands for breeding and forages offshore (DAWE, 2021).	Island, coastal and offshore NatureMap records only.	**Low** No suitable habitat recorded within the MESA and EISA.	-
Crested Tern *(Sterna bergii)*	MI	MI		Sandy beaches, shallow lagoons, coral reefs, estuaries, mudflats and open ocean (Birdlife International, 2018).	Many coastal records from the region.	**Low** No suitable habitat recorded within the MESA and EISA.	-
Eastern Osprey *(Pandion haliaetus cristatus)*	MI	MI		Littoral and coastal environments as well as terrestrial wetlands. Requires large areas of fresh, brackish or saline water for foraging (DAWE, 2021).	NatureMap records only.	**Low** No suitable habitat recorded within the MESA and EISA.	-
Roseate Tern *(Sterna dougallii)*	MI	MI		Rocky and sandy beaches, coral reefs and islands (DAWE, 2021)..	Coastal and island records only.	**Low** No suitable habitat recorded within the MESA and EISA.	-
Grey-tailed Tattler *(Tringa brevipes)*	MI	MI	P4	Prefers sheltered coastal areas with rock platforms, reef or intertidal mudflats (DAWE, 2021).	NatureMap records only.	**Low** No suitable habitat recorded within the MESA and EISA.	-
Peregrine Falcon *(Falco peregrinus)*		OS		Widespread but uncommon; variety of habitats ranging from urban areas, coastal cliffs, riverine gorges, wooded watercourses or margins of cleared lands (Australian Government & DotEE, 2019b).	Multiple records from the greater region.	**Medium** May utilise all habitat types for foraging purposes on an irregular basis. No nesting habitat present.	-
Hooded Plover *(Thinornis rubricollis)*			P4	Sandy ocean beaches and inland salt lakes for foraging purposes. Breeding habitat consists sandy beaches above the high tide mark and coastal dunes (Birdlife Australia, 2020).	A single record from sandy beach habitat near Jurien Bay.	**Medium** Ephemeral salt lake habitat within the MESA and EISA may be used for foraging purposes. No nesting habitat present.	-
Blue-billed Duck			P4	Prefers deep and permanent freshwater wetlands that allow	Aerial imagery does not show any wetland or	**Low**	-

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence	
	EPBC Act	BC Act	DBCA			Spectrum (2022a)	360 Environmental (2021)
(Oxyura australis)				diving behaviour while foraging (NSW Government & Office of Environment and Heritage, 2020).	watercourse habitat that coincides with the single record for this species in the region.	Ephemeral freshwater habitat is present though unlikely to be deep enough to be suitable for the Blue-billed Duck.	
Grey Wagtail (*Motacilla cinerea*)	MI, MA	MI		Wetlands, especially water courses, but also on the banks of lakes and marshes, as well as artificial wetlands (Commonwealth of Australia, 2015)	Database records only.	-	**Low** No suitable habitat in the BBSA or recent DBCA records.
Reptiles							
Black-striped Burrowing Snake *(Neelaps calonotos)*			P3	Dunes and sandplains vegetated with heaths and woodland (Wilson and Swan, 2017).	Recorded within the Proposal (Spectrum, 2022a) just off the entrance track in the south of the MESA.	**Recorded** Suitable sandy heath and woodland habitat is present within the MESA and EISA.	**Medium** Preferred habitat within the BBSA, within known distribution, no recent DBCA records.
Jewelled Southwest Ctenotus (*Ctenotus gemmula)*			P3	Pale sandplains in association with heaths and woodland (Wilson and Swan, 2017).	Multiple records from approximately 15 km east southeast of the Proposal (2013).	**Medium** Suitable pale sandplain with heath and woodland is present within the MESA and EISA though no individuals were recorded during two phases of Level 2/ Detailed survey.	**High** Preferred habitat within the BBSA, within known distribution, DBCA database search shows five nearby records.
Western Spiny-tailed Skink *(Egernia stokesii badia)*	EN	VU		Typically found in York Gum (*Eucalyptus loxophleba*) woodland, also Gimlet (*E. salubris*) and Salmon Gum (*E. salmonophloia*). Hollows of fallen timber used as shelter (Australian Government & DotEE, 2020)	A single record from 34 km north of the Proposal (2011).	**Low** No suitable hollow habitat present within the MESA and EISA. The MESA and EISA is also outside of the species predicted range.	-
Woma Python (south west population)			P1	Wheatbelt and Goldfields sandplains (Maryan *et al.,* 2007). Specific habitat preferences in the region are unknown.	Historical records (NatureMap only) from Badgingarra, east of the Proposal.	**Low**	-

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence	
	EPBC Act	BC Act	DBCA			Spectrum (2022a)	360 Environmental (2021)
(Aspidites ramsayi)						No recent records in the region. Previous records all occur inland of the MESA and EISA.	
Jurien Bay Skink *(Liopholis pulchra longicauda)*	VU	VU		Woodlands and heaths on islands off Jurien Bay (Wilson and Swan, 2017).	This subspecies is known only from islands off Jurien Bay.	**Very Low** Does not occur on the mainland, island populations only.	-
Lancelin Island Skink *(Ctenotus lancelini)*	VU	VU		Limestone outcrops on Lancelin and Favorite Islands (Wilson and Swan, 2017).	No known mainland population. Restricted to Lancelin and Favourite Islands.	**Very Low** Does not occur on the mainland, island populations only.	-
Invertebrates							
Bothriembryontid Land Snail (Moore River) *(Bothriembryon perobesus)*			P1	Stabilised sand dunes supporting *Banksia* and/or *Eucalyptus* woodland over heath (Bennelongia, 2013).	A single record from 19 km south east of the Proposal (2012).	**High** Suitable sand dune with woodland over heath habitat exists within the MESA and EISA.	-
Spiny Katydid *(Austrosaga spinifer)*			P2	No habitat information available.	Two records from less than 5 km west of the Proposal (1984). Aerial imagery suggests the habitat is similar to that found within the Proposal (sandplain with heath and proteaceous woodland).	**Medium** No specific habitat information is available for this species.	-
Woollybush Bee *(Hylaeus globuliferus)*			P3	Associated with *Adenanthos cygnorum* and *Banksia attenuata* from north of Eneabba, the Swan Coastal Plain and south coast (Invertebrate Solutions, 2019)	Two records from the Hill River region approximately 18 km north of the Proposal (1996).	**Medium** Suitable Woollybush and *Banksia* habitat may occur within the MESA and EISA.	-
Graceful Sun Moth *(Synemon gratiosa)*			P4	Coastal heath on secondary Quindalup Dunes hosting *Lomandra maritima*. Also present in *Banksia* woodland on	Multiple coastal records located west of the Proposal.	**Low** Previous targeted survey (360 Environmental, 2012a) completed according to DEC guidelines did not	-

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence	
	EPBC Act	BC Act	DBCA			Spectrum (2022a)	360 Environmental (2021)
				Spearwood and Bassendean Dunes hosting *Lomandra hermaphrodita* (DotE, 2019).		detect Graceful Sun-moth within the MESA and EISA. Known host species, *Lomandra hermaphrodita,* was recorded in low density only.	

6.3.12 Significant Fauna – Field Results

Four significant fauna species were recorded during the four field surveys (360 Environmental, 2012a; 2012c & 2021; Spectrum 2022a; Table 31).

Table 31: Significant fauna recorded (360 Environmental, 2012c & 2021; Spectrum, 2022a)

Species	Conservation Status			Detailed Fauna Assessment (360 Environmental, 2012c)	Detailed Fauna Survey – Phase 2 (Spectrum, 2022a)	Basic survey – external infrastructure corridors (Spectrum, 2022a)	BBSA (360 Environmental, 2021)	Details
	EPBC Act	BC Act	DBCA					
Common Greenshank (*Tringa nebularia*)	MI	MI			•			Opportunistic and Systematic Survey
Black-striped Snake *(Neelaps calonotos)*			P3		•			Opportunistic
Western Brush Wallaby *(Notamacropus irma)*			P4	•		•		2012 survey - Opportunistic 2021 – Opportunistic (observed crossing road)
Carnaby's Cockatoo (*Zanda latirostris*)	EN	EN				•	•	2021 – Opportunistic and Systematic Survey BBSA - Systematic Survey

The recorded species and those with a high likelihood of occurrence are discussed in the following sections. The location of each significant fauna record is shown in Figure 65 and Figure 66.

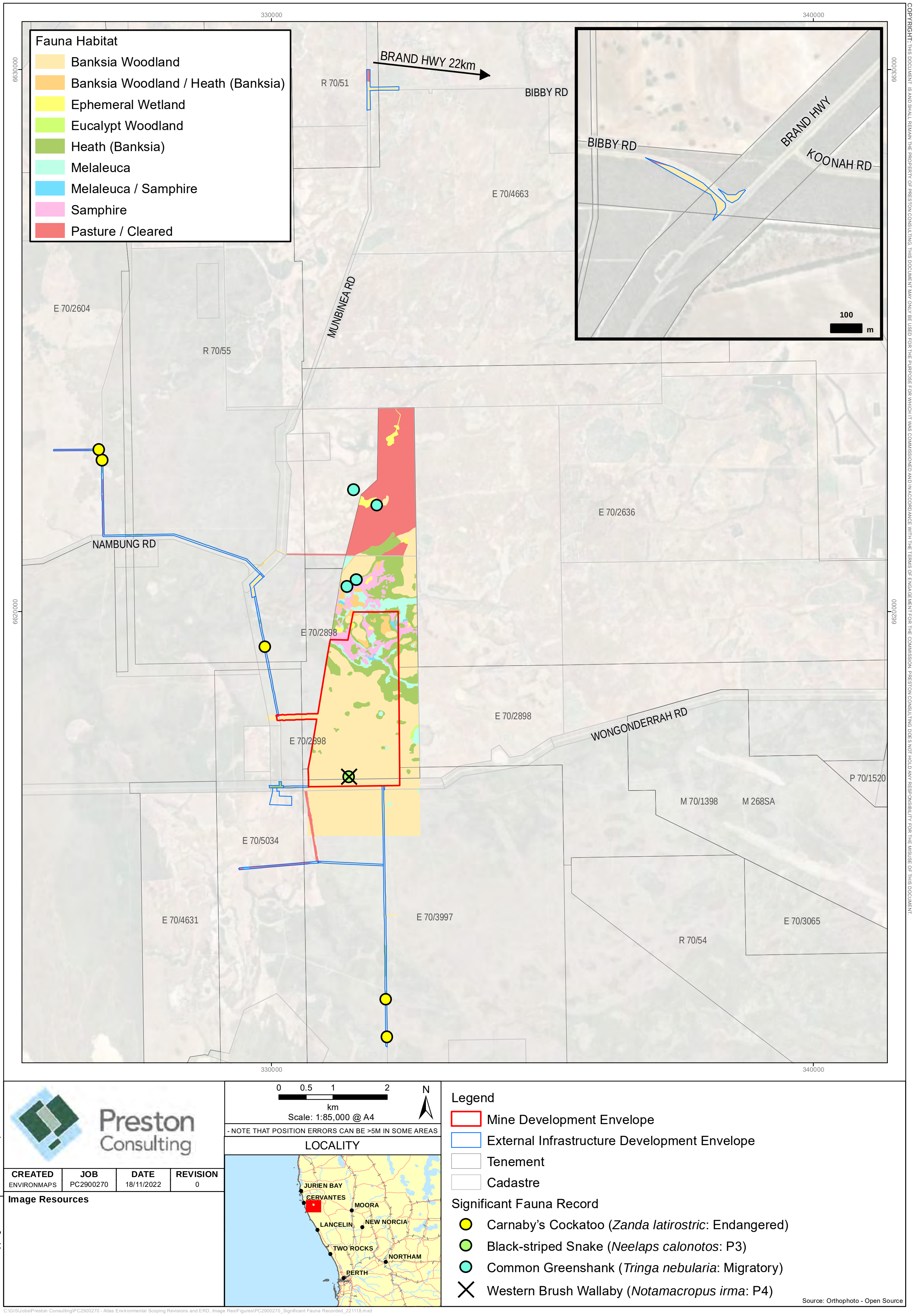


Figure 65: Significant fauna recorded

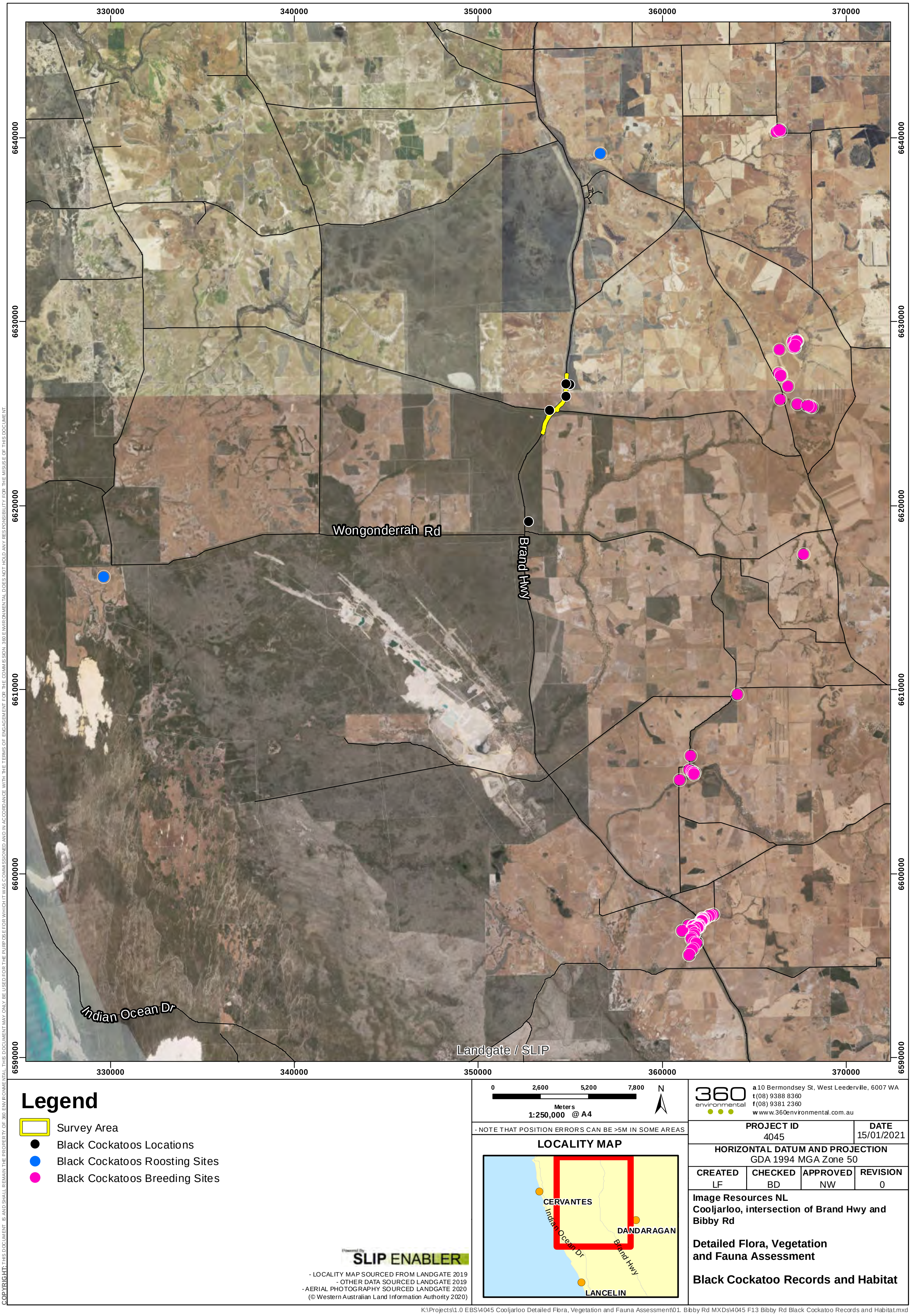


Figure 66: Significant Fauna (Carnaby's Cockatoo) locations in BBSA (360 Environmental, 2021)

Western Brush Wallaby (Notamacropus Irma; P4)

Ecology, Habitat and Distribution: The Western Brush Wallaby was once very common, prior to extensive land clearing for agriculture within its range. The species is now restricted to the south west of WA from Kalbarri to Cape Arid (Van Dyck and Strahan, 2008). Western Brush Wallaby are thought to occur in open forest or woodland, particularly favouring open, seasonally wet flats with low grasses and scrubby thickets. It is also found in some areas of mallee and heathland (DEC, 2012). Recent research indicates that a dense understorey may form critical habitat with individuals preferentially utilising dense understorey in Banksia woodlands (Povh *et al.*, 2019).

Western Brush Wallaby feed sparingly on a wide range of plants rather than extensively on a few species, indicating they require floristically diverse habitat for foraging (Wann and Bell, 1997). Their home range has been calculated to be approximately 10 - 12 ha (Povh *et al.*, 2019). Foxes are thought to have also been a major factor in the species decline through predation on juveniles. Population increases have been observed in areas where fox control programs have been implemented.

Likelihood of Occurrence – Recorded: Western Brush Wallaby was recorded within the MESA on one occasion during the first phase of Detailed (then Level 2) survey (360 Environmental, 2012c) in Banksia Woodland habitat. Two additional observations were made outside the MESA during the Detailed (360 Environmental, 2012c) and Basic / Targeted (Spectrum, 2022a) surveys. All habitat types within the MESA, EISA and BBSA with the exception of the Ephemeral Wetland and Samphire habitats are expected to host Western Brush Wallaby.

Carnaby's Cockatoo (Zanda latirostris; Endangered)

Ecology, Habitat and Distribution: The Carnaby's Cockatoo is endemic to the south west of WA. It occurs between the Murchison River to Esperance, and inland to Coorow, Kellerberrin and Lake Cronin (Cale, 2003). There has been a shift in its breeding range to the west and the south since the middle of the 1900s. It is now located in the Jarrah-Marri forest of the Darling Scarp, and the Tuart forests of the Swan Coastal Plain. Breeding takes place from July to mid-December (Johnstone and Johnstone, 2006). Carnaby's Cockatoos pair for life and only one chick per year will be raised, remaining with the parents for up to 18 months (Shah, 2006).

The Carnaby's Cockatoo utilises a variety of forests, shrublands and banksia woodlands. The species uses native shrubland, kwongan heathland and proteaceous woodland, including banksia woodland for foraging. Roost sites are often associated with riparian vegetation, large trees such as pine trees or eucalypt trees with a closed canopy. Breeding habitat consists of woodland or forests that provide hollows in live or dead trees (any eucalypt species). Wandoo, tuart, jarrah, york gum, karri and marri are typical breeding trees (DotEE, 2017a). Carnaby's Cockatoos often move up to 13 km a day with the greatest distances covered in the early morning and late evening (Shah, 2006). The birds then travel between roost sites, foraging sites and wetlands for drinking.

Likelihood of Occurrence – Recorded: The species has been recorded in small and large flocks moving through the local region and birds utilising Banksia Woodland habitats 6 km north of the MESA at the intersection of Munbinea Road and Bibby Road during the initial Basic fauna survey. Carnaby's Cockatoo were also recorded at three locations during the Basic fauna assessment of the EISA, and a large flock of up to 100 individuals were observed flying over Banksia woodland to the west of the Proposal, however a location could not be determined due to the distance from the observers (Spectrum, 2022a). Further foraging evidence of the species (chewed Banksia flowers) was recorded along the eastern edge of the Survey Area and at a site at the south of the Survey Area by Spectrum (2022a).

Previous Carnaby's Cockatoo assessments identified that only suitable foraging habitat occurs within the MESA. Two roost sites were identified within 12 km of the MESA and an additional seven roost sites are located in the surrounding region. The survey areas are all located just outside of the breeding range of Carnaby's Cockatoo, however the region is considered important foraging habitat.

The species was recorded within the BBSA. In two locations, a number of individuals were observed foraging in Banksia and at another location a flock of Carnaby's Cockatoos were observed flying overhead. Evidence of Carnaby's Cockatoo was also seen at two other sites, with calls heard at one site and evidence of foraging (chewed Banksia) seen at the other site (360 Environment, 2021).

The species has been allocated a high likelihood of occurrence because suitable foraging habitat occurs across the survey areas including Banksia Woodland and Heath (Banksia) and the species has been recently recorded just outside of the MESA and within the BBSA.

Habitat Assessment – Spectrum (2022a) defined and assessed potential Carnaby's Cockatoo habitat within the MESA and EISA. Suitable foraging habitat in the form of Banksia Woodland, Heath (Banksia), Banksia Woodland/Heath (Banksia) and Eucalypt Woodland was calculated to account for 864.3 ha (70.3%) of the MESA and EISA. The Eucalypt Woodland may also be considered potential roosting habitat though the habitat is located outside of the MESA and EISA and no Carnaby's Cockatoos were observed utilising the area for this purpose (Spectrum, 2022a). A total of 21.7 ha of Carnaby's Cockatoo foraging habitat was also recorded within the BBSA, and was identified to be very high quality. No potential breeding habitat was recorded within the BBSA, however the non-endemic trees (0.1 ha) were considered potential roosting habitat.

Using the scoring tool outlined in the Revised Draft Referral Guideline for Three Threatened Black Cockatoo Species (DotEE, 2017a), the identified habitat for the Carnaby's Cockatoo within the MESA and EISA was assessed by Spectrum (2022a) as follows:

Starting score:

- (High Quality): proteaceus woodland and heathland dominated by Banksia species with some native *Eucalyptus rudis* woodland present.

Additions:

- +3 Is within the Swan Coastal Plain (important foraging area).

Subtractions:

- -1 Is >12 km from a known breeding location.

The overall scoring of the foraging habitat for the Carnaby's Cockatoo was rated as Nine (very high quality) based on the above criteria. Evidence and observations of Carnaby's Cockatoo foraging have been recorded and the species has been well documented using similar habitats across the surrounding region (Spectrum, 2022a). The MESA and EISA is located outside of the breeding range of Carnaby's Cockatoo however the region is considered as important foraging habitat as juvenile cockatoos move into the area after fledging from breeding sites located to the east. Two roost sites were identified within 12 km of the MESA and EISA and an additional seven roost sites are located in the surrounding region (Figure 67).

Three Important Bird Areas for Carnaby's Cockatoo occur in the surrounding region (Dutson, Garnett and Gole, 2009; DPaW, 2013). Spectrum (2022a) summarises these as follows:

- Coomallo: Located approximately 40 km to the northeast of the Proposal, this area supports at least 1% of the Carnaby's Cockatoo breeding population (minimum of 40 breeding pairs) which nest in woodland remnants and isolated paddock trees and feed in native shrublands;
- Koobabbie: Located near Coorow and approximately 110 km northeast of the Proposal, supporting at least 1% of the Carnaby's Cockatoo breeding population (up to 32 breeding pairs), this large pastoral property has 254 ha of remnant Wandoo and Salmon Gum woodland vegetation. Fledglings have been recorded at Coomallo Creek and Beekeepers Nature Reserve; and
- Northern Swan Coastal Plain: Located between the Swan River and Moore River, this area supports 4,600 - 15,000 birds in the non-breeding season and a small number of pairs of breeding birds; this is the largest population of birds that gather in the non-breeding season.

Regionally, approximately 44,000 ha of Carnaby's Cockatoo habitat occurs within the conservation reserves listed below with additional areas of Carnaby's Cockatoo habitat located outside of the conservation estates which are also utilised for foraging and nesting.

- Badgingarra National Park: 13,108 ha;
- Coomallo Nature Reserve: 8.807 ha;
- Southern Beekeepers Nature Reserve: 10,808 ha;
- Nambung National Park: 8,362 ha;
- Hill River Nature Reserve: 882 ha; and
- Un-named Conservation Park: 2,369 ha.

Breeding sites in the region surrounding the Survey Area include Three Springs, Coomallo, Carnamah, Coorow, Badgingarra and Moora regions which are vacated by the end of February each year. Adult Carnaby's Cockatoo and their fledglings fly west to coastal feeding habitat where they aggregate in flocks in the Kwongan heath and pine plantations (Saunders, 1980). Occasionally a flock of 60 - 100 birds remain in the Badgingarra National Park area into March-April (Ron Johnstone pers. comm., 2008) and from July through to September the Carnaby's Cockatoo population moves back to breeding sites (Williams *et al.*, 2017; Figure 68).

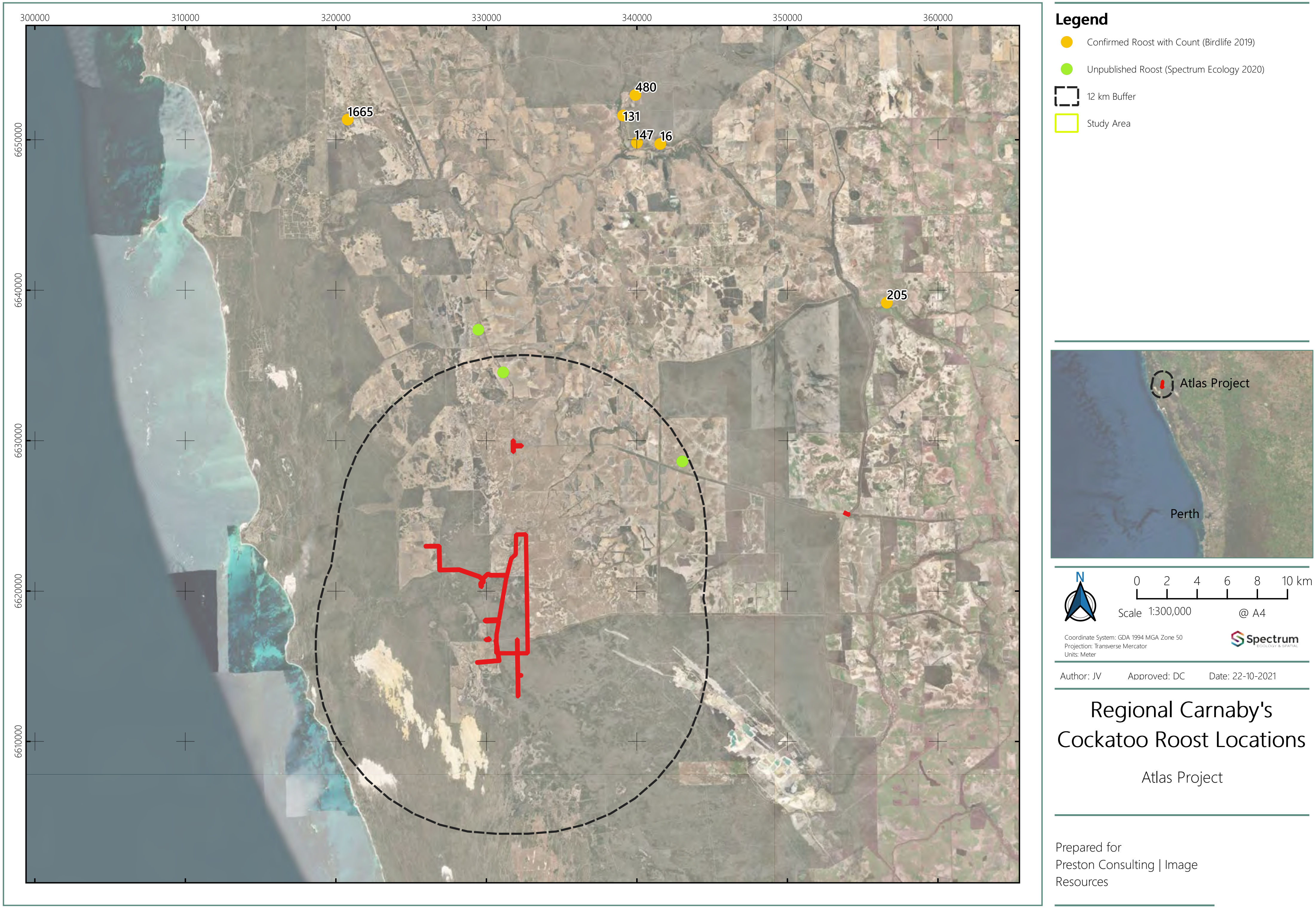


Figure 67: Regional Carnaby's Black Cockatoo Roost Locations

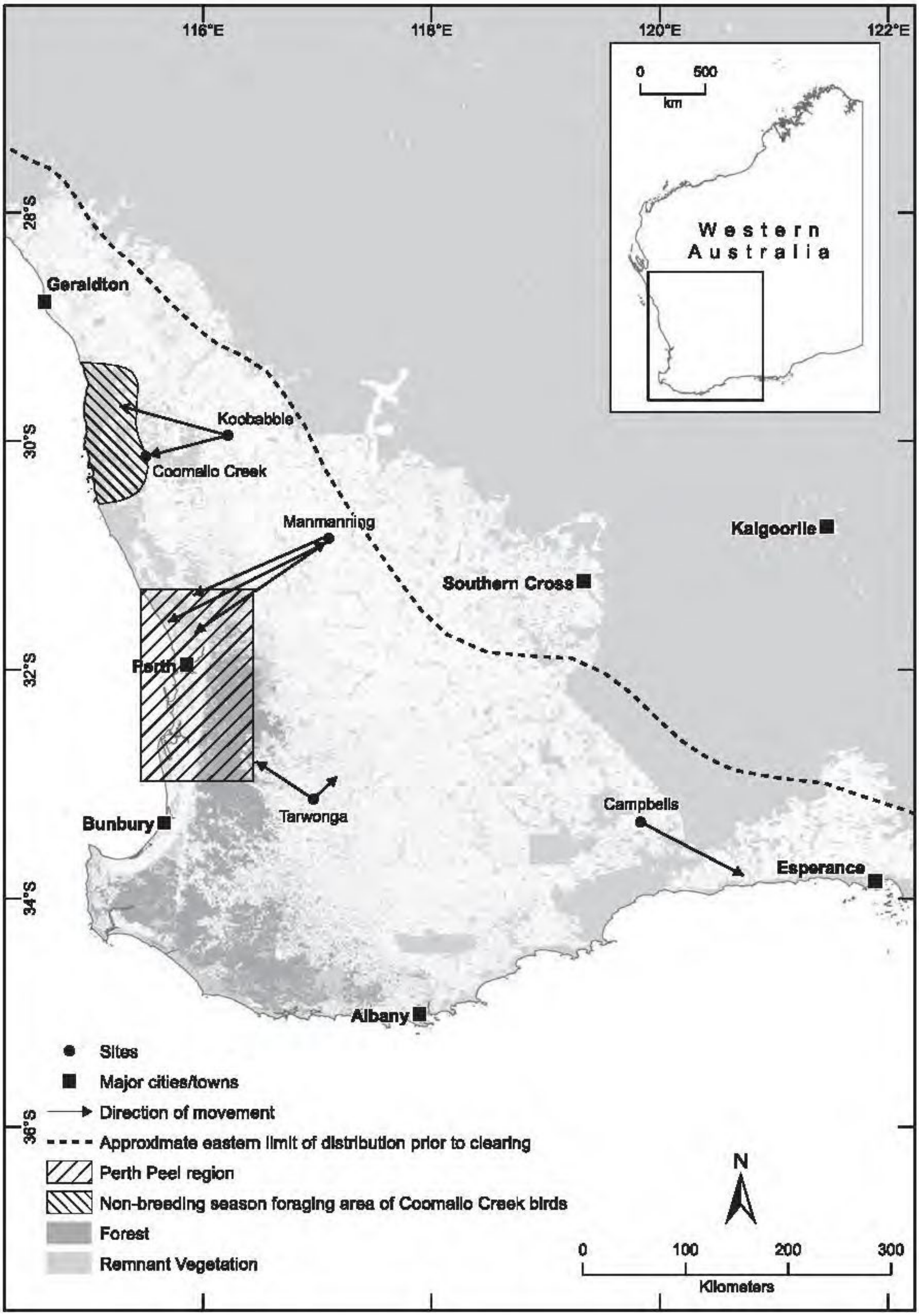


Figure 68: Known movement patterns of Carnaby's Cockatoo (Williams *et al.*, 2017).

Common Greenshank (Tringa nebularia; Migratory)

Ecology, Habitat and Distribution: The Common Greenshank is a migratory, non-breeding visitor to Australia between August and March though some individuals overwinter in Australia, particularly juveniles. The species inhabits a variety of freshwater habitats including open mudflats and ephemeral salt lakes and wetlands of still, shallow water. This excitable and vocal species is solitary when feeding. It is often observed wading in shallow water, lunging at fish or running to catch prey. They will roost in small flocks or on the margin of larger flocks of other species (Menkhorst *et al.*, 2019).

Likelihood of Occurrence – Recorded: Common Greenshank were recorded on six occasions at three locations during the Detailed fauna survey (Spectrum, 2022a). Initially the species was recorded utilising a shallow pool within the Ephemeral Wetland habitat type. This dried up during the survey period and the species was then observed at an artificial dam within pasture in the northern part of the MESA.

A further record was made to the west of the MESA associated with an artificial dam. It is likely that the original six birds first recorded were moving between areas of suitable habitat and consequently the same individuals were recorded at nearby dams. Natural habitat for Common Greenshank and other significant shorebird and wader species is limited and temporary, available only immediately after significant rainfall. Seasonally inundated low-lying samphire and ephemeral wetlands within the MESA and EISA provides temporary habitat for this species.

Fork-tailed Swift (Apus pacificus; Migratory)

Ecology, Habitat and Distribution: The Fork-tailed swift is a migratory, non-breeding visitor to Australia. Within WA, records are most abundant in coastal areas of the south west, Pilbara, and Kimberly regions. The species is known to be highly nomadic, rarely landing, spending much of their time foraging in large flocks high above the canopy. The species is known to be insectivorous but its food source is relatively unknown within Australia (Menkhorst *et al.*, 2019).

Likelihood of Occurrence – High: Three regional records exist from NatureMap and DBCA databases, the most recent recorded in 2012. Two of these records occur along the coast and one further inland to the north-east. Due to the aerial lifestyle of this species it is unlikely to directly utilise any terrestrial habitats within the survey areas.

Jewelled Southwest Ctenotus (Ctenotus gemmula; P3)

Ecology, Habitat and Distribution: The Jewelled Southwest Ctenotus is found in pale sand-plains supporting heaths in associated with *Banksia* or mallee woodlands (Wilson and Swan, 2017).

Likelihood of Occurrence – High: The *Banksia* or mallee woodlands habitat is equivalent to the *Banksia* woodland/*Allocasuarina* shrubland identified within the BBSA and is likely to be similar to habitat within which nearby records of the species were identified by DBCA database searches, which were approximately 13 km southwest of the BBSA (DBCA, 2020b). The BBSA is only 8 km away from the Swan Coastal Plain IBRA regional boundary, therefore records in the vicinity of the BBSA are considered part of the Swan Coastal Plain population, as distinct from populations that occur along the southern coastline (360 Environmental, 2021).

Black-striped Snake (Neelaps calonotos; P3)

Ecology, Habitat and Distribution: This fossorial elapid is rarely seen above ground and is restricted to the coastal sandplain region between Cataby and Mandurah with what appears to be isolated population occurring further north near Eneabba and Dongara. The species inhabits dunes and sandplains vegetated with heaths and eucalypt/banksia woodlands. Black-striped Snakes are specialist feeders, preying largely on the small fossorial slider skink, *Lerista praepedita* (Wilson and Swan, 2017).

Likelihood of Occurrence – Recorded: This species was recorded opportunistically within the MESA while foraging in Banksia Woodland habitat. One individual was raked from a track side spoil heap (mounded sand and vegetation left from track construction). Banksia Woodland, Heath (Banksia) and Banksia Woodland/ Heath (Banksia) habitat is expected to host the Black-striped Snake though detection can be difficult due to their mostly subterranean habits.

Bothriembryontid Land Snail (Moore River) (Bothriembryon perobesus; P1)

Ecology, Habitat and Distribution: The Bothriembryontid Land Snail (Moore River) is known to occupy stabilised sand dunes supporting Banksia and/or Eucalyptus woodland over heath (Bennelongia, 2013).

Likelihood of Occurrence – High: The Bothriembryontid Land Snail (Moore River) was collected in 2013 by Bennelongia from stabilised dunes within the Cooljarloo West Development Envelope, 20 km south east of the Proposal (Bennelongia, 2013). The closest record is from 18 km west of the Proposal near Cervantes and records also exist from many other locations within the immediate region from between 1955 and 2017 (WAM). The species has been allocated a high likelihood of occurrence due to the proximity of previous records and suitable habitat existing within the survey areas in the form of Banksia Woodland, Heath (Banksia) and Banksia Woodland/ Heath (Banksia).

6.3.13 Short-range Endemic Invertebrates

Desktop Searches

The WAM Invertebrate Database search identified a total of 24 potential SRE species in the region surrounding the Proposal. The list is comprised of ten Arachnids (a mite, eight spiders and a scorpion), 13 Diplopods (millipedes) and one Gastropod (snail). An additional Chilopod (centipede), two Isopods (wood lice) and an Oligochaeta (earthworm) were identified by the literature review. Many of the species identified were collected at Cooljarloo, approximately 18 km south east of the Proposal.

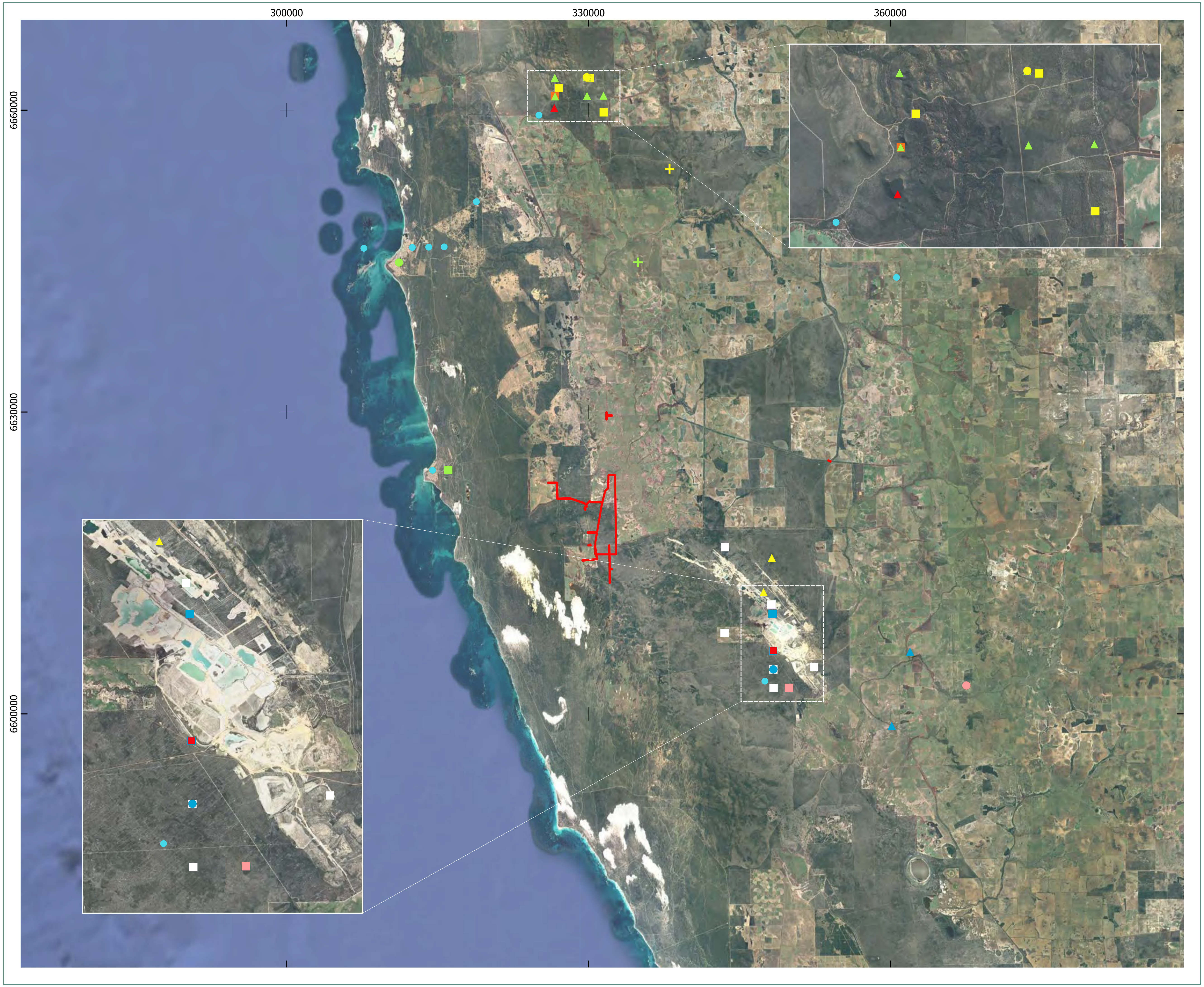
The search results and their relevant details are listed in Table 32 and shown in Figure 69.

Table 32: WAM Invertebrate Database Results and Literature Review Records

Family and Species	Previous Records	Additional Information
ARACHNIDA		
Acari		
Erythraeidae		
Leptus minno	Multiple records from Coomallo Creek, 31 km north of the Proposal.	Mite species recorded in 1991.
Araneae		
Anamidae		
Aname \`MYG632\`	Multiple specimens collected from Mt Lesueur National Park and the Coorow-Greenhead Road. Nearest record is located 32 km north of the Proposal.	Wishbone Trapdoor Spider (Mygalomorphae) collected in 2016.
Idiopidae		
Bungulla banksia	Multiple records both north and south of the Proposal. The two nearest specimens were collected from Cooljarloo, 18 km south east of the Proposal.	Armoured Trapdoor Spider (Mygalomorphae). The specimen nearest to the Proposal was collected in 2007.
Bungulla riparia	Recorded from both Mt Misery and Mt Lesueur, 37 km east and 38 km north respectively.	Armoured Trapdoor Spider (Mygalomorphae). Mt Misery specimens were collected in 1956, Mt Lesueur in 1989.
Euoplos mcmillani	Recorded from multiple locations both south east and north of the Proposal. The nearest record is located 18 km southeast of the Proposal at Cooljarloo.	Armoured Trapdoor Spider (Mygalomorphae). The specimens nearest to the Proposal were collected in the vicinity of Cooljarloo in both 2010 and 2014.
Idiosoma gardneri	Two records from Mt Lesueur, 38 km north of the Proposal.	Mt Lesueur Shield-backed Trapdoor Spider (Mygalomorphae). Both specimens were collected in 1989. This species is also listed by the DBCA as Priority 2.
Idiosoma kwongan	Specimens collected from three locations, the nearest located 40 km north of the Proposal near Mt Lesueur.	Kwongan Heath Shield-backed Trapdoor Spider (Mygalomorphae). Eight specimens collected between 1980-90 from three locations. This species is also by the DBCA as Priority 1.
Idiosoma \`MYG221\`	Specimens collected from Cooljarloo.	Shield-backed Trapdoor Spider. Specimens collected in 2010. The *Idiosoma* genus is known to host range restricted and threatened species.
Idiosoma \`MYG222\`	Specimens collected from Cooljarloo.	Shield-backed Trapdoor Spider. Specimens collected in 2010. The *Idiosoma* genus is known to host range restricted and threatened species.
Scorpiones		
Urodacidae		
Urodacus 'sp. nov. Gairdner Range'	Two specimens collected 21 km north of the Proposal in the Gairdner Range.	Scorpion. Specimens collected in 1990.

Family and Species	Previous Records	Additional Information
CHILOPODA		
Geophilomorpha		
Mecistocephalidae		
Mecistocephalus sp. B07	One specimen collected at Cooljarloo.	Record from previous regional survey report (Bennelongia, 2013).
DIPLOPODA		
Polydesmida		
Paradoxosomatidae		
Antichiropus sulcatus	Multiple records north and south east of the Proposal. The nearest record is from 13 km south east.	Millipede. The most recent records of this species are from 2018 at Cooljarloo.
Antichiropus whistleri	Multiple records east and south east of the Proposal, the nearest located 11 km east at Cooljarloo.	Millipede. The most recent records of this species are from 2018 at Cooljarloo.
Antichiropus \`cooljarloo\`	Collected from two sites at Cooljarloo.	Millipede. Specimens collected in both 2014 and 2017. The genus *Antichiropus* is known to contain range restricted and threatened species.
Antichiropus \`DIP057\`	Collected from two locations, at Cooljarloo and 67 km north at Eneabba.	Millipede. The most recent specimens were collected at Cooljarloo in 2012. The genus *Antichiropus* is known to contain range restricted and threatened species.
Antichiropus \`DIP076\`	Collected from two locations, at Cooljarloo and 67 km north at Eneabba.	Millipede. The most recent specimens were collected at Cooljarloo in 2010. The genus *Antichiropus* is known to contain range restricted and threatened species.
Antichiropus \`DIP160, cataby\`	Collected from two locations near Cataby, 32 km south east of the Proposal.	Millipede. The most recent specimens were collected in 2017. The genus *Antichiropus* is known to contain range restricted and threatened species.
Antichiropus \`GI/UBS1\`	Collected at Beekeepers Nature Reserve, 30 km north west of the Proposal.	Millipede. Four specimens were collected in 2008. The genus *Antichiropus* is known to contain range restricted and threatened species.
Antichiropus \`GI\`	Two specimens collected at Ranger Cave (Nambung National Park), 16 km west of the Proposal.	Millipede. Two specimens were collected in 1995. The genus *Antichiropus* is known to contain range restricted and threatened species.
Antichiropus \`ML1\`	Recorded from multiple sites near Mt Lesueur, 38 km north of the Proposal. Also recorded from a second location further east at Coomallo Hill.	Millipede. The Mt Lesueur and Coomallo Hill specimens were collected in 1989 and 2006 respectively. The genus *Antichiropus* is known to contain range restricted and threatened species.
Antichiropus \`Mt Lesueur 2\`	Recorded from two locations near Mt Lesueur, approximately. 40 km north of the Proposal. Also known from Alexander Morrison National Park, 61 km north east of the Proposal.	Millipede. The Mt Lesueur and Alexander Morrison National Park specimens were collected in 1989 and 1999 respectively. The genus *Antichiropus* is known to contain range restricted and threatened species.
Antichiropus \`UBS2?\`	Recorded from one location at Cooljarloo.	Millipede. Eight specimens were collected in 2010. The genus *Antichiropus* is known to contain range restricted and threatened species.

Family and Species	Previous Records	Additional Information
Antichiropus `whistleri?`	Collected from two locations, 127 km apart. At Lesueur National Park and Boonanarring Nature Reserve, 37 km north and 87 km south east.	Millipede. Specimens were collected at Boonanarring in 2017 and Mt Lesueur in 2018. The genus *Antichiropus* is known to contain range restricted and threatened species.
Polyzoniida		
Siphonotidae		
`*Vombatotus lesueuri*`	Two specimens collected from the Mt Lesueur area, 40 km north of the Proposal.	Millipede. Two specimens were collected in 1989.
CRUSTACEA		
Isopoda		
Armadillidae		
Acanthodillo sp. B09	Two specimens collected at Cooljarloo.	Record from previous regional survey report (Bennelongia, 2013).
Platyarthridae		
Trichorhina sp. B14	Four specimens collected at Cooljarloo.	Record from previous regional survey report (Bennelongia, 2013).
MOLLUSCA		
Gastropoda		
Bothriembryontidae		
Bothriembryon perobesus (Moore River)	Known from many locations surrounding the Proposal. The nearest record is from near Cervantes, 18 km west of the Proposal.	Land Snail. Records exist from between 1955 and 2017. The Moore River population is listed as Priority 1 by the DBCA. Also recorded at Cooljarloo (Bennelongia, 2013).
OLIGOCHAETA		
Oligochaeta sp.	One specimen collected at Cooljarloo.	Record from previous regional survey report (Bennelongia, 2013).



Legend

Survey Area

WAM Myriapods and Arachnids Database

- Aname `MYG632`
- Antichiropus `cooljarloo`
- Antichiropus `DIP057`
- Antichiropus `DIP076`
- Antichiropus `DIP160, cataby`
- Antichiropus `GI/UBS1`
- Antichiropus `GI`
- Antichiropus `ML1`
- Antichiropus `Mt Lesueur 2`
- Antichiropus `UBS2?`
- Antichiropus `whistleri?`
- Antichiropus sulcatus
- Antichiropus whistleri
- Bungulla banksia
- Bungulla riparia
- Euoplos mcmillani
- Idiosoma `MYG221`
- Idiosoma `MYG222`
- Idiosoma gardneri
- Idiosoma kwongan
- Leptus minno
- Urodacus `sp. nov. Gairdner Range`
- `Vombatotus` `lesueuri`

WAM Mollusc Database

- Bothriembryon perobesus

N

0 5 10 km

Scale 1:340,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum ECOLOGY & SPATIAL

Author: JV Approved: DC Date: 22-10-2021

WAM SRE Database Results

Atlas Project

Prepared for
Preston Consultancy | Image Resources

Figure 69: WAM SRE Database Search Results

Field Survey

Spectrum's Detailed and Basic (2022a) surveys within the MESA recorded 22 potential SRE species consisting of one araneomorph spider, 13 pseudoscorpions, one snail, three isopods and four millipedes (Table 33). Twelve of these potential SREs appear to have only been recorded from the MESA, including one araneomorph spider and 11 pseudoscorpions. An additional 34 specimens (four species) from SRE target groups were also recorded though are known to be widespread and as such not potential SREs.

The regional SRE survey (Spectrum, 2022b) identified 20 potential SRE taxa, including three pseudoscorpions, one snail, nine isopods, four centipedes, one millipede, one flatworm, and one ostracod. A further six taxa were collected that were determined to be widespread or unlikely to be SRE. Four of the 12 target potential SREs originally known only from the MESA were subsequently recorded in the regional SRE survey (Table 33).

Each SRE target group recorded during the Basic and Detailed survey is discussed separately in detail below. Due to the change in taxonomists and reference collections between the basic and detailed SRE surveys (Bennelongia) and the regional survey (Alacran), undescribed SRE taxa were sometimes given different phrase names. Where a species has been assigned different names by Bennelongia and Alacran in Appendix 13, the species name listed by Bennelongia has been adopted for the purposes of this ERD.

Table 33: SRE recorded (Spectrum 2021, 2022b)

Class / Order & Family	Species	Survey			Additional records outside survey area
		Basic	Detailed	Regional	
ARACHNIDA					
Araneae					
Salticidae	*Maratus* 'BAR130'		X		
Pseudoscorpions					
Atemnidae	Atemnidae sp. 712345*		X	X	
Atemnidae	*Oratemnus* 'BPS326'		X		
Chthoniidae	*Austrochthonius* sp. 712610*		X	X	
Olpiidae	*Beierolpium 8/4 'BPS253'*	X			
Olpiidae	*Beierolpium 8/4 'BPS322'*		X		
Olpiidae	*Beierolpium 8/4 'BPS323'*		X		
Olpiidae	*Beierolpium 8/4 'BPS324'*		X		
Olpiidae	*Beierolpium 8/2 'BPS325'*		X		
Olpiidae	*Beierolpium* sp.	X			
Olpiidae	*Euryolpium* 'BPS251'	X			
Olpiidae	*Euryolpium* 'BPS252'	X		Not Targeted	X
Olpiidae	*Euryolpium* sp.	X		Not Targeted	X
Olpiidae	*Olpiidae* sp.	X			

Class / Order & Family	Species	Survey			Additional records outside survey area
		Basic	Detailed	Regional	
GASTROPODA					
Stylommatophora					
Punctidae	Westralaoma cf. *aprica*	X	X	Not Targeted	X
ISOPODA					
Armadillidae	*Buddelundia* sp. B38		X	X	X
Philosciidae	*Laevophiloscia* sp. B23		X	Not Targeted	X
Philosciidae	*Laevophiloscia* sp. B24		X	X	X
MYRIAPODA					
Polydesmida					
Paradoxosomatidae	*Antichiropus sulcatus* (formerly *Antichiropus* sp. 712504*)			Not Targeted	X
Paradoxosomatidae	*Antichiropus sulcatus* (formerly *Antichiropus* sp. 712514*)			Not Targeted	X
Paradoxosomatidae	*Antichiropus whistleri* (formerly *Antichiropus* sp. 713613*)			Not Targeted	X
Paradoxosomatidae	*Antichiropus whistleri* (formerly *Antichiropus* sp. 713614*)			Not Targeted	X

*Bennelongia internal specimen identification number. Details associated with each taxon supplied by Bennelongia.

Araneae (Spiders)

The order Araneae is divided into two infraorders, the Araneomorphae or modern spiders and the Mygalomorphae or primitive spiders. Typically, short-range endemism is associated with the Mygalomorphae and in particular the trapdoor spiders, due to their limited dispersal capabilities and sedentary nature. However, certain genera within the Araneomorphae have been recognised as containing potential SREs. The specimen *Maratus* 'BAR130' collected in Banksia Woodland habitat during the Spectrum (2022a) survey (Figure 70) belongs to one such genus and after preliminary analysis appears to be an undescribed species. No further specimens of the *Maratus* genus were collected during the regional SRE survey (Spectrum, 2022b).

The genus Maratus (Karsch, 1878) is comprised of 86 species, 47 of which could be considered SREs based on the current understanding of their distributions (Schubert, 2020). As for many potential SRE taxa, further targeted survey effort and taxonomic resolution may show these species to have larger distributions than once thought. At this time *Maratus* 'BAR130' has been included as a potential SRE in accordance with the Precautionary Principle.

No Mygalomorph spiders or other potential SRE Araneomorph spiders were collected during the field surveys.

Pseudoscorpiones

Pseudoscorpions are small arachnids that resemble small scorpions, however, they do not have an elongated tail. Pseudoscorpions are often associated with vegetated habitats where they are recorded from under bark and from within leaf litter. A total of 15 pseudoscorpion specimens from three families, representing 13 potential SRE species, were collected during the Basic and Detailed survey (Spectrum, 2022a).

Morphospecies *Atemnidae* sp. 712345, *Austrochthonius* sp. 712610, *Beierolpium* 8/2 `BPS325`, *Beierolpium* 8/4 `BPS322`, *Beierolpium* 8/4 `BPS323`, *Beierolpium* 8/4 `BPS324` and *Oratemnus* `BPS326` were collected only from within the MESA during Spectrum's (2022a) survey (Figure 70) and are not known from any other locations.

Following the Detailed survey, genetic sequencing was completed by Bennelongia on two morphospecies in an effort to align them with those recorded outside the MESA. Sequencing failed for the single *Beierolpium* '8/4 Na03' specimen available, likely due to its small size. *Beierolpium* '8/2 Na04' was sequenced successfully and did not align with any previously recorded species.

A single specimen of *Atemnidae* sp. Was collected during the regional SRE survey. Specimens from this and previous surveys are juvenile, and DNA sequencing is recommended if further resolution is required. Seven specimens of *Austrochthonius* sp. Were recorded in the regional SRE survey. The taxonomy of this group is unresolved with numerous undescribed morphospecies known. However, most *Austrochthonius* morphospecies appear to be widespread (Alacran, 2022).

No further specimens of *Beierolpium 8/4*'BPS253', *Beierolpium* '8/2 Na04', *Beierolpium* '8/4 Na02', *Beierolpium* '8/4 Na03', *Beierolpium* '8/4 Na01', *Beirolpium* sp., Olpiidae sp., *Euryolpium* 'BPS251' or *Oratemnus* sp. 'Na01' were recorded during the regional SRE survey.

Pseudoscorpions are included as an SRE target group though Harvey (2002) states that few SRE species are known from this order and those species that fit the criteria are troglobitic. Since that time, epigean SRE pseudoscorpion species have been described from the Pilbara region of WA (Harvey *et al.*, 2016) though it is unknown if similarly range restricted species occur on the Swan Coastal Plain.

Gastropoda (Snails)

One potential SRE Punctid land snail species was recorded from both inside and outside the MESA (Figure 70). *Westralaoma* cf. *aprica* was recorded from leaf litter in Samphire habitat approximately 1.3 km west of the MESA during the Basic survey. The species was also collected within a leaf litter sample during the Detailed survey in Melaleuca habitat. Both locations are low lying and prone to seasonal inundation though they are separated by a significant area of typically dry Banksia Woodland habitat. The Basic survey record is associated with a dampland drainage system that flows east-west through the centre of the MESA. The Detailed survey record location is from a small depression, isolated by dry Heath (Banksia) and Banksia Woodland habitat (Figure 70). Unfortunately, only shells were collected so no further analysis is possible.

Short-range endemism is well documented within the Australian land snails (Harvey, 2002; EPA 2016a). Within the northern Swan Coastal Plain region, the snail *Bothryembryon perobesus* (P1) is recognised as an SRE species though it is unknown if any further land snail species from the region are range restricted.

Isopoda (Wood Lice)

Isopods are crustaceans found in marine, freshwater and terrestrial environments. Terrestrial isopods (superfamily Oniscoidea) have segmented exoskeletons, seven pairs of legs and are often associated with decaying wood leading to the common name wood louse. Four possible species of isopod (57 specimens), representing three potential SREs, were recorded within the MESA during the Detailed survey (Figure 70).

Morphological analysis suggested that the three potential SRE species *Buddelundia* sp. B38, *Laevophiloscia* sp. B23 and *Laevophiloscia* sp. B24 had been previously recorded from approximately 10 km south-east of the MESA. Due to the difficulty in identifying many species using morphological characters alone, the two *Laevophiloscia* sp. Were genetically sequenced to confirm the conspecificity with specimens recorded outside of the Spectrum Fauna Survey Area. *Laevophiloscia* sp. B23 was found to align with those specimens collected at Cooljarloo. Unfortunately, the sequencing of *Laevophiloscia* sp. From Cooljarloo failed and could not be compared to specimens collected within the MESA. The failure was attributed to preservation techniques used in 2012 when the specimens were collected. Four specimens of Buddelundia '7' were recorded from two locations during the regional SRE survey, while 12 specimens of *Laevophiloscia* sp. B24 were recorded from three locations. The remaining species, *Porcellionides pruinosus*, is an introduced cosmopolitan species native to Europe.

Short-range endemism in terrestrial isopods appears to be directly related to the availability of microhabitats with high levels of moisture and accrued surface organic material. Species with limited distributions are known from the Darling Scarp and it has been suggested that range restricted species may also occur on the Swan Coastal Plain (Judd, 2004). The MESA is predominantly comprised of habitat types that do not maintain moist microhabitats and organic material is typically limited to thin layers that are unlikely to act as an effective buffer against seasonal aridity. The exception to this is the Melaleuca habitat that may retain enough moisture to be suitable for moisture dependent isopod species.

Chilopoda (Centipedes)

Two centipede species, *Lamyctes* nr *africanus* and *Scolopendrinae* \`BSCOL071\`, were collected during the Detailed survey. The former species belongs to the order Lithobiomorpha (rock centipedes), a group not associated with short-range endemism. The latter is an unusual animal that does not fit within any of the currently recognised genera of the family Scolopendridae. Due to the unusual nature of the specimen, Bennelongia have recommended the specimen be genetically sequenced in an effort to resolve its identification. However, it must be made clear that the order Scolopendrida (that the specimen belongs to) is not known to host SRE species (Harvey, 2002). Scolopendrids are typically widespread and highly mobile, and the species was assessed as unlikely to be an SRE. Therefore, the specimen was not assessed according to the standard SRE categories for target SRE groups (Table 2.2 of Appendix 13). DNA sequencing was not undertaken as the specimen does not belong to an SRE target group. Due to its unusual nature, however, Alacran have submitted this specimen for inclusion in the WAM Invertebrate Database.

Diplopoda (Millipedes)

Four potential SRE specimens of the millipede genus *Antichiropus* (*Antichiropus* sp. 712504, *Antichiropus* sp. 712514, *Antichiropus* sp. 713613 and *Antichiropus* sp. 713614) were collected from three locations during the Detailed survey (Figure 70). The genus is known to contain many undescribed taxa and a high proportion of SRE species, likely due to poor mobility and an extremely seasonal life cycle that is strictly associated with rainfall (Harvey, 2002). Male only characters (e.g., gonopod morphology) are the primary diagnostic features used when identifying species which makes species level identification difficult when only juvenile or female specimens are available (Woircieszek, Harvey and Rix, 2010). All five specimens collected during the survey were female or juvenile and as such, genetic sequencing was undertaken to determine which species they represent.

DNA analysis successfully identified *Antichiropus* sp. 712504 and *Antichiropus* sp. 712514 as *Antichiropus sulcatus*, a species previously recorded outside the MESA at Eneabba and Cooljarloo. The remaining millipede specimens *Antichiropus* sp. 713613 and *Antichiropus* sp. 713614 aligned with *Antichiropus whistleri*, a relatively widespread species. Though confirmed to occur outside the MESA, both species are still regarded as potential SREs.

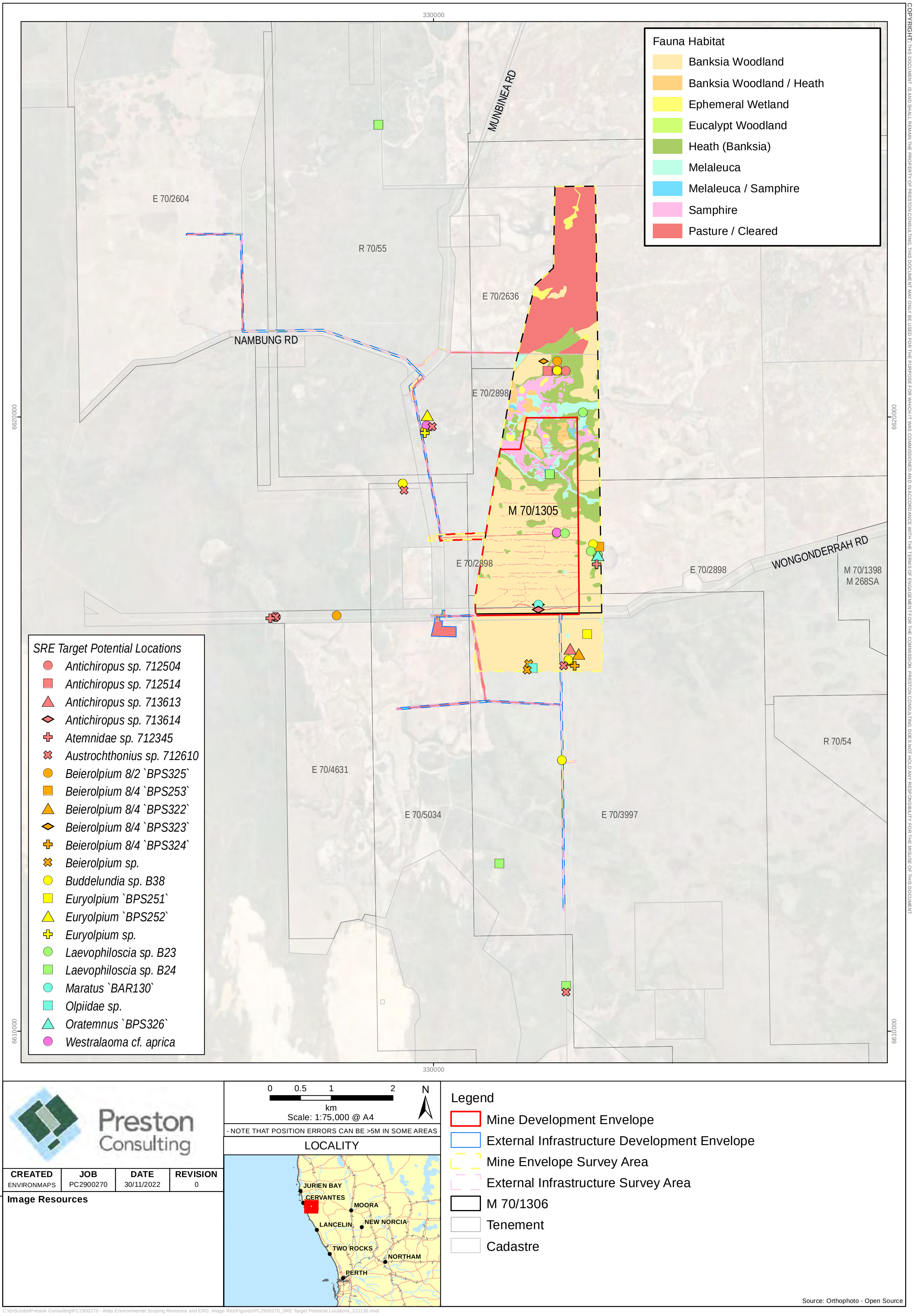


Figure 70: Potential SRE locations

6.3.14 Subterranean Fauna

Water quality parameters measured across four bores were more variable than previous measures of the borefield aquifer which showed the aquifer to be moderately fresh and slightly acidic. Water quality measurements during the November 2020 Bennelongia survey identified the water to be neutral to alkaline. Salinity at one bore (monitoring bore ATOB02) was well outside the range of previous readings but within the tolerances of stygofauna (Bennelongia,2021).

In November 2021, water quality parameters were measured across five bores in the borefield. Water quality measurements during the November 2021 Bennelongia survey identified the water to be moderately fresh and slightly acidic. The salinity of monitoring bores was variable but within the tolerances of stygofauna (Bennelongia, 2022).

The Bennelongia (202a) survey resulted in collection of a single nematode specimen from bore CS35D; the other five bores returned no invertebrates. The Bennelongia (2022) survey resulted in the collection of thirteen nematode specimens from bores C29S and C29D, and one tubificid specimen from bore C29D. Nematodes are not assessed in the EIA process due to a lack of ecological knowledge and unresolved taxonomy.

The stygofauna results of surrounding areas were also reflected by results of sampling for the Proposal. Despite habitat appearing to be suitable for stygofauna, the two stygofauna surveys showed that a most depauperate stygofauna community is present (Bennelongia, 2021; Bennelongia, 2022).

Habitat at the Proposal is unlikely to be prospective for troglofaunal because of a shallow water table (Bennelongia, 2021; Bennelongia, 2022).

6.3.15 Environmental Values

The information provided in Section 6.3 was utilised to determine the environmental values that require assessment for this factor. Environmental Values were included for assessment based on the following parameters from the EPA's Environmental Factor Guideline; Terrestrial Fauna (EPA, 2016d):

- Fauna species listed under the EPBC Act or BC Act that were recorded or considered likely to occur within the survey areas;
- Species with restricted distribution;
- Species with a degree of historical impact from threatening processes;
- Species that provide an important function required to maintain the ecological integrity of a significant ecosystem; and
- Habitat types that are important to the life history of a significant species, i.e., breeding, feeding and roosting or aggregation areas, or where they are unique or isolate habitats in the landscape or region.

Section 6.3.11 identified four listed fauna species that were recorded within the survey areas:

- Western Brush Wallaby (*Notamacropus Irma*; P4);
- Common Greenshank (*Tringa nebularia*; Migratory);
- Black-striped Snake (*Neelaps calonotos*; P3); and
- Carnaby's Cockatoo (*Zanda latirostric;* Endangered).

A further three listed fauna species are considered to have a high likelihood of occurring within the survey areas:

- Jewelled Southwest Ctenotus (*Ctenotus gemmula*; P3) (BBSA only);
- Fork-tailed Swift (*Apus pacificus*; Migratory); and
- Bothriembryontid Land Snail (Moore River) (*Bothriembryon perobesus*; P1).

Twenty-two potential SRE species were recorded during Spectrum's (2022a) surveys. Of these, eight species appear to have only been recorded from the MESA.

Seven fauna habitat types and two ecotone/ mixed habitats were identified within the MESA and EISA and two fauna habitat types were identified within the BBSA. Banksia Woodland habitat is considered important for several significant fauna species including Carnaby's Cockatoo (foraging only), Western Brush Wallaby, Jewelled Southwest Ctenotus and Black-striped Snake. Habitat formed by a mosaic of Banksia Woodland and Banksia Woodland (Heath) is also considered likely to be utilised by these species. Immediately following significant rainfall, the Ephemeral Wetland and Samphire fauna habitat may represent temporary habitat for migratory shorebirds including Common Greenshank which was recorded within the Ephemeral Wetland habitat. The Melaleuca fauna habitat type was assessed to be the most likely habitat to host SRE invertebrate species due to the mesic microhabitats it supports and its limited coverage within the Survey Area.

The following Environmental Values were therefore determined to require assessment for this factor:

- General fauna species and habitat, including several habitat types that may be used by significant fauna such as Western Brush Wallaby, Jewelled Southwest Ctenotus, Bothriembryontid Land Snail, Malleefowl, Fork-tailed Swift, Common Greenshank, and other migratory shorebirds;
- Carnaby's Cockatoo (*Zanda latirostris;* Endangered); and
- SRE invertebrate species.

6.4 Potential Impacts

Table 34 defines the potential impacts (direct, indirect and cumulative) on the environmental values for this factor in a local and regional context.

Table 34: Potential impacts on terrestrial fauna

Environmental value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
General fauna species and habitat Bassendean 1030 vegetation association has more than 64% of pre-European extent remains including 9.6% that is protected for conservation. Nine fauna habitat types and two ecotones	Clearing of up to 318 ha of fauna habitat. Death or injury of fauna due to vehicle strike or earthmoving equipment. Fauna entrapment in excavations.	Increased predation or competition from introduced fauna. Alterations to fauna behaviour (including feeding or breeding characteristics) as a result of elevated dust, light or noise emissions. Reduction in habitat health as a result of: • Alterations to fire regimes;	Impacts to general fauna habitat from the Cooljarloo West Titanium Minerals Project approximately 20 km to the south east. Impacts to regional habitat from agriculture,	Clearing of up to 318 ha of fauna habitat in addition to historic disturbance and disturbance associated with other proposals. Potential death or injury of fauna from vehicle

Environmental value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
mapped within the survey areas.	Radiation exposure.	• Burying as a result of unintentional discharge of sand slurry from surface pipelines; • Establishment or spread of weed species / populations; • Reduction of groundwater depth; • Hydrocarbon spills; • Introduction or spread of dieback; and • Increase in dust emissions	resources and road infrastructure.	strike or entrapment. Some indirect impacts to fauna habitat health and fauna behavioural impacts. Radiation exposure.
Carnaby's Cockatoo (*Zanda latirostric;* Endangered) Banksia woodland and heath habitats provide very high value foraging habitat for Carnaby's Cockatoo.	Clearing of up to 289 ha of very high value foraging habitat.	Increased predation or competition from introduced fauna. Alterations to behaviour as a result of elevated dust, light or noise emissions. Reduction in habitat health as a result of: • Alterations to fire regimes; • Establishment or spread of weed species / populations; • Reduction of groundwater depth; • Hydrocarbon spills; • Introduction or spread of dieback; and • Increase in dust emissions.	Impacts to general fauna habitat from the Cooljarloo West Titanium Minerals Project approximately 20 km to the south east. Impacts to regional habitat from agriculture, resources and road infrastructure.	Clearing of up to 289 ha of very high value foraging habitat in addition to historic disturbance and disturbance associated with other proposals. Potential death or injury from vehicle strike. Some indirect impacts to habitat health and behavioural impacts.
SRE Invertebrate Fauna 22 potential SRE species recorded within the survey areas.	Clearing of up to 318 ha of potential SRE habitat.	Reduction in habitat health as a result of: • Alterations to fire regimes; • Vehicle vibrations causing habitat collapse; • Burying as a result of unintentional discharge of sand slurry from surface pipelines; • Establishment or spread of weed species / populations; • Reduction of groundwater depth; • Hydrocarbon spills; and • Introduction or spread of dieback.	No other proposals are located in close proximity to the Proposal, however local habitat has been impacted by agriculture, resources and road infrastructure.	Clearing of up to 318 ha of potential SRE habitat. Potential death or injury of fauna from vehicle strike or entrapment Some indirect impacts to habitat health.

6.5 Assessment of Impacts

The following sections assess the potential impacts on each environmental value identified in Section 6.3.15.

6.5.1 General Fauna Species and Habitat

Direct Disturbance -Regional Scale

The Proposal will result in the clearing of up to 318 ha of native fauna habitat, 191.2 ha of which will remain cleared for the life of the Proposal, 0.6 ha that will remain cleared permanently for the Bibby Road / Brand Highway intersection and up to 126.2 ha of fauna habitat that will be progressively rehabilitated as the staged pit blocks progress.

At a regional scale disturbance for the Proposal occurs predominately within vegetation association 'Bassendean 1030: Low woodland or open low woodland', which has 64.0% of its pre-European extent remaining. The Bibby Road / Brand Highway intersection upgrades at the eastern end of the EIDE disturbs a small 0.6 ha section of the vegetation system association unit Lesueur 1031: Mosaic shrublands – hakea scrub-heath/Shrublands; dryandra heath. At the western most end of the EIDE the PBA corridor intersects vegetation system association unit 'Jurien 1029: Scrub heath – mixed heath with scattered tall shrubs Acacia spp.', however, all disturbance in this area is on previously cleared land.

The Proposal will disturb 0.35% of the remaining vegetation association 1030, or 0.23% of the pre-European extent. This minor reduction is unlikely to be regionally significant given there will be 63.65% of the pre-European extent remaining after the implementation of the Proposal.

As part of the assessment of the regional significance of the clearing, the extent of the proposed clearing has been compared with the mapped regional extent of remnant native vegetation within a 10, 15, 20 and 25 km radius of the Proposal. In contrast to other areas of the Swan Coastal Plain region, the extent of remaining native vegetation remains relatively high in the vicinity of the Proposal. 21,610 ha of native fauna habitat remains within 10 km of the Proposal (68.8% of original extent), 48,893 ha remains within 15 km of the Proposal (69.7% of the original extent), 78,215 ha remains within 20 km of the Proposal (68.8% of the original extent), and 110,098 ha remains within 25 km of the Proposal (67.5% of original extent). The Beekeepers Nature Reserve and Nambung National Park also lie in proximity to the Proposal, providing protection for an estimated 13,433 ha of similar native fauna habitat.

The proposed clearing represents a reduction of 1.47% of the regional extent of native vegetation within 10 km of the Proposal, 0.65% within 15 km, 0.40% within 20 km and 0.28% within 25 km. The cumulative impacts of the proposed and existing fauna habitat clearing will therefore not be significantly increased, and significant areas of native fauna habitat will remain after implementation of the Proposal, including large areas within conservation estate. Given all areas of clearing for the Proposal will be rehabilitated and revegetated progressively or during closure and with consideration of the short mine life, clearing for the Proposal is unlikely to represent a significant impact to fauna habitats in a general regional context. This clearing is assessed in more detail from a local and ecological context in the sections below.

Direct Disturbance – Local Scale

Nine fauna habitat types (plus two ecotones) occur within the survey areas including areas allocated as Pasture/Cleared. The Pasture/Cleared habitat type is not typically considered suitable for native fauna, however several common bird species and Western Grey Kangaroo will forage on seeds and vegetation when conditions are suitable.

Table 35 and Figure 71 summarise the local extent of recorded native fauna habitats, their extent within the development envelopes and the extent of proposed clearing. Areas within the pit footprint will be progressively rehabilitated as the staged mining blocks progress. All other areas of disturbance will remain cleared for the life of the Proposal, with disturbance for the Bibby Road / Brand Highway intersection likely to remain permanently cleared for future road users. To allow some flexibility for the final disturbance footprint, habitat disturbance estimates in Table 35 have been slightly overestimated and therefore the total indicative disturbance of native habitat exceeds the proposed 318 ha of total clearing for the Proposal. As these estimates represent the maximum indicative disturbance for each habitat type, the actual clearing of individual habitat types will likely be less than estimated.

Table 35: Potential impacts on general fauna habitat at a local scale

Fauna / Habitat	Extent in Survey Areas (ha)	Extent in development envelopes (ha)		Extent of Indicative Disturbance			
				Permanent or life of the Proposal (ha)	Progressively Rehabilitated (ha)	Total (ha)	Proportion of mapped extent
Banksia Woodland	**687.7**	343.0	(50%)	160.2	72.6	232.8	34%
Heath (Banksia)	**168.3**	76.1	(45%)	26.3	23.3	49.7	30%
Samphire	**65.6**	24.5	(37%)	8.5	10.6	19.2	29%
Melaleuca	**51.4**	17.4	(34%)	5.5	7.6	13.1	26%
Banksia Woodland / Heath (Banksia)	**22.5**	7.6	(34%)	1.2	5.2	6.5	29%
Melaleuca / Samphire	**3.8**	2.7	(70%)	0.4	1.0	1.4	38%
Banksia woodland / Allocasuarina shrubland	21.7	0.6	(3%)	-	-	0.0	0%
Ephemeral Wetland	**13.7**	1.2	(9%)	0.0	0.5	0.5	3%
Eucalypt Woodland	**1.4**	-	-	-	-	-	0%
TOTAL NATIVE HABITAT	**1036.1**	**473.0**	**(46%)**	**202.2**	**120.9**	**323.2**	**31%**
Grove of Non-endemic trees	0.1	-	-	-	-	-	0%
Pasture / Cleared	**239.5**	53.4	(22%)	42.0	5.2	47.3	20%
TOTAL	**1275.7**	**526.4**	**(41%)**	**244.3**	**126.2**	**370.4**	**29%**

Based on data presented in Table 35, only a small portion (or none) of the locally mapped extent of the following native fauna habitats and ecotones occur within the development envelopes:

- Banksia woodland / Allocasuarina shrubland (3%);
- Ephemeral Wetland (9%); and
- Eucalypt Woodland (none).

The Cleared/Pasture habitat within the development envelopes has been predominately aligned with pre-existing tracks and road reserves to minimise additional disturbance for the Proposal, and areas of pasture provide minimal habitat value for native fauna species.

Additional assessment of the remaining habitats is provided in the following sections. Habitat values associated with the two ecotones are closely reflected within the respective overlapping habitat types.

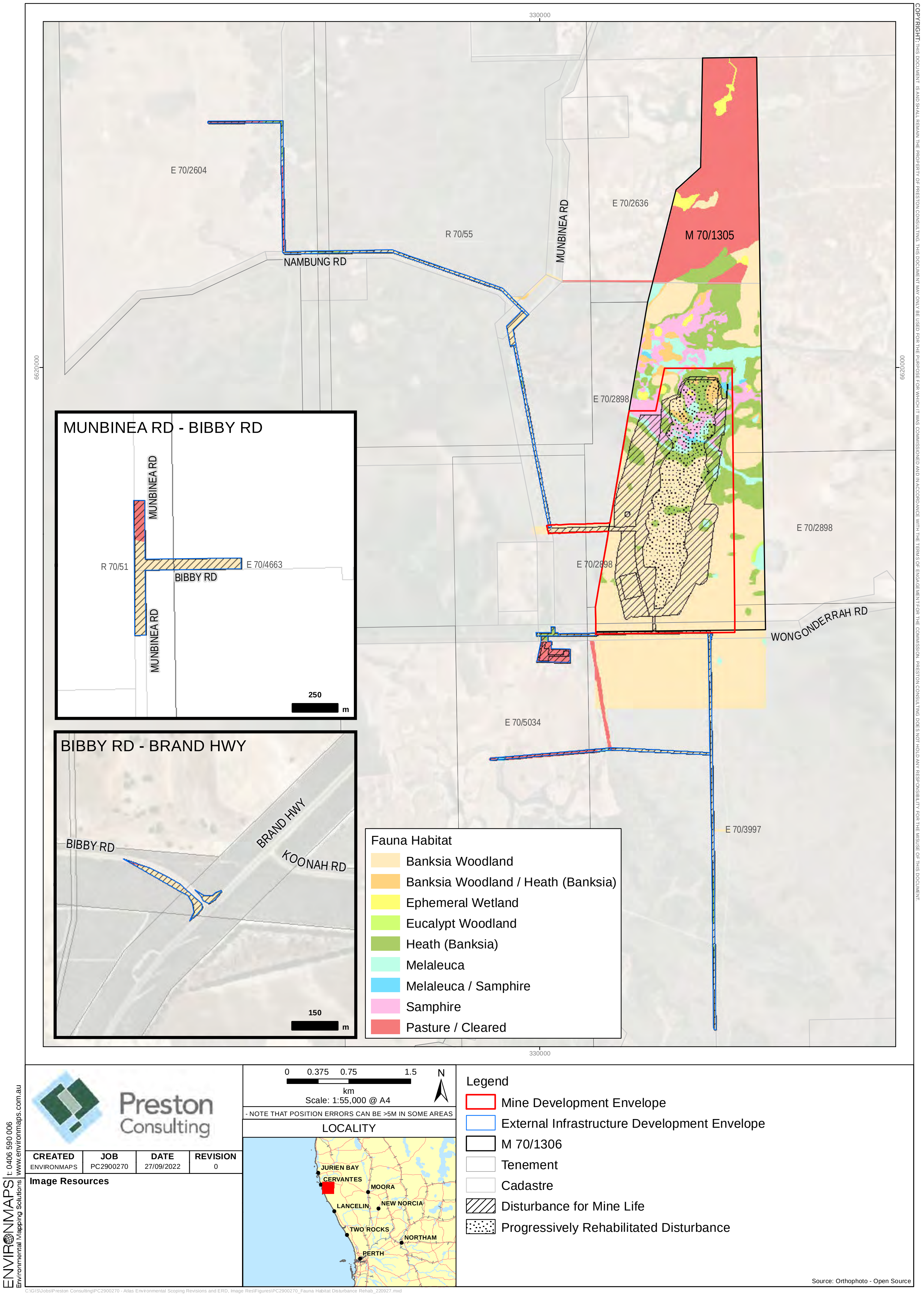


Figure 71: Fauna habitats to be disturbed by the Proposal

Banksia Woodland

The Banksia Woodland habitat types are the most extensive habitat type, accounting for approximately 65% of the habitats mapped within the development envelopes. Up to 232.8 ha of this habitat type is proposed to be disturbed, as well as 5.0 ha of Banksia Woodland / Heath (Banksia) ecotone.

Avifauna species associated with Banksia Woodland habitat include generalist species such as the Rufous Whistler, Australian Magpie, Willie Wagtail and Magpie-lark. Spectrum (2022a) recorded an abundance of nectarivorous species such as White-cheeked and Brown Honeyeaters, likely due to the nectar provided by flowering *B. menziesii* and *B. attenuate*, however birds of prey were scarce, with only one Australian Kestrel recorded. The most encountered reptile species within Banksia Woodland were the Western Heath Dragon, restricted to sandy habitats, and the West-coast Laterite Ctenotus which is a habitat generalist. The Crawling Toadlet and Moaning Frog were recorded on multiple occasions, both during systematic trapping and opportunistic nocturnal surveys. Mammal capture and observation rates were low during the survey though the Dusky Dunnart and Honey Possum were both captured within Banksia Woodland habitat. The Dusky Dunnart is a small carnivorous marsupial that preys on any fauna species it can overpower. The Honey Possum is endemic to WA and feeds exclusively on nectar within proteaceous woodlands and heath.

Two significant vertebrate fauna species (Western Brush Wallaby; P4 and Black-striped Snake P3) were recorded from Banksia Woodland habitat within the MDE and three species were assessed to have a high likelihood of occurrence within this habitat (Carnaby's Cockatoo (EN), Fork-tailed Swift (MI) and the Bothriembryontid Land Snail (P1) (360 Environmental, 2012c; Spectrum, 2022a).

Banksia Woodland may also provide limited microhabitats (e.g., deep leaf litter beds) suitable for use by SRE species, however the habitat was regionally extensive with a high level of connectivity prior to European settlement and as such is unlikely to have provided conditions known to produce SREs. Spectrum (2022a) captured nine potential SREs within Banksia Woodland habitat including two millipede, five pseudoscorpion, one isopod and one spider.

An estimated 60% of native Banksia Woodland has been cleared within the Swan Coastal Plain and consequently, this vegetation community has been listed as a TEC / PEC. A key reason for the listing of Banksia Woodlands as a TEC / PEC is the fauna assemblages it supports. Impacts to this TEC / PEC has been assessed in detail in Section 5.5, which concluded that the disturbance of this TEC / PEC would be considered a significant residual impact of the Proposal. Offsets are proposed to counterbalance this residual impact (Section 12). The disturbance of this TEC / PEC would also be considered significant from a fauna perspective, particularly due to the loss of foraging habitat for the Carnaby's Cockatoo. Those impacts are discussed in detail in Section 6.5.2.

Heath (Banksia)

Heath (Banksia) habitat covers approximately 14% of the development envelopes. Up to 49.7 ha of this habitat type is proposed to be disturbed, as well as 6.5 ha of Banksia Woodland / Heath (Banksia) ecotone.

Structurally this habitat type was lower and denser than Banksia Woodland. The dominant shrub species *Banksia telmatiaea* provides both shelter for heath species and abundant nectar when in flower. Generalist bird species such as the Australian Magpie, Black-faced Woodswallow, Brown Honeyeater and Singing Honeyeater were regularly recorded by Spectrum (2022a) as well as heath specialist species like the Tawny-crowned Honeyeater and White-browed Scrubwren. A single Australian Kestrel was also recorded which prefer habitats with low vegetation over which to hunt. Few reptiles were recorded within the Heath (Banksia) though the fossorial Western Slender Blue-tongue and Burton's Legless Lizard were recorded by Spectrum (2022a) during systematic trapping and opportunistically. Three species of frog were captured systematically including a single Turtle Frog, an unusual burrowing species not recorded anywhere else in the survey areas. No native mammals were captured within Heath (Banksia) habitat though Western Grey Kangaroos were conspicuous and regularly observed.

No conservation significant vertebrate fauna species were recorded from Heath (Banksia) habitat. Five species were however assessed to have a high likelihood of occurrence within this habitat; Carnaby's Cockatoo (EPBC/BC Act Endangered), Fork-tailed Swift (EPBC/BC Act Migratory), a Bothriembryontid Land Snail (DBCA Priority 1; Moore River sub-population), Black-striped Burrowing Snake (DBCA Priority 3) and the Western Brush Wallaby (DBCA Priority 4). Heath (Banksia) is a proteaceous woodland and is known to provide important foraging habitat for Carnaby's Cockatoo though it does not represent breeding habitat.

Heath (Banksia) represents suitable habitat for Malleefowl (*Leipoa ocellata*) though no individuals or secondary evidence in the form of nesting mounds (contemporary or historical) or tracks were observed (Spectrum, 2022a).

As with the Banksia Woodland, Heath (Banksia) habitat may provide limited microhabitats (e.g., deep leaf litter beds) suitable for use by species SREs, however, the habitat is well drained and does not provide the habitat isolates and mesic (moderate or well-balanced supply of moisture) refugia typically associated with SRE fauna. Spectrum (2022a) captured two potential SREs (one isopod and one centipede) within Heath (Banksia) habitat.

The disturbance of this habitat type is considered significant due to the loss of foraging habitat for the Carnaby's Cockatoo. Those impacts are discussed in detail in Section 6.5.2.

Samphire

Samphire habitat covers approximately 5% of the development envelopes. Up to 19.2 ha of this habitat type is predicted to be disturbed, as well as 1.2 ha of the Melaleuca / Samphire ecotone.

These are low lying, saline areas that often occur adjacent to Ephemeral Wetland habitat. Vegetation is typically low and dense, offering little protection from the wind. Generalist bird species may pass through Samphire habitat though the species most frequently encountered are known to prefer the open, seasonally inundated habitat that Samphire provides. The Australian Pipit and White-fronted Chat are two such species that were recorded during the survey. Spectrum (2022a) recorded only three reptile species within Samphire habitat, two Shrubland Morethia Skinks and a Common Dwarf Skink. This limited result reflects the saturated substrate (restricting options for burrowing species) and sparse vegetation (offering little shelter and food resources). Consequently, there are no Samphire specialists occurring in the region (Spectrum, 2022a). A single Crawling Toadlet was also recorded. No mammals were captured during systematic trapping within Samphire habitat. Western Grey Kangaroos were observed frequently passing through this habitat though they did not appear to be foraging or sheltering within it. No conservation significant vertebrate fauna species were recorded from Samphire habitat, however, the Common Greenshank (EPBC/BC Act Migratory) was recorded from an Ephemeral Wetland immediately adjacent to systematic trapping site APS7TRAP located in Samphire habitat.

During significant rainfall events these low-lying Samphire areas are likely to become inundated and provide temporary habitat for a range of shorebird and wader species, many of which are listed as migratory under state and federal legislation. Suitable habitat for these species within the survey areas is dependent on rainfall and season, with suitable conditions generally lasting for very short periods, if at all. Due to the temporary nature of the flooding within the Samphire habitat, it is not likely to represent critical habitat as more permanent and substantial habitat is available within the immediate region (e.g., Lake Thetis 16 km west of the Proposal).

Fork-tailed Swifts (EPBC/BC Act Migratory) may also pass over this habitat though are unlikely to be impacted by any on ground development or infrastructure due to their aerial habits.

Samphire habitat within the survey areas did not possess relictual (a restricted area whose range was far wider during a previous geologic epoch) habitat characteristics typically associated with terrestrial SRE species, however five SRE species were collected via wet pitfall trap from this habitat (Spectrum, 2022a).

Approximately 63% of the locally mapped extent of this habitat type has now been excluded from the development envelopes and it is estimated that 70% of the extent will not be disturbed by the Proposal. Given the limited habitat value this impact is considered unlikely to be significant.

Melaleuca

Melaleuca habitat, found in low lying depressions and associated with ephemeral wetlands and drainage lines, covers approximately 3% of the development envelopes. Up to 13.1 ha of this habitat type is predicted to be disturbed, as well as 1.4 ha of the Melaleuca / Samphire ecotone.

These areas are intermittently inundated following significant rainfall, creating damplands that support mesic microhabitats. The dense shrub cover and flowering plant species found within Melaleuca habitat supports a variety of bird species. Large numbers of nectarivorous Grey-breasted White-eyes, Singing Honeyeaters and Whitecheeked Honeyeaters were recorded as well as insectivorous species such as Splendid Fairy-wrens, Willie Wagtails and Rainbow Bee-eaters (Spectrum, 2022a). Small pools associated with minor drainage lines also provide habitat for Australian Spotted Crake and Pacific Black Ducks. Few reptiles were recorded within this habitat type. The West-coast Laterite Ctenotus (a skink) and Common Dwarf Skink were the most frequently encountered by Spectrum (2022a) and Bobtails were also regularly seen basking at the bases of shrubs in the mornings during trap clearance.

The thick vegetation, damp conditions and areas of surface water provide optimal conditions for certain frog species within the Melaleuca habitat. Moaning Frogs and Crawling Toadlets were captured in large numbers and the only records of the Squelching Froglet were also made in this habitat (Spectrum, 2022a).

No mammals were directly observed in Melaleuca habitat though secondary evidence suggested that Western Grey Kangaroos regularly use these areas for foraging and shelter.

Two conservation significant vertebrate fauna species were assessed by Spectrum (2022a) to have a high likelihood of occurrence within Melaleuca habitat. Western Brush Wallaby (DBCA P4) is known to utilise areas of dense vegetation for shelter and the Fork-tailed Swift (EPBC/BC Act

Migratory) is likely to pass over this habitat on occasion though is unlikely to be affected by on ground development due to their aerial habits.

The freshwater damplands associated with Melaleuca habitat provide microhabitats suitable for SRE invertebrate species. Five potential SRE species were recorded from Melaleuca habitat (Spectrum, 2022a).

Impacts to this habitat type are unlikely to be significant as 66% of the locally mapped extent of this habitat type was excluded from the development envelopes and it is estimated that 74% of the extent will not be disturbed by the Proposal.

Summary

No fauna species restricted to the above-mentioned fauna habitats and the Proposal's proximity to the Beekeepers Nature Reserve and Nambung National Park provides protection of similar and connected habitats in the local area. Given the proposed progressive rehabilitation method and the presence of similar habitat in the survey areas, the direct disturbance of the Proposal is therefore considered unlikely to have a significant impact on the availability of habitat for general fauna populations in the area.

The Banksia Woodlands and Heath (Banksia) habitat types are considered to be significant foraging habitat for Carnaby's Cockatoo and therefore the disturbance of those habitat types are likely to be considered significant. A detailed assessment of these impacts is provided in Section 6.5.2.

Vehicle / Earthmoving Equipment Strike

There is a risk of fauna death or injury if fauna are struck by earthmoving equipment during clearing or mining. The majority of larger fauna would be expected to flee the areas to be cleared as the equipment approaches. It is likely however that there will be some fauna injuries or deaths during these activities. Image will implement management measures to minimise this likelihood (refer to Section 6.5).

Vehicle strike may lead to fauna injuries or fatalities as light vehicles and trucks will regularly use the haul and access roads. Vehicle movements have been avoided where possible, for example a slurry pipeline is proposed between the FPP and the WCP (reducing the need to transport ore via truck). Furthermore, vehicles will be speed restricted on site to reduce the likelihood of vehicle strike.

Based on the above, any fauna strike impacts are likely to be rare and not significant on a local or regional scale.

Introduced Fauna

Introduced species were recorded in fauna surveys within the study areas including cats and foxes (Spectrum, 2022a). The Proposal has the potential to introduce additional species or increase the population of existing introduced species, through the following vectors:

- Food wastes at work areas; or
- Presence of cleared corridors that may be utilised by introduced fauna for access or predation.

The workforce will be relatively small, and the appropriate management and disposal of food wastes (refer to Section 6.5) will ensure that food wastes do not attract fauna to the area. No pets will be brought to site.

Roads can result in increases in predator activity by providing movement pathways or improved access for predatory hunting and travel (Raiter, 2016). Pipeline and access road corridors will utilise existing disturbance associated with tracks and agricultural land wherever possible and are therefore unlikely to significantly increase feral predator activity. Cleared areas for mining and processing are likely to present the greatest risk, however regular vehicle movements and mining activity in these areas are likely to deter feral animal presence. Feral animal controls will be implemented for the Proposal where required to minimise the presence and activity of introduced species (refer to Section 6.5).

With the implementation of controls (refer to Section 6.5) potential introduced fauna impacts described above are expected to be able to be appropriately mitigated such that impacts are not significant on a local or regional scale.

Altered Fauna Behaviour

The Proposal has a small operational footprint and will produce low levels of artificial light and noise emissions will be relatively localised. The main sources of noise and light emissions will be the processing areas (FPP and WCP), which cover only several hectares. Equipment moving within the mining area will produce noise emissions, however this will be limited to a small area given the progressive mining footprint. Nevertheless, it is expected that some fauna will keep their distance from the mining area while operating. With the implementation of controls (refer to Section 6.5) potential increased risks to fauna from light or noise emissions are expected to be able to be appropriately mitigated such that impacts are not significant on a local or regional scale.

Altered Fire Regimes

Fire is a known disturbance mechanism within the Swan Coastal Plan, however survey areas at the Proposal were characterised as being long unburnt with no fire thought to have occurred in the area for more than 12 years.

Mining activities have the potential to ignite bushfires through hot work and other activities, however with appropriate firefighting and prevention management measures in place (Section 1.4), the development of the Proposal will improve the ability to immediately fight fire outbreaks and prevent them from spreading. The potential for increased fire risk is therefore not expected to be significant.

Habitat Burial as a Result of Slurry Spills

The slurry pipeline will transport slurried ore between the FPP and the WCP. Although the pipeline will run through cleared areas within the plant and loadout area, a rupture of this pipeline has the potential to release sand slurry (sand and water) into the surrounding habitat if it were to occur. Routine inspections and leak detection (where there is potential to impact native vegetation) is proposed for this pipeline, which will trigger an automatic shut-down of the pipeline feed. This will restrict the volume of sand slurry that would be released into the surrounding environment. Image will also investigate the option of containing a spill if it was to occur, by placing the pipe in a system of bunds and sumps designed to contain spillage. The details of these systems are generally planned and managed via a Works Approval under Part V of the EP Act and a Mining Proposal under the Mining Act. Additional mitigation measures are proposed in Section 6.5 to minimise the likelihood and potential impact of a slurry pipeline spill.

Weeds

Weeds have the potential to reduce habitat quality by outcompeting and displacing native vegetation if introduced or conditions are altered to favour their growth. Weeds may be spread and/or introduced by vehicles and equipment, resulting in soil and weed vegetative material being transported around site and being present on equipment entering and exiting site.

A total of 89 introduced species were identified during flora / vegetation surveys for the Proposal. None of these species are listed as WoNS, however one is listed as a Declared Pest under the BAM Act (the one leaf Cape Tulip (*Moraea flaccida*)). Given the presence of these weed species, weed management measures will be implemented to prevent or minimise the spread of weeds and any increased competition with native species (Section 1.4).

Reduction of Groundwater Depth

Dewatering of the mine pit will be required to allow the safe 'dry' mining of the resource. Much of the vegetation in the area was considered to be potentially groundwater-dependant therefore significant investigations have been undertaken to identify suitable drawdown mitigation measures. These are discussed in detail in Section 7.5, however in general terms a series of short trenches will be installed around the edge of the mine disturbance footprint and water will be pumped into these pits to keep the aquifer in the surrounding vegetation at background levels. Impacts from groundwater drawdown are therefore predicted to not extend outside the proposed disturbance areas.

Groundwater abstraction for water supply is proposed to occur within one or more borefields. The focus of this abstraction is to target aquifers that have little to no connection to the superficial aquifer, such that there would be a negligible reduction in the level of groundwater that may currently be accessed by vegetation. Hydrogeological investigations are well-progressed but are yet to be finalised, however a water supply source will not be developed unless the parameters above are able to be met.

Hydrocarbon Spills

Considering the small scale of operations planned for the Proposal, large-scale hydrocarbon spills are considered unlikely. Small hydrocarbon spills associated with hydraulics failures on machinery and refuelling spills may occur on occasion in operational areas. Spills generally result in a defined area of hydrocarbon-contaminated soil that can be remediated via passive means such as bioremediation. Proposed control measures are identified in Section 6.5 and are designed to further reduce the risk of fauna habitat impacts from hydrocarbon spillage.

Dieback

Dieback disease caused by *P. cinnamomi* continues to be a significant environmental issue within the southwest region of WA, affecting the distribution and abundance of many native plant species. Assessment of Dieback occurrence at the Proposal identified 297.3 ha of Uninterpretable vegetation, in which dieback may be present (in very low levels as an endemic or incipient disease) without showing signs of its presence or the determination of the presence of the pathogen is not possible using interpretation methods. Given the risk of dieback, hygiene management measures will be required to be implemented to prevent the introduction of dieback (Section 6.5).

Vegetation and Dust

The construction and operation of the Proposal will result in the generation of dust. Dust generation is discussed further in Section 9.5. There is the potential deposited dust to affect the health of susceptible vegetation by adversely affecting photosynthesis and transpiration rates. As the Proposal is in an area of high biodiversity, the potential for deposited dust to have an effect upon the health of vegetation has been considered.

There are no specific assessment guidelines available for impacts on vegetation from dust deposition, however, several studies on impacts on vegetation from particulate deposition have been completed in Australia and globally. Most studies of the effects of mineral dusts on vegetation have focussed on dusts that have chemical effects (e.g., cement dust) or where dust loads exceed 7 g/m^2. Relatively inert mineral dust, such as those generated in the mining process or from unsealed haul roads principally influence light and temperature relations of leaves.

A study by Doley and Rossato (2010) used published data to assess the impacts of particulate deposition on photosynthesis in cotton leaves and canopies. The study indicated that many plant species have similar ranges of values for the photosynthetic parameters used in assessing the impacts on cotton and it is possible to use the cotton estimates as a general estimate to model the impacts of particulate deposition and thereby the environmental risks associated with dust generating activities. The results of the study indicated that at deposition levels of approximately 9 g/m^2/month, the estimated reductions in canopy photosynthesis of cotton plants would be less than 7% with a <1% decrease in productivity (Doley & Rossato, 2010).

The dust assessment in Section 9.5.3 determined that dust deposition levels were unlikely to be significant in surrounding areas. The separation distance between the Proposal and the closest conservation reserves (Nambung National Park, over 1.5 km away from mining areas) exceeds the recommended generic buffer distance (discussed further in Section 9.5) established for protection of amenity (EPA, 2005), considered in the context of this Proposal to be a suitable proxy for the assessment of potential effects upon vegetation from dust deposition.

More generally, native vegetation in the region is expected to be reasonably tolerant to dust deposition and at minimal risk of physiological impacts (Eco Logical Australia, 2016), being adapted to high dust levels that occur naturally in summer under the combination of high winds and low rainfall. Dust deposition will be mitigated to some extent by periodic high rainfall events, which would remove built-up materials on foliage.

Based on the above, dust emissions from the Proposal are not expected to have a significant impact on fauna habitat condition.

Radiation

The Proposal will involve mining the Atlas deposit, a mineral sands deposit which contains naturally-occurring Uranium (U) and Thorium (Th) within heavy minerals (approximately 8.1% of the ore reserve). The decay series of naturally-occurring ^{238}U and ^{232}Th contain gamma-emitting radionuclides are a potential source of external radiation/hazard when present in elevated concentrations. The temporary stockpiling and transport of HMC for the Proposal therefore has the potential to cause elevated radiation exposures of fauna during operations. Radiation associated with the Proposal is discussed further in Section 10 and the associated mitigation (including the implementation of a Radiation Management Plan: RMP) of impacts to human health are expected to adequately address any potential impacts to fauna.

Potential exposure pathways for fauna include:

- Radionuclides in fugitive dust and in radon (^{222}Rn) and thoron (^{220}Rn);
- Direct exposure to the external gamma radiation from HMC stockpiles and in certain sections of the plant; and
- Indirect exposure where radionuclides in fugitive dust enter the body via inhalation, ingestion, and wounds, or by absorption through the skin.

Inhalation of radionuclides in fugitive dust is expected to be an insignificant pathway at the Proposal. The mineral grain is large and heavy, minimising the possibility of suspension in air for considerable distances. Furthermore, ore bearing heavy mineral sand is transported in the form of a wet slurry, from the stage of primary screening in the open pit, further eliminating the possibility of exposure by dust emission.

Radon is not expected to be generated in measurable amounts due to the relatively low content of uranium in the HMC. Thoron is expected to be detectable, but the exposures are expected to be insignificant due to low thorium concentrations in the HMC and the very short half-life of thoron (only 56 seconds).

Direct exposure of fauna to the external gamma radiation from HMC stockpiles is unlikely to occur during operations due to increased activity, noise and light acting as a deterrent in these areas. Furthermore, the relatively low concentrations of thorium and uranium in the HMC is considered unlikely to result in significant exposure to any fauna that may incidentally traverse the area. Radiation from the Proposal is therefore unlikely to result in any unacceptable risk to fauna to fauna.

Summary

The Proposal will result in clearing of up to 318 ha of native vegetation, 122.9 ha of native vegetation cleared for the mine pit will be progressively rehabilitated during operations, 0.6 ha will remain permanent cleared (Bibby Road / Brand Highway intersection) and the remaining 183 ha will be rehabilitated post-closure.

Management and monitoring is proposed during the operational phase to further minimise indirect impacts to general fauna and their habitats (refer to Section 6.5).

The assessment above identified that the Proposal was unlikely to result in significant impacts to general fauna species and their habitats, however there are potential impacts to specific fauna values that require further assessment. These assessments are provided in the following sections.

6.5.2 Carnaby's Cockatoo (*Zanda latirostris*)

Direct Disturbance

Carnaby's Cockatoo were recorded within the survey areas and very high quality foraging habitat was mapped within the development envelopes. No roosting or breeding habitat was recorded within the development envelopes.

Spectrum (2022a) identified suitable foraging habitat within the development envelopes in the form of Banksia Woodland, Heath (Banksia) and Banksia Woodland/Heath (Banksia).

The Proposal will result in the clearing of up to 289 ha of the identified very high value Carnaby's Cockatoo foraging habitat, 187.8 ha of which will remain cleared for the life of the Proposal, and up to 101.2 ha that will be progressively rehabilitated as the staged pit blocks progress (Figure 72).

Foraging Value

One of the primary threats to Carnaby's Cockatoo is the ongoing loss of Banksia Woodland habitat on the Swan Coastal Plain. Although detailed research into the feeding ecology of Carnaby's Cockatoo is ongoing, *Banksia* spp. Are known to be critical food sources. An estimated 60% of native Banksia Woodland has been cleared within the Swan Coastal Plain and consequently, this ecological community has been listed as a TEC/PEC.

Using the DotEE (2017a) scoring tool, Spectrum (2022a) assessed the identified habitat for the Carnaby's Cockatoo within the development envelopes as nine (very high quality) foraging habitat. Evidence and observations of Carnaby's Cockatoo foraging have been recorded and the species has been well documented using similar habitats across the surrounding region (Spectrum, 2022a).

The Proposal is located outside of the breeding range of Carnaby's Cockatoo, however the region is considered as important foraging habitat as juvenile cockatoos move into the area after fledging from breeding sites located to the east. While breeding, black cockatoos will generally forage within a 6 – 12 km radius of their nesting site. Following breeding, birds assemble into flocks and move through the landscape searching for food, usually foraging within 6 km of a night roost. Because of this mobility, potential for reduced seed set and flowering due to drought, and the irregular or infrequent flowering and fruiting patterns of many of their food sources, large areas of foraging habitat are required to support black cockatoo populations (DSEWPaC, 2012). Two roost sites were identified within 12 km of the Proposal and an additional seven roost sites are located in the surrounding region (Figure 67).

Significance of Disturbance

Up to 289 ha of Carnaby's Cockatoo foraging habitat is proposed to be disturbed, which represents 33% of the total extent mapped within the survey areas. More than 589.5 ha of mapped very good quality foraging habitat will therefore remain intact in the immediate area, in addition to the extensive habitat outside the survey areas.

As part of the assessment of the regional significance of the clearing, the extent of the proposed clearing has been compared with the mapped regional extent of remaining remnant native vegetation within a 10, 15, 20 and 25 km radius of the Proposal. While it is acknowledged that only a portion of the remaining remnant vegetation would be Carnaby's Cockatoo foraging habitat, it provides general context of the likely proportion of remaining foraging habitat that is likely to remain in the surrounding area.

In contrast to other areas of the Swan Coastal Plain region, the extent of remaining native vegetation remains relatively high in the vicinity of the Proposal. 21,610 ha of native fauna habitat remains within 10 km of the Proposal (68.8% of original extent), 48,893 ha remains within 15 km of the Proposal (69.7% of the original extent), 78,215 ha remains within 20 km of the Proposal (68.8% of the original extent), and 110,098 ha remains within 25 km of the Proposal (67.5% of original extent). The Beekeepers Nature Reserve and Nambung National Park also lie in proximity to the Proposal, providing protection for an estimated 13,433 ha of similar native fauna habitat.

The proposed disturbance represents a reduction of 1.47% of the regional extent of native vegetation within 10 km of the Proposal, 0.65% within 15 km, 0.40% within 20 km and 0.28% within 25 km. The cumulative impacts of the proposed and existing vegetation clearing will therefore not be significantly increased, and significant areas of foraging habitat are likely to remain after implementation of the Proposal, including large areas within conservation estate. Given all areas of clearing for the Proposal will be rehabilitated and revegetated progressively or during closure and with consideration of the short mine life, clearing for the Proposal is unlikely to represent a significant impact to fauna habitats in a general regional context.

The clearing of habitat will be progressive, therefore there will be areas of foraging habitat that will be retained as mining progresses. Additionally, the short mine life would result in rehabilitation to commence within a short period following the completion of mining.

Based on the information provided above, it is likely that the Proposal will progressively remove foraging habitat, and there will be some time before suitable foraging species grow to a maturity level that is suitable to once again support foraging by this species. While this loss is unlikely to result in significant impacts to local and regional populations (given the large areas of remaining foraging habitat in the area), Image is aware that habitat loss is a key contributor to the decline of this species in WA. Taking this into consideration, the loss of any foraging habitat is considered to be a significant residual impact and offsets are proposed to counterbalance that impact (Section 12).

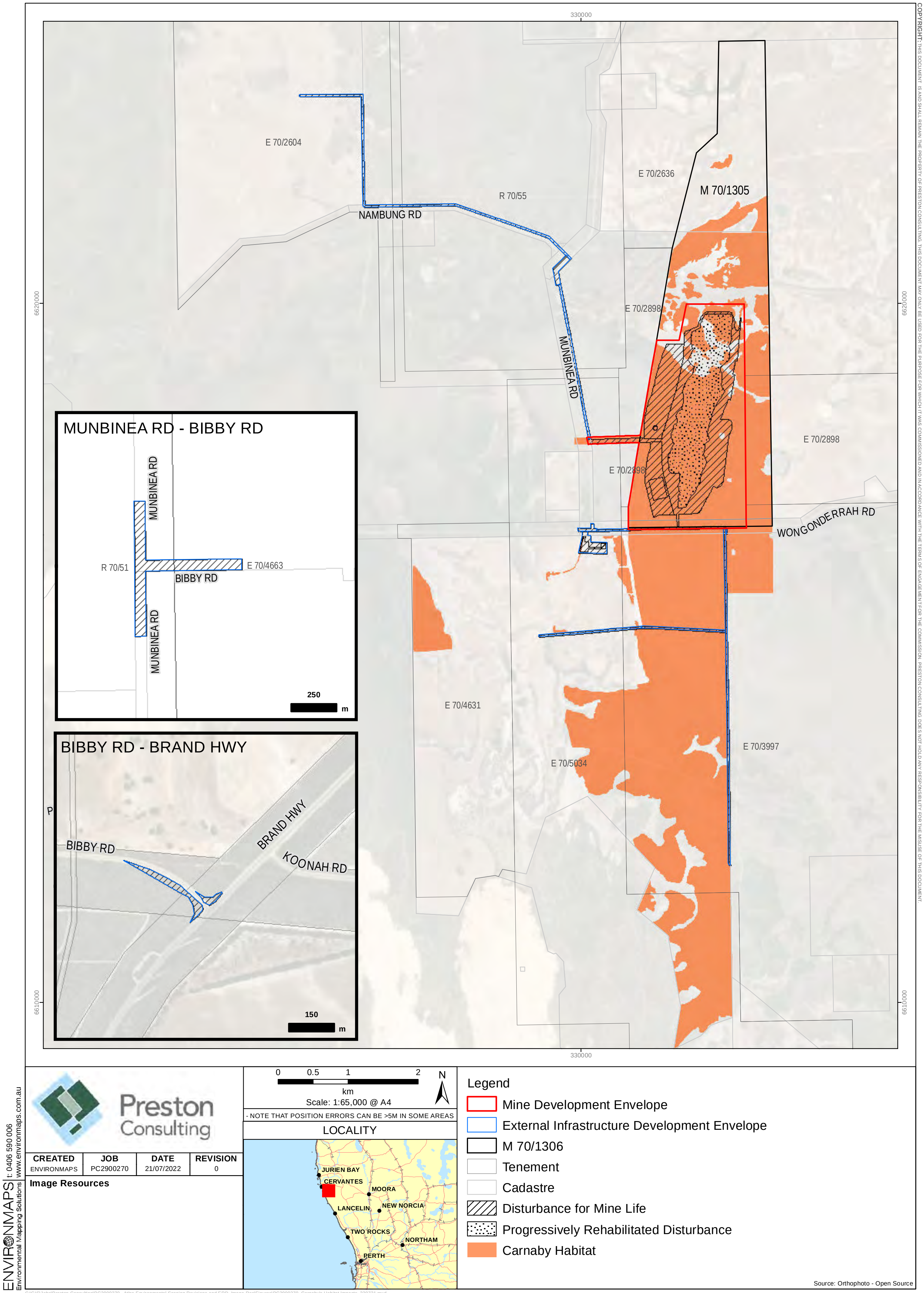


Figure 72: Mapped Carnaby's Cockatoo foraging habitat in relation to the disturbance footprint

Introduced Fauna

Introduced species were recorded in fauna surveys within the study areas including cats and foxes (Spectrum, 2022a). The Proposal has the potential to introduce additional species or increase the population of existing introduced species, through the following vectors:

- Food wastes at work areas; or
- Presence of cleared corridors that may be utilised by introduced fauna for access or predation.

The workforce will be relatively small, and the appropriate management and disposal of food wastes (refer to Section 6.5) will ensure that food wastes do not attract fauna to the area. No pets will be brought to site.

Roads can result in increases in predator activity by providing movement pathways or improved access for predatory hunting and travel (Raiter, 2016). Pipeline and access road corridors will utilise existing disturbance associated with tracks and agricultural land wherever possible and are therefore unlikely to significantly increase feral predator activity. Cleared areas for mining and processing are likely to present the greatest risk, however regular vehicle movements and mining activity in these areas are likely to deter feral animal presence. Feral animal controls will be implemented for the Proposal where required to minimise the presence and activity of introduced species (refer to Section 6.5).

With the implementation of controls (refer to Section 6.5) potential introduced fauna impacts described above are expected to be able to be appropriately mitigated such that impacts to Carnaby's Cockatoo individuals or populations are not significant on a local or regional scale.

Altered Behaviour

The Proposal has a small operational footprint and will produce low levels of artificial light and noise emissions. The main sources of noise and light emissions will be the processing areas (FPP and WCP), which cover only several hectares. Equipment moving within the mining area will produce noise emissions, however this will be limited to a small area given the progressive mining footprint. Nevertheless, Carnaby's Cockatoo may keep some distance from the mining area while operating. One potential roosting site was identified on Nambung Station, near the proposed accommodation camp, however this site is located away from the mining areas and within the existing caravan park. Some behavioural impacts may occur due to noise and activity at the accommodation camp, however this will be short-term given the short mine life of the Proposal.

With the implementation of controls (refer to Section 6.5) potential increased risks to Carnaby's Cockatoo from light or noise emissions are expected to be able to be appropriately mitigated such that impacts are not significant on a local or regional scale.

Vehicle / Earthmoving Equipment Strike

There is a risk of death or injury if fauna are struck by vehicles, or earthmoving equipment during clearing or mining. Carnaby's Cockatoo would be expected to flee the areas to be cleared as equipment approaches and given their roosting and foraging behaviour would be unlikely to frequently utilise road surfaces and cleared areas. Nevertheless Image will implement management measures to minimise the likelihood of fauna strike (refer to Section 6.5), for example vehicles will be speed restricted on site to reduce the likelihood of vehicle strike.

Based on the above, Carnaby's Cockatoo strike impacts are likely to be rare and therefore would be unlikely to result in significant impacts to the species on a local or regional scale.

Indirect Habitat Impacts

Section 6.5.1 provides a detailed assessment of indirect impacts on fauna habitat, which showed that indirect impacts would be minimal outside the area of direct disturbance. This assessment is suitable for this value also, with the Proposal considered unlikely to indirectly impact Carnaby's Cockatoo habitat if the mitigation measures listed in Section 6.5 are implemented.

Summary

Breeding or roosting habitat has not been recorded within the development envelopes. The Proposal will result in the clearing of up to 289 ha of the identified very high value Carnaby's Cockatoo foraging habitat.

This section has identified that there are large areas of similar potential foraging habitat in the region including the nearby Beekeepers Nature Reserve and Nambung National Park that will not be impacted by the Proposal. However, given the extent of the reduction in habitat for this species across its range the residual impacts described above are deemed to be significant and are proposed to be counterbalanced by offsets (refer to Sections 6.5 and 12).

6.5.3 SHORT-RANGE ENDEMIC FAUNA

Direct Disturbance

Spectrum (2022a) identified 22 potential SRE species recorded within the survey areas of which five were recorded within the MDE and three within the indicative disturbance footprint.

The Melaleuca fauna habitat type was assessed to be the most likely habitat to host SRE species due to the mesic microhabitats it supports and its limited coverages within the survey areas. Samphire habitat within the survey areas did not possess relictual habitat characteristics typically associated with terrestrial SRE species. However, five species belonging to SRE target groups were collected via wet pitfall trap from this habitat. Complex, mesic, and often isolated microhabitats in an otherwise dry and well drained environment may support relictual species isolated by aridification or habitat specialists that have adapted to utilise these areas.

As discussed in Section 6.5.1, the Proposal will result in the clearing of up to 318 ha of native fauna habitat, including habitat where three of the 22 potential SRE species were recorded. All three species were however also recorded locally outside of the MDE. Local populations of these species are therefore not restricted to the MDE and are expected to continue to occupy the local area.

Two potential SRE species *Maratus* 'BAR130' and *Antichiropus whistleri* (formerly *Antichiropus* sp. 713614) were recorded within the MDE, however they are well outside of the indicative disturbance footprint (Figure 73). *Antichiropus whistleri* has been recorded elsewhere, outside of the development envelopes. The specimen *Maratus* 'BAR130' collected in Banksia Woodland by Spectrum (2022a) was noted to be an undescribed species following preliminary analysis. No further specimens of the *Maratus* genus were collected during the regional SRE survey (Spectrum, 2022b). To ensure impacts to this species are minimised Image will ensure that record location and adjoining habitat remains outside the disturbance area. This is committed to in Section 6.5.

Impacts of the Proposal on potential SRE species recorded are summarised in Table 36 and shown in Figure 73.

Table 36: Potential SRE fauna impacted by the Proposal

SRE fauna	Records within Survey Area	Recorded locations within MDE	Records in indicative disturbance footprint	Records restricted to the disturbance footprint
Potential SRE Fauna (inclusive of species below)	22	5	3	0
Laevophiloscia sp. B23	1 (Additional record outside of the survey area at Cooljarloo)	1	1	0
Laevophiloscia sp. B24	1 (3 additional records found in the regional survey)	1	1	0
Westralaoma cf. aprica	1 (Additional records 10 km south east of the survey areas)	1	1	0
Maratus 'BAR130'	1	1	0	0
Antichiropus whistleri	2	1	0	0

Clearing of up to 26 ha for the life of the Proposal is required within the EIDE for the development of the borefields, pipeline corridors and road upgrades. This infrastructure is proposed to be developed over a relatively small area which is unlikely to contain significant portions of any single SRE habitat. The clearing for the EIDE is typically in narrow corridors and will not result in the complete clearing of any single habitat type. It is therefore unlikely that any SREs would be restricted to the EIDE.

All of the SREs that were recorded within the indicative disturbance footprint of the Proposal were also recorded outside of the development envelopes. The development envelopes also do not contain restricted habitats for SREs. The recorded species are also potentially widespread in the broader environment but have either not been recorded or the survey data has not been made available to Image.

Indirect Impacts to Habitat

Section 6.5.1 provides a detailed assessment of indirect impacts on fauna and their habitat, which showed that indirect impacts would be minimal outside the area of direct disturbance. This assessment is suitable for SREs also, with the Proposal considered unlikely to indirectly impact SRE habitat if the mitigation measures listed in Section 6.5 are implemented.

Summary

Despite there being evidence of SREs within the development envelopes, the habitat that is to be disturbed and rehabilitated is not restricted and extends outside the development envelopes. All of the SREs that were recorded within the indicative disturbance footprint of the Proposal were also recorded outside of the development envelopes.

Based on the above, Image considers that the Proposal is unlikely to have a significant impact on local SRE populations if the mitigation measures listed in Section 6.5 are implemented.

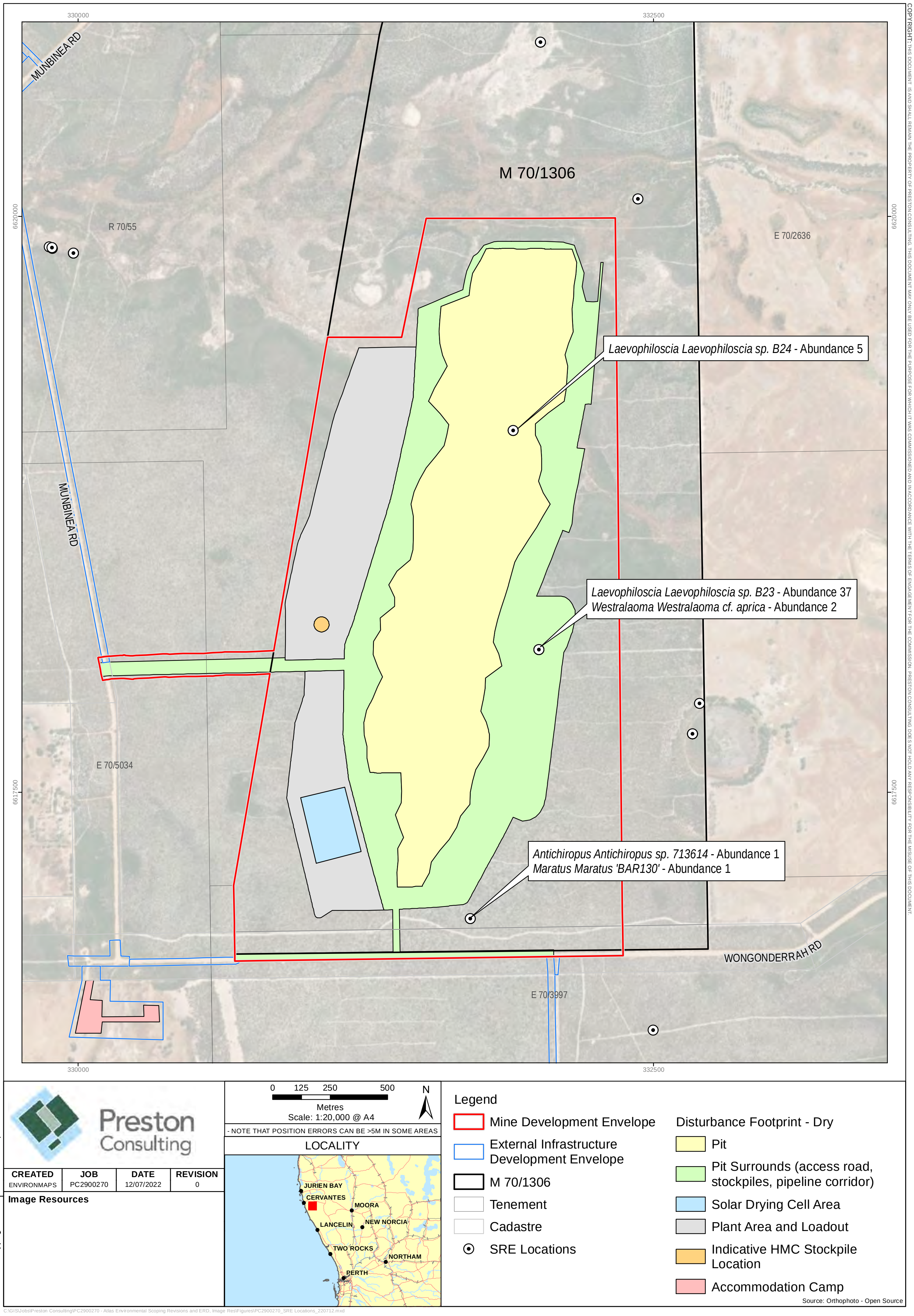


Figure 73: Potential SRE species to be disturbed by the Proposal

6.6 MITIGATION

Atlas has mitigated the potential impacts to this factor according to the mitigation hierarchy; avoid, minimise, rehabilitate and offset.

6.6.1 AVOID

Image conducted extensive flora and vegetation surveys of the areas within and surrounding the development envelopes and have utilised this information to conduct multiple mine planning, infrastructure and access road design revisions. This avoidance process resulted in the final boundaries of the development envelopes and disturbance footprint presented in this ERD, specifically modifications made to reduce the overall scale of the Proposal to avoid the following values identified during the surveys:

1. Direct and indirect impacts to general fauna habitats including habitat types that may be used by significant fauna;
2. Direct and indirect impacts to Carnaby's Cockatoo foraging and potential roosting habitat; and
3. Potential SRE records and habitat.

6.6.2 MINIMISE

The following mitigation measures are proposed to ensure that direct and indirect impacts to terrestrial fauna are minimised:

1. **Implement industry best practice management measures for terrestrial fauna:**
    a. Vegetation clearing will be managed through internal ground disturbance procedures;
    b. Boundaries of areas to be cleared or disturbed will be identified by GPS coordinates and maps of boundaries will be provided to dozer operator to minimise clearing;
    c. Progressive clearing will be undertaken;
    d. The disturbance footprint will be developed to the minimum required to ensure safe and adequate construction and operation;
    e. Water or dust suppressants will be applied to disturbed areas and product transfer/storage areas as required to minimise dust generation;
    f. Emergency response capabilities will be maintained to prevent fire outbreaks where possible;
    g. Weed and dieback hygiene and management measures / procedures will be implemented to prevent spread of weeds / dieback and the introduction of new weed species as a result of construction and operation;
    h. Fauna egress mechanisms will be installed in trenches, turkeys nests and solar drying ponds;
    i. Low noise equipment will be used where practicable;
    j. All incidents resulting in fauna injury or death will be reported internally;
    k. Vehicle speed limits will be set and enforced;
2. **Obtain and comply with the following approvals:**
    a. Ministerial Statement to be issued under Part IV of the EP Act;
    b. Works Approval(s) and Licence to be issued under Part V of the EP Act;

   c. Mining Proposal to be approved under the Mining Act;
3. **Ensure recorded location for SRE species *Maratus* 'BAR130' and adjoining area remains undisturbed;**
4. **Prepare and implement a Fauna Habitat Management Plan (FHMP)**. The FHMP will include commitments to minimise impacts to fauna habitat, and in particular Carnaby's Cockatoo foraging habitat, including:
   a. Commitments to minimise habitat disturbance during construction and operations;
   b. Minimum infill planting or seeding requirements for species utilised for Carnaby's Cockatoo foraging in rehabilitation areas;
   c. Annual monitoring of rehabilitation success, in particular the species utilised for Carnaby's Cockatoo foraging;
   d. Reporting and recording of Carnaby's Cockatoo and other significant fauna sightings;
   e. Reporting of introduced fauna sightings within rehabilitated areas;
   f. Annual targeted fauna survey of rehabilitation areas to assess the usage characteristics of these areas against baseline sites;
5. **Ensure groundwater abstraction (mine pit and water supply) and recharge is managed in accordance with the measures described in Section 7.6 to minimise drawdown impacts to vegetation**;
6. **Implement the following measures to minimise the risk and impact of hydrocarbon spills**:
   a. Hydrocarbons will be stored either within a bunded area or within self-bunded tanks;
   b. All spills will be controlled, contained and cleaned up as soon as practicable;
   c. Service vehicles will be fitted with spill kits;
   d. Spill kits will be located at all workshop and fuel storage areas;
   e. Environmental incident recording, investigation and reporting system;
7. **Comply with Water Quality Protection Guidelines and guidance notes**, particularly in relation to the storage and use of hydrocarbons and other harmful chemicals, the design and operation of vehicle maintenance areas and facilities, and the handling and storage of other waste materials, including contaminated soils.
8. **Implement Dieback Management Plan (DMP; Appendix 7)** to mitigate dieback risks and impacts. Dieback surveys will be revised regularly to maintain the currency of comprehensive occurrence information in accordance with relevant guidance throughout the life of the Proposal. The DMP will be reviewed prior to commencement of the Proposal and annually for the life of the Proposal. The DMP will be revised as required on the basis of survey results, change in dieback occurrence and changes to the Proposal.

6.6.3 Rehabilitate

During and after the mining stage of the Proposal the site will be rehabilitated to reinstate the flora and vegetation of areas that were disturbed. The mining pits will be progressively filled and rehabilitated to the pre-mining profile with the pre-existing land use reinstated as mining advances and actioned in accordance with the MCP.

An interim MCP has been prepared to accompany this ERD (Appendix 2) which was developed according to DMIRS Guidelines (2020a; 2020b). Key rehabilitation measures captured within the MCP are summarised below:

1. All infrastructure will be removed from site;
2. All long-term disturbance areas will be respread with topsoil (or ripped and seeded if topsoil is no longer viable) and rehabilitated;
3. All earthmoving equipment will be cleaned free of any soil material to minimise the risk of weed or dieback introduction;
4. Rehabilitation specific to Carnaby's Cockatoo foraging habitat will be conducted in areas previously vegetated by similar habitat types, utilising best-practice methods; and
5. Carnaby's Cockatoo foraging species will be included in the rehabilitation seed mix if suitable.

Image also proposes to develop a specific Banksia Woodland Rehabilitation Management Plan which will be developed and implemented prior to the disturbance of any Banksia Woodland TEC / PEC. This Plan will be an appendix to the final MCP and will draw on current rehabilitation practices for Banksia woodlands and is intended to be developed in consultation with DBCA and relevant rehabilitation experts. The Plan will include rehabilitation and revegetation of proposed offset sites.

The MCP will be submitted to DMIRS for assessment and approval prior to the construction of the Proposal and will be reviewed and revised at least every three years, or prior to closure, whichever is the earliest.

6.6.4 OFFSETS

After the implementation of the mitigation measures described above, it is predicted that the Proposal will have an unavoidable significant residual impact on very high value Carnaby's Cockatoo foraging habitat.

Proposed offsets for the unavoidable residual impacts on Carnaby's Cockatoo foraging habitat are discussed in Section 12.

6.7 PREDICTED OUTCOME

The EPA's environmental objective for this factor is to "protect terrestrial fauna so that biological diversity and ecological integrity are maintained". In the context of this objective: "ecological integrity" is listed as the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements (EPA, 2016d).

Image conducted extensive ecological surveys of the areas within and surrounding the development envelopes. Targeted significant fauna surveys were also conducted over the development envelopes and in surrounding areas.

Image has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes, however some direct and indirect impacts to terrestrial fauna are unavoidable. The Proposal will result in the clearing of up to 318 ha of native fauna habitat which will be rehabilitated progressively and following mine closure. All of the impacted habitats are well distributed throughout the region and species that potentially use the development envelopes generally have relatively wide-ranging distributions and/or will persist in adjoining unaffected areas given the presence of extensive areas of similar habitat nearby. This includes the Beekeepers Nature Reserve and Nambung National Park which lie in proximity to the Proposal, providing protection for an estimated 13,433 ha of similar native fauna habitat.

With the implementation of controls, the Proposal will not result in significant residual impacts to regional fauna habitats and general fauna species. Management and monitoring is proposed during the operational phase to further minimise indirect impacts to general fauna species and habitats (refer to Section 6.5).

Carnaby's Cockatoo was recorded in the survey areas and is listed as Endangered under the EPBC Act and BC Act. It is primarily threatened by the loss and fragmentation of breeding and foraging habitat as a result of vegetation clearing. While no Carnaby's Cockatoo breeding trees were identified, the majority of the development envelopes was identified as containing very high quality foraging habitat for this species. After the implementation of avoidance, minimisation and rehabilitation mitigation measures, the residual impacts to Carnaby's Cockatoo foraging habitat, summarised as: Loss of up to 289 ha of very high value Carnaby's Cockatoo foraging habitat for a period of 15 years (up to five years construction and operation plus ten years before rehabilitation is suitable for foraging by Carnaby's Cockatoo).

These residual impacts were deemed to be significant and are proposed to be counterbalanced by offsets to ensure that the EPA objective can be met. The proposed offset site takes advantage of similar habitat in excellent to pristine condition in close proximity and provides connectivity to the Proposal.

If the Proposal is approved, the Ministerial Statement is likely to contain a condition requiring the development and implementation of an Offset Strategy. The offset measures will be reviewed and refined in the Offset Strategy and will be informed by discussions with DMIRS, DBCA, DCCEEW and EPA Services to ensure they adequately counterbalance the residual impacts.

Based on the above the Proposal is expected to be able to meet the EPA's objective for this factor.

7 INLAND WATERS

7.1 EPA OBJECTIVE

The EPA Objective for this key environmental factor is to maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.

7.2 POLICY AND GUIDANCE

Relevant EPA and Commonwealth Government guidance documents for Inland Waters are summarised in Table 37.

Table 37: Policy and guidance relevant to the Inland Waters key environmental factor.

Policy and Guidance	How guidance has been considered
WA Government	
Key EPA documents	
Statement of Environmental Principles, Factors and Objectives (EPA, 2021b)	This document was considered in the preparation of this ERD and to inform EIA. It was used identify the Key Environmental Factors likely to be impacted by the Proposal and the EPA's objective for each factor.
Statutory Guidelines for Mine Closure Plans (DMIRS, 2020b);	This document has been considered in the design and planning of the Proposal, it has also been considered in the preparation of mitigation measures and a preliminary MCP for the Proposal.
EIA (Part IV Divisions 1 and 2) Administrative Procedures (EPA, 2021e);	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
EIA (Part IV Divisions 1 and 2) Procedures Manual (EPA, 2021a); an	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
Instructions on how to prepare *EP Act* Part IV Environmental Management Plans (EPA, 2021f)	This document was considered in the preparation of management plans for the Proposal.
Relevant EPA Factor Guidelines	
Environmental Factor Guideline – Inland Waters (EPA, 2018)	This document was considered in the preparation of this section (Section 7) of the ERD.
Other Policy and Guidance	
WA Water in Mining Guideline. Water licensing delivery report series. Report No. 12. (Department of Water (DoW), 2013)	This document was considered in the preparation of a groundwater management plan for the Proposal, and in the preparation of this section (Section 7) of the ERD.
Operational Policy 5.12 – Hydrogeological reporting associated with a groundwater well licence (DoW, 2009)	This document was considered in the preparation of this section (Section 7) of the ERD.
WA Environmental Offsets Policy (EPA, 2011)	This document was considered during EIA for Inland Waters however it was determined not be relevant as offsets were not required.
WA Environmental Offsets Guidelines (EPA, 2014a)	This document was considered during EIA for Inland Waters however it was determined not relevant as offsets were not required.
WA Environmental Offsets Template (EPA, 2014b)	This document was considered during EIA for Inland Waters however it was determined not relevant as offsets were not required.

Policy and Guidance	How guidance has been considered
Commonwealth Government	
Key Documents	
Generic guidelines for the content of a draft EPBC Act PER/Environmental Impact Statement (EIS) (including the objects and principles of the EPBC Act 1999) (DotEE, 2016a)	This document was considered in the preparation of this section (Section 7) of the ERD.
EPBC Act Environmental Offsets Policy (DSEWPaC, 2012a) – including the Offset Assessment guide	This document was determined to not be required as offsets for the Inland Waters environmental factor are not required.
Environmental Management Plan Guidelines (DotE, 2014a)	This document was considered in the preparation of management plans for the Proposal.
EPBC Act Condition Setting Policy (DAWE, 2020a)	This document was used as guidance for the management of the potential impacts of the Proposal.
EPBC Act Outcomes-based conditions policy (DotE, 2016a)	This document was used as guidance for the management of the potential impacts of the Proposal.
Relevant Technical Guidance	
Relevant EPBC Act listed species specific survey guidelines and protocols.	This document was used as guidance when undertaking surveys of EPBC listed species and potential survey limitations.
Relevant EPBC Act listed species specific Recovery plans, Threat Abatement Plans, Approved Conservation Advices and other documents	This document was used as guidance to assess and manage EPBC listed species that may be impacted by the Proposal.

7.3 Receiving Environment

7.3.1 Survey Effort

The information in this section has been sourced from the survey reports listed in Table 38.

Table 38: Studies completed for the Proposal

Study	Reference	Report attached as
Water Sampling and In-situ parameters survey	MWES, 2012	Appendix 14
Hydrogeological and Hydrological Scoping Study	URS, 2013	Appendix 15
Atlas and Boonanarring Heavy Mineral Sand Proposals, Quarterly Environmental Water Sampling Survey	MWES, 2013	Appendix 16
Image Resources Atlas Proposal Baseline Hydrology Report	MWES, 2022a	Appendix 17
Image Resources Atlas Proposal Groundwater Hydrology Report	MWES, 2022b	Appendix 18
Image Resources Atlas Proposal Groundwater Operating Strategy	MWES 2022c	Appendix 19
Image Resources, Atlas Proposal Surface Water Management Plan	MWES, 2022d	Appendix 20
Image Resources Atlas Mineral Sands Project Infiltration Pond Testing Report & Managed Aquifer Recharge Application	MWES, 2022e	Appendix 21
Acid Sulphate Soils Investigation and Management Plan	Mine Earth, 2022a	Appendix 22

Baseline data relevant to this section has been sourced from the following:

- Water Sampling and In-Situ Parameters Survey for the Atlas, Boonanarring, and Gingin North Mineral Sand Proposals (MWES, 2012);
- Hydrogeological and Hydrological Scoping Study carried out by URS (2013); and
- A Quarterly Environmental Water Sampling Survey for the Atlas and Boonanarring Heavy Mineral Sand Proposals (MWES Consulting, 2013).

MWES Consulting (MWES, 2022a; Appendix 17) conducted a hydrology assessment of the Atlas Deposit to establish baseline surface water characteristics and predict the Proposal's impacts on local and regional surface water systems. Information collected by MWES (2022a) allowed for the development of a Surface Water Management Plan (SWMP) for the Proposal (MWES, 2022d; Appendix 20). The scope of the assessment included;

- Review of relevant hydrological background information for the Nambung River and the regional hydrological context;
- Characterisation of baseline conditions for regional climate and physiography, land use, catchments and hydrology;
- Description of rainfall runoff, peak flow estimates, and major stormwater controls; and
- Environmental risks and impact assessment of the Proposal on local tributaries and riverine systems.

MWES (2022b) conducted a groundwater assessment, to characterise groundwater hydrology and hydrogeology of the Atlas mineral resource (AMR; Figure 74) and model impacts associated with the Proposal. The Proposal will only mine the southern half of the AMR. MWES (2022b) developed a groundwater flow model in accordance with the most recent Australian groundwater modelling guidelines (Barnett et.al. 2012) and using information gained from several sources:

- Historical DWER monitoring bore drilling and monitoring (DWER monitoring bore locations are shown in Figure 74);
- Geological and seasonal groundwater level data sourced from new dual-level piezometers, installed into Superficial and Mesozoic sediments at 18 sites across the Proposal (Figure 75). At eight sites where superficial formations were thin or unsaturated, both piezometers were installed into Mesozoic rocks. Three new production bores were installed at the AMR, alongside an associated observation bore. Another bore was installed to replace an existing domestic water supply bore at Nambung Station; and
- Three 48-hour pumping tests, one in the Superficial Aquifer and two in the upper part of the Yarragadee Aquifer.

The groundwater flow model was used to determine the magnitude of dewatering required, potential impacts of the cone of drawdown on the surrounding environment, and to inform decisions on Proposal mining methods, impacts and ongoing groundwater management requirements.

The whole of minesite water balance was determined for a dry mining with drawdown mitigation mining plan. It was constructed using GOLDSIM software which is both a flexible and a complex graphical calculation system with inherent checking routines, a spreadsheet data input system, and a quick graphical reporting platform. The quarterly mine dewatering pumping and drawdown mitigation scheme infiltration rates were copied from the groundwater flow model to the mine water balance model. The water balance was calculated by taking the mine dewatering production rate from the raw process plant, mining and infiltration pond consumptions. It was assumed that there will be no additional water recovered from within the mine from oversize discharge, stacked sand or from the solar drying cells. The recovery from decanted sand tailings was accounted for in the process plant raw consumption.

Acid Sulphate Soils (ASS) often occur beneath the water table in sandy soil profiles of the Swan Coastal Plain and are often associated with mineral sand deposits (DER, 2015a). An ASS Assessment was therefore conducted by Mine Earth Pty Ltd (Mine Earth) to determine Potential ASS (PASS) and Actual ASS (AASS) at the Proposal (Mine Earth, 2022a; Appendix 22). The ASS assessment included:

- Analysis of the Proposal drilling database to identify the presence and location of soils typically associated with ASS;
- A dedicated sampling and analysis program to quantify the presence and location of PASS;
- Assessment of relevant groundwater analysis data; and
- Assessment of risks and associated management protocols for ASS.

ASS investigations are discussed in greater detail in Section 8.3.5.

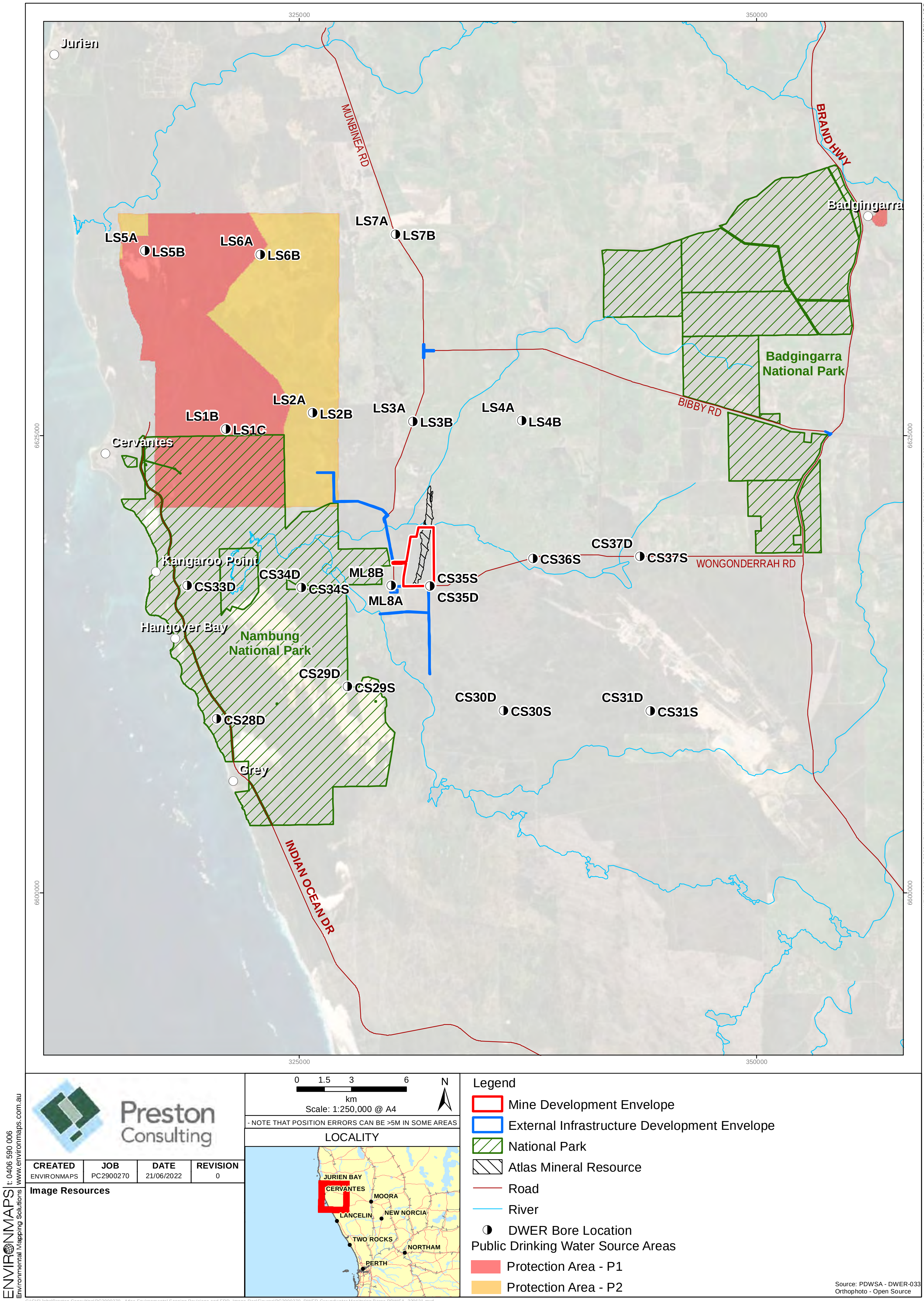


Figure 74: Regional DWER Bore Locations

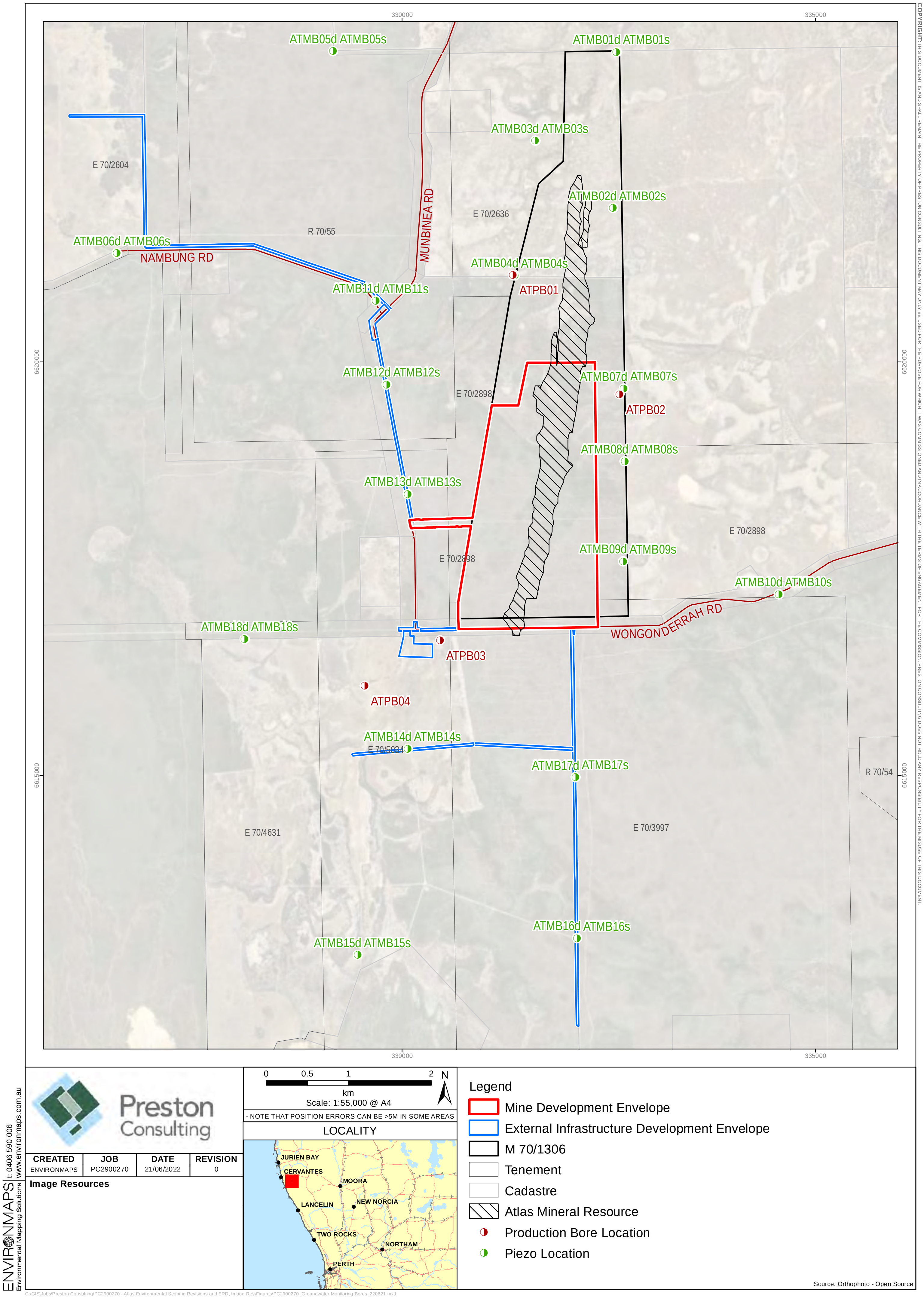


Figure 75: Groundwater bore and piezometer locations at the Proposal

7.3.2 Climate

The region has a Mediterranean climate with a mean maximum temperature of 15.1 – 34.6°C in summer and 7.1 – 18.8°C in winter. The average annual rainfall at this location (Badgingarra Research Station; ID: 009037) is about 537.6 mm, and variable (274 – 785 mm per annum or about 51 – 146% of average). Most rainfall occurs from May – August (winter) and September – April is dry (summer) (BoM, 2022a). Average annual pan evaporation is approximately 2,400 mm (~300 mm in winter, and ~950 mm/day in summer) (BoM, 2022b).

The Badgingarra Research Station was Identified as the closest active weather station with monthly records for both rainfall and temperature, data from 2021 is illustrated in Figure 76 (BoM, 2022b).

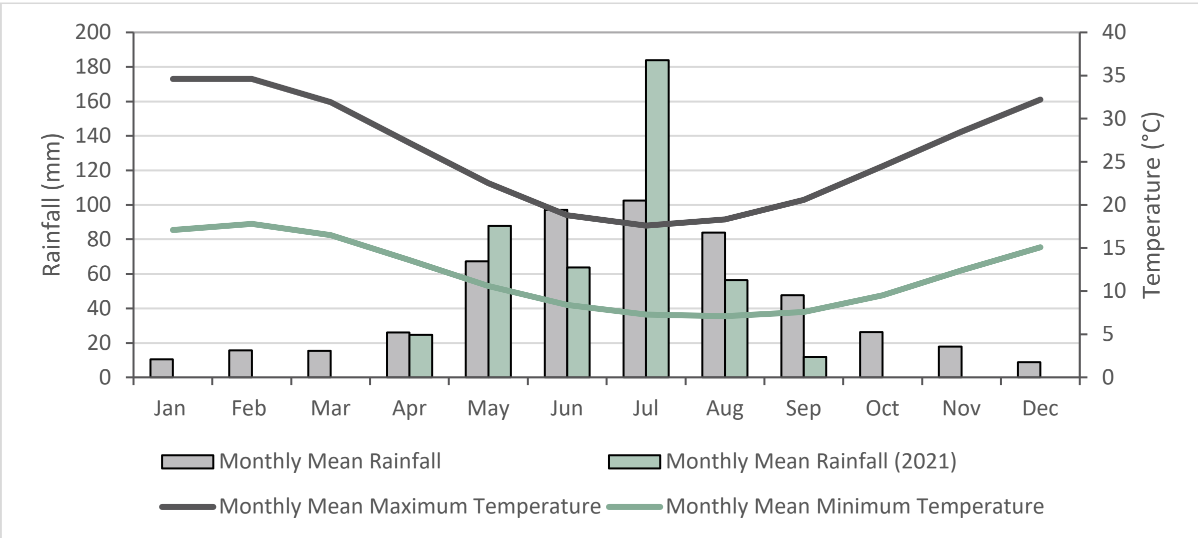


Figure 76: Rainfall and temperature data for Badgingarra Research Station (ID: 009037)

Rainfall at the Proposal

Intensity-Frequency-Depth data is required to characterise storm rainfall intensities and is provided by BoM. Information is provided for various Average Exceedance Probabilities (AEP), and the equivalent Average Recurrence Intervals (ARI), up to the 2,000-year ARI.

Mine closure requires consideration of rare storms that could occur in time undefined after closure. For example, the 10,000-year rainfalls can be used as the basis for extreme rainfalls, taken as 24% greater than the 2,000-year rainfalls (based on extrapolation of actual statistical rainfall data); or approximately two times the 100 year rainfalls.

On this basis, rainfall intensity data (IFD) for the Proposal is shown in Table 39.

Table 39: Rainfall IFD Statistics (mm)

Duration	Annual Exceedance Probability				Return Period (years)	
	50%	10%	5%	1% = 100	500	1000
1-Hour	17.5	27.8	32.4	44.7	60.7	68.8
2-Hour	22.1	34.9	40.7	56.5	76.7	87
6-Hour	32.2	51	59.9	84.3	114	129

Duration	Annual Exceedance Probability			Return Period (years)		
	50%	10%	5%	1% = 100	500	1000
12-Hour	40.5	64.8	76.2	108	146	166
24-Hour	49.6	79.6	93.4	133	181	205
36-Hour	55	87.7	102	146	204	234
48-Hour	58.8	93	108	153	214	244
72-Hour	64.5	99.9	115	161	220	250
96-Hour	69.2	105	120	164	222	251
120-Hour	73.9	110	124	167	224	253

Long term rainfall patterns are described by the SILO database of daily climate statistics on a 0.05 degree grid (https://www.longpaddock.qld.gov.au/silo/gridded-data/) for the period 1889 – 2020 (131 complete years). The local grid point data was used to create the 100-year rainfall residual mass graph for the site which is shown in Figure 77. The residual mass graph plots the cumulative deviation from the average daily rainfall over the selected period (1920 – 2019).

Figure 77 shows the reliable seasonal rainfall cycle with a typical amplitude of about 250 mm. Longer term trends include the excess (above average rainfall) of 1500 mm over 14 years from 1920 and the deficit of 1700 mm since 2000.

Daily totals from the 131 year record show some notable differences from the IFD statistics. The maximum one day total from the longer SILO record (88 mm) is considerably lower than the IFD (100 year ARI = 133 mm), whilst over seven days the SILO maximum (167 mm) agrees with the IFD (100 year = 172 mm). The differences reflect greater regional smoothing in the IFD grids (i.e., greater granularity in the SILO grids).

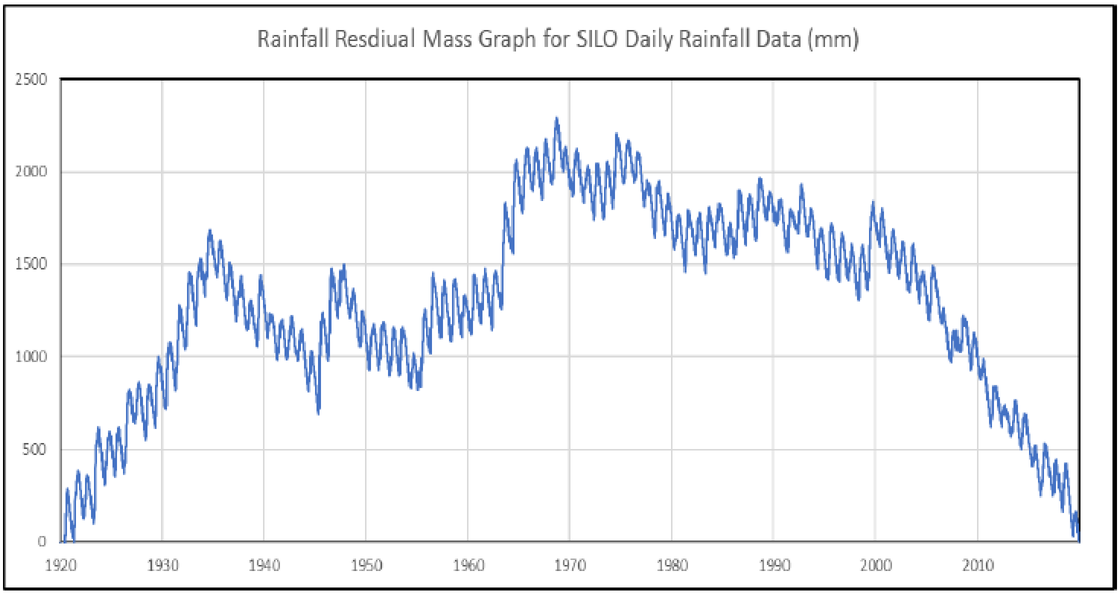


Figure 77: 100-Year Rainfall Residual Mass Graph

7.3.3 Surface Water

The information contained within this section has been sourced from MWES (2022a; Appendix 17) unless otherwise stated.

Relevant Regional Physiography

The Proposal is located near the centre of the Swan Coastal Plan which extends 15 - 20 km further east to where the Gingin scarp is formed by a low ridge of Mesozoic sedimentary rocks (Figure 78). The local Quaternary Bassendean Dune System forms a deflated landscape of sparse low fixed dunes with interdunal swamps. Toward the coast, the more recent Tamala Limestone and Safety Bay Sands form a more rugged and elevated topography.

Local drainage rises on the Gingin scarp 15 - 20 km to the east at a ridge line elevation of 200 - 300 m. The Mount Jetty and Bibby Creeks flood-out and coalesce near the site in an area of very low surface gradients. The creek-lines reform and coalesce to the west as the Nambung River which discharges into Tamala Limestone 6 km east of the coast. This river system has important conservation value for the diversity of habitats it provides. The site ground elevation is mostly in the range 39 - 45 m AHD with a very slight overall gradient across the site of about 0.2% west toward the coast. The local surface is bisected by a widely spaced array of low fixed dunes. Many of the dunes are oriented parallel to the coast, some are perpendicular and other orientations are present.

Flat and low-lying country of the local area and of the Swan Coastal Plain generally are subject to seasonal inundation. Mapped wetlands comprise a large portion of the local area. These include a variety of vegetation zones and geomorphic features. Much of the local mapped wetland area is part of the Nambung Flats, a seasonal swamp formed by the combination of surface runoff accumulation and seasonal groundwater level rise.

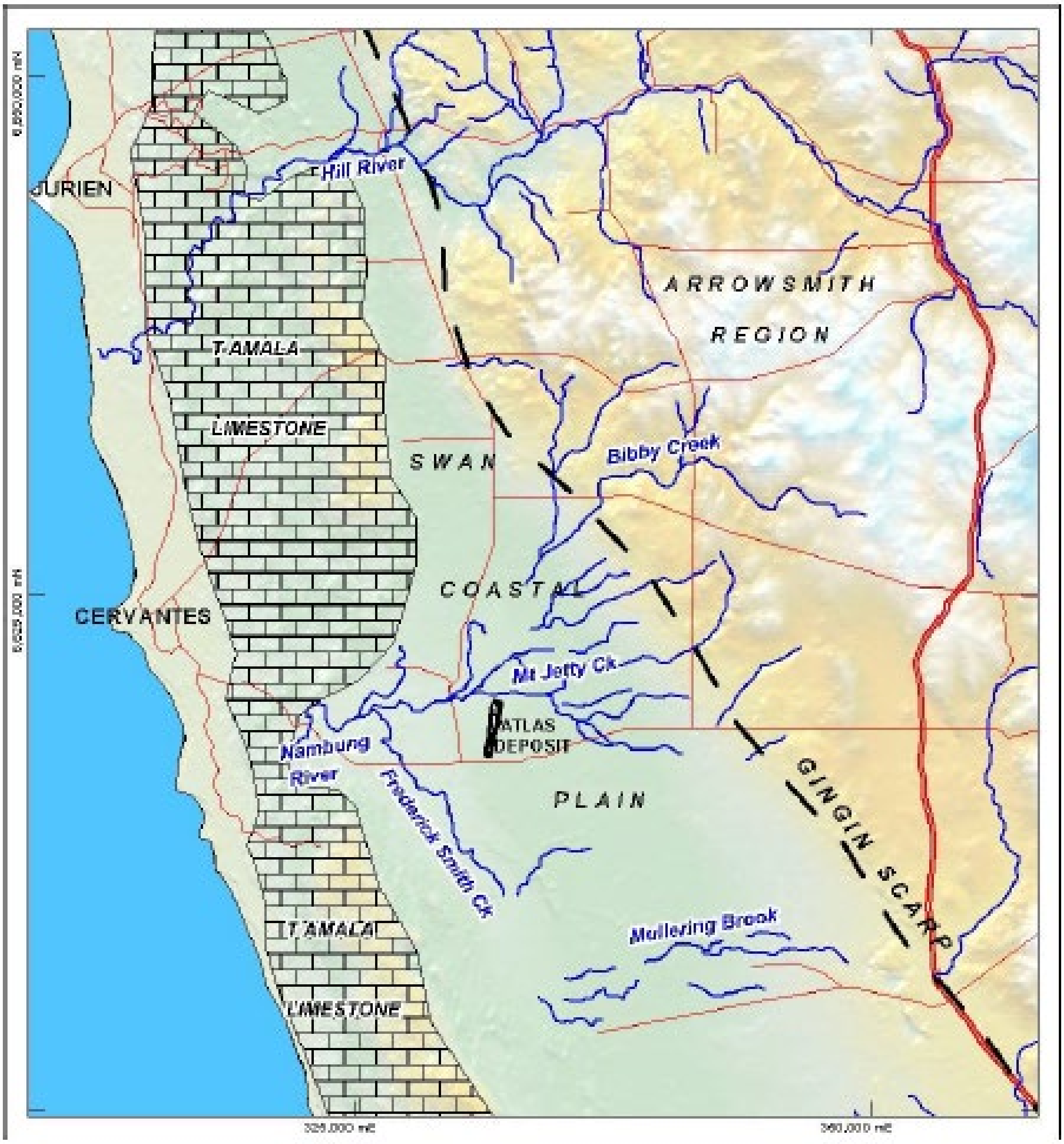


Figure 78: Regional Physiography

Catchments and Hydrology

The Proposal is located in the Nambung River catchment (Figure 79). The Nambung River catchment is located south of the Hill River catchment and to the west and north of the Moore River catchment, covering a total area of 2,959 km^2 divided equally between hill country between the Brand Highway and Moora, and lowlands of the Swan Coastal Plain. Most of the catchment hill country drains to Mullering and Minyulo Brooks which flood out onto swamps and claypans of the Swan Coastal Plain. Large flows in Mullering Brook may indirectly feed into Frederick Smith Creek which is a direct tributary of the Nambung River.

Minor creeks in the north of the Nambung catchment, including Bibby Creek and Mount Jetty Creek, rise on the western slopes of the hill country and discharge into the Nambung Flats. The overflow from this collection of swamps is the main course of the Nambung River. The river terminates in karst country within the Nambung National Park.

Four sub-catchments discharge west through or near the Proposal, and form the Nambung River at their confluence immediately downstream of Munbinea Rd. The sub-catchments have a combined area of 354 km^2 or 12% of the Nambung River catchment. Since these local catchments comprise the steepest and most direct surface flow paths, they will potentially provide an out-size volumetric contribution to smaller and early wet season flow events. Sub-catchment geometrical parameters are summarised in Table 40 and detailed in Figure 80.

Table 40: Nambung sub-catchment geometrical parameters

Name	Downstream	Area (km^2)	Mainstream Length (km)	Mainstream Slope (%)
Bibby	Munbinea Rd	185.2	31.5	0.47
Central	Munbinea Rd	42.3	15.5	0.62
Jetty	Munbinea Rd	99.4	18.3	0.56
South	Munbinea Rd	26.7	9.7	0.22
Hill River*	Gauge 617002	539.0	39.2	0.46
Nambung River	Nambung Caves	2,959.0	N.D.	N.D

* Excludes large flat upstream catchment area from which little runoff occurs

Active parts of the remaining 88% of the Nambung River catchment (2,700 km^2), drain into the river downstream to the west of the Proposal via tenuous and disconnected flow paths. This larger portion is dominated by areas of very low surface gradient including parts of the Swan Coastal Plain, and Dandaragan Plateau. There is no continuous water course through the majority of the catchment area. Runoff rates are evidently very low and local runoff is mostly retained in seasonal swales and ponds.

The downstream river floodplain and the terminal karst habitat (Nambung Caves) are considered the primary environmental receptors for any potential surface water impacts, however surface water discharge from the sub-catchment occurs rarely in response to extreme and sustained rainfall and comprises an infinitesimal portion of the Nambung River flow. There is no potential for measurable water quantity or quality impact during moderate to large stormwater flow events due to the dilution factor imposed by the large catchment area active during such events.

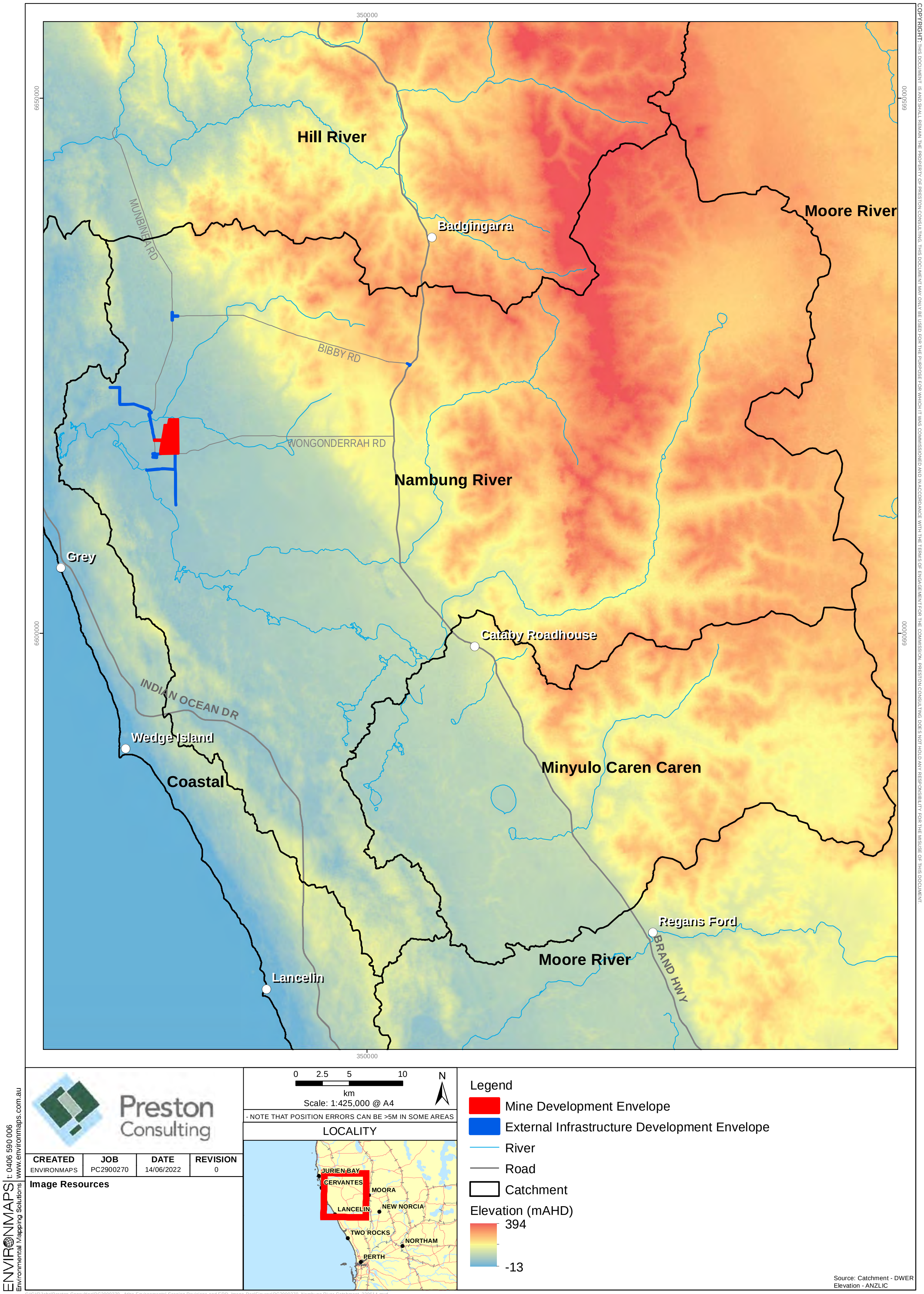


Figure 79: The Nambung River Catchment and Atlas Proposal Location

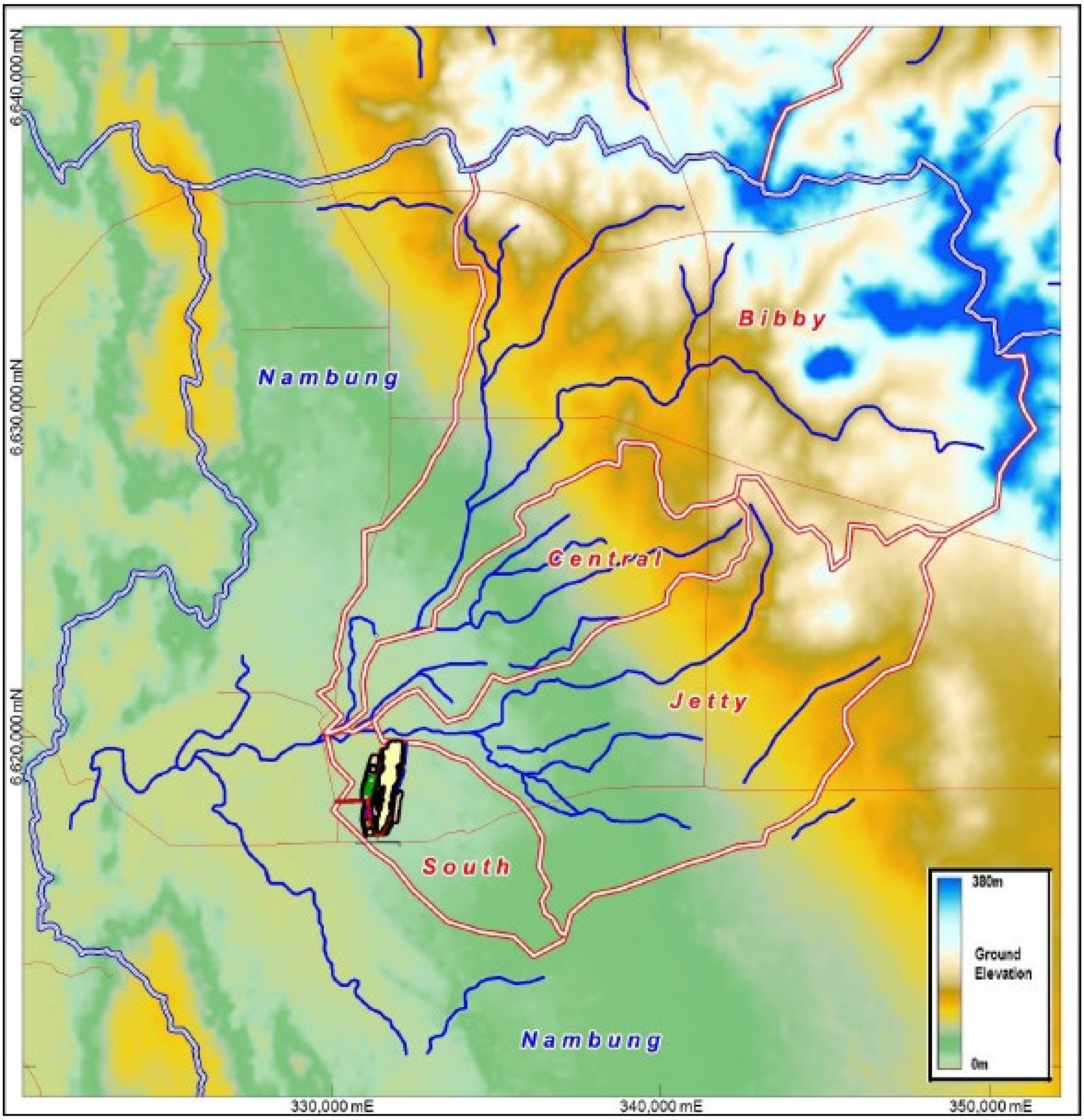


Figure 80: Sub-Regional Catchment Boundaries at the Proposal

2021 Rainfall Records

Commencing 6 February 2021 there was widespread (Jurien to Hill River, Nambung Station and beyond) rainfall of about 100 mm including 90.5 mm on the 7 February 2021 at Nambung Station. That 24-hour total has a frequency of about 20 years ARI. Despite the dry catchment, the intense rain resulted in a brief, moderate magnitude peak flow rate of 9 cumecs at the Hill River gauging station. A similar brief and moderate flow probably occurred in the Nambung River in response to the February rain event. Winter monthly rainfall totals were generally unremarkable (as summarised in Table 41). However, Nambung Station received above average rainfall in the months of May to July 2021 and in particular received 319.4 mm over 49 days from 29 May to 16 July 2021.

Table 41: 2021 Winter Rainfall

SITE	Parameter	Rainfall (mm/month)				
		May	June	July	August	Winter Total
SILO 130 Year Data Set	median	81	118	117	89	409
	mean	85	129	125	93	432
	80th percentile	124	164	161	120	517
	90th percentile	148	205	191	142	586
Badgingarra (9037)	Measured Rainfall	88	64	184	56	392
Nambung (9276)		153	129	147	44	473
Hill River (509168)		106	61	180	52	399

The Nambung River flowed over Munbinea Rd until late August, indicating a period of near continuous flow of about three months. Frederick Smith Creek and the Mount Jetty Creek were still flowing on 7 September 2021, when follow-up field reconnaissance was undertaken. There was extensive surface water across the Nambung Flats - mostly contained in the numerous shallow swales and ponds which characterise the area. The following specific observations and estimations were made:

- Flow rate on Bibby Creek through Bibby Road culvert approximately 12km NE of the Proposal was about 106 L/sec;
- Wyip Pool (one of the Nambung River terminal pools) water level about 22.0 m AHD and depth 1.5 m; and
- Peak seasonal water level at Wyip Pool about 23.2 m AHD.

The 2021 flows in Nambung River are the largest and longest duration since 1999 or 2005 and should have restored the Lower Nambung habitat after a lengthy period of drought. However, the 2021 hydrological records are unremarkable in context of long-term records and do not affect the peak flow assessment presented below which are developed from the records up to 2020.

Local Hydrology

Detailed topography for the mine site is shown in Figure 81, which shows the indicative mine disturbance footprint, with colour fill ground elevation and one metre interval surface contours. There is a general convergence of surface water flow lines toward the Mt Jetty Creek confluence with Bibby Creek at Munbinea Rd (i.e., the upstream end of the Nambung River) to the north and outside of the MDE. A minor swale is aligned northwest across the north end of the MDE at a ground elevation of 39 – 40 m. This swale would convey any flow from the South sub-catchment under extreme or prolonged rainfall. The Proposal is located in a minor sub-catchment of the Nambung River (the South catchment) which comprises less than 1% of the Nambung River catchment. The catchment is small and relatively flat and there are no substantial natural drainage lines across the mine disturbance areas. Surface water discharge from the sub-catchment occurs rarely in response to extreme and sustained rainfall and comprises an infinitesimal portion of the Nambung River flow. During such events the sub-catchment provides a trivial contribution to the Nambung River flow.

7.3.4 Geology

The information contained within this section has been sourced from MWES (2022b) unless otherwise stated.

The Proposal lies within the Swan Coastal Plain under flat lying to gently sloping and westerly draining terrain, lying immediately west of a topographic domain dominated by rolling hill topography. It is located approximately 12 km west of the Gingin Scarp. The Proposal site is characterised by four geological layers:

- A thin layer of clean dune sands;
- An underlying discontinuous clayey sand layer with clay and silt fines, in concentrations ranging 10 - 20% in the central region of the AMR and 20 - 25% at the ends of the AMR. The concentration of clay and silt fines decreases with depth;
- A third layer of clay and silt fines at the base of the Superficial Aquifer, in concentrations less than 10% (and often less than 5%); and
- The fourth layer, the Mesozoic Yarragadee Formation (sand dominated) and Cattamarra Coal Measures (clay dominated).

The AMR is formed in surficial marine sediments eroded into Cretaceous basal sediments during the Pleistocene marine transgressions. The AMR is predominantly comprised of pale deep Bassendean sands with areas of yellow deep sand, gravelly sands, sandy duplexes and wet soils. Several superficial formations, Tamala Limestone, Bassendean Sand and Guildford Formation contain various hydraulically connected sediments with thickness dependent on depth of saturation. They are unconfined and are only significantly developed to the west of the Gingin Escarpment.

Mesozoic rocks outcrop at the surface in the plateau region to the east of the Gingin Escarpment, referred to as the Arrowsmith Region. To the west of the escarpment, the subsurface geology comprises flat lying Quaternary and Pliocene superficial formations separated by an unconformable erosional surface from a series of older Mesozoic formations that form part of the Perth Basin. The Mesozoic rocks are located along the eastern edge of the Beagle Ridge, a mid-basin ridge of relatively shallow pre-Permian aged basement. The Mesozoic rocks are generally downfaulted to the east towards the Coomaloo Trough by a series of north-south orientated normal faults. Some small graben structures have preserved pockets of younger rocks, such as the wedge-shaped body of south dipping Yarragadee Formation sediments that lie beneath most of the AMR. The structural sub-division for the area between the Beagle Ridge and the Coomaloo Trough has been named the Cadda Terrace (Mory & Iasky 1996). The distribution of the Mesozoic stratigraphy is shown in Figure 82.

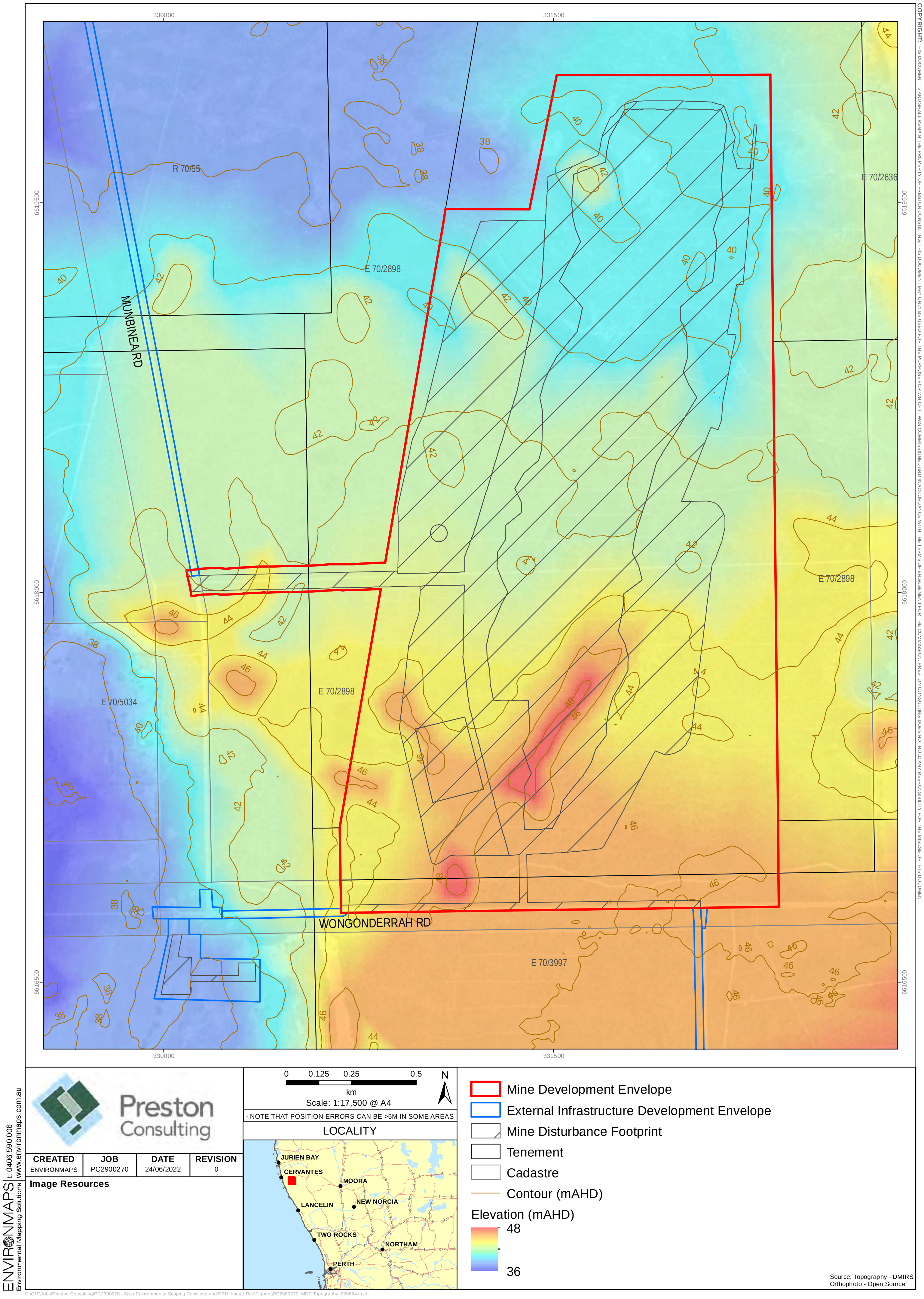


Figure 81: Proposal-scale topography

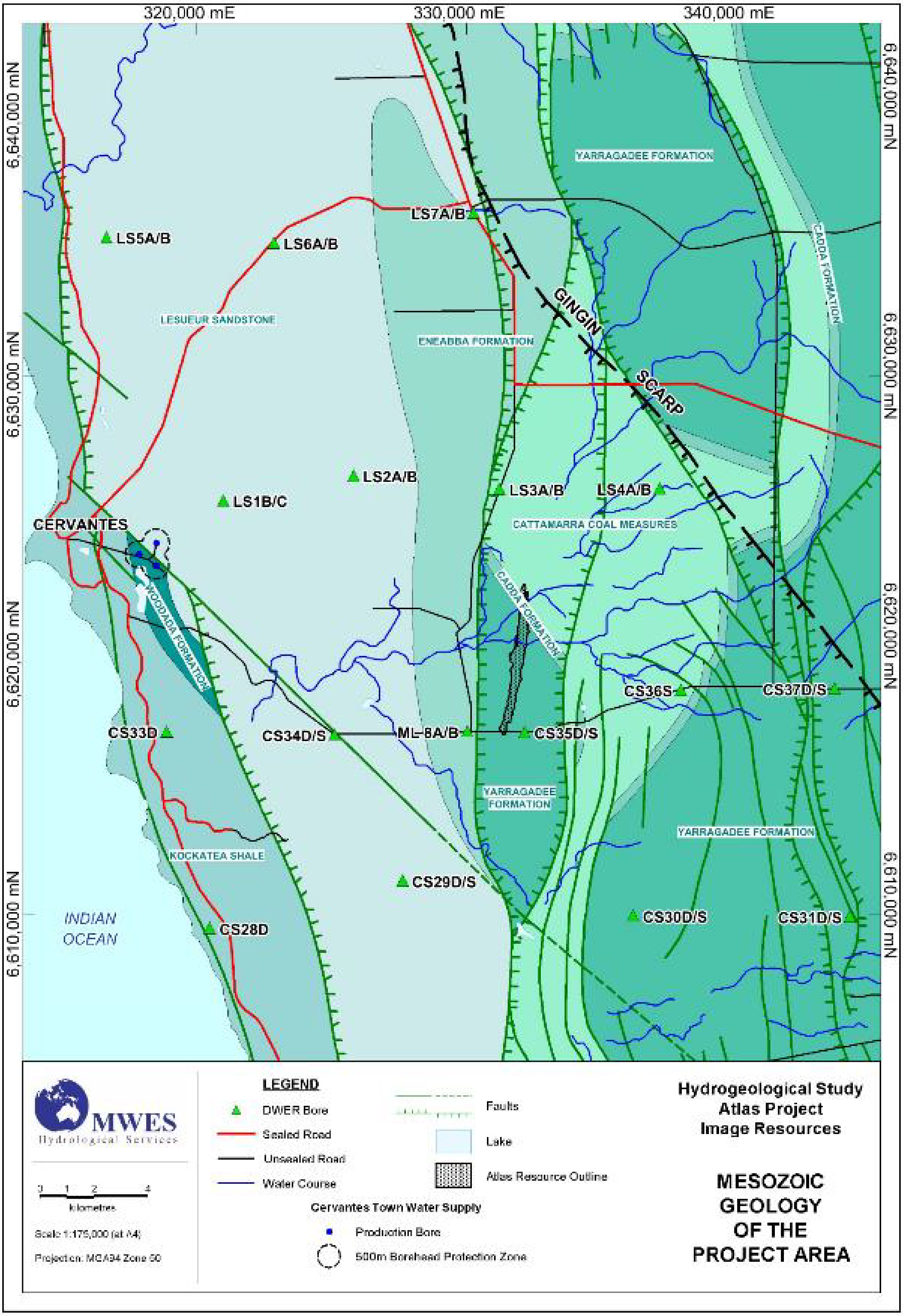


Figure 82: Regional Mesozoic geology

7.3.5 Groundwater

The information contained within this section has been sourced from MWES (2022b; Appendix 18) unless otherwise stated.

The AMR is a shallow beach strand mineral sand deposit located on the western side of the Swan Coastal Plain, a low-lying area covered by coastal sediments overlying Mesozoic rocks. The water table across the AMR occurs between 2 - 8 m below ground level. MWES's (2022b) conceptual hydrogeological model comprises two aquifer systems; the Superficial/ Tamala Limestone aquifer system, and the Mesozoic aquifer system. Both are in hydraulic connection in the mine area.

The groundwater formations within the MDE include the Superficial Aquifer and the Yarragadee Aquifer, both of which are unconfined. Downgradient of the Proposal is the Tamala Limestone, which sits beneath the Nambung National Park. The hydraulic connection between the Superficial aquifer, Yarragadee and Tamala Limestone is considered high. Seasonal groundwater levels within the AMR vary by an average of 0.49 m in shallow bores and 0.39 m in deep bores from the start to the end of the rainy season.

Groundwater Levels

In the following discussions on groundwater levels, reference to the 'shallow aquifer', means the aquifer observed in the shallow monitoring bores and piezometers, regardless of whether they were screened in the Superficial Aquifer, Tamala Limestone or various Mesozoic aquifers. Similarly, the 'deep aquifer' refers to the deep observation level, which were usually developed in the Mesozoic aquifers. Only three deep bores observe groundwater in the Superficial Aquifer: CS31D (Yoganup Formation), and CS28D and 33D (Tamala Limestone) (Figure 74).

Average depths to groundwater surrounding the AMR are shown in Figure 83.

Long-term Groundwater Levels

Most bores show a rise in groundwater levels coinciding with high rains around 1999 and have dropped since. Groundwater levels in the CS36 and 37, and LS3, 4 and 7 bores have remained relatively steady since they were installed, with deep bore LS3A showing a distinct rising trend. DWER monitoring bores at site CS34 have declined over the entire period from 1993 to present. Closer to the AMR (CS35), groundwater levels have been steady since 2006.

Seasonal Groundwater Levels

Seasonal groundwater levels surrounding the AMR were mapped in the early and late part of the winter rainy season. Groundwater levels in shallow piezometers generally rose from the start to the end of the rainy season by an average 0.49 m in a range 0.14 - 0.92 m. The degree of rise decreases towards the coast where water levels in DWER monitoring bores can fall by as much as 0.07 m. In the deep piezometers, the seasonal rise is similar, averaging 0.39 m in a range from 0.04 - 0.75 m. Similarly, the rise becomes a fall towards the coast by as much as 0.29 m.

From the southern part of the AMR to the northern part, the groundwater levels ramp up from 39 - 42 mAHD. The levels can vary depending on the depth of the piezometer or the season. The seasonal variation is about 0.6 m.

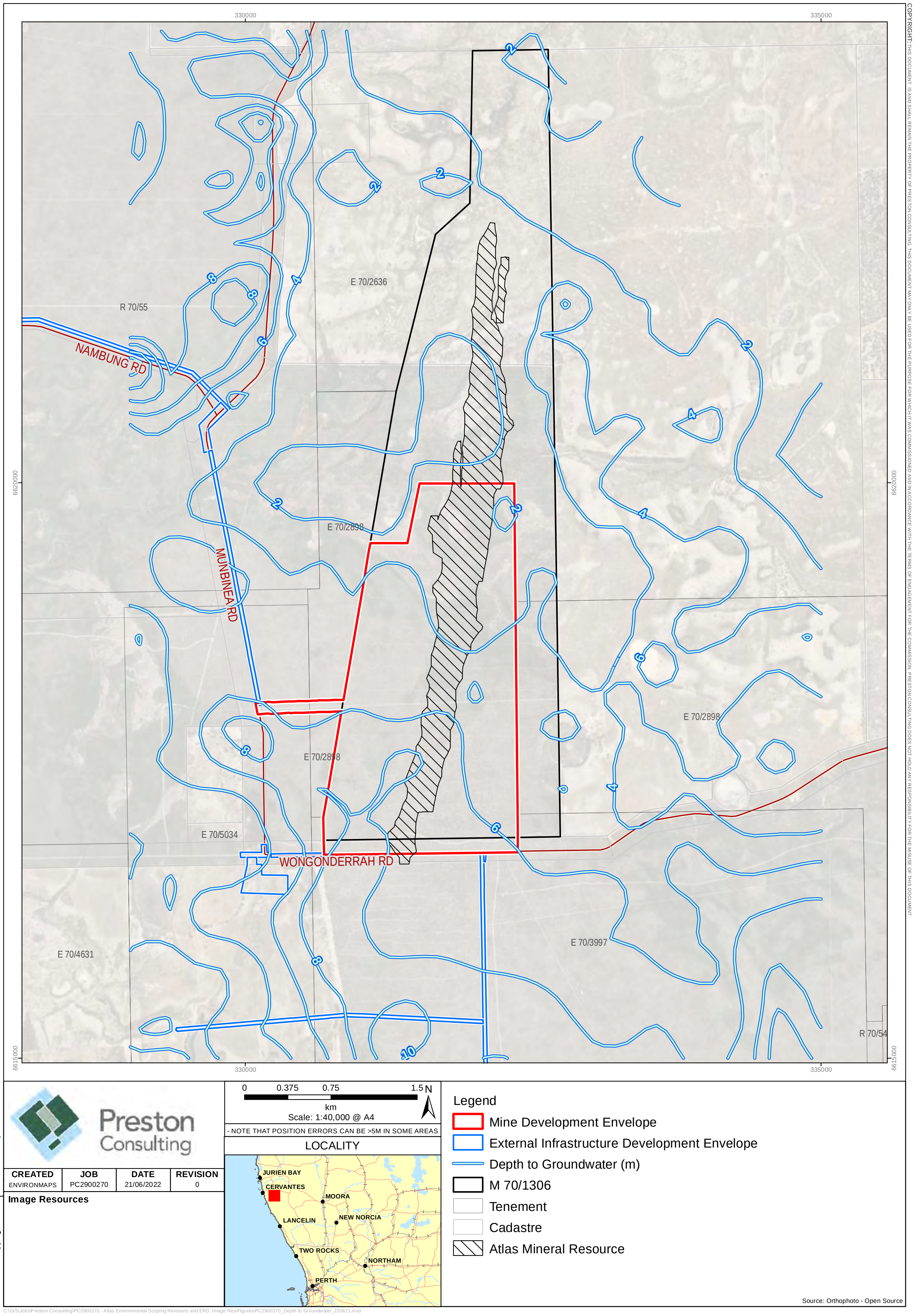


Figure 83: Average depth to groundwater

Stratigraphy and Saturated Thickness

The base of the Superficial Aquifer and the Tamala Limestone drop from 85 mAHD near the Gingin Escarpment to -20 mAHD near the coast (Figure 84). Groundwater levels also drop towards the coast and the difference between the two levels was mapped as the saturated aquifer thickness (Figure 85). Saturation generally thickens towards the south, north and west, with the thickest saturation in the southeast part of the AMR. Two prominent areas where there is no saturation are either side of the AMR as shown in Figure 85. The AMR lies mainly in a north-south orientated zone of thicker saturation.

Closer to the AMR, the thicker zones of saturation are evident near production bore ATPB02 and west of ATPB03 (PB2 and PB3 in Figure 86). Most of the AMR lies beneath the water table and will require dewatering to allow dry mining.

The thickness of all saturated aquifers across the AMR was calculated by subtracting the groundwater depth from an indicative pit depth. The resulting submergence ranges from 0 - 12.8 m and the average is 6 m. Highest values are in the north where the water table is most shallow.

The lithology at the contact between the superficial formations and the underlying Mesozoic formations was mapped in the pit area using mineral exploration lithology logs, particularly the measured clay fines concentrations. Sand dominated lithologies at the base of the superficial formations overlie sands and sandstone in the Yarragadee Formation, extending north into part of the Cattamarra Coal Measures (CCM). Only small sections of clayey sediments are found above thin and insignificant clay units in the Yarragadee Formation. Often the clayey sand was deposited adjacent to underlying Mesozoic clay units, implying local erosion and transport of clay into the overlying units.

Larger clayey sediment patches are common at the base of the superficial formations to the north of the AMR where they overlie the main part of the CCM. This part of the CCM has more extensive clay units. There were also clayey lithologies in the superficial formations in three piezometers, ATMB12, 15 & 18. Here they overlie the Eneabba Formation or are close to the contact with the Lesueur Sandstone. The Superficial Aquifer is therefore in direct hydraulic connection with the underlying Mesozoic aquifers and only a poorly developed and patchy aquitard sometimes separating the aquifers.

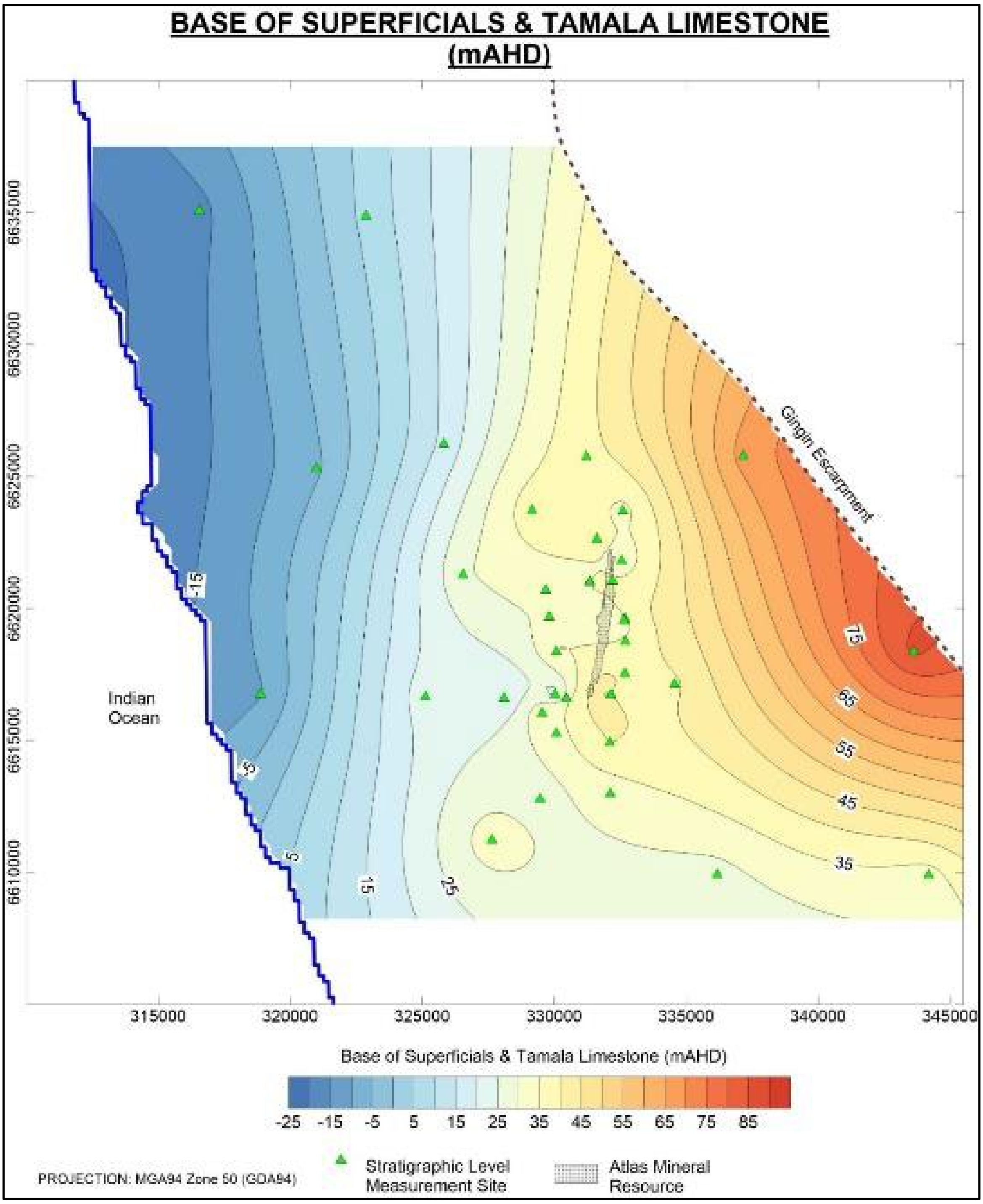


Figure 84: RL Base of superficial formation and Tamala Limestone

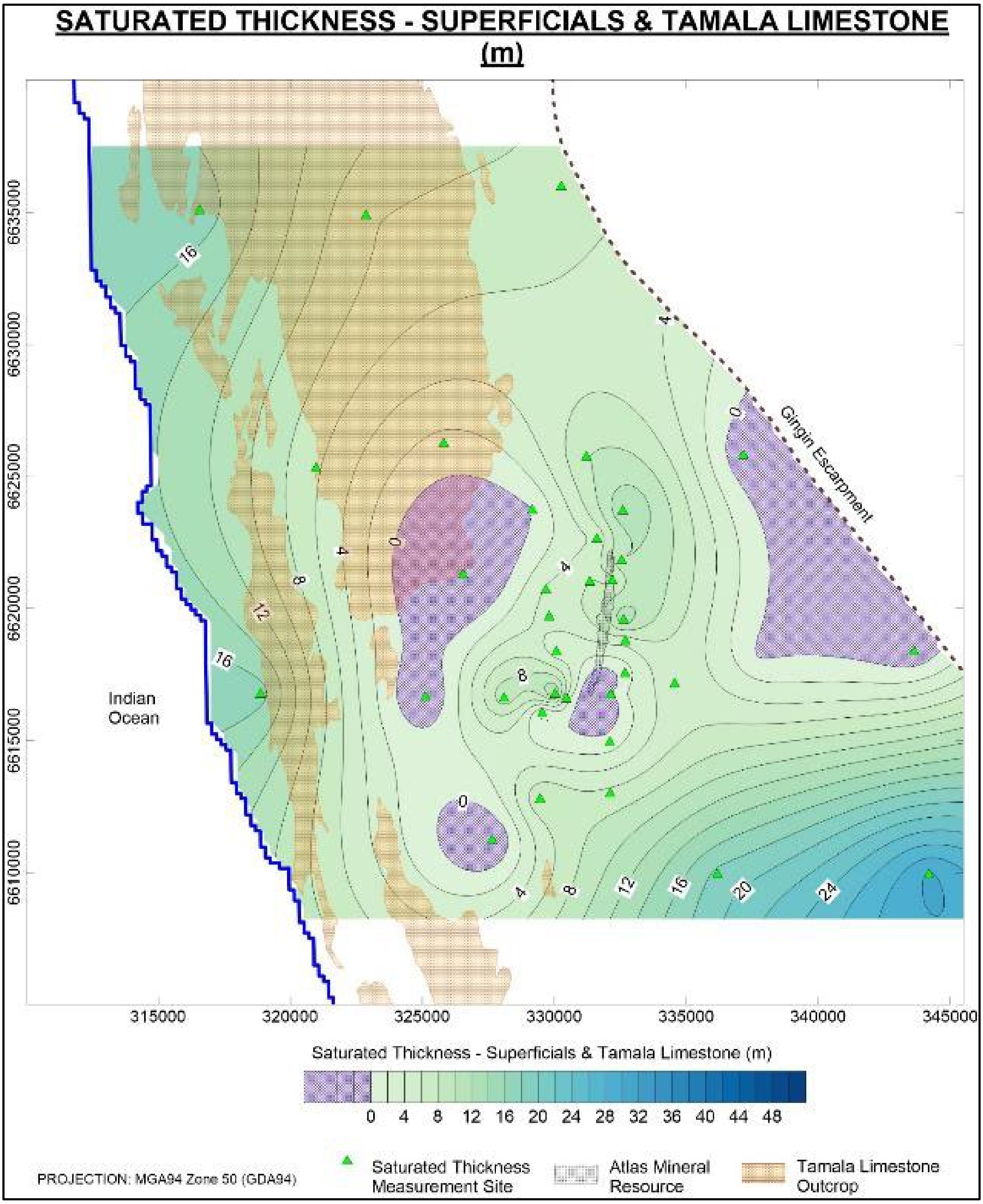


Figure 85: Saturated Thickness - Superficial and Tamala Limestone – Regional

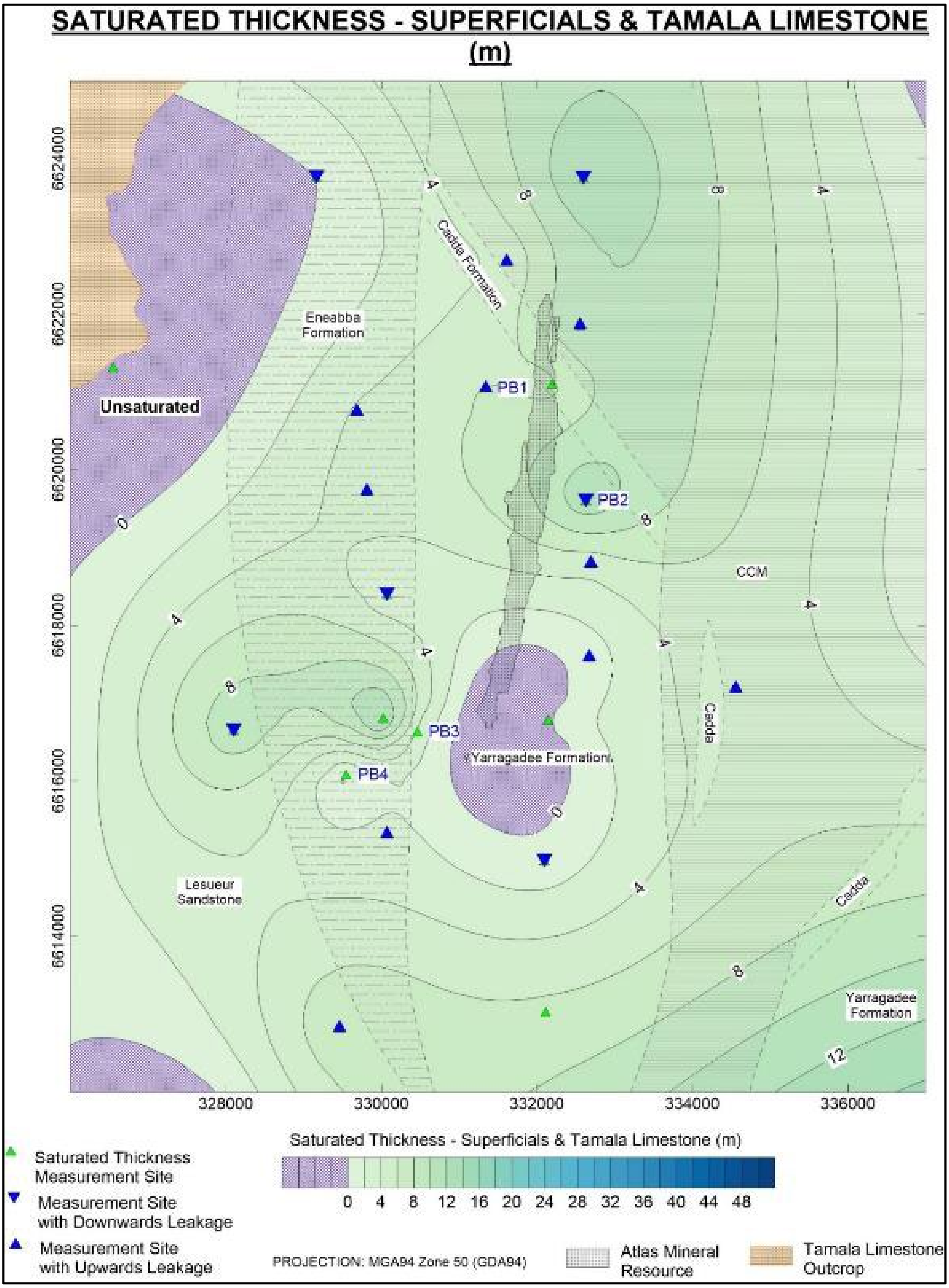


Figure 86: Saturated Thickness - Superficial and Tamala Limestone - local

Superficial / Tamala Limestone Aquifer System

Superficial geological formations at the Proposal have been subdivided into two main aquifer systems:

- An undifferentiated Superficial Aquifer, of the Middle to Late Pleistocene aged Bassendean Sand and Guildford Formation as well as the Pliocene aged Yoganup Formation; and
- Aquifers that also comprise part of the Superficial Aquifer but have been separately differentiated as the Late Pleistocene aged Tamala Limestone, due to their unique and contrasting hydrogeological properties (pale yellow, weathering to grey, and consists of calcareous quartz sand commonly cemented by limestone). The aquifer is karstic in nature, containing numerous solution channels and cavities. The Nambung cave system is developed in the limestone. (Kern, 1993 & 1997).

The superficial formations comprise a single unconfined aquifer system that is generally thin near the AMR and thickens to the north and south. The AMR lies in a saddle between two areas with no saturation as shown in Figure 85 and Figure 86. Another smaller area without saturation occurs near the southern end of the AMR, but the AMR itself is almost fully saturated as described previously. The thickness of saturation is the difference between the mapped base of the Superficial Aquifer (Figure 84) and the groundwater level (MWES, 2022b, Appendix 18), both sloping to the west. The groundwater level is seasonally variable with water appearing above the ground surface in some areas during the rainy season.

The superficial groundwater flow system is bounded to the west by the Indian Ocean and to the east by the Gingin Escarpment. Groundwater flow is westerly and there are significantly different hydraulic conductivities between the Superficial Aquifer and the Tamala Limestone. There are also hydraulic connections between the Mesozoic aquifers to the east of the Gingin Escarpment and the Superficial Aquifer to the west (Kern, 1993).

Recharge to the Superficial Aquifer from rainfall and associated runoff is widespread over the AMR, while vertical movement in and out of the underlying Mesozoic aquifers is variable as defined by the shallow and deep piezometers and monitoring bores (Figure 87). Areas with downward vertical leakage are mainly in the southern part of the AMR where the Superficial Aquifer overlies the Yarragadee Aquifer. North of the AMR and large areas further north, east and west of the AMR have upward vertical movement. To the north and east they overly the Cattamarra Aquifer while to the west they overly the Lesueur Aquifer. The Eneabba Aquifer has variable upward and downward leakage.

Aquifer transmissivity is progressively higher from the Guildford Formation aquifer located in the south-east part of the study area, to the Bassendean Sand and to the Tamala Limestone aquifers located in the western part. Historical pumping tests in the Bassendean Sand aquifer typically produce hydraulic conductivities of 5 - 20 m/day, while the Tamala Limestone is highly transmissive with hydraulic conductivities ranging from 100 - 1,000 m/day (DoW, 2017).

At production bore site ATPB02, the transmissivity in the Superficial Aquifer was measured as 40 - 110 m^2/day, equivalent to a maximum hydraulic conductivity of 8 m/day (transmissivity = hydraulic conductivity times aquifer thickness). This bore was representative of a thicker part of the Superficial Aquifer close to the orebody. It had a coquinite layer at the base and was almost entirely sand.

At the AMR, mineral drilling lithology logs and measured clay fines concentrations show a layered pattern with a clayey sand layer between a high permeability, but only partly saturated dune sand and a basal sand layer. The latter will also have high permeability, due to its inherent low clay fines concentration.

The measured Storage Coefficient in the Superficial Aquifer was between $4e^{-3}$ and $5e^{-4}$ (average $2e^{-3}$). The specific yield was not measured but was estimated as 0.1 based on the grainsize of the sand units.

At the AMR, the Superficial Aquifer is in hydraulic connection with the underlying Mesozoic aquifers.

Mesozoic Aquifer System

The permeability in each of the Mesozoic units is controlled by the proportion of coarse clastic sediments vs fine grained silt and clay-based sediments as well as the degree of weathering and lithification. Intergranular pore cementation and presence of a clay matrix will all impact the permeability of the aquifer. Even a small percentage of intergranular material can impact the permeability considerably.

Groundwater in the Mesozoic aquifers flow from east to west. Flow rates are expected to vary with depth as well as between the different formations:

- The top 50 m of the Mesozoic aquifers was estimated to contain higher transmissivities as they are generally more weathered with less clay and cement matrix. All aquifers are regionally unconfined and hydraulically connected to the overlying superficial aquifers. Some local confinement can occur where silt and clay units immediately underly the Superficial Aquifer or north of the AMR where thin clays overly the Cattamarra Aquifer. The transmissivity of the shallow part of the Yarragadee Aquifer was measured at production bore sites ATPB01 and 03. These were between 2 and 8 m^2 /day and averaged 5 m^2 /day, or an equivalent hydraulic conductivity of 0.3 m/day. The storage coefficient ranged from $6e^{-5}$ to $1e^{-4}$ and averaged $9e^{-5}$;
- Lower aquifer transmissivities are expected in the deeper parts of the Yarragadee, Eneabba, and Lesueur aquifers due to inter-granular kaolin clay matrix and diagenesis causing matrix cement to form in the sandstones. Studies at the Jurien town water supply borefield have suggested the upper unconsolidated section of the Lesueur Aquifer is typically an order of magnitude higher than the lower section (DoW, 2017); and
- Even lower transmissivities are expected in aquifers with dominant siltstone and claystone such as the Cattamarra and Eneabba aquifers. The sands and sandstone layers in these aquifers are poorly developed but do have some permeability. Thin (3 m) sands and sandstones were intersected in the Eneabba Aquifer in production bore ATPB04, a private bore drilled for Nambung Station. The bore produced a low airlift yield of between 0.5 and 1.0 L/sec.

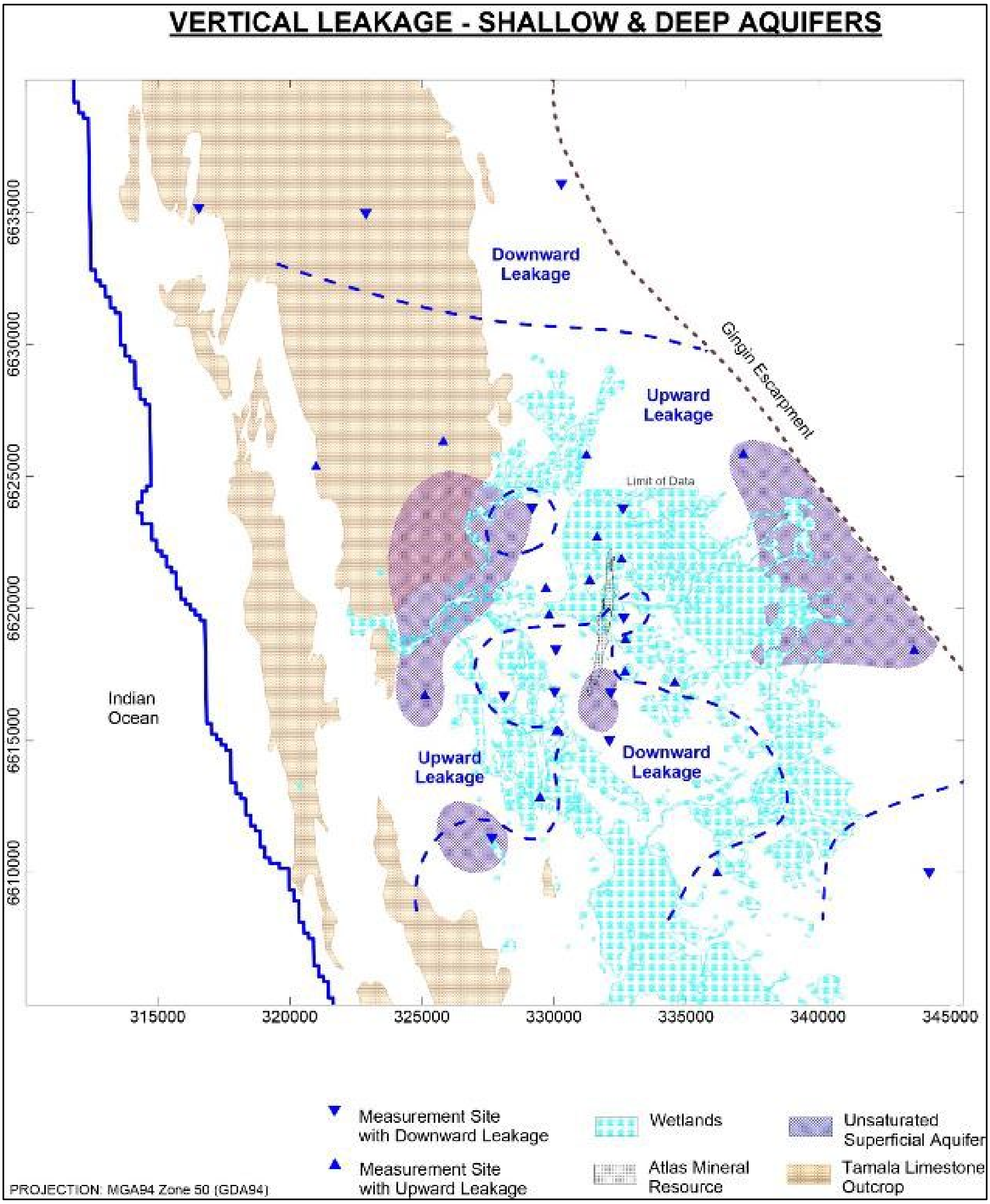


Figure 87: Vertical Leakage

Groundwater Quality

Groundwater salinity close to the water table (shallow aquifers) and deeper (deep aquifers) is shown in Figure 88. The salinity measured as Electrical Conductivity (EC) varies widely from 560 - 28,200µS/cm (equivalent to 400 - 22,000 mg/L Total Dissolved Solids; TDS).

Low salinity groundwater occurs in the western area where there is either downward leakage from rainfall recharge (south of piezometer ATMB12) or where the Mesozoic aquifers have inherently low groundwater salinity (Yarragadee, Lesueur, and parts of the Eneabba Aquifer).

The high salinity water is to the east of the AMR where there is an upward flow of saline groundwater from the Cattamarra Aquifer and further localised evaporative concentration or salts. Commander (1978) observed groundwater salinity increasing in the direction of flow along the Eneabba Borehole Line, possibly accounting for some of the inherent high groundwater salinity in the Cattamarra Aquifer. Kern (1993 & 1997) observed high salinities in parts of the Superficial Aquifer where groundwater discharged to wetlands. Salinisation was caused by evaporative concentration of salts in the near-surface part of the aquifer.

Higher salinities in the shallow aquifer compared to the deep aquifer could indicate interactions with surface water and evaporative concentration of salts. This is particularly apparent in piezometers ATMB02, 8 and 10 supporting this localised evaporative concentration theory. In other piezometers positioned along the edge of the saline water body, such as ATMB01 and 7, the shallow piezometers have lower salinities and appear to be evidence for salinity stratification. The higher salinity at the base of the aquifer is due to the higher density of the salt water.

Groundwaters in the MDE are neutral to slightly acidic and alkaline. The pH values range from 6.2 - 8.2.

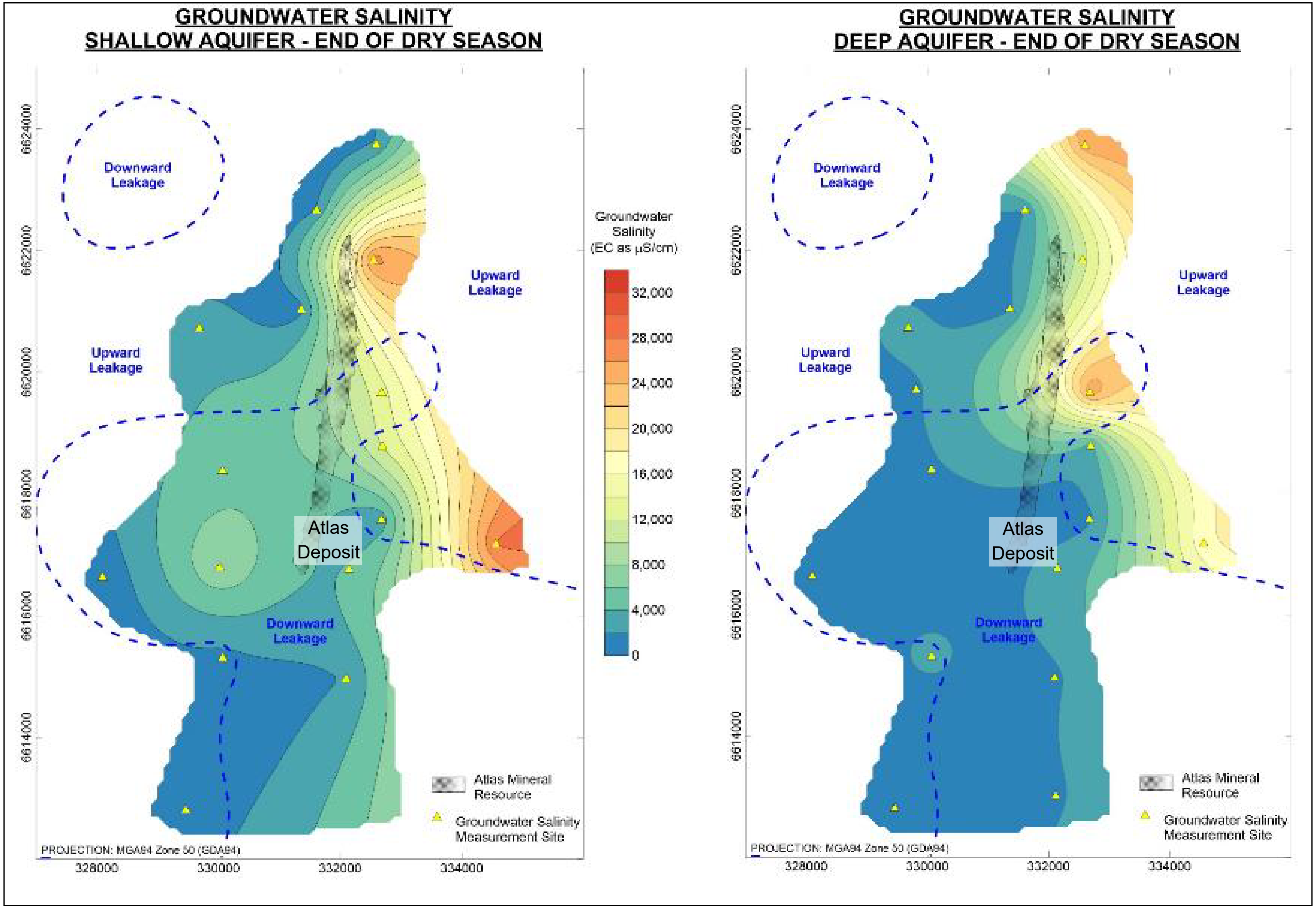


Figure 88: Groundwater Salinity Distribution

7.3.6 Local Groundwater Users

Private Bores and Soaks

MWES's (2022b; Appendix 18) database searches identified several privately owned bores and soaks (bulldozed scrapes into the watertable) in the local area. Names and locations are summarised in Table 42 and shown in Figure 89. Almost no construction or hydrogeological information are available from these bores and soaks. The Midlands No. 6 bore on Figure 89 is likely to be wrongly located in the DWER database as this bore could not be located.

The Moora Region-White bore is a domestic supply bore for Nambung Station that was failing, probably due to its shallow depth, low permeability Eneabba Aquifer sediments and the drying climate. Image replaced the bore in 2020 with a new, larger diameter and deeper bore named ATPB04.

Table 42: Private Bores and Soaks Summary

Site Type	Site ID[1]	Site Short Name[2]	MGA94 mE	MGA94 mN
Stock	Nambung - 27	27	328630	6615934
	Nambung - 42	42	325611	6622213
	Nambung - No1	No1	330313	6616011
	Nambung - No1 Yewadabby No. 1	No1 Yewadabby	329598	6617508
	Nambung - No10 Surveyors Swamp	No10 Surveyors Swamp	327787	6610923
	Nambung - No2 - Bore	No2	331327	6611098
	Nambung - No2 - West	No2 - West	335853	6619443
	Nambung - No3	No3	330205	6608620
	Nambung - No4	No4	330200	6608839
	Nambung - No9	No9	328784	6611975
Domestic	Moora Region - White	White	329544	6616088
Soak	Nambung - 21	Nambung - 21	333677	6621520
	Nambung - 22	Nambung - 22	330633	6623045
	Nambung - 24	Nambung - 24	330661	6621779
	Nambung - No11	Nambung - No11	329449	6616364
	Nambung - No2 - Soak	Nambung - No2	329927	6617147
	Nambung - No5	Nambung - No5	328857	6608844
	Nambung - No6	Nambung - No6	328842	6609305
	Nambung - No7	Nambung - No7	329610	6610163
	Nambung - No8 Flour Bag Flat	Nambung - No8 Flour Bag Flat	329169	6610974

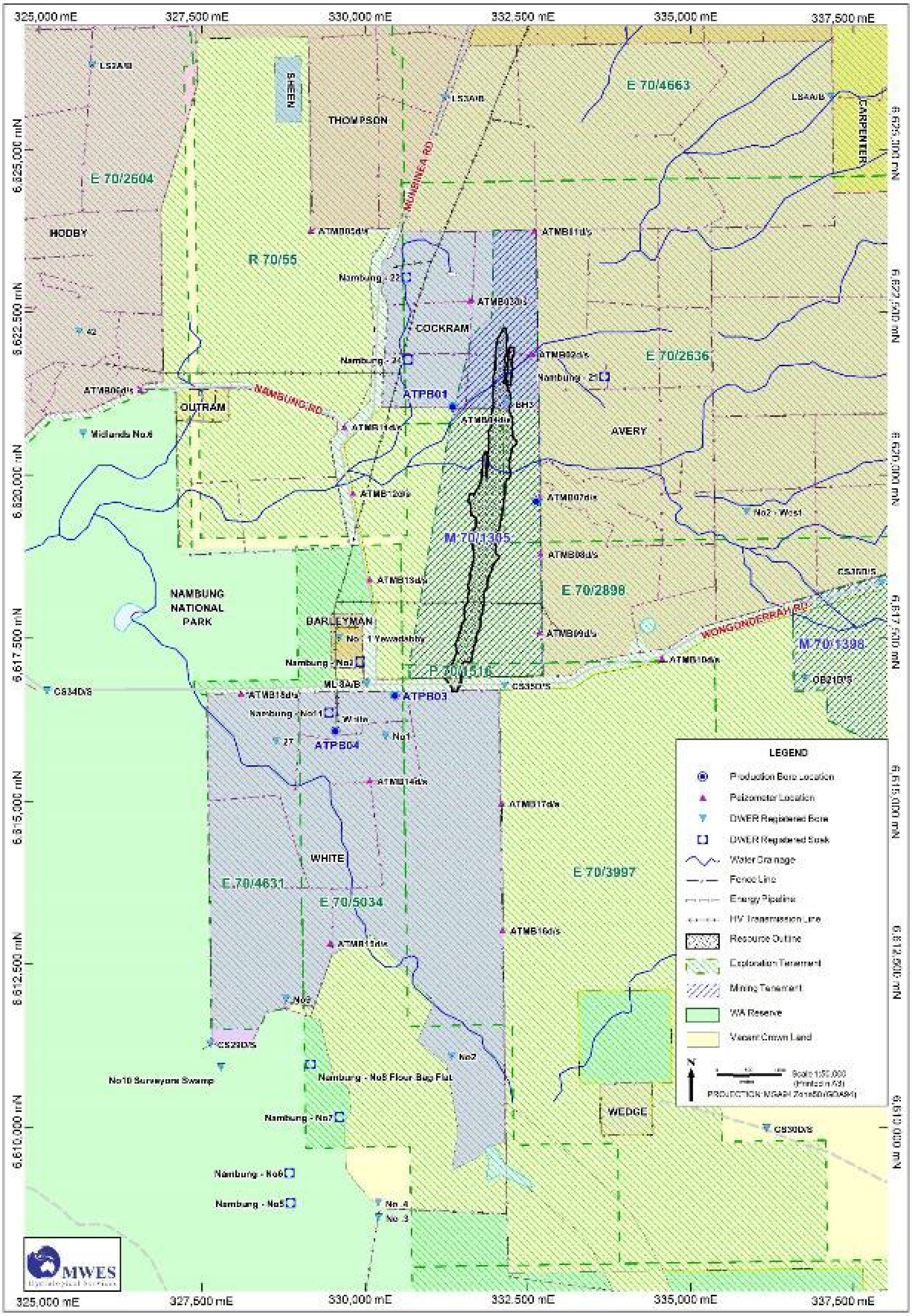


Figure 89: Private bores and soaks

Cervantes Town Water Supply

The Cervantes town water supply is the closest major borefield to the Proposal. It comprises four shallow production bores that draw water from the unconfined Tamala Limestone aquifer. The production bores are screened at depths between 7 - 20 m below ground. Average production capacity has been restricted to about 260,000 kL/yr to minimise possible saltwater intrusion from the oceanic side of the borefield.

The P1 and P2 protection areas shown in Figure 74 are required to restrict land use activities that can potentially contaminate local aquifers. The P1 area is the highest priority area outside of the 500 m borehead protection zone. P1 areas are declared over land where the provision of highest quality drinking water is the prime beneficial use. The lower priority P2 area is defined to ensure there is no increased risk of pollution to the Cervantes town water source (WRC, 1999).

7.3.7 Potential Acid Mine Drainage

ASS often occur beneath the water table in sandy soil profiles of the Swan Coastal Plain and are often associated with mineral sand deposits (DER, 2015a). ASS are naturally occurring soils and sediments that contain iron sulfides, predominantly in the form of pyrite materials. The disturbance of ASS and exposure to oxygen results in sulfuric acid being formed, which can lead to the release of metals, nutrients and acidity into the soil and groundwater system (DER, 2015b).

The Proposal is located outside of the Swan Coastal Plain ASS risk mapping area, however land units that are considered an ASS risk are located within or in close proximity to the MDE (i.e. wetlands, high groundwater table areas) (DER, 2015a). ASS have been encountered at numerous other mineral sands mines on the northern Swan Coastal Plain (e.g., Boonanarring, Cooljarloo), typically at the boundary of geological formations. Within mineral sands deposits, ASS are typically associated with dark coloured soils and those soils with higher clay contents. A Targeted ASS investigation was therefore conducted at the Proposal, in accordance with the Government of WA guidelines for identification and investigation of ASS and acidic landscapes (DER, 2015a). The information contained within this section has been sourced from the ASS Investigation and Management Plan for the Proposal (Mine Earth, 2022a; Appendix 22) unless otherwise stated.

Acid Sulfate Soils Groundwater Assessment

Groundwater samples were collected from monitoring bores surrounding the Proposal, shown in Figure 75. Groundwater from these bores was analysed, and the following chemical indicators were used to indicate whether groundwater has been affected by the oxidation of sulfides in ASS:

- An alkalinity:sulfate ratio of less than 5;
- A pH of less than 5; and
- A soluble aluminium concentration greater than 1 mg/L (DER, 2015b).

The alkalinity:sulfate ratio of the majority of the groundwater samples was less than five, indicating that the groundwater may have been affected by the oxidation of sulfides. However, none of the samples had a pH less than 5 and only one of the samples had a soluble aluminium concentration greater than 1 mg/L.

The alkalinity of the groundwater is a measure of the natural buffering capacity of the groundwater, such that the lower the total alkalinity and the higher the total acidity, the more vulnerable groundwater is to acidification (DER, 2015b). Several samples had alkalinity levels that were inadequate to maintain a stable acceptable pH level.

PASS materials identified within the AMR therefore have the potential to impact the surrounding environment through direct disturbance of the soil and through lowering of the groundwater table. Both processes result in exposure of PASS to oxygen with subsequent potential oxidation of the PASS materials and generation of acidity.

ASS investigations are discussed in greater detail in Section 8.3.5.

7.3.8 Environmental Values

Based on the information provided in Section 7.3, the following environmental values were determined to require assessment for this factor:

- Surface water, including downstream karst systems;
- Superficial / Tamala Limestone Aquifer System beneath and surrounding the Proposal; and
- Mesozoic Aquifer System (Lesueur, Yarragadee and / or Eneabba aquifers).

7.4 Potential Impacts

Table 43 defines the potential impacts (direct, indirect and cumulative) on the environmental values for this factor in a local and regional context.

Table 43: Potential impacts on inland waters

Environmental value and current extent	Potential direct impacts	Potential indirect impacts	Impacts associated with other proposals	Total cumulative impacts
Surface Water Proposal is located in a minor sub-catchment of the Nambung River which comprises less than 1% of the Nambung River catchment.	Small area of intersection with a minor sub-catchment of the Nambung River Minor creek crossings for road upgrades	• Contamination from hydrocarbon or chemical spills or disturbance of ASS • Sedimentation during earthmoving or as a result of slurry pipeline spills	There are no proposals in the vicinity with potential to impact surface water, however the broader catchment has been impacted by agriculture	• Small area of intersection with a minor sub-catchment of the Nambung River • Minor creek crossings for road upgrades • Contamination from hydrocarbon or chemical spills. • Sedimentation during earthmoving or as a result of slurry pipeline spills
Superficial / Tamala Limestone Aquifer System Underlying groundwater within the Superficial is neutral to slightly acidic and alkaline (pH values range from 6.2 – 8.2). Salinity ranges between 400 - 22,000 mg/L TDS.	Dewatering of up to 1.1 GL/yr during construction and up to 0.75 GL/yr during operation.	Contamination of groundwater from hydrocarbon, chemical spills or disturbance of ASS	**Jurien, Nambung, Perth - Superficial Swan:** 3.2 GL/year allocated to Cooljarloo (Tronox Management Pty Ltd).	• Abstraction of up to 4.3 GL/yr (combined peak of the Proposal and Cooljarloo) • Drawdown potentially impacting other water users and GDEs • Contamination of groundwater from hydrocarbon, chemical spills or disturbance of ASS

Environmental value and current extent	Potential direct impacts	Potential indirect impacts	Impacts associated with other proposals	Total cumulative impacts
Mesozoic Aquifer System Salinity ranges between 400 - 22,000 mg/L TDS.	Abstraction of up to 2.2 GL/yr from one or more borefields during operation	None predicted	**Nambung Yarragadee:** 2.5 GL/year allocated to Cooljarloo (Tronox Management Pty Ltd). **Lesueur:** 0.1 GL/year to Cervantes 'Public Drinking Water Supply Area' **Eneabba:** No Licences.	Abstraction of up to 4.8 GL/yr (combined peak of the Proposal and other allocations)

7.5 Assessment of Impacts

7.5.1 Surface Water

Direct Impacts

The Proposal is located in the Nambung River catchment, which terminates in karst country within the Nambung National Park. The Mount Jetty and Bibby Creeks flood-out and coalesce near the Proposal in an area of very low surface gradients. The creek-lines reform and coalesce to the west as the Nambung River which discharges into Tamala Limestone 6 km east of the coast. This river system has important conservation value for the diversity of habitats it provides.

The Proposal design has been revised to a include a considerable reduction in the mine area, in part due to an increased understanding of surface water values via baseline surveys and investigations. The revised mine area has been designed to avoid mining within the Mount Jetty and Bibby Creeklines, and minimise disturbance within sub-catchments that are known to contribute to the Nambung River during low-flow events.

The Proposal is located in a minor sub-catchment of the Nambung River (the South catchment) which comprises less than 1% of the 2,959 km^2 Nambung River catchment. The catchment is small and relatively flat and there are no substantial natural drainage lines across the mine disturbance areas. Runoff rates are very low and local runoff is mostly retained within the catchment in seasonal swales and ponds.

There is a general convergence of surface water flow lines toward the Mt Jetty Creek confluence with Bibby Creek at Munbinea Rd (i.e., the upstream end of the Nambung River) to the north and outside of the MDE. A minor swale is aligned northwest across the north end of the MDE at a ground elevation of 39 – 40 m. Surface water discharge from the sub-catchment occurs rarely in response to extreme and sustained rainfall and comprises an infinitesimal portion of the Nambung River flow. During such events the sub-catchment provides a trivial contribution to the Nambung River flow. There is therefore no potential for measurable water quantity or quality impacts during moderate to large stormwater flow events due to the dilution factor imposed by the large catchment area active during such events.

A SWMP was developed for the Proposal by MWES (2022d; Appendix 20). The SWMP will be implemented for the Proposal for the management and control of surface water interaction with the Proposal mine and infrastructure. The SWMP includes a monitoring program for the purpose of developing and improving the baseline hydrological knowledge and to identify opportunities for improved water management.

Based on the above, the disturbance within this catchment is unlikely to significantly impact surface water systems in a regional or local context.

Watercourse Crossings

A small section of the EIDE crosses a seasonal drainage line where Mount Jetty and Bibby Creeks converge to form the Nambung River. The crossing runs parallel to the existing Munbinea Road floodway to the north west of the MDE. This narrow corridor may be required for a water supply pipeline connecting the PBA borefield to the MDE.

Due to the upstream containment within the floodplains and minor swales that make up the Nambung Flats, the crossing is predominately dry and only flows seasonally in response to high and continuous rainfall. During such events however the concentration of flows from the four upstream catchments can result in considerable inundation of the floodway.

Where the pipeline crosses the river concrete risers will be installed to allow surface water flows to pass below the pipeline with minimal interruption. The risers will be engineered to maintain structural stability and support the pipeline above high flow events at the floodway. In additional to minimising disruption of surface water flows the pipeline crossing will be adequately designed to avoid costly damage to the pipeline.

The Munbinea Road floodway will also be utilised by traffic related to the Proposal including haulage of HMC to port. The current sealed road surface at the floodway has been constructed to convey existing local traffic including large trucks travelling to and from Nambung Station. The floodway is expected to adequately accommodate the increased traffic associated with the Proposal.

Monitoring, maintenance and retro-fitting improved drainage where required will further reduce the frequency and consequence of impacts to surface water drainage.

Contamination

The implementation of the Proposal will require the development of supporting infrastructure and the maintenance and operation of machinery that has the potential to contaminate surface water with hydrocarbons and chemicals if spills were to occur.

The South Catchment is small and relatively flat, minor flows are retained locally and there are no substantial natural drainage lines across the mine disturbance areas. Surface water discharge from the sub-catchment occurs rarely in response to extreme and sustained rainfall and comprises an infinitesimal portion of the Nambung River flow. During such events the sub-catchment provides a trivial contribution to the Nambung River flow. There is no potential for measurable water quantity or quality impact during moderate to large stormwater flow events due to the dilution factor imposed by the large catchment area active during such events.

Sewage from the accommodation camp will be treated at a wastewater treatment plant (WWTP). The treated wastewater will be disposed of via irrigation to a dedicated vegetated (non-native) area adjacent to the camp, located away from surface water drainage lines. The wastewater will be treated to a minimum low exposure risk level quality and licenced under Part V of the EP Act and the *Health Act 1911* (WA).

Sand mining and heavy mineral separation is largely a physical rather than chemical process, so stormwater contamination risks are generally unlikely. The Proposal disturbance area is relatively isolated from the natural creeklines and hence does not present a particular contaminant risk. Based on the above, any spills that occur within the development envelopes are unlikely to reach any surface water features, and mitigation measures are proposed (7.6) to ensure spills are contained and cleaned up. Given this, and the low volumes of hydrocarbons and chemicals to be stored on site, the risk of a significant impact to surface water quality is considered unlikely.

Sedimentation and Erosion

Mine infrastructure is located within the small and relatively flat South catchment and there are no substantial natural drainage lines across the mine disturbance areas. Runoff rates are very low and local runoff is mostly retained within the catchment in seasonal swales and ponds.

Where required, drainage diversions around the stockpiles and hardstands will retain stormwater locally, allowing infiltration or evaporation. To accommodate high-flow events pond freeboard and sediment basins will be designed for a minimum first flush capacity of nominally 25 mm across the micro-catchment and to allowing sufficient holding time to enable the majority of sediment to drop out of the water column prior to release. Provided the mine workings are isolated from wetland water there can be no impact on the stormwater component of the water balance in localised wetlands outside the mine bunds.

A water supply pipeline carrying groundwater abstracted from one or more borefields will be constructed within the development envelopes and a slurry pipeline will be constructed from the FPP to the WCP (within the MDE). Both pipelines have been designed to run though cleared areas wherever possible, however a rupture of either pipeline would result in water / sand slurry being deposited adjacent to the pipeline potentially resulting in sedimentation and / or erosion. Leak detection (where there is potential to impact native vegetation) is proposed for the pipelines, which will trigger an automatic shut-down of the pipeline feed. This will restrict the volume of water / sand slurry that would be released into the surrounding environment. Image will also investigate the option of containing a spill if it was to occur, by placing the slurry pipe in a system of bunds and sumps designed to contain spillage. This option however may not be pursued along the whole length of the pipelines as the area likely to be affected by a spill may be less than the clearing of vegetation required to develop this containment infrastructure. The details of these systems are generally planned and managed via a Works Approvals under Part V of the EP Act and a Mining Proposal under the Mining Act. Additional mitigation measures are proposed in Section 7.6 to minimise the change and potential impact of a slurry pipeline spill. In the event of a spill any spilt sand slurry would be cleaned up as soon as practicable. It is likely that the spilt sand slurry would settle quickly and the water would infiltrate the sand. The MDE comprises mainly sandy soils with high hydraulic conductivities (Mine Earth 2021).

Based on the above, erosion and sediment losses are expected to be able to be adequately minimised using the mitigation measures proposed in Section 7.6 such that they do not have a significant impact on surface water systems.

Disturbance of Acid Sulfate Soils

Exposure of PASS to the atmosphere (oxygen) may result in acidification and the potential for leaching of salts or metals, thereby affecting groundwater quality. PASS occurring below the water table may be exposed to oxygen by direct disturbance during excavation.

Mine Earth (2022a) conducted ASS investigations for the Proposal. PASS have been detected in some samples and distribution is variable. The ASS investigation results and ASS management for the Proposal is discussed in more detail in Section 8.3.5. Further assessment of PASS will be undertaken within the deposit during operations to further quantify distribution and volumes of PASS material.

Mitigation of ASS will include the implementation of the ASS Management Plan (ASSMP; Appendix 22) as detailed in the Section 8.6.

Based on the information provided above and in Section 8.3.5, and with the implementation of the mitigation detailed in Section 8.6, impacts associated with ASS are predicted to be able to be managed such that they do not cause a significant impact to surface waters. Monitoring and management actions to minimise the risks associated with the PASS have been detailed in Section 8.6.

7.5.2 Superficial Aquifer

Dewatering

As discussed previously, the Proposal design has been revised to a include a considerable reduction in the mine area, resulting in a substantial reduction in total disturbance and subsequent groundwater abstraction requirements.

The Proposal deposit is partially submerged below the water table so dewatering will be required to allow dry mining. Image require dewatering of 1.1 GL/yr during the first year of the Proposal (construction), decreasing to a relatively consistent 0.75 GL/yr during operation.

MWES (2022b) developed a groundwater flow model to determine the magnitude of dewatering required, potential impacts of the cone of drawdown on the surrounding environment, and to inform decisions on Proposal mining methods, impacts and ongoing groundwater management requirements. In the model, the hydraulic conductivity of the Superficial Aquifer was amalgamated and set at the high end of a possible range as the dewatering potential of the AMR and the extent of drawdown is only dependent on the permeability of the basal sand layer and the underlying Mesozoic aquifer system. Due to the geometry of an excavation, more aquifer is exposed along the large area at the base of the pit compared to the thin section along the walls.

Furthermore, the high hydraulic conductivity was useful to simulate a conservative approach to determining the extent of the cone of drawdown, and therefore potential impacts in the root zone of GDEs. The extent of the cone of drawdown and the pit pumping rates will be controlled by depressurisation of the basal sand layer in the Superficial Aquifer as well as the hydraulically connected Mesozoic sand aquifers. This depressurisation will underdrain the overlying clayey sand layer, particularly relevant to the region outside the pit crest. The depressurisation will propagate upwards, potentially impacting vegetation. The rate of underdrainage is highly variable due to the layers discontinuity and variable slimes concentration.

MWES (2022b) modelled the cone of drawdown for the original, much larger mine plan which proposed dry mining of the full AMR. The maximum extent of drawdown for dry mining without mitigation was modelled at 1.3 km from the Proposal mine pit. The combined drawdowns (superimposing drawdowns from all staged mining blocks) from the original mine plan are shown in Figure 90. There are no private bores or soaks within this area, however GDEs within the cone of drawdown would have likely been impacted. As discussed in Section 5.3, all vegetation types within the MESA and EISA are potentially GDEs. Understanding the extent of drawdown and associated potential impacts to GDEs was an important influencing factor in Image's decision to reduce the mine area for the Proposal.

Although the considerable reduction in mine area for the Proposal will result in an overall reduction in impacts associated with groundwater drawdown, the maximum extent of drawdown for the retained mine blocks would still potentially extend to 1.3 km.

Image determined that significant mitigation measures should be implemented to minimise these potential impacts. MWES (2022e) was therefore engaged to conduct infiltration pond testing to support a Drawdown Mitigation Scheme (DMS) for the Proposal. The DMS is discussed in detail in the following section.

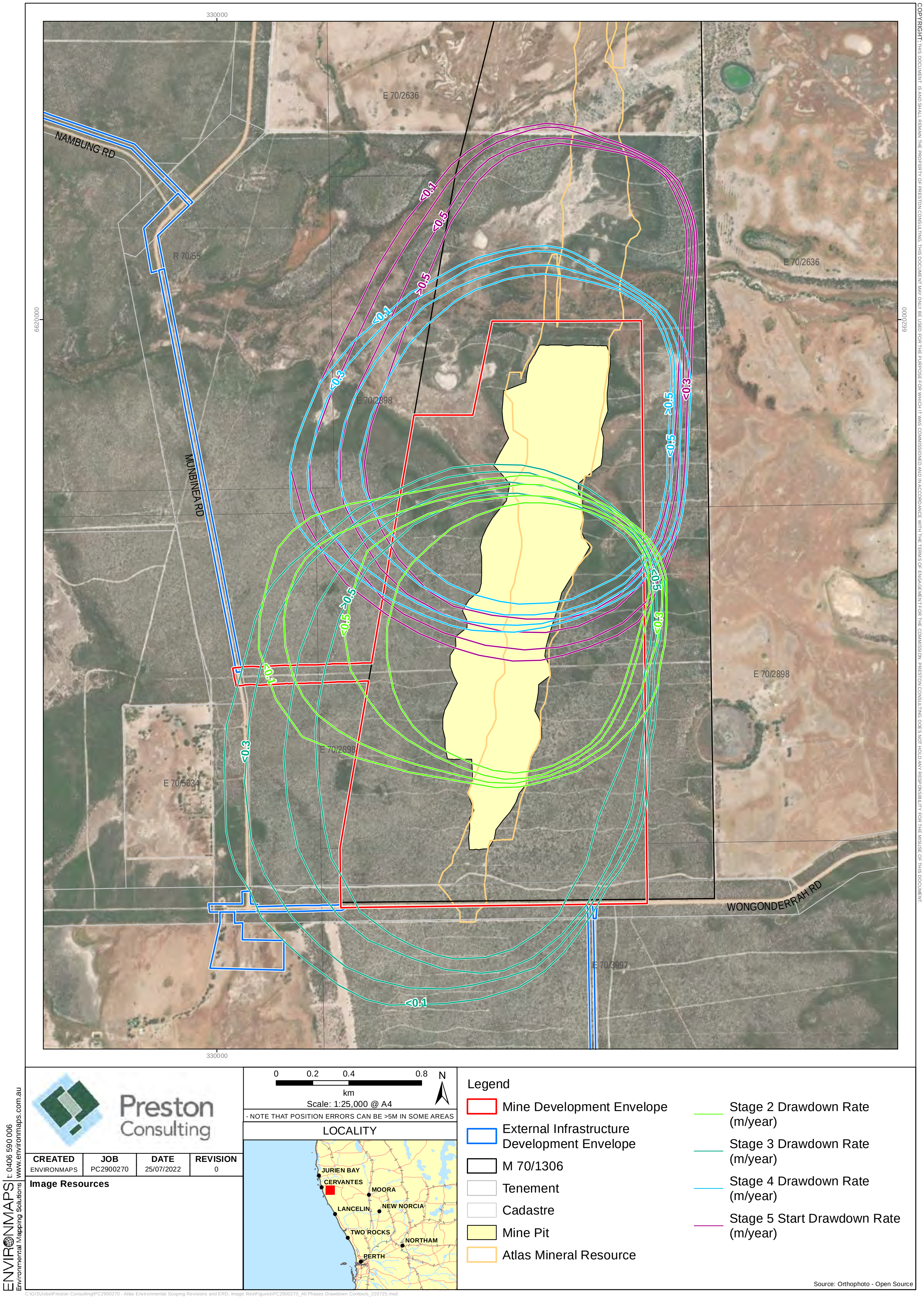


Figure 90: Maximum drawdown extent modelled without DMS mitigation

Drawdown Mitigation Scheme

Image commissioned MWES to conduct drawdown and infiltration testing (MWES, 2022e; Appendix 21) at the Proposal to determine the feasibility of the DMS scheme by assessing impacts of dewatering drawdown on the surrounding environment and other users. The DMS involves keeping the water table at its original level. The DMS is a type of Managed Aquifer Recharge (MAR) classified as "infiltration or injection for environmental benefit" (DWER, 2021a). Based on the successful infiltration tests MWES recommended the design specifications for the DMS.

The DMS consists of a series of excavated narrow ponds located optimally around the mine excavation. A line of recharge ponds will be constructed intermittently (approximately 100 - 200 m apart) at a minimum of approximately 100 m from the pit crest and remaining within the disturbance footprint. These small open ponds, about 10 m long, 5 m wide and 1 m deep are favoured at the recharge points rather than soak wells or bores. This is because ponds are relatively easy to rehabilitate or reduce and enlarge as necessary if they are found to be infiltrating too fast or slow. In a few places ponds may need to be deeper to penetrate through surface clayey sand. As the mine pit progresses, ponds each side of the pit will continue to be recharged until the groundwater within the pit area returns to pre-mining levels.

Clean water, with compatible quality to the local groundwater will be reticulated to the ponds by connecting pipelines and allowed to infiltrate to the top of the groundwater table. The hose or pipe leading into each pond will include a valve to enable adjustment and of flow and a flow meter to measure the flow. The inflow rate can be controlled using a float switch placed in the pond, keeping the pond water level at a pre-determined depth and avoiding overflow. Pipe and flow control infrastructure will be moved to new pit blocks as pit water levels recover in each of the previously mined areas.

At the Proposal, this scheme has advantages over physical barriers in preventing all drawdown propagating past the barrier. Physical barriers such as grout curtains and membranes must be completely sealed and placed all the way to the bottom of any permeable formation. These are expensive and any minor leak will cause drawdown beyond the barrier. At the Proposal, there are no impermeable layers to seat the grout or membrane barrier as there is continuous hydraulic connection to several hundred metres depth. Any gaps beneath the barrier will allow equalisation of groundwater levels either side of the barrier and continued outward propagation of drawdown.

MWES modelled the progressive drawdown contours depicting the water table drawdown during each progressive stage of mining with the implementation of the DMS (MWES, 2022e; Appendix 21). The indicative infiltration pond locations and modelled maximum extent of drawdown for the Proposal with DMS is shown in Figure 60.

MWES (2022e) concluded that implementation of the DMS can feasibly mitigate potential impacts to the surrounding environment and other users by limiting the maximum extent of groundwater drawdown to within the proposed disturbance areas. Management and implementation of the DMS will form part of the Groundwater Operating Strategy (GOS; Appendix 19) for the Proposal.

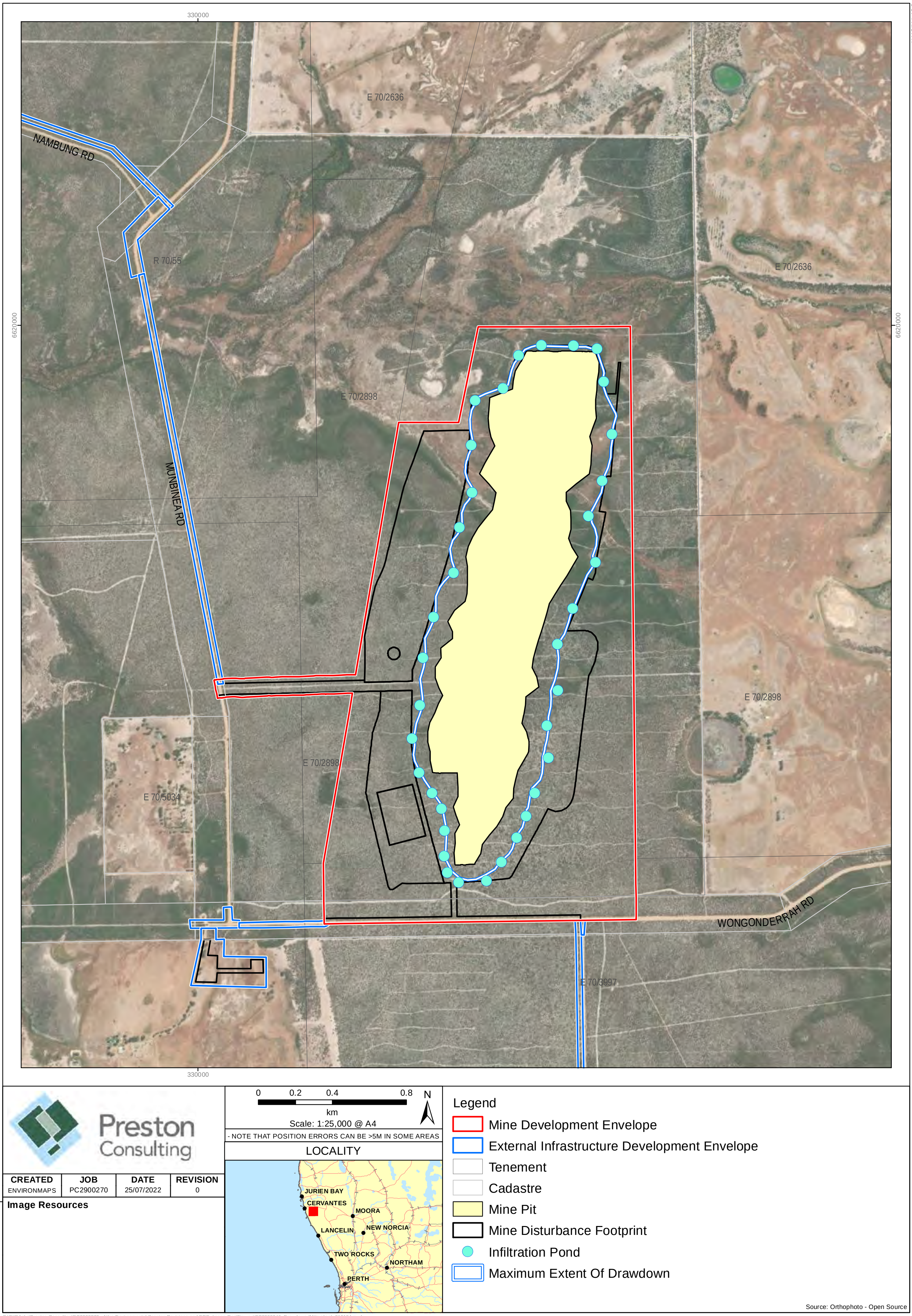


Figure 91: Maximum drawdown extent with DMS

Contamination

The implementation of the Proposal will require the development of supporting infrastructure and the maintenance and operation of machinery that has the potential to contaminate groundwater with hydrocarbons and chemicals if spills were to occur.

Diesel use at the Proposal is estimated to be 11 ML/yr for all site and transport operations. In addition to diesel used for mobile equipment, the power station will be diesel-fired, and small generators may be used for mobile power around the site. Approximately 220,000 L diesel storage is required for power generation and emergency diesel engines at the mine. Two other fuel facilities are likely to support the mining fleet (around 220,000 L). These diesel storage facilities will have secondary containment; they will either be either self-bunded or located within bunded areas.

In addition to diesel fuel, most earthmoving equipment uses hydrocarbon-based materials for hydraulics and failed hydraulic systems can result in relatively small hydrocarbon spills. Considering the above, and the small scale of operations planned for Image, large-scale hydrocarbon spills are considered unlikely. Small hydrocarbon spills associated with hydraulics failures on machinery and refuelling spills may occur on occasion in operational areas.

Given the shallow depth to groundwater within the MDE, the cumulative total of spillage over long periods may infiltrate to groundwater resulting in contamination. Spills generally result in a defined area of hydrocarbon contaminated soil that can be remediated via passive means such as bioremediation thus avoiding infiltration to groundwater. Proposed control measures are identified in Section 8.5 and are designed to further reduce the risk of soil contamination from hydrocarbon spillage.

Hydrocarbon storage above 100,000 L is subject to the licencing requirements of the Dangerous Goods Safety (Storage and Handling of Non-Explosives) Regulations 2007. Fuel storage at the mine site is likely to exceed this threshold and be subject to a Dangerous Goods Licence. Areas of suspected or actual hydrocarbon contamination will be subject to the *Contaminated Sites Act 2000* (WA) (CS Act).

With the implementation of controls (Section 7.6), hydrocarbon and chemical storage and spills are expected to be able to be managed to prevent significant impacts to groundwater.

Disturbance of Acid Sulfate Soils

Exposure of PASS to the atmosphere (oxygen) may result in acidification and the potential for leaching of salts or metals, thereby affecting groundwater quality. PASS occurring below the watertable may be exposed to oxygen by direct disturbance during excavation and indirect disturbance associated with groundwater drawdown during mining.

Mine Earth (2022a) conducted ASS investigations for the Proposal. PASS have been detected in some samples and distribution is variable. The ASS investigation results and ASS management for the Proposal is discussed in more detail in Section 8.3.5. Further assessment of PASS will be undertaken within the deposit during operations to further quantify distribution and volumes of PASS material.

While groundwater drawdown has the potential to expose PASS material to indirect disturbance, the DMS will be implemented to limit drawdown to the Proposal's disturbance footprint. Mitigation of ASS will include the implementation of the ASSMP (Appendix 22) as detailed in the Section 8.6. The GOS will also include monitoring procedures and thresholds to identify changes in pH and metals concentrations.

Based on the information provided above and in Section 8.3.5, and with the implementation of the mitigation detailed in Section 8.6, impacts associated with ASS are predicted to be able to be managed such that they do not cause a significant impact to surface waters. Monitoring and management actions to minimise the risks associated with the PASS have been detailed in Section 8.6.

7.5.3 Mesozoic Aquifer System

The Proposal water balance identified the need for additional water supplies of up to 2.2 GL/yr. As discussed in Section 7.5.2 the connectivity between the deep Mesozoic and shallow superficial aquifers was determined to be high beneath the Proposal and hydrological modelling has indicated that the drawdown associated with extraction would potentially result in significant impacts to GDEs. Consequently, investigations into off-site water supply options were initiated to source sufficient volumes whilst avoiding impacts to GDEs and other local groundwater users.

Preliminary desktop modelling was conducted for several potential bore locations within an approximate 15 km radius. A conceptual determination of potential flow rates and drawdowns at each site was used as there are limited bores to inform the assessment of prospectivity and the hydraulic characteristics of the Mesozoic aquifers in the immediate area.

The prospectivity of each bore location, water quality, land access and logistical requirements were assessed to determine a short list of three prospective borefields that required further field assessment. These conceptual bore sites PBA, PBB and PBF align with the EIDE pipeline corridors shown in Figure 3. Image are currently progressing investigations at potential bore sites to determine the actual hydraulic characteristics at the target bore sites and monitoring bores are planned between the borefield and the nearest sensitive environments to monitor the extent of drawdown. The borefield/s will need to produce approximately 70 L/sec during the second quarterly mining period, but this drops to around 50 L/sec for the remainder of the mine life.

Dependant on the outcomes of water supply investigations water will be abstracted from the Lesueur, Yarragadee and / or Eneabba aquifers. Table 44 details the current understanding of the target aquifers based on preliminary desktop modelling and investigations.

Table 44: Target aquifers for abstraction

Target Site ID	Target Aquifer/s	Groundwater Sub-Area	Groundwater Sub-Area & Unallocated Resources[1]		Expected Salinities
			Unconfined	Confined	
PBA	Superficial Aquifer with Tamala Limestone overlying Lesueur Sandstone	Cervantes	Superficial 22.7 GL/yr	Lesueur fully allocated.	900 to 2,000 mg/L TDS, possibly increasing with depth.
PBB	Thin superficial sands overlying Lesueur	Nambung	Superficial 0.4 GL/yr	Lesueur 2.7 GL/yr.	4,000 to 6,000 mg/L TDS at depth.

Target Site ID	Target Aquifer/s	Groundwater Sub-Area	Groundwater Sub-Area & Unallocated Resources[1]		Expected Salinities
			Unconfined	Confined	
	Sandstone and/ or Eneabba Aquifer.			Eneabba 0.3 GL/yr.	
PBF	Yarragadee Aquifer Unit A	Nambung	Superficial 0.4 GL/yr	Yarragadee 6.3 GL/yr	Possible >4,000 mg/L TDS. Could be much higher if drilled close to Cattamarra Aquifer.

Abstraction of groundwater for the Proposal will require a 5C Licence under the RIWI Act and management and monitoring will be outlined in the GOS. The licence application will be supported by H3 level hydrological investigations verifying that the proposed abstraction volumes will not result in drawdown impacts to wetlands, GDEs or other groundwater users.

7.6 Mitigation

Image has mitigated the potential impacts to this factor according to the mitigation hierarchy; avoid, minimise, rehabilitate, offset. Offsets are not expected to be required for this factor.

7.6.1 Avoid

The key avoidance mechanism implemented by Image was the design of the Proposal to avoid key environmental features. Image has conducted extensive hydrological, hydrogeological and ecological studies, and this information has been utilised to design the Proposal and its MDE boundaries to avoid the following:

- Groundwater drawdown impacts to GDEs;
- Seasonal ponds;
- Mount Jetty Creek; and
- Bibby Creek.

7.6.2 Minimise

The following mitigation measures are proposed to ensure that direct and indirect impacts to inland waters are minimised:

1 **Obtain and comply with Works Approval and Licence issued under Part V of the EP Act.** A Works Approval and Licence will be required for the Proposal, specifically for the FPP, slurry and return water pipeline and WCP. These infrastructure items present the highest surface water and groundwater pollution risks for the Proposal. Therefore, the Works Approval and Licence is the primary mechanism for ensuring the design and operation of the Proposal is conducted in a manner that minimises pollution impacts to inland waters. The Works Approval and Licence will ensure that the following mitigation measures are implemented at a minimum:
   - Routinely inspect the condition and performance of pipelines, containment systems and internal drainage structures, to ensure they are in acceptable condition and / or operating appropriately;
   - The following controls will be implemented to minimise the risk of impact from unintentional slurry pipeline spills:

- Pipeline will be fitted with leak detection (where there is potential to impact native vegetation);
- Flows will be shut off if leaks are detected;
- Pipeline will be inspected regularly, especially during extreme heat or fire events;
- Pipeline will be located off road surfaces to reduce the risk of vehicle collisions;
- Where the pipeline has to cross a road, then it will be buried;
- Investigations will be conducted into the cause of any spills, and remedial actions will be taken to minimise the chance of reoccurrence;

2 **Obtain and comply with a Mining Proposal issued under the Mining Act**. A Mining Proposal will be required for the Proposal, for all works within M70/1305. The Mining Proposal is a primary mechanism for ensuring the mining operations are conducted in a manner that does not pose a significant risk to inland waters;

3 **Obtain and comply with a 5C Licence for groundwater abstraction.** The 5C Licence is the primary mechanism for ensuring the groundwater abstraction is conducted in a manner that does not pose a significant risk to the Superficial, Yarragadee, Eneabba and/or Lesueur Aquifer or other users. The Licence application will be supported by H3 level hydrological investigations verifying that the proposed abstraction volumes will not result in drawdown impacts to wetlands, GDEs or other groundwater users;

4 **Implement Flood and Stormwater Controls**. Allowing for contingencies, the required flood protection level was determined to be 41.5 m AHD (MWES, 2022c). Bunding to this elevation will be installed temporarily for the duration of the pre-strip mine and rehabilitation period for each mine block. Stormwater containment within the plant area will be applied to areas of potential contamination such as workshops, machinery lay-down etc. Precise locations will depend on the finalised site levelling, layout and utilisation;

5 **Implement the following measures to minimise the risk and impact of hydrocarbon spills:**

- Hydrocarbons will be stored either within a bunded area or within self-bunded tanks;
- All spills will be controlled, contained and cleaned up as soon as practicable;
- Service vehicles will be fitted with spill kits;
- Spill kits will be located at all workshop and fuel storage areas;
- Environmental incident recording, investigation and reporting system;

6 **Comply with Water Quality Protection Guidelines and guidance notes,** particularly in relation to the storage and use of hydrocarbons and other harmful chemicals, the design and operation of maintenance areas and facilities, the siting and operation of wastewater storage systems, and the handling and storage of other waste materials, including contaminated soils**.**

7 **Inspect for erosion within the mine and along the access corridor**. If erosion is noted, then install erosion controls to minimise further erosion; and

8 **Implementation of the SWMP (Appendix 20) including the following institutional controls:**

- Drainage diversions around the stockpiles and hardstands will retain stormwater locally;
- Mine workings isolated from wetland water through the construction of mine bunds;
- Pond freeboard and sediment basins will be designed for a minimum first flush capacity of nominally 25 mm; and

- Monitoring of flood controls and water levels and quality.

9 **Prepare a Final Infrastructure Design Plan** prior to ground disturbance, which will provide further detail that demonstrates that the final locations of all Proposal infrastructure and related disturbance has been selected to avoid groundwater drawdown impacts outside of the disturbance footprint;

10 **Implement a DMS.** The scheme will align with *'Managed aquifer recharge in Western Australia (2021)'* to manage the recharge of the Superficial Aquifer to mitigate the impacts of groundwater drawdown; and

11 **Ensure abstraction within the Mesozoic Aquifer System does not result in drawdown impacts to wetlands, GDEs or other groundwater users.** H3-level hydrological investigations will be completed verifying that the proposed abstraction volumes will not result in drawdown impacts;

12 **Implementation of the GOS (Appendix 19)** including detailed management and monitoring of the DMS, as well as typical monitoring and management measures required under RIWI Act approvals for groundwater abstraction. Monitoring of groundwater within the superficial and Mesozoic aquifer systems will be undertaken over the life of the Proposal. Monitoring will be conducted during operations and closure to identify changes in groundwater levels, water quality. Monitoring will be conducted to provide ongoing calibration of the DMS and to provide early detection of drawdown beyond specified limits and changes in water quality.

7.6.3 Rehabilitate

Rehabilitation and closure of the Proposal will be progressive and in accordance with the MCP. Mining pits will be progressively filled and rehabilitated to pre-mining profile with pre-existing land use reinstated as mining advances. This includes deposition of clay fines, overburden, tailings, subsoil and topsoil into the mine void before surface drainage and re-vegetation works are undertaken. One of the planned outcomes of all rehabilitated areas will be to reinstate inland water regimes.

An interim MCP has been prepared to accompany this ERD (Appendix 2) which was developed according to DMIRS Guidelines (2020a; 2020b). Key rehabilitation measures captured within the MCP are summarised below:

1. Land will be made physically safe, stable and non-polluting;
2. Soil profile will be reestablished to support native vegetation growth;
3. The site will be left in a safe, stable, non-polluting and tidy condition with no remaining plant or infrastructure that is not required post-mining use or agreed used by other stakeholders;
4. Any identified site contamination is to be reported in accordance with the CS Act; and
5. No contaminated soils post-closure.

The MCP describes the associated management and monitoring proposed during the closure phase including:

- Materials balance for closure and rehabilitation demonstrating the quantities, availability and management for all rehabilitation materials;
- Identified knowledge gaps to be filled prior to closure;
- Closure tasks; and
- Completion criteria, monitoring and reporting during closure.

The MCP will be submitted to DMIRS for assessment and approval under the Mining Act prior to any disturbance at the Proposal and will be reviewed and revised every three years, or prior to closure, whichever is the earliest.

7.7 PREDICTED OUTCOME

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

The Proposal has been designed to ensure that hydrological regimes are maintained.

The project disturbance area is relatively isolated from the natural creek-lines and hence does not present a particular contaminant risk. Minor flows are retained locally within the South Catchment and there are no defined drainage lines in these areas. During moderate to large stormwater flow events, there is no potential for measurable water quantity or quality impact due to the dilution factor imposed by the large catchment area active during such events. There is one crossing of a seasonal drainage line that only contains flow during flood events. Image will ensure that the existing floodway crossing is maintained and pipeline infrastructure is supported on concrete risers to ensure flows are maintained with minimal restrictions.

The Proposal is not expected to significantly impact the quality of groundwater or surface water. Leaks and spills of slurry sand are able to be managed such that impacts are rare and restricted in extent if they were to occur. Erosion and hydrocarbon spills are able to be mitigated such that significant impacts are unlikely. The design and operation of the FPP, slurry pipeline, water pipeline WCP and WWTP will be regulated under Part V of the EP Act and the Mining Act.

The key risk to the inland waters is the drawdown of the superficial aquifer beyond the mine area potentially impacting GDEs. The DMS has been designed and will be implemented to limit drawdown to the Proposal's disturbance footprint and therefore restricting drawdown impacts to areas that have been cleared for the Proposal.

The implementation of design and operation mitigation measures, and regulation under Part V of the EP Act and the Mining Act, are expected to ensure that the Proposal does not significantly impact inland waters. The EPA objective for this factor is therefore able to be met.

8 TERRESTRIAL ENVIRONMENTAL QUALITY

8.1 EPA Objective

The EPA Objective for this key environmental factor is to maintain the quality of land and soils so that environmental values are protected.

8.2 Policy and Guidance

Relevant EPA and Commonwealth Government guidance documents for Terrestrial Environmental Quality are summarised in Table 37.

Table 45: Policy and guidance relevant to the Terrestrial Environment Quality key environmental factor.

Policy and Guidance	How guidance has been considered
WA Government	
Key EPA documents	
Statement of Environmental Principles, Factors and Objectives (EPA, 2021b)	This document was considered in the preparation of this ERD and to inform EIA. It was used identify the Key Environmental Factors likely to be impacted by the Proposal and the EPA's objective for each factor.
Statutory Guidelines for Mine Closure Plans (DMIRS, 2020b);	This document has been considered in the design and planning of the Proposal, it has also been considered in the preparation of mitigation measures and a preliminary MCP for the Proposal.
EIA (Part IV Divisions 1 and 2) Administrative Procedures (EPA, 2021e);	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
EIA (Part IV Divisions 1 and 2) Procedures Manual (EPA, 2021a); an	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
Instructions on how to prepare *EP Act* Part IV Environmental Management Plans (EPA, 2021f)	This document was considered in the preparation of the ASSMP for the Proposal.
Relevant EPA Factor Guidelines	
Environmental Factor Guideline – Terrestrial Environmental Quality (EPA, 2016k)	This document was considered in the preparation of this section (Section 8) of the ERD.
Other Policy and Guidance	
Treatment and management of soil and water in acid sulfate soil landscapes (DER, 2015b)	This document was used as guidance for the EIA for the Proposal.
WA Environmental Offsets Policy (EPA, 2011)	This document was considered during EIA for Terrestrial Environment Quality however it was determined not be relevant as offsets were not required.
WA Environmental Offsets Guidelines (EPA, 2014a)	This document was considered during EIA for Terrestrial Environment Quality however it was determined not relevant as offsets were not required.
WA Environmental Offsets Template (EPA, 2014b)	This document was considered during EIA for Terrestrial Environment Quality however it was determined not relevant as offsets were not required.

Policy and Guidance	How guidance has been considered
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Commonwealth of Australia, online resource, 2018)	These guidelines were used as guidance during EIA for Terrestrial Environment Quality and the preparation of the ASSMP for the Proposal.
Identification and investigation of acid sulphate soils and acidic landscapes (Department of Environmental Regulation, 2015)	This document was used as guidance for the EIA for the Proposal.
Commonwealth Government	
Key Documents	
Generic guidelines for the content of a draft EPBC Act PER/Environmental Impact Statement (EIS) (including the objects and principles of the EPBC Act 1999) (DotEE, 2016a)	This document was considered in the preparation of this ERD and while undertaking EIA.
Environmental Management Plan Guidelines (DotE, 2014a)	This document was considered in the preparation of the ASSMP for the Proposal.
EPBC Act Condition Setting Policy (DAWE, 2020a)	This document was used as guidance for the likely regulation of Proposal impacts.
EPBC Act Outcomes-based conditions policy (DotE, 2016a)	This document was used as guidance for the likely regulation of Proposal impacts.
Relevant Technical Guidance	
None identified.	

8.3 Receiving Environment

The section below has been sourced from the following reports:

- Atlas Project ASS Investigation and Management Plan (Mine Earth, 2022a; Appendix 22); and
- Atlas Project Soil, Overburden and Tailings Assessment Report (Mine Earth, 2022b; Appendix 23).

8.3.1 Survey Effort

Soil Physical and Chemical Characteristics

Mine Earth (2022a) assessed soil physical and chemical characteristics to provide an indication of the susceptibility of a soil to erosion, the ability to support vegetation growth and baseline values for potentially problematic characteristics. The following physical and chemical analyses were conducted on selected samples of topsoil, subsoil, overburden from the Study Area (Figure 92), and representative tailings materials:

- Physical soil analyses:
  - Soil texture and particle size distribution (including coarse rock fraction >2 mm);
  - Emerson Aggregate Test to indicate soil structural stability and potential for clay dispersion upon saturation;
  - Water retention characteristics (field capacity);
  - Saturated hydraulic conductivity;
  - Soil strength (modified Modulus of Rupture);

    - Soil water repellence;
- Chemical soil analyses:
    - pH and electrical conductivity;
    - Effective cation exchange capacity and Exchangeable Sodium Percentage (ESP);
    - Total organic carbon (to indicate organic matter content);
    - Plant-available nutrients (Nitrogen, Phosphorous, Potassium, Sulphur); and
    - Total metal concentrations.

All soil test work analyses were conducted in accordance with standard analytical procedures to assess potential soil physical and chemical characteristics related to the support of plant growth and use as a rehabilitation medium (Rayment, 2011). Descriptions of relevant soil classification categories and all external laboratory results for the surface soil, overburden and tailings samples are provided in Mine Earth (2022b; Appendix 23).

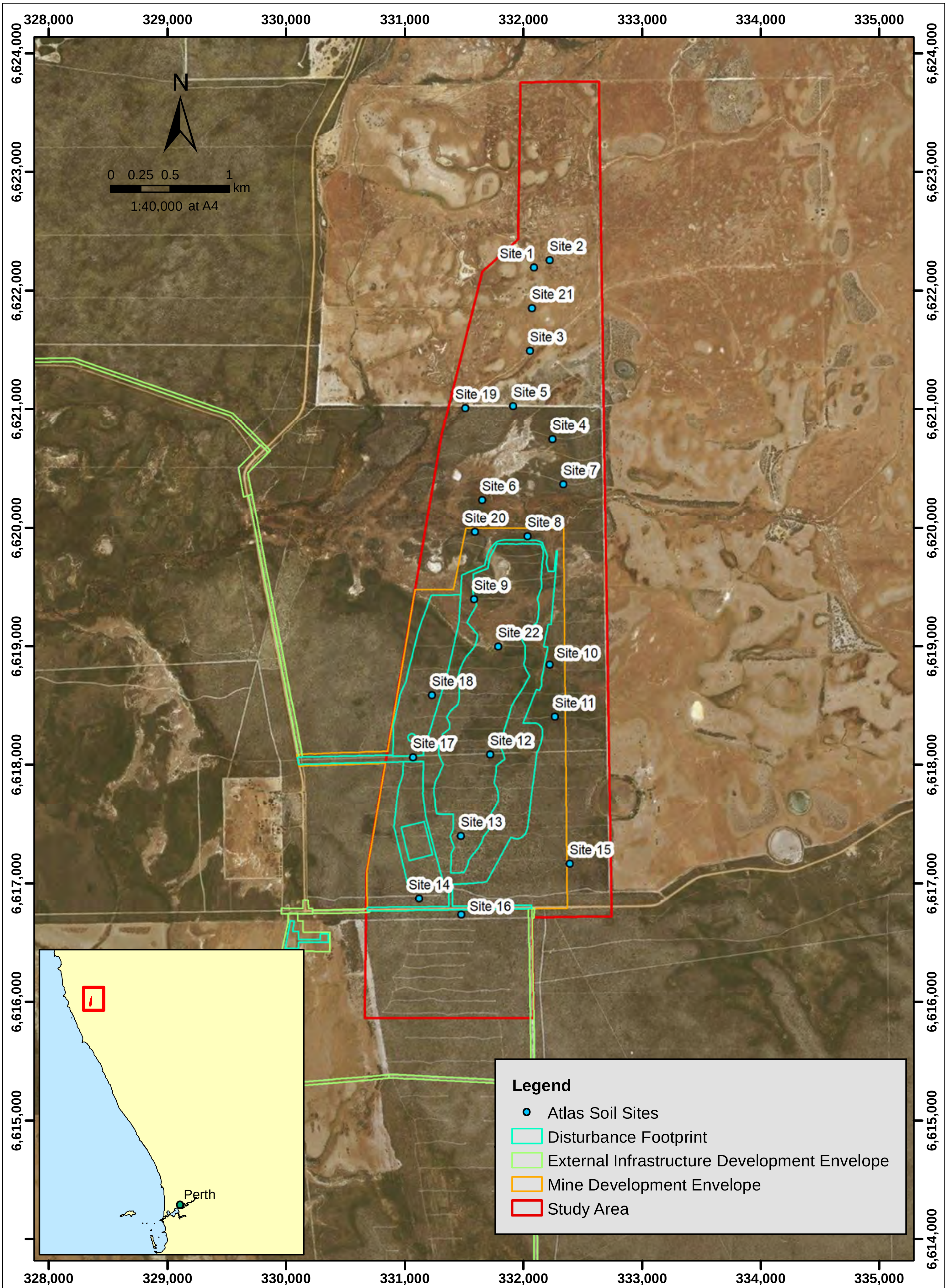
Sampling

Soil samples were collected from 22 sites within the Study Area in March 2021 (Figure 92). Soil profile descriptions and sampling was facilitated by a backhoe (at 19 sites) or collected by hand in areas where access was restricted (three sites). Samples were taken from 3 - 5 depth intervals at each soil sampling site, depending upon the near-surface soil profile morphology and depth of excavation possible.

Field-based observations made during the sampling program included a description of soil surface characteristics, soil profile morphology, vegetation assemblage present and the surface drainage characteristics of each soil sampling site, as per the Australian Soil and Land Survey guidelines (CSIRO, 2009). Soil pits were back-filled immediately after sampling.

Samples of deeper overburden soil materials were sourced from the ASS sampling and analysis program (Mine Earth, 2022a). The location of overburden samples assessed as part of this investigation are detailed in Figure 93.

Representative samples of tailings slimes and tailings sand fractions were supplied by Image Resources.



MINE EARTH

Date: 9/06/2022
Author: Julia Heide

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Surface Soil Sampling Locations

Figure 92: Study Area and soil sampling locations

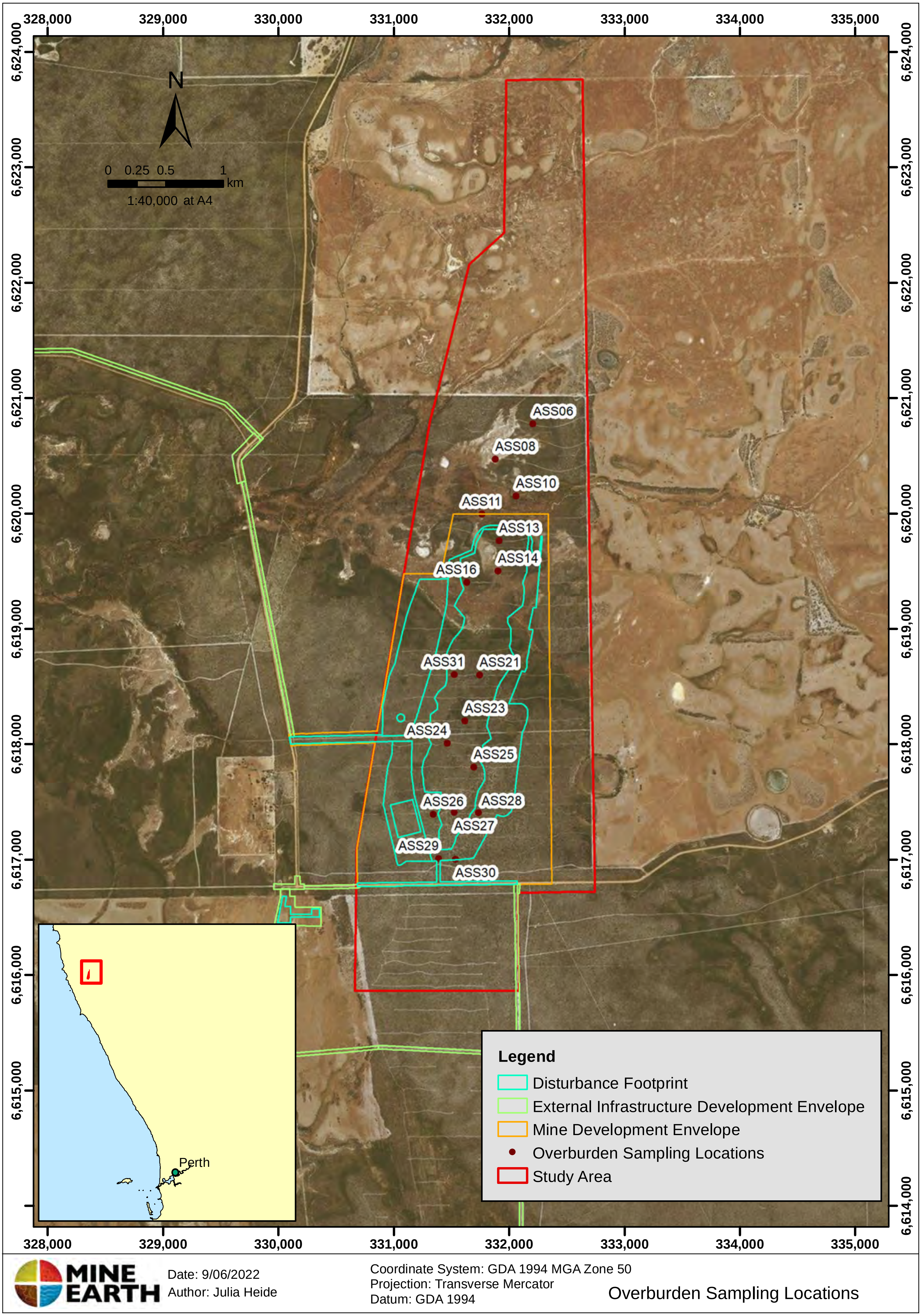


Figure 93: Overburden sampling locations

Laboratory Analysis

Laboratory analysis was conducted to determine physical and chemical properties of topsoil, subsoil, overburden and tailings that may influence their management during mining operations and at mine closure. The identification of physical and chemical soil characteristics facilitates delineation of Soil Management Units (SMUs) against which management decisions (soil stripping, stockpiling and use as rehabilitation resource) can be based. Chemical analysis of baseline conditions also provides an indication of potential impact with respect to saline, sodic and metalliferous properties of the soil materials present.

Acid Sulfate Soils

A Targeted ASS investigation was conducted for the Proposal, in accordance with the WA Department of Environmental Regulation (DER) *guidelines for identification and investigation of ASS and acidic landscapes* (DER Guidelines; DER, 2015a).

ASS often occur beneath the water table in sandy soil profiles of the Swan Coastal Plain and are often associated with mineral sand deposits (DER, 2015a). ASS are naturally occurring soils and sediments that contain iron sulfides, predominantly in the form of pyrite materials. The disturbance of ASS and exposure to oxygen results in sulfuric acid being formed, which can lead to the release of metals, nutrients and acidity into the soil and groundwater system (DER, 2015b).

ASS includes PASS and actual ASS (AASS). PASS are soils or sediments which contain iron sulfides or other sulfide minerals that have not been oxidised, and AASS are soils or sediments which contain iron sulfides or other sulfidic materials that have undergone some oxidation (DER, 2015a).

The Proposal is located outside of the Swan Coastal Plain ASS risk mapping area, however land units that are considered an ASS risk (i.e. wetlands, creeklines, high groundwater table areas) are located within the Study Area (DER, 2015a). ASS have been encountered at numerous other mineral sands mines on the northern Swan Coastal Plain (i.e., Boonanarring Project and Cooljarloo Mineral Sands Project), typically at the boundary of geological formations. Within mineral sands deposits, ASS are typically associated with dark coloured soils and those soils with higher slimes (clay) contents.

An ASSMP is required when net acidity as equivalent sulphur (%S) minus acid neutralising capacity is greater than 0.03%S in soils, in accordance with the DER Guidelines. In addition, it has been identified that $pH_{Fox}<3$ and an analytical value of 0.01%S or greater are reliable indicators of ASS and can be used as a basis for managing PASS in Bassendean sands (University of WA (UWA)/Department of Environment and Conservation (DEC), 2011).

Drilling Database Review

The Proposal drilling database was interrogated to identify the presence and location of soils typically associated with ASS (i.e., dark coloured, clay-rich soils). Figures relating to interrogation of the drilling database are included in the Mine Earth ASS Investigation and Management Plan report (Appendix 22).

Drill logs from 2,664 drill holes (comprising 30,204 individual drill logs) from across the Study Area were interrogated. Based upon the information detailed within the drilling database, it was identified that PASS soils (i.e., dark soil colours with HSL) were present at variable depths within the soil profiles. There appeared to be little spatial correlation of PASS soils, either with position in the landscape and/or depth within the soil profiles (Appendix 22).

Due to the identification of PASS soils (i.e., dark coloured soils with high clay contents) within the drilling database, a dedicated sampling and analysis program was undertaken to further quantify the presence of ASS within the deposit.

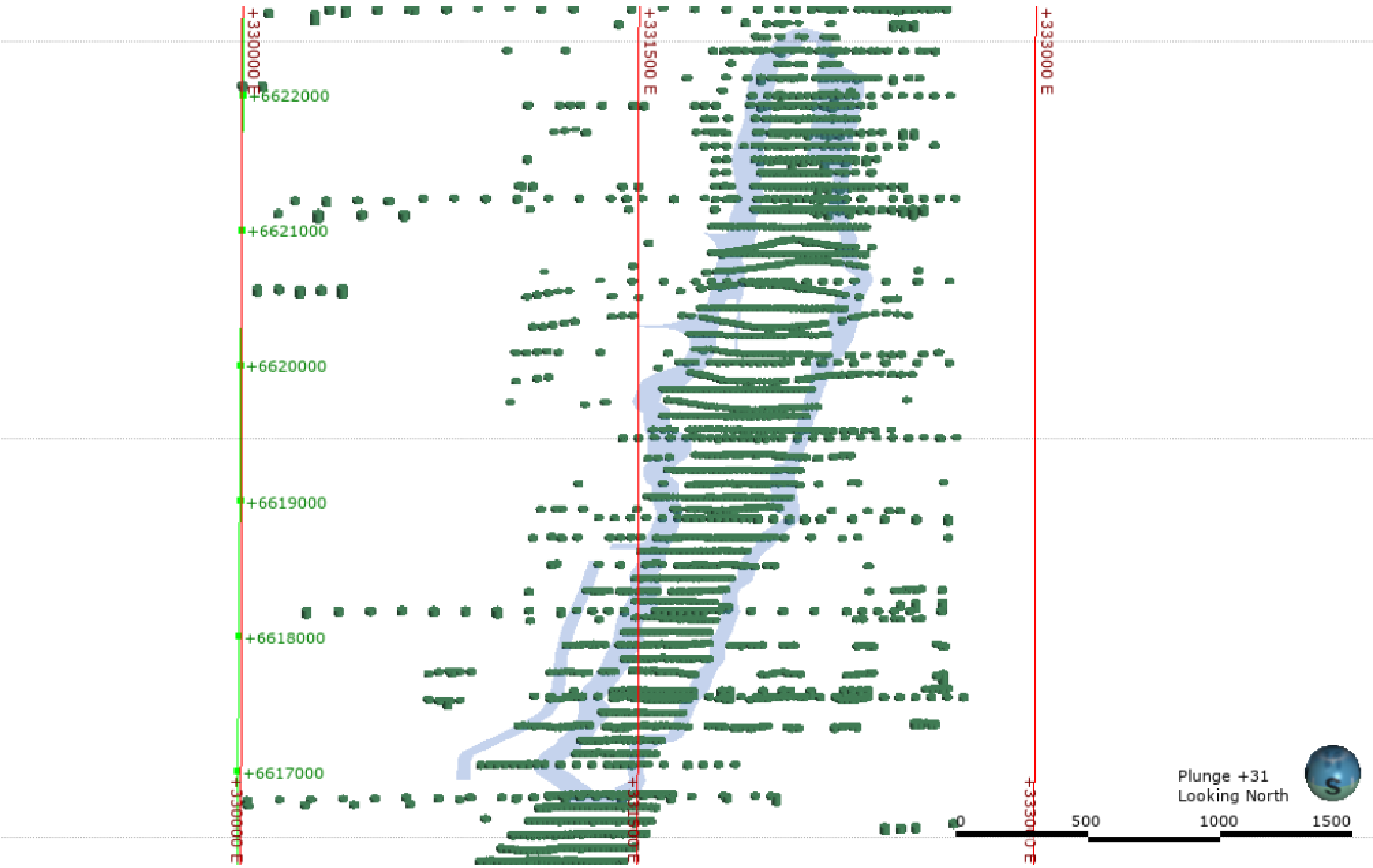


Figure 94: Drilling database search

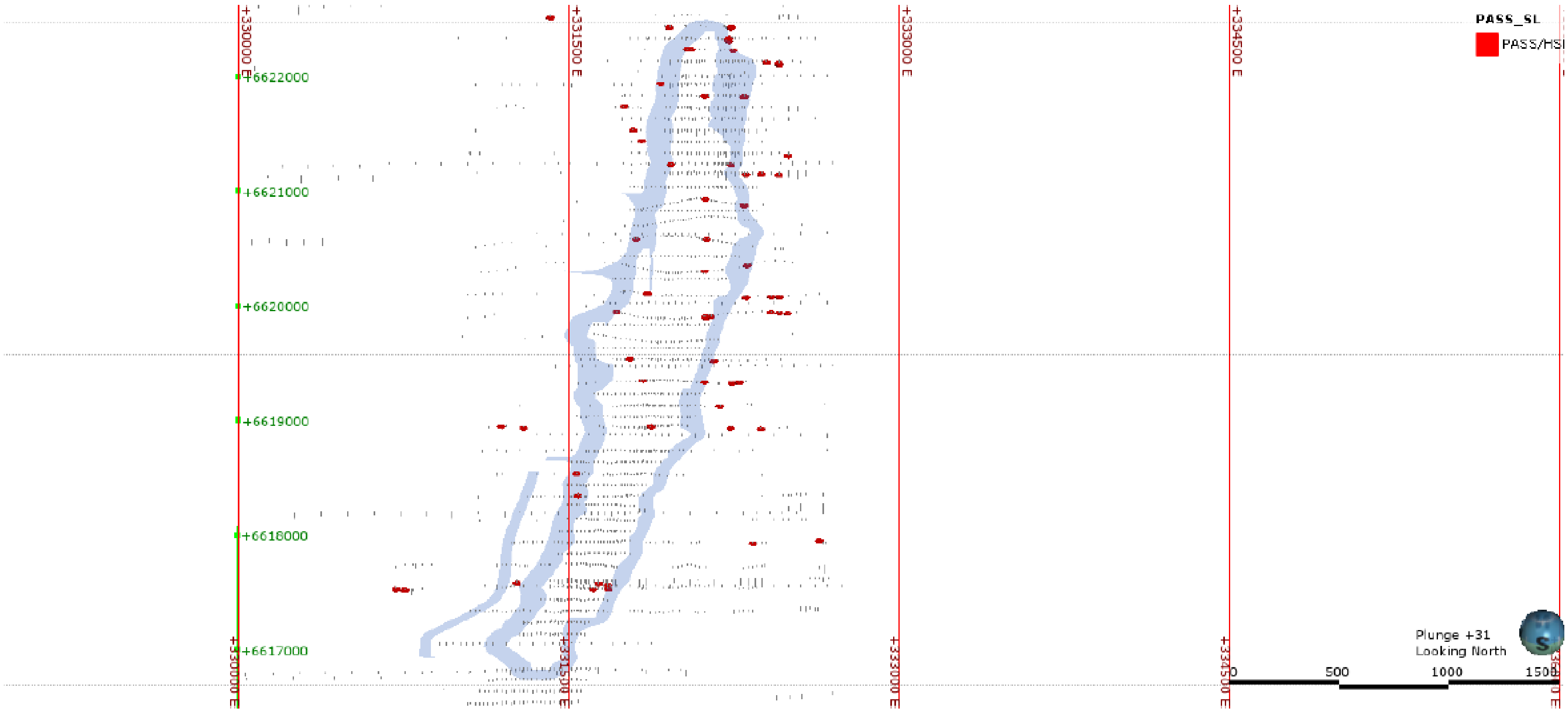


Figure 95: Drillholes logged with combination of PASS and high slimes content

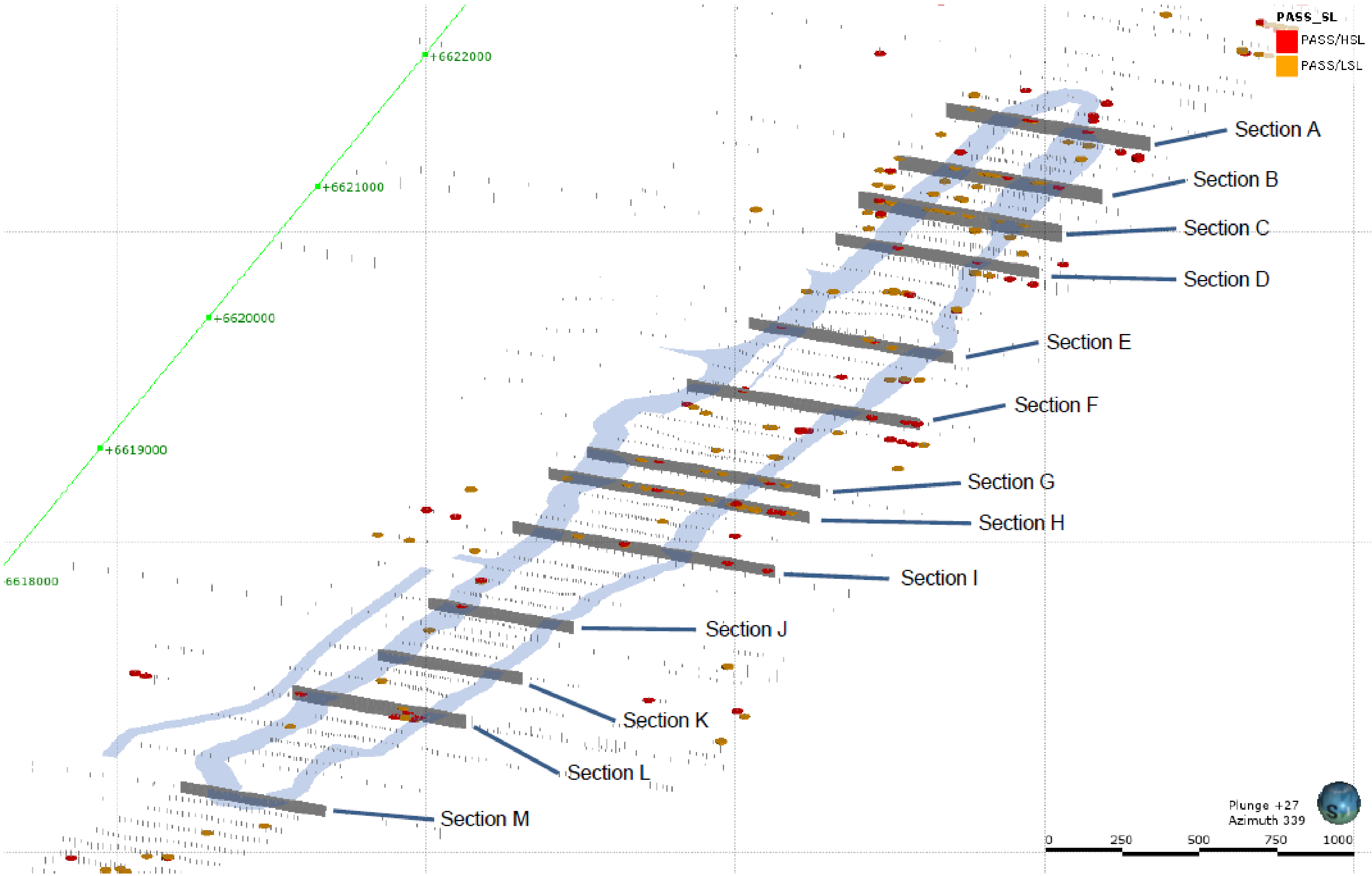


Figure 96: Location of drilling database cross-sections

Sampling

Where there is an identified risk of ASS occurring within a project's disturbance area, a site-based ASS investigation requires sampling and analysis of soils to a depth of 1 m below the proposed disturbance and/or maximum groundwater drawdown level.

Sampling locations were selected based on the following:

- Proximity to soils identified as PASS (i.e., dark coloured soils with high slimes content) within the drilling database;
- Distribution across the deposit to ensure that the locations selected are spatially representative of the geological units and topography across the site;
- Sampling to 1 m below the proposed depth of mining disturbance; and
- Site access for drilling activities.

Drilling locations for the ASS sampling program are shown in Figure 97. The drill log summary and photos of the 1 m sample intervals for all holes are provided as part of Appendix 22.

Laboratory Analysis

A total of 245 samples from 26 drillholes were submitted for analysis of pH (pH_f) and oxidised pH (pH_{FOX}). The initial screening test results indicated that PASS may be present across the deposit. Based on the Suite 1 analysis results, a total of 72 samples were selected for the second analysis suite (Suite 2) *WA - Chromium Suite for Acid Sulfate Soils* to further quantify the acid forming potential of the samples. This analysis suite includes a variety of parameters and identifies actual acidity, potential acidity, acid neutralising capacity and acid base accounting. The Suite 2 analysis is not subject to significant interferences from sulphur in organic matter or sulfate materials (DER, 2015b).

The DER Guidelines stipulate 'ASS action criteria' based on net acidity. If the ASS action criteria are exceeded by any sample result, an ASSMP will need to be developed and implemented for disturbance of ASS (DER, 2015b). The ASS action criteria are defined as follows:

- Net acidity as equivalent sulphur (%S) – acid neutralising capacity = 0.03%S; and
- Net acidity as equivalent acidity (mol H+/tonne) – acid neutralising capacity = 18 mol H+/tonne.

Tailings pH

The pH of the tailings slimes and tailings sand fraction was assessed on representative samples (Mine Earth, 2022a).

Total and Leachable Metals

Total metals were analysed for selected samples from the ASS investigation. The samples selected comprised material representative of the overburden waste above the ore zone from across the deposit. Samples of the tailings slimes and tailings sand fractions from metallurgical testing were also assessed.

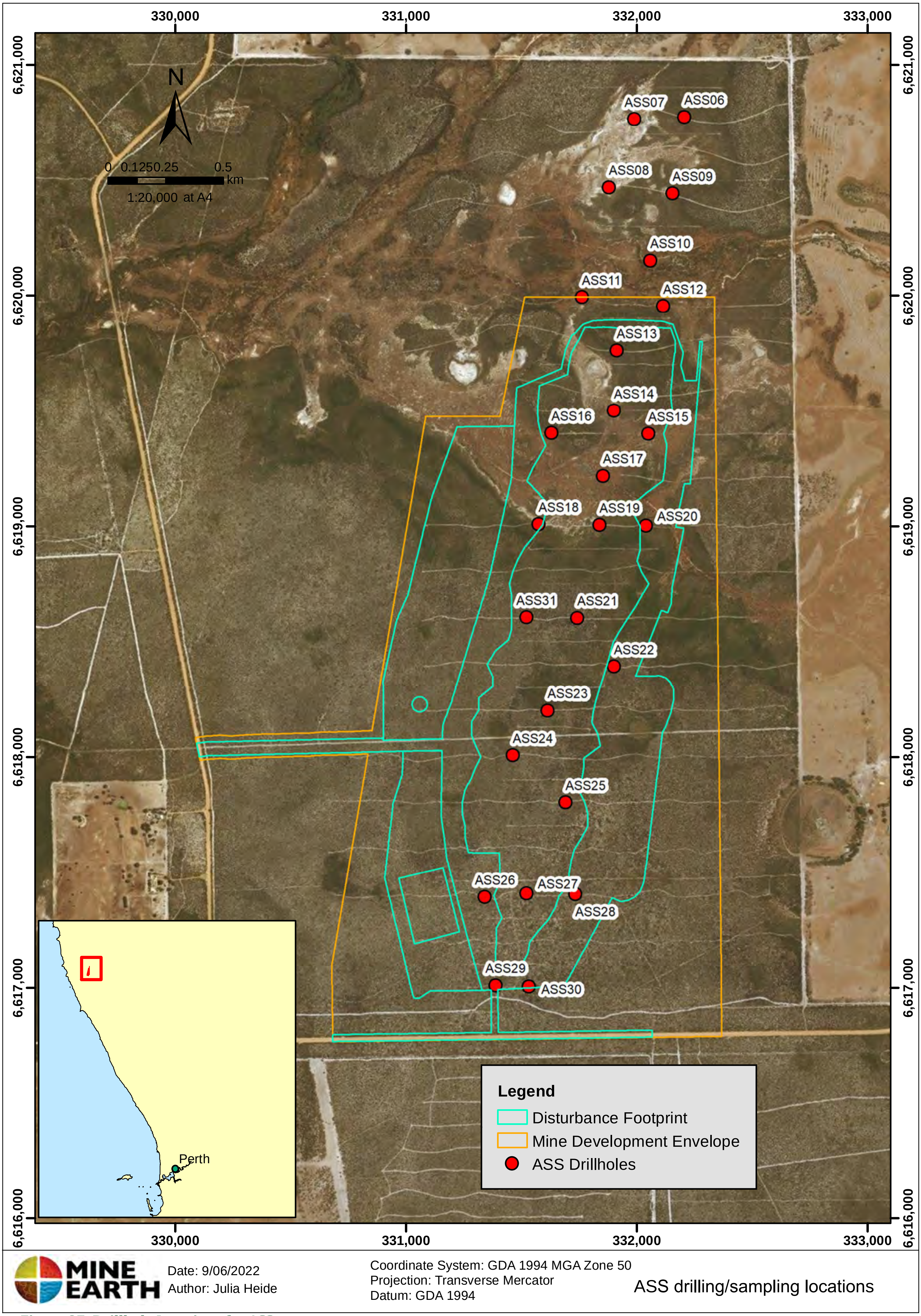


Figure 97: Drillhole Locations for ASS assessment

Groundwater Assessment

Groundwater samples were collected from monitoring bores surrounding the Proposal in December 2021. It should be noted that some of these bores are located a considerable distance from the deposit, and as such do not all represent groundwater quality immediately surrounding the deposit. Groundwater from these bores was analysed and the results were interpreted by MWES Hydrological Services (MWES, 2022b; Appendix 18). Groundwater is discussed in more detail in Section 7.3.5 and monitoring bore locations are shown in Figure 75.

8.3.2 Topsoil and Subsoil

The results of Mine Earth's (2022b) soil survey and laboratory test work program are discussed in the following sections. Sampling site and surface soil profile descriptions for the 22 surveyed sites presented within Appendix 22.

The vegetation descriptions and vegetation units at each sampling location are derived from the Morgan, 2022. Soil colour classifications are derived from the Munsell Soil Colour Charts.

Physical Characteristics

The physical characteristics of the topsoil and subsoil materials within the Study Area, as determined by the filed investigation and laboratory analysis of collected samples, are discussed in the following sections.

Profile Morphology

The surface soil profiles within the Study Area exhibited minor variation in terms of morphological characteristics. The soil profiles were grouped into three soil-landform associations, namely 'Low sandy rises', 'Sandy plains', and 'Drainage lines / flats'. The landform and soil profiles within these soil associations were typically characterised as follows:

- Low sandy rises;
    - Low undulating hills;
    - Deep, single grained, structureless sandy soils to >1.5 m depth;
- Sandy plains;
    - Relatively flat landform surface, with gentle relief;
    - Single grained, structureless sandy soils (to variable depths of 0.6 - 1.3 m) over weakly structured clayey sand horizons;
    - Saturated soils present at some sampling locations, at variable depths within the soil profiles;
- Drainage lines /flats;
    - Flat landform surface situated low in the landscape, dissected by shallow drainage channels;
    - Single grained, structureless sandy soils (to variable depths of 0.5 to 0.9 m) over weakly structured to massive, clayey sand to light clay horizons with moderate to strong consistence;
    - Saturated soils present at depths ranging from 1.0 - 1.4 m; and
    - Orange iron mottling often present within clay rich, saturated horizons at depths of 1.2 - 1.4 m.

Texture

There were a range of particle size distributions exhibited throughout the Study Area, with soil textures ranging from 'sand' (<5% clay) to 'medium clay' (30 - 35% clay). The near surface soils (<0.5 m) at all sampling sites were classified as sands, with sandy soil textures extending to the base of sampling at all 'Low sandy rise' locations. Increased clay content at depths below 0.5 m were recorded for some 'Sandy plain' soil profiles, with soil textures classified as 'clayey sands' (approximately 5 - 10% clay).

There was a distinct increase in clay content observed within the soil profiles of the 'Drainage line / flats', with sharp textural boundaries observed at depths ranging from 0.5 - 0.8 m at those sampling locations. Clay content of the soils below 0.5 - 0.8 m within the 'Drainage line / flats' soil profiles ranged from approximately 9 - 33%.

Structure

Mine Earth (2022a) classified the structure of the sandy surface soils (to approximately 0.5 m depth) across the Study Area and to the base of sampling in the 'Low sandy rise' sites as 'single-grained', with no aggregation of soil particles upon disturbance. Deep soils (i.e., below approximately 0.5 m) within the 'Sandy plain' soil landform association exhibited some weak aggregation, corresponding to an increase in clay content at depth.

The clay rich soils below 0.5 - 0.8 m depth within the 'drainage lines / flats' typically exhibited a 'massive' soil structure with a very firm consistence (Mine Earth, 2022b).

Structural Stability

The Emerson Aggregate Test identifies the potential slaking and dispersive properties of soil aggregates. The dispersion test identifies the properties of the soil materials under a worst-case scenario, where severe stress is applied to the soil material. Generally, samples allocated into Emerson Classes 1 and 2 are those most likely to exhibit dispersion of the clay sized fraction and therefore be the most problematic.

The majority of the 'clayey' soils from the 'Sandy plain' and 'Drainage lines / flats' soil-landform associations were identified as Emerson Class 3 (slaking, remoulded soil partially dispersed), Class 5 (aggregate slakes but does not disperse, no dispersion of remoulded soil, soil:water suspension remains dispersed), or Class 6 (aggregate slakes but does not disperse, no dispersion of remoulded soil, dispersion of a 1:5 soil:water suspension). These results indicate that the soils are not prone to dispersion of the clay fraction in their natural state but may exhibit dispersion following severe disturbance (Mine Earth, 2022b).

Several clay-rich subsoil samples from 'Drainage lines / flats' sampling classified as Emerson Class 2. These samples exhibited partial dispersion of the clay fraction upon saturation of an undisturbed soil aggregate.

It should be noted that the salinity of some soils, particularly those from within the 'Drainage lines / flats' soil-landform association, may have a flocculating effect on clay particles, masking the potential dispersion in these clay-rich, highly sodic soil materials (Mine Earth, 2022b).

Hydraulic Conductivity

Saturated hydraulic conductivity was determined for the <2.0 mm fraction of selected, representative soil samples from the Study Area. Drainage classes were determined for each sample according to their K_{sat} (Hunt and Gilkes, 1992).

The drainage class of soil samples from the Study Area ranged between 'extremely slow' and 'very rapid'. As would be expected, the coarser textured (sandy) 'near surface' soils sampled from all soil-landform associations within the Study Area recorded the highest hydraulic conductivity and are classified as free-draining. The low K_{sat} values recorded for the clay rich subsoil horizons within the 'Drainage lines / flats' soil-landform association indicate a propensity for waterlogging and / or surface run-off and erosion, particularly if placed close to the surface in reconstructed soil profiles.

Water Retention

The field capacity (or upper storage limit) of a soil material refers to the maximum water holding capacity of a freely drained soil, or the volumetric water content after gravity induced drainage has ceased. The field capacity of the <2 mm fraction of the soils from the Study Area ranged between 23% and 55%. These values are considered 'moderate' to 'high' for the field capacity of a soil (Hazelton and Murphy, 2007). The water retention characteristics of the soils throughout the Study Area were generally reflective of the soil textures present, with the finer textured (clay rich) subsoils from the 'Drainage lines / flats' soil-landform association typically having a higher field capacity water content than the coarser textured (sandy) soils from the 'surface and near surface horizons across the Study Area (Mine Earth, 2022b).

Water Repellence

There were a wide range of soil water repellency ratings recorded for the surface soils sampled from across the Study Area, with water repellency ratings ranging from 'Not significant' to 'Severe water repellence' (King, 1981). The water repellency of the surface samples at the 0-10 cm depth interval was typically greater than that measured for the 10-20 cm depth interval, reflective of the higher organic matter contents in the surface soils. There was no apparent correlation between the water repellency of the surface soils (0-20 cm) and soil-landform association. All samples assessed from below the 0 - 20 cm depth intervals recorded water repellency ratings of 'Not significant' (Mine Earth, 2022b).

Strength

A modified Modulus of Rupture (MOR) test was conducted on selected samples, representative of the various soil materials from across the Study Area. This test is a measure of soil strength and identifies the tendency of a soil to hard-set as a direct result of soil slaking and dispersion. A MOR of over 60 kPa has been described as the critical value for distinguishing potentially problematic soils in agricultural scenarios (Cochrane and Aylmore, 1997). Restricted root penetration into the soil matrix is a likely consequence of a high MOR. In reconstructed soil profiles, materials normally deep within the profile that may have a high MOR can often be re-deposited closer to the surface, leading to germination / emergence and root penetration problems.

As this test is conducted on reconstructed soil blocks composed of the <2 mm soil fraction, it does not take into account the effect of soil structure on soil strength, nor any degree of compaction that may be present in the field. It does, however, provide insight into the potential for soils to hard-set and compact with repeated wetting and drying cycles, and the ability of roots to fracture the soil and penetrate crack faces.

The majority of the sandy surface / near-surface soils sampled from across the Study Area (i.e. across all soil-landform associations) recorded MOR values of zero, indicating no propensity to hard-set with repeated wetting / drying cycles. Ten of the 29 samples test recorded MOR values above zero, however only two samples, both from the clay rich horizons within the 'Drainage lines / flats' soil-landform association recorded MOR values above the 60 kPa threshold.

Soil Chemical Characteristics

The chemical characteristics of the topsoil and subsoil materials within the Study Area, as determined by the field investigation and laboratory analysis of collected samples, are discussed in the following sections.

<u>pH and Electrical Conductivity</u>

Soil pH (H_2O) results indicated substantial variation between and within the various soil-landform associations / sample depths within the Study Area, ranging from pH 5.4 (classified as 'strongly acidic') for a sample from 10-20 cm depth at a 'Drainage line / flats' site, to pH 10.0 ('strongly alkaline') for a sample from 90-100 cm depth within the 'drainage line/ flats' soil-landform association (Figure 98). On average, soils from the 'Drainage line / flats' were typically the most alkaline, with average soil pH increasing with sample depth. The soil pH of samples from the 'Low sandy rise' and 'Sandy plain' sites were relatively similar within the top 0.5 m of the soil profiles, and generally classified as 'slightly acidic' to 'neutral' (Mine Earth, 2020a).

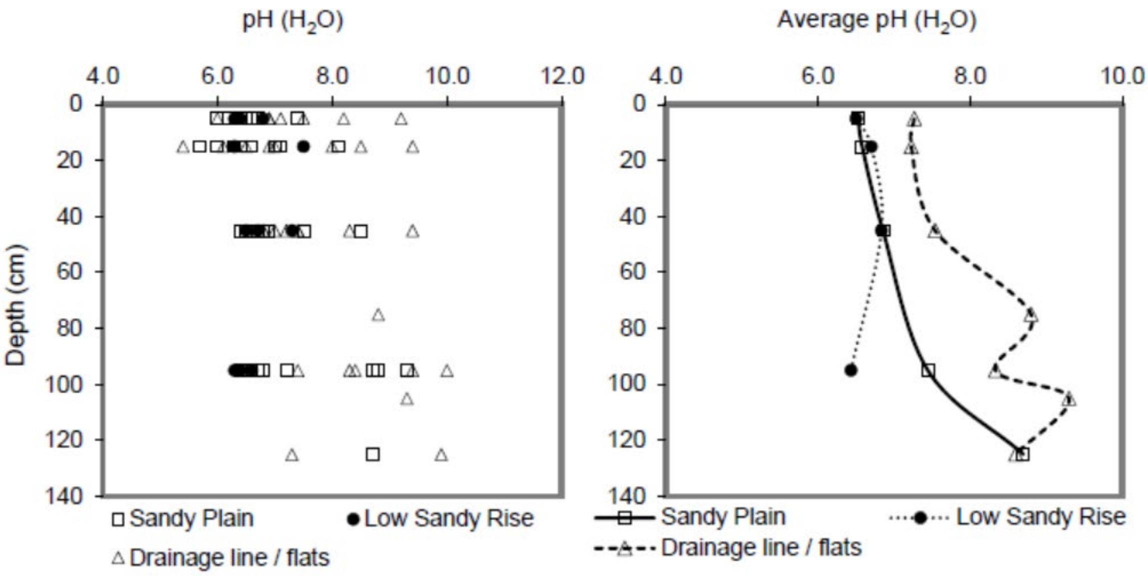


Figure 98: Individual and average pH (H_2O) of soils with depth for each soil-landform association

Electrical conductivity (EC) is a measurement of the soluble salts in soils or water. Soil salinity results from natural processes of landscape evolution, hydrological processes and rainfall (Hunt and Gilkes, 1992). There was a substantial range of EC values recorded for the soils within the

Study Area, with individual values ranging between 0.010 deciSiemens per metre (dS/m) (non-saline) and 2.526 dS/m (extremely saline) based on standard United States Department of Agriculture (USDA) and Commonwealth Scientific and Industrial Research Organisation (CSIRO) electrical conductivity categories (Mine Earth, 2020a). While there was a range of soil salinities measured across the Study Area, the majority of the soil samples were classed as either 'non-saline' (< 0.010 dS/m) or 'slightly saline' (0.2 - 0.33 dS/m) (Figure 99).

On average, soils from the 'Low sandy rise' soil-landform association recorded the lowest EC values, with EC being uniformly low through the soil profiles (Figure 99). The average EC values of soils with the 'Drainage lines / flats' and 'Sandy plain' soils was low (classed as non to slightly saline) within the upper 0.5 m of the soil profiles. Salinity increased with sample depth below approximately 0.5 m, corresponding to soils with increased clay contents and soil saturation at those sample depths (Figure 99).

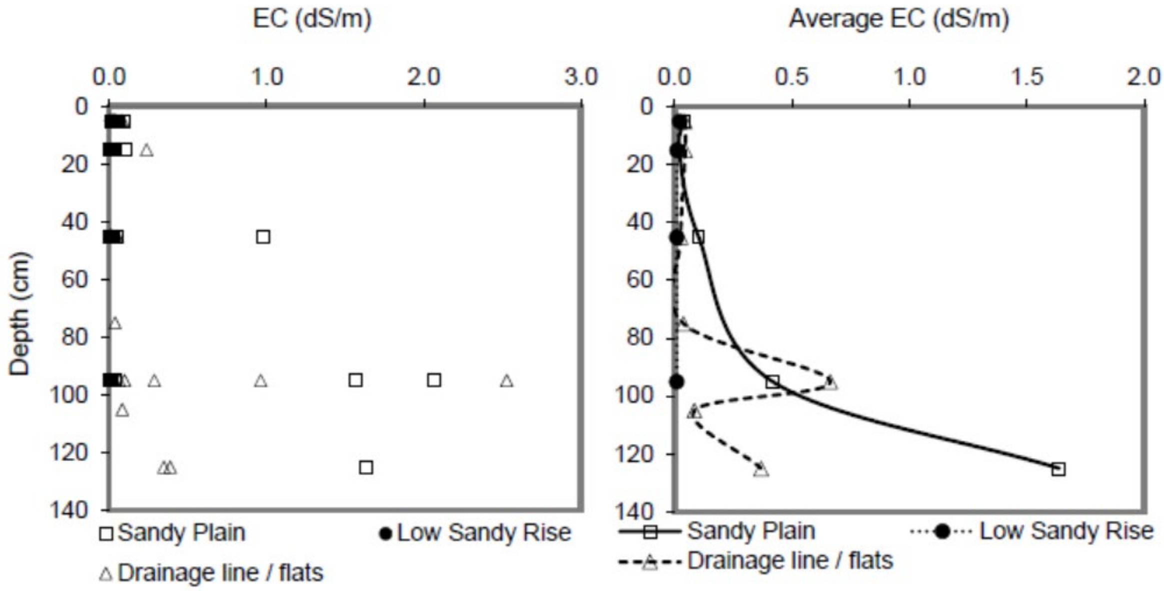


Figure 99: Individual and average electrical conductivity (dS/m) of soils with depth for each soil landform association

Organic Matter

The organic matter content of the soils within the Study Area was determined as a measure of the Soil Organic Carbon Percentage (SOC%). The SOC% of the sampled soils was low, as is typical of most sandy soils in the region, ranging between <0.05% and 1.48%. As would be expected, there was generally a sharp decrease in SOC% with depth away from the soil surface.

Exchangeable Cations and Exchangeable Sodium Percentage

Exchangeable cation concentration, effective cation exchange capacity (eCEC) and ESP results were highly variable across the various soil-landform associations and with sample depth (Table 46). While a number of soils sampled from each of the soil-landform associations were classed as sodic and highly sodic, the low clay content of the surface and near-surface sandy soil horizons indicates that sodicity is unlikely to influence the structural stability of those soils.

The exchangeable cation and ESP results should be viewed in conjunction with the Emerson Test results, the amount of clay in the soil and the salinity of the material, to identify the likely influence on the physical stability of the soil once the materials are salvaged and utilised as a rehabilitation resource. Sodicity and its influence on clay dispersion, is only likely to have a detrimental influence on the structure of the clay-rich soils situated at depth within the 'Drainage lines / flats' soil-landform association. The Emerson Test identified partial dispersion of the clay fraction in a number of those samples (Table 46).

Table 46: Exchangeable cations and ESP of selected samples

Site #	Depth (cm)	Soil-landform association	Exchangeable cations (meq/100g)				eCEC (meq/100g)	ESP (%)	% clay
			Ca	Mg	K	Na			
1	0-10	Sandy Plain	0.57	0.15	0.02	0.05	0.79	6.3	2.9
	10-20		0.14	0.05	0.02	0.05	0.26	19.2	1.9
	40-50		0.12	0.05	0.02	0.05	0.24	20.8	2.9
	90-100		0.12	0.05	0.03	0.05	0.25	20.0	1.9
3	0-10	Drainage line / flats	0.65	0.20	0.02	0.05	0.92	5.4	3.0
	10-20		0.05	0.05	0.03	0.05	0.18	27.7	1.9
	40-50		0.05	0.05	0.02	0.05	0.17	29.4	2.9
	90-100		0.23	0.42	0.05	0.24	0.94	25.5	14.5
4	0-10	Sandy Plain	4.02	0.31	0.03	0.05	4.41	1.1	4.0
	10-20		0.05	0.05	0.02	0.05	0.17	29.4	1.9
	40-50		0.16	0.05	0.02	0.05	0.28	17.8	2.9
	90-100		8.18	1.08	0.03	0.10	9.39	1.0	7.9
	120-130		1.85	1.15	0.07	0.05	3.12	1.6	6.8
8	0-10	Drainage lines / flats	0.29	0.18	0.03	0.05	0.55	9.0	3.0
	10-20		0.19	0.05	0.01	0.05	0.30	16.6	2.9
	40-50		0.10	0.05	0.02	0.05	0.22	22.7	1.9
	90-100		0.19	0.28	0.04	0.05	0.56	8.9	1.9
9	0-10	Drainage lines / flats	0.63	0.39	0.03	0.05	1.10	4.5	2.9
	10-20		0.12	0.05	0.02	0.05	0.24	20.8	1.9
	40-50		0.05	0.05	0.02	0.05	0.17	29.4	1.9
	90-100		0.80	1.58	0.15	0.24	2.77	8.6	8.8
10	0-10	Drainage lines / flats	0.71	0.32	0.03	0.05	1.11	4.5	2.9

Site #	Depth (cm)	Soil-landform association	Exchangeable cations (meq/100g)				eCEC (meq/100g)	ESP (%)	% clay
			Ca	Mg	K	Na			
	10-20		0.23	0.12	0.02	0.05	0.42	11.9	1.9
	40-50		0.21	0.12	0.03	0.05	0.41	12.2	3.9
	90-100		6.09	3.42	0.19	1.35	11.23	12.0	14.1
	120-130		1.96	0.76	0.07	0.41	3.20	12.8	33.6
12	0-10	Sandy Plain	0.84	0.19	0.02	0.05	1.10	4.5	3.0
	10-20		0.31	0.05	0.02	0.05	0.43	11.6	1.9
	40-50		0.15	0.05	0.01	0.05	0.26	19.2	0.9
	90-100		0.05	0.05	0.01	0.05	0.16	31.2	2.9
14	0-10	Low Sandy Rise	0.58	0.05	0.01	0.05	0.69	7.2	1.0
	10-20		0.60	0.10	0.02	0.05	0.77	6.4	1.9
	40-50		0.14	0.05	0.02	0.05	0.26	19.2	1.9
	90-100		0.05	0.05	0.02	0.05	0.17	29.4	0.9
18	0-10	Sandy Plain	1.24	0.21	0.02	0.05	1.52	3.2	0.9
	10-20		0.85	0.16	0.01	0.05	1.07	4.6	2.9
	40-50		0.26	0.05	0.02	0.05	0.38	13.1	2.9
21	10-20	Sandy Plain	0.11	0.05	0.01	0.05	0.22	22.7	1.9
22	0-10	Drainage line / flats	5.51	0.68	0.02	0.05	6.26	0.8	3.9
	10-20		0.57	0.05	0.02	0.05	0.69	7.2	2.9
	40-50		3.03	0.58	0.04	0.05	3.70	1.3	3.9
	70-110		1.44	2.53	0.23	0.05	4.25	1.1	12.3
	100-110		1.65	3.69	0.57	1.07	6.98	15.3	23.9

* Shading of ESP values denotes non-sodic (green), sodic (orange) and highly sodic (red).

Nutrients

Nitrogen

The plant-available nitrogen concentrations of the soils from the Study Area were variable but generally low and ranged from <1 (below detection limit) to 15 mg/kg nitrate and from <1 (below detection limit) to 8 mg/kg ammonium. The highest plant-available nitrogen concentrations were recorded for the surface samples within the 'Drainage lines / flats' soil-landform association. As would be expected, there was typically a decrease in plant-available nitrogen concentration with depth through the soil profiles.

Phosphorous

The plant-available phosphorous concentrations of the majority of soils from the Study Area were classed as low (<10 mg/kg) (Moore, 1998). This was particularly the case for the soils within the 'Low sandy rise' and 'Sandy plain' soil-landform associations. The highest plant-available phosphorous concentrations were recorded for the upper soil profile samples from the 'Drainage lines / flats' soil-landform association.

Potassium

The plant-available potassium concentrations of the soils from the Study Area ranged from low to high (high rating: >200 mg/kg) (Moore, 1998). Soils sampled from the 'Low Sandy Rise' typically reported the lowest plant-available potassium concentrations, with samples from the 'Drainage lines / flats' and 'Sandy Plains' recording higher concentrations with sample depth, corresponding to an increase in clay content within those soil profiles.

Sulphur

There was a wide range of plant-available sulphur concentrations measured for soils from the Study Area, with individual values ranging from 0.25 mg/kg (classed as very low) to 204 mg/kg (classed as high) (Moore, 1998). On average, soils from the 'Sandy Plain' and 'Drainage lines / flats' soil-landform association recorded the highest plant-available S values, which increased with depth through the soil profiles.

Total Metal Concentrations

The total concentration of selected metals was measured for selected samples that were representative of the soils sampled and associated landscape positions. The results are presented in Table 47. As a point of comparison, the Average Crustal Abundance (ACA; Reimann and de Caritat, 1998) for each metal is also provided in Table 47.

Note, the relatively high baseline concentrations (above the ACA) of Arsenic in three of the deep, clay-rich subsoil samples within the 'Drainage lines / flats' soil-landform association. One of those samples (Site 10, 120-130 cm depth) also recorded a concentration of Lead above the ACA. The majority of soil samples from all soil-landform associations recorded concentrations of Selenium slightly above the ACA. There was no apparent correlation between Selenium concentration and sample depth.

Table 47: Total metal concentrations for selected soul samples

Site	Sample depth (cm)	Soil-landform association	Total metal concentration (ug/kg)						
			As	Cd	Cr	Co	Pb	Mo	Se
1	0-10	Sandy plain	48	10.9	1,047	46	2,170	102	171
	40-50		126	2.6	394	19	768	24	122
2	0-10	Sandy plain	59	26.6	1,278	99	1,590	74	87
3	0-10	Drainage lines / flats	49	29.6	1,056	84	1,809	48	204
	40-50		228	16.6	1,052	107	1,340	23	160
	90-100		1,138	1.6	20,945	3,649	6,840	125	883
4	0-10	Sandy plain	362	5.2	1,814	108	1,780	146	86
	40-50		123	1.6	1,565	43	1,711	53	151
	120-130		1,590	2.3	13,244	1,425	6,963	99	187
6	0-10	Drainage lines / flats	128	5.2	1,495	103	2,915	65	161
	40-50		66	1.3	861	53	1,653	37	92
8	0-10	Drainage lines / flats	111	4.5	1,673	115	3,050	80	150
	40-50		95	1.4	1,255	70	2,740	53	90
	90-100		759	1.4	2,319	348	1,402	33	126
10	0-10	Drainage lines / flats	271	3.9	1,855	71	1,843	48	200
	40-50		535	2.4	2,780	83	3,660	39	51
	120-130		7,073	2.5	71,230	2,795	19,396	393	186
12	0-10	Sandy plain	153	2.1	520	32	881	52	106
	40-50		105	3.4	363	26	1,019	84	121
13	0-10	Low sandy rise	117	2.8	611	22	638	57	74
	40-50		128	2.5	539	25	821	92	112
14	0-10	Low sandy rise	96	2.9	599	25	437	58	82
	40-50		115	2.8	705	41	557	85	69
15	0-10	Sandy plain	39	3.0	446	24	573	60	60
	40-50		35	8.5	360	25	756	137	116
17	0-10	Low sandy rise	77	7.7	719	34	664	98	95
	40-50		30	2.3	272	16	544	93	76
18	0-10	Sandy plain	54	3.1	550	26	674	66	78
	40-50		36	1.4	413	20	674	88	93
19	0-10	Drainage lines / flats	84	7.8	1,139	138	2,299	99	99
	40-50		155	2.7	712	72	656	38	112
	120-130		1,131	4.6	4,090	745	1,918	71	49
20	0-10	Drainage lines / flats	256	9.6	1,579	380	2,822	62	150
	40-50		308	3.6	730	65	1,397	37	119
	90-100		3,116	3.6	1,446	231	1,346	51	164
21	0-10	Sandy plain	87	18.0	1,994	114	2,801	61	128
	40-50		156	2.5	2,108	136	1,737	23	109
22	0-10	Drainage lines / flats	253	4.0	2,089	144	1,887	43	160

Site	Sample depth (cm)	Soil-landform association	Total metal concentration (ug/kg)						
			As	Cd	Cr	Co	Pb	Mo	Se
	40-50		445	2.2	3,176	132	2,349	38	192
	100-110		1,727	2.7	18,098	4,762	5,379	79	187
Average crustal abundance[1]			**1,500**	**110**	**100,000**	**20,000**	**14,000**	**1,500**	**50**

* Individual values above the Average Crustal Abundance are highlighted in yellow.

8.3.3 Overburden and Tailings

Physical Characteristics

Mine Earth's (2022b) assessment of the physical characteristics of overburden and tailings materials are summarised in the following sections. Detailed results are provided in Table 8 of Appendix 23.

Soil Texture

The soil texture of the overburden samples logged during the drilling program, ranged from sands to sandy clays, corresponding to clay contents of <5% to 40%. The was substantial variation present in the texture of the overburden soils both within and between the soil profiles from the various soil-landform associations, however, in general, the overburden materials from within the 'Low sandy rises', were generally courser in texture than those overburden materials from lower in the landscape.

As would be expected the textures of the tailings slimes and tailings sand samples were classified as heavy clay and sand respectively.

Structural Stability

The degree of clay dispersion within the overburden samples was variable, both within and between the soil profiles from the various soil-landform associations, with Emerson test classifications ranging from Class 1 (dry aggregate slakes and completely disperses), to Class 5 (aggregate slakes but does not disperse, no dispersion of remoulded soil, soil:water suspension remains dispersed)). Although variable, there was a general trend of the clay rich overburden materials from lower in the landscape, i.e., from within the 'Drainage lines / flats' soil-landform association, having a greater propensity for dispersion of the clay fraction than the coarser textured overburden materials from higher in the landscape. The propensity for clay dispersion in these overburden materials is likely to be exacerbated following severe disturbance.

The tailings slimes material was identified as Emerson Class 1 (dry aggregate slakes and completely disperses). The tailings sand material was identified as Emerson Class 5 (aggregate slakes but does not disperse, no dispersion of remoulded soil, soil:water suspension remains dispersed), albeit with a very low clay fraction.

Hydraulic Conductivity

The hydraulic conductivity of the overburden samples was variable, reflecting the variable soil textures present across the Study Area. Although variable, there was a general trend of lower hydraulic conductivity for the clay rich overburden materials from lower in the landscape

('Drainage lines / flats') with drainage classifications ranging from 'slow' to 'moderately slow'. Overburden materials from these areas having a greater propensity for dispersion of the clay fraction than the coarser textured overburden materials from the 'Low sandy rises', which were typified by coarser soil textures recorded 'moderate' to 'very rapid' drainage classifications.

As would be expected, the tailings sand sample exhibited a 'very rapid' drainage classification, and the tailings slimes, with a heavy clay texture, recorded an 'extremely slow' drainage classification.

Water Repellence

As would be expected for samples from deep within the soil profile with very low organic matter concentrations, all overburden samples exhibited negligible levels of water repellence.

Soil Strength

Hard-setting characteristics of the overburden materials were variable, again reflective of the variable soil textures and degree of clay dispersion within the materials. As was the case for the soils from higher in the soil profiles, overburden soils from lower in the landscape with higher clay contents (i.e. within the 'Drainage lines / flats') exhibited high MOR values above the 60 kPa threshold to denote potential hard-setting upon disturbance, wetting and drying cycles. The coarser textured (i.e. sandy) overburden materials exhibited low MOR values and a low hard-setting potential.

The tailings slimes samples exhibited the highest MOR values, reflective of its clay rich texture and dispersive nature. As would be expected, the tailings sand sample, which has a negligible clay fraction recorded a very low MOR.

Chemical Characteristics

Mine Earth's (2022b) assessment of the chemical characteristics of overburden and tailings materials are summarised in the following sections. Detailed results are provided in Table 9 and 10 of Appendix 23.

pH and Electrical Conductivity

The overburden samples recorded a substantial range in pH values, ranging from pH 4.4 (very strongly acid) to pH 9.4 (strongly alkaline). There was no apparent correlation between soil pH of the overburden materials and position within the landscape.

The tailings slimes sample recorded a pH of 7.8, classified as pH neutral.

There was a substantial range of EC values recorded for the overburden materials, with individual values ranging between 0.010 dS/m (non-saline) and 3.886 dS/m (extremely saline) based on standard USDA and CSIRO electrical conductivity categories. Overburden materials from within the 'Drainage lines / flats' soil-landform association typically recorded the highest EC values. Overburden materials from within the 'Low sandy rise' soil-landform association recorded non-saline EC values.

The tailings slimes sample recorded an EC of 0.9 dS/m, classified as moderately saline.

Soil Organic Matter

Soil organic matter in the overburden samples was very low, ranging from <0.05 - 0.34% as would be expected for soil from deep within the profile.

Exchangeable Cation and Exchangeable Sodium Percentage

Exchangeable cation concentration and eCEC were variable throughout the overburden samples, with the ESP results indicating that most all overburden samples were classified as sodic or highly sodic. The exchangeable cation and ESP results should be viewed in conjunction with the Emerson Test results, the amount of clay in the overburden and the salinity of the material, to identify the likely influence on the physical stability of the overburden upon disturbance. Sodicity and its influence on clay dispersion, is only likely to have a detrimental influence on the structure of the more clay-rich overburden materials, as reflected by the dispersive and hard-setting nature of the more clay-rich overburden samples.

The tailings slimes sample reported a high eCEC and highly sodic ESP, reflective of its high propensity to disperse upon saturation (Emerson Class 1).

Soil Nutrients

Soil nutrient concentrations were typically low in the overburden and tailings samples, except for moderate to high concentrations of potassium and sulphur in some clay-rich overburden samples from within the 'Drainage lines / flats' soil-landform association, and the tailings slimes sample.

Total Metal Concentrations

Total metals concentrations for the overburden and tailings samples were generally low and either below the level of detection or the average crustal abundance (Reimann, C. and de Caritat, P, 1998). Exceptions were minor elevations above the average crustal abundance for As and Zn in a small number of overburden samples. The tailings slimes sample also reported a minor elevation in As (16 mg/kg), above the average crustal abundance.

8.3.4 Soil Landform Association Mapping

Three soil-landform associations were identified within the Study Area namely 'Low sandy rises', 'Sandy plains' and 'Drainage line / flats'. Identification of the soil-landform associations was based on field observations of morphological differences between the soil profiles, position within the landscape and analysis of physical and chemical soil characteristics. Approximate boundaries of the soil-landform associations within the Study Area are detailed in Figure 100.

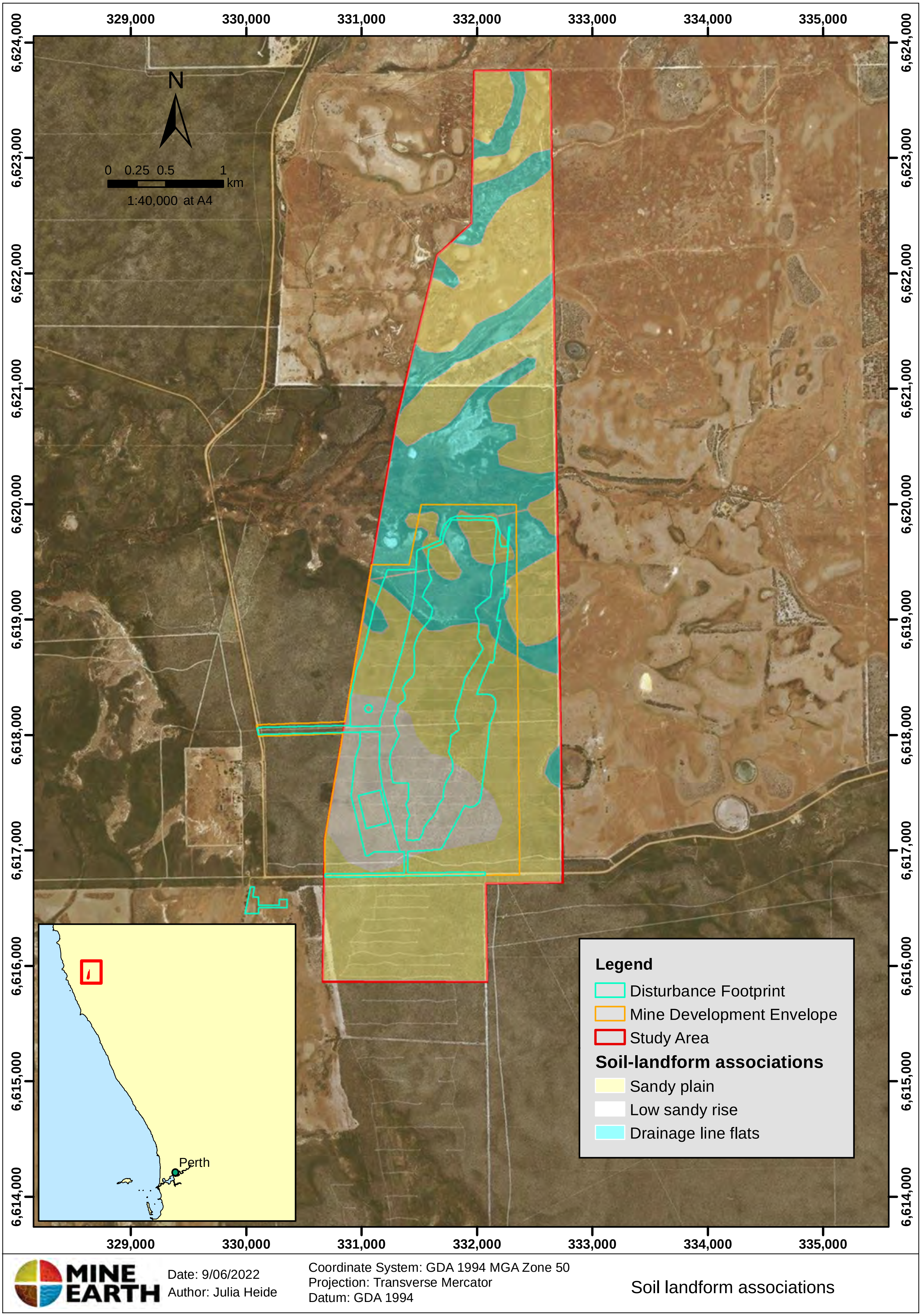


Figure 100: Soil-Landform Associations

8.3.5 Acid Sulfate Soils

Mine Earth's (2022a) ASS analysis results are summarised in the following sections. Detailed results are provided in Appendix 22.

Suite 1 – Screening Analysis

The full results of the pH_F and pH_{FOX} analysis are summarised as follows:

- pH_F values ranged from 3.8 - 9.5 and did not appear to have any correlation with depth (Figure 101);
- Majority of soils had a $pH_F > 5$;
- One sample recorded $pH_F \leq 4$, indicating actual acid soil (Drill hole 23, 2 to 3 m depth);
- Five samples recorded $pH_F > 4$ but ≤ 5, indicating a strong potential for ASS;
- pH_{FOX} values ranged from 1.9 - 9.2 with no apparent correlation with depth (Figure 102);
- 34 samples recorded $pH_{FOX} \leq 3$;
- The change in pH (ΔpH) from pH_F to pH_{FOX} ranged from 0 - 6.4 pH units;
- 43 samples recorded ΔpH >3 pH units; and
- Samples recording low pH_{FOX} values were distributed throughout the soil profile from near surface to the base of sampling (Figure 102).

The initial screening test results indicated that PASS may be present across the deposit. Based on the Suite 1 analysis results, 72 samples were selected for the second analysis suite (Suite 2) *WA - Chromium Suite for Acid Sulfate Soils* to further quantify the acid forming potential of the samples.

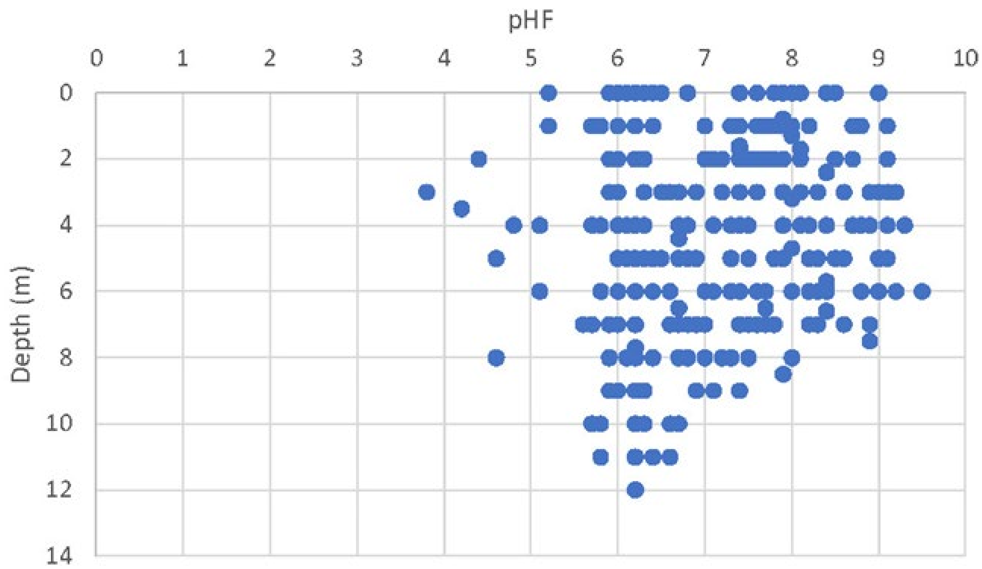


Figure 101: pH_F results with sample depth for all samples

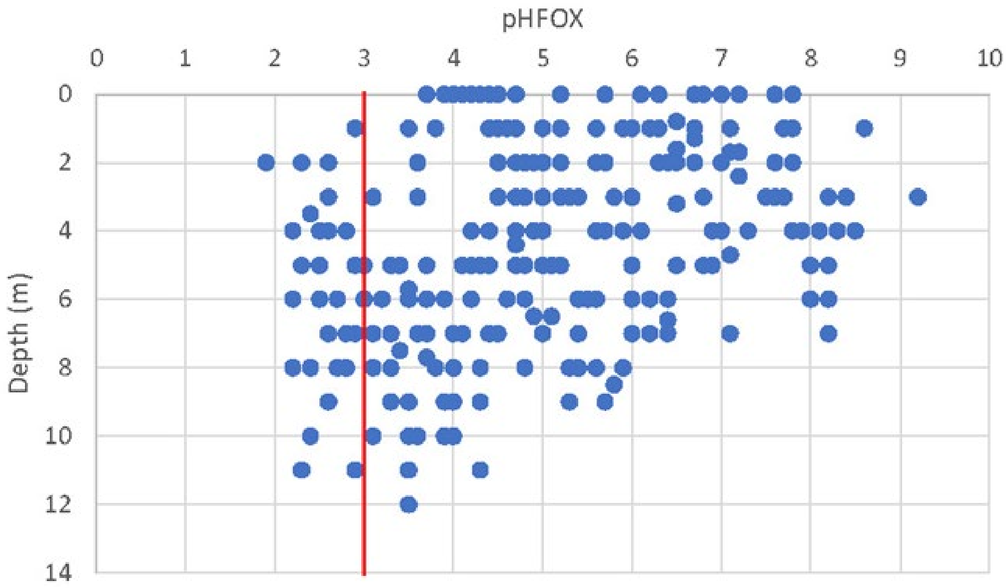


Figure 102: pH_{FOX} results with depth for all samples (red line indicates pH_{FOX}<3)

Suite 2 – CRS Analysis

Nine of the 72 samples tested exceeded the ASS action criteria (Table 48). Samples exceeding the ASS action criteria were present within five of the drilling locations, at sample depths ranging from 2-10 m.

Table 48: Samples exceeding ASS action criteria

Hole ID	Depth from (m)	Depth to (m)	Net Acidity excluding ANC Sulphur (sulphur %)	Net Acidity excluding ANC (acidity units)
ASS07	2	3	0.21	129
ASS23	7	8	0.10	61
ASS27	8	9	0.04	22
ASS29	4	5	0.04	24
ASS29	7	8	0.04	22
ASS31	2	3.5	0.06	36
ASS31	6	7	0.04	23
ASS31	9	10	0.04	25
ASS31	11	12	0.03	19

Bassendean sands contain single crystal and framboidal aggregates of sub-micron-sized pyrites. They generally have less than one per cent clay and therefore, extremely poor acid-buffering capacity (DER, 2015b). The DER Guidelines state that for Bassendean sands, where a chromium reducible sulphur (S_{cr}) value is less than 0.03% and pH_{Fox}<3, the soil should be treated by neutralisation with alkaline materials as if it had an inorganic sulphur content of 0.03% (DER, 2015b).

In addition, research into the properties of Bassendean sands has determined that a combination of pH_{Fox}<3 and an analytical value of 0.01%S_{cr} or greater are reliable indicators of ASS and can be used as a basis for identifying and managing PASS in Bassendean sands (UWA/DEC, 2011). Eighteen samples recorded a pH_{Fox}<3 and >0.01%S_{cr}, and therefore exceed the ASS action criteria for Bassendean sands (Table 49).

The samples identified as triggering one or all of the ASS action criteria were located within drillholes 7, 18, 23, 24, 27, 29 and 31 (Figure 103), indicating an inconsistent spread across the deposit. Full laboratory results of the Suite 2 analysis are included in Appendix 22.

Table 49: Suite 2 ASS results for samples exceeding all ASS action criteria for Bassendean sands

Hole ID	Depth from (m)	Depth to (m)	pH_{FOX}	Chromium Reducible Sulphur (%)
ASS07	2	3	2.3	0.204
ASS18	5	6	2.5	0.014
ASS23	5	6	3	0.014
ASS23	7	8	2.6	0.093
ASS24	7	8	2.8	0.014
ASS24	8	10	2.2	0.019
ASS27	6	8	2.2	0.025
ASS27	8	9	2.7	0.015
ASS29	2	3	2.9	0.016
ASS29	4	5	2.8	0.018
ASS29	7	8	2.6	0.035
ASS29	10	11	3.1	0.019
ASS31	2	3.5	2.6	0.051
ASS31	6	7	2.5	0.035
ASS31	7	8	2.8	0.036
ASS31	9	10	2.6	0.029
ASS31	11	12	2.3	0.011

Tailings pH

The pH of the tailings slimes and tailings sand fraction was assessed on representative samples supplied by Image Resources (Mine Earth, 2022a). The pH (H_2O) of the tailings slimes and sand fractions were recorded as 7.9 and 6.9 respectively. Given the exposure of the ore / tailings samples to oxidation and the circumneutral pH values recorded, it is reasonable to assume that the tailings materials, as received / tested, are unlikely to acidify as a result of ASS oxidation.

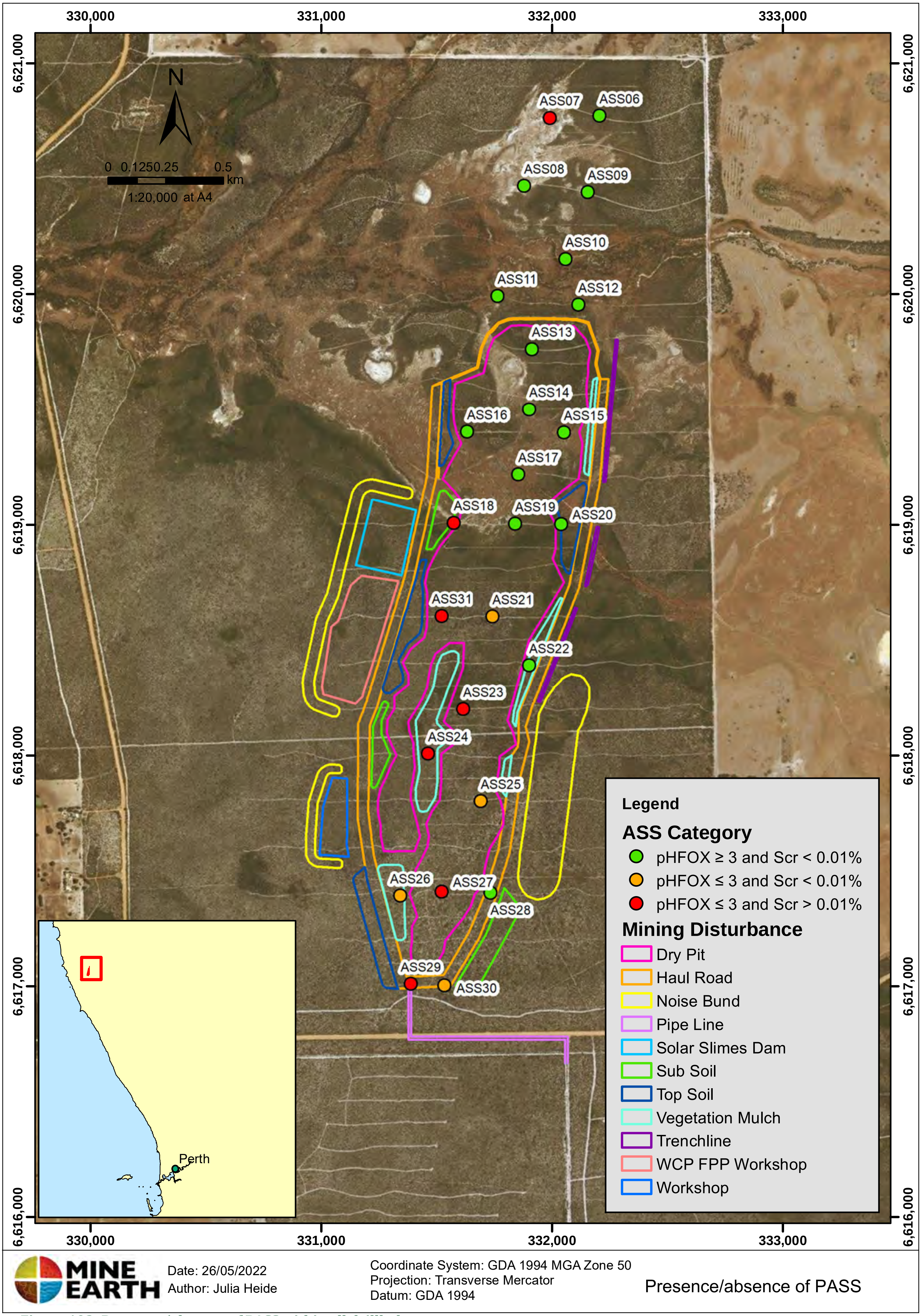


Figure 103: Presence/absence of PASS within all drillholes

Total and Leachable Metals

Total metals were analysed for selected samples from the ASS investigation. The samples selected comprised material representative of the overburden waste above the ore zone from across the deposit. Samples of the tailings slimes and tailings sand fractions from metallurgical testing (as supplied by Image) were also assessed. The results indicated minor elevated concentrations, relative to the average crustal abundance (Reimann and de Caritat, 1998), for Zinc (in three overburden samples) and Arsenic (six overburden samples and the tailings slimes sample).

An assessment of leachable metals was undertaken via an acetic acid leach of the selected samples. Leachable metal concentrations were mostly below detection limits, except for Barium, Boron, Manganese and Zinc for some samples. All concentrations were below trigger values for livestock drinking water (ANZECC/ARMCANZ, 2000). These results indicate that leachate from the soils / overburden materials under acidic conditions is unlikely to contain large concentrations of metals and metalloids that will potentially impact the surrounding environment.

Detailed account of assessment results of total metal concentrations and leachable metals are provided in Table 3 and 4 of Appendix 22.

Groundwater

High dissolved concentrations of Iron, Manganese, Arsenic and Nickel are common in superficial aquifers across the Perth Basin and particularly in the Bassendean Sands (Davidson, 1995; MWES, 2022b). High iron concentrations are present within some shallow bores and levels decrease significantly with depth. High Manganese concentrations observed in some bores are associated with saline groundwater. Other elements such as Arsenic and Nickel have moderately low concentrations and are patchy in distribution (MWES, 2022b). Elevated sulfate concentrations were present in some samples.

Chemical indicators within groundwater can be used to indicate whether groundwater has been affected by the oxidation of sulfides in ASS as follows:

- An alkalinity:sulfate ratio of less than 5;
- A pH of less than 5; and
- A soluble aluminium concentration greater than 1 mg/L (DER, 2015b).

The alkalinity:sulfate ratio of the majority of the groundwater samples was less than 5, indicating that the groundwater may have been affected by the oxidation of sulfides. However, none of the samples had a pH less than 5 and only one of the samples had a soluble aluminium concentration greater than 1 mg/L.

The alkalinity of the groundwater is a measure of the natural buffering capacity of the groundwater, such that the lower the total alkalinity and the higher the total acidity, the more vulnerable groundwater is to acidification (DER, 2015b). Several samples had alkalinity levels that were inadequate to maintain stable acceptable pH levels.

8.3.6 Environmental Values

Based on the information detailed above, the following environmental values were determined to require assessment for this factor:

- The ecosystem health values that the soils within the Project Area support, including biodiversity and seed banks.

8.4 Potential Impacts

Table 50 defines the potential impacts (direct, indirect and cumulative) on the environmental value for this factor in a local and regional context.

Table 50: Potential Impacts to Terrestrial Environmental Quality

Environmental value	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
The ecosystem health values that the soils within the DEs support, including biodiversity and seed banks	Discharge of an estimated 30 kL/day of treated sewage via irrigation	Contamination of soil from seepage from the solar drying ponds Hydrocarbon spills causing contamination Erosion from active or rehabilitated structures spreads sediment into terrestrial environment Disturbance of ASS	No other proposals are located in proximity to the Proposal The surrounding area has been impacted by agriculture	Direct impacts from wastewater disposal and potential indirect impacts

8.5 Assessment of Impacts

8.5.1 Wastewater Disposal (Sewage)

An estimated 30 kL of sewage from the accommodation camp will be treated at a wastewater treatment plant each day during construction and operation. The treated wastewater will be disposed of via irrigation to a dedicated area adjacent to the camp, sized in accordance with DWER requirements to minimise nutrient loading of the soils. The wastewater will be treated to a minimum low exposure risk level quality and licenced under Part V of the EP Act and the *Health Act 1911* (WA).

8.5.2 Disturbance of Acid Sulfate Soils

As described in Section 8.3.1 and 8.3.5, PASS has been detected in some samples and distribution is variable. Further assessment of PASS will be undertaken within the deposit during operations to further quantify distribution and volumes of PASS material.

Topsoil

Topsoil and subsoil do not required neutralisation if the pH is greater than 4 (DER, 2015b). The baseline soil investigation (Mine Earth, 2022b) indicated that all soils sampled to a depth of 1 m from across the study area had a pH >5. Therefore, topsoil (and subsoil) materials are unlikely to require any treatment for PASS and will consequently be managed as per mitigation measures outlined in Section 8.6.

Subsoil / Overburden

The depth of overburden within the proposed pit ranges from 0.2 - 1.5 m. Subsoil / overburden will be removed and initially stockpiled external to the pit until sufficient areas of the pit are available to allow progressive backfill and surface soil profile construction / rehabilitation.

Total Leachable Metals

Minor elevated concentrations, relative to average crustal abundance, of Zn and As were determined within overburden samples (Mine Earth, 2022a). Assessment of select samples via an acetic acid leach determined leachable metal concentrations to be below trigger values, except for Ba, B, Mn and Zn in some samples. All concentrations were below trigger values for livestock drinking water (ANZECC/ARMCANZ, 2000).

These results indicate that leachate from soils / overburden materials under acidic conditions is unlikely to contain concentrations of metals and metalloid that will potentially impact the surrounding environment.

Additional analysis of soil / overburden materials throughout mining operations will facilitate further delineation of the distribution of likely PASS and volumes of material requiring management, to minimise the risk associated with the PASS. Management and treatment of PASS during operation is detailed in Section 8.6.

Summary

Based on the information provided above and in Section 7.3 impacts associated with ASS are predicted to be able to be managed such that they do not cause a significant impact to Terrestrial Environmental Quality. Monitoring and management actions to minimise the risks associated with the PASS have been detailed in Section 8.6.

8.5.3 Seepage From the Solar Drying Ponds

The Solar Drying Ponds will accept an estimated 0.8 Mt of clay fines over the life of the Proposal, with the design to be subject to mandatory assessment and regulation under both the Mining Act and Part V of the EP Act (Works Approval). This figure includes clay fines established in solar drying ponds within the mine pit following mining. The temporary storage of clay fines into the solar drying ponds, prior to placement within the mine void, will also be licenced under Part V of the EP Act and regulated with mandatory annual geotechnical inspections and reporting.

The assessment of seepage impacts from the Solar Drying Ponds is based on the following:

- The geochemical characteristics of the clay fines and resulting leachates;
- The receiving environment for those leachates;
- The potential pathways and sensitive receptors for leachates of concern; and
- The physical characteristics of the construction materials for the Solar Drying Ponds and their potential to erode.

Clay Fines Characterisation

Acid-forming tendency

The pH (H_2O) of the clay fines and sand fractions were recorded as pH 7.9 and pH 6.9 respectively. Given the exposure of the ore / clay fines samples to oxidation and the circum neutral pH values recorded, it is assumed that the clay fines materials, as received / tested, are unlikely to acidify as a result of ASS oxidation.

Total Leachable Metals

Results of total metals concentrations within clay fines indicated minor elevated levels of As in comparison to Average Crustal Abundance outlined by Reimann and de Caritat (1998). All other metal concentrations remained below average (Mine Earth, 2022a).

Assessment of leachable metals undertaken via an acetic acid leach of selected samples determined leachable metal concentrations were mostly below detection limits, except for Ba, B, Mn and Zn for some samples with all concentrations remaining below trigger values for livestock drinking water (ANZECC/ARMCANZ, 2000). A detailed account of assessment results of total metal concentrations and leachable metals is provided in Table 3 and 4 of Appendix 22.

Disposal of Clay Fines

Mine Earth (2022) identified the physical properties of the clay rich fines to have potentially problematic characteristics if placed at, or close to the surface of reconstructed / rehabilitated soil profiles. The assessment determined that clay fines will require treatment with alkaline material (as detailed in Section 8.6) prior to final disposal within the pit.

Summary

Based on the information provided above, with appropriate mitigation, significant impacts to terrestrial environmental quality from the Solar Drying Ponds are considered unlikely, and the detailed design and approval processes under Part V of the EP Act and the Mining Act are expected to ensure that the EPA objective for this factor can be met.

8.5.4 Seepage from Other Processed Materials

Tailings Sands

Tailings sand derived from ore processing will be returned to the pit void as a single waste stream and/or co-disposed with tailings clay fines into pit voids. Mine Earth (2022b) characterised the sand fraction generated from mining activities as 'sand', with low soil strength and a 'very rapid' drainage classification with concentrations of all metals below average crustal abundance.

Sand tails will be regularly assayed to ensure S_{cr} concentrations are below 0.01%S_{Cr} and pH_{FOX} values are >3. If necessary, additional lime sand will be incorporated during disposal. Process water will be derived from the tailings sands and will be routinely field monitored for pH in order to ensure the pH of the water is above 5.5.

Based on low metal concentration and monitoring and management actions of sand fractions, significant impacts to terrestrial environmental quality from the sand fractions deposited within the mine void are considered unlikely.

Heavy Minerals Concentrate

The Heavy Minerals Concentrate will be stockpiled and stored on a limestone bunded treatment pad prior to transport off site.

8.5.5 Hydrocarbon spills

Diesel use at the Proposal is estimated to be 11 ML/yr for all site and transport operations. In addition to diesel used for mobile equipment, the power station will be diesel-fired, and small generators may be used for mobile power around the site. Approximately 220,000k L diesel storage is required for power generation and emergency diesel engines at the mine. Two other fuel facilities are likely to support the mining fleet (around 220,000 L). These diesel storage facilities will have secondary containment; they will either be either self-bunded or located within bunded areas.

In addition to diesel fuel, most earthmoving equipment uses hydrocarbon-based materials for hydraulics, and failed hydraulic systems can result in relatively small hydrocarbon spills. Considering the above, and the small scale of operations planned for Image, large-scale hydrocarbon spills are considered unlikely. Small hydrocarbon spills associated with hydraulics failures on machinery and refuelling spills may occur on occasion in operational areas. Spills generally result in a defined area of hydrocarbon contaminated soil that can be remediated via passive means such as bioremediation. Proposed control measures are identified in Section 8.6 and are designed to further reduce the risk of soil contamination from hydrocarbon spillage.

8.6 Mitigation

Image has mitigated the potential impacts to this factor according to the mitigation hierarchy; avoid, minimise rehabilitate, offset. Offsets are not expected to be required for this factor.

8.6.1 Avoid

The Proposal has been designed to avoid permanent waste dump impacts by progressively backfilling the mine pit. Other potential impacts could not be avoided and require mitigation (refer below).

8.6.2 Minimise

The following mitigation measures are proposed to ensure that direct and indirect impacts to terrestrial environmental quality are minimised:

1. **Obtain and comply with Works Approval and Licence issued under Part V of the EP Act.** A Works Approval and Licence will be required for the Proposal, specifically for mineral sands mining or processing and for the wastewater treatment plant (sewage). These items encompass all pollution risks for the Proposal. Therefore, the Works Approval and Licence is the primary mechanism for ensuring the design and operation of the Proposal

is conducted in a manner that minimises pollution impacts to terrestrial environmental quality. The Works Approval and Licence will typically ensure that the following mitigation measures are required:

a. Sufficient freeboard will be included in the solar drying pond wall designs to prevent overtopping;
b. The design of the solar drying pond walls will be risk assessed and where required, engineered to hold the required capacity of the clay fines and a significant rainfall event;
c. The design of the solar drying ponds will be risk assessed and where required, engineered and constructed according to specifications;
d. The integrity of the solar drying pond walls will be assessed during regular inspections;
e. The following controls will be implemented to minimise the risk of impact from unintentional tailings pipeline spills:
    i. Pipelines will be inspected for leaks regularly, especially during extreme heat or fire events;
    ii. Flows will be shut off if leaks are detected;
    iii. Pipelines will be located off access road surfaces;
    iv. If pipelines have to cross access roads, then they will be buried;
    v. Investigations will be conducted into the cause of any spills, and remedial actions will be taken to minimise the chance of reoccurrence;
f. The quality of groundwater around the Proposal will be monitored; and
g. Sewage will be treated and discharged to a dedicated irrigation area that is appropriately sized for the predicted volumes;

2. **Implementation of ASSMP (Appendix 22) including the following institutional controls:**
    a. Monitoring for pH_{FOX} values and Scr values in subsoils, overburden and ore during mining;
    b. Identified PASS materials stored and treated in accordance with the guidelines for treatment and management of soil and water in ASS landscapes (DER, 2015b);
    c. Treatment pads for temporary storage and treatment of PASS material will be constructed of compacted crushed limestone or similar material and will be constructed to prevent infiltration of leachate and external runoff from the surface;
    d. Routine monitoring of process water quality from process water dams; and
    e. Implementation of the Groundwater Management Plan (discussed in further detail in Section 7.6) to mitigate groundwater drawdown impacts to ASS;
3. **Obtain and comply with a Mining Proposal issued under the Mining Act.** A Mining Proposal (MP) will be required for the Proposal, for all works apart from minor works that may occur within MRWA tenure. The MP is the primary mechanism for ensuring the design of Proposal structures are safe and stable, such that the risk of erosion is minimised. The MP will ensure that the following mitigation measures are implemented at a minimum:
    a. Geotechnical stability standards are met;
    b. Geotechnical monitoring and inspections are conducted; and
    c. Mitigation measures previously listed in item 1 (for Works Approval and Licences);
4. **Implement the following measures to minimise the risk and impact of hydrocarbon spills:**
    a. Hydrocarbons will be stored either within a bunded area or within self-bunded tanks;

b. All spills will be controlled, contained and cleaned up as soon as practicable;
c. Service vehicles will be fitted with spill kits;
d. Spill kits will be located at all workshop and fuel storage areas; and
e. Environmental incident recording, investigation and reporting system.

8.6.3 Rehabilitate

The mining pits will be progressively filled and rehabilitated to the pre-mining profile with the pre-existing land use reinstated as mining advances and actioned in accordance with the MCP.

An interim MCP has been prepared to accompany this ERD (Appendix 2) which was developed according to DMIRS Guidelines (2020a; 2020b). Key rehabilitation measures captured within the MCP are summarised below:

1. Land will be made physically safe, stable and non-polluting;
2. Soil profile will be reestablished to support native vegetation growth;
3. The site will be left in a safe, stable, non-polluting and tidy condition with no remaining plant or infrastructure that is not required post-mining use or agreed used by other stakeholders;
4. Any identified site contamination is to be reported in accordance with the CS Act; and
5. No contaminated soils post-closure.

The MCP describes the associated management and monitoring proposed during the closure phase including:

- Materials balance for closure and rehabilitation demonstrating the quantities, availability and management for all rehabilitation materials;
- Identified knowledge gaps to be filled prior to closure;
- Closure tasks; and
- Completion criteria, monitoring and reporting during closure.

The MCP will be submitted to DMIRS for assessment and approval under the Mining Act prior to any disturbance at the Proposal and will be reviewed and revised every three years, or prior to closure, whichever is the earliest.

A site specific Soil and Mine Waste Management Plan (SMWMP) has been developed by Mine Earth (2022c) for the Proposal to provide management requirements and soil profile reconstruction planning to maximise the success of rehabilitation success post mining. The SMWMP has been provided as Appendix 24.

8.7 Predicted Outcome

The EPA's environmental objective for this factor is "to maintain the quality of land and soils so that environmental values are protected" (EPA, 2016k). In the context of this objective: "terrestrial environmental quality" is defined as the chemical, physical, biological and aesthetic characteristics of soils (EPA, 2016k). The specific environmental values to be protected are 'the ecosystem health values that the soils support, including biodiversity and seed banks'.

The Proposal is not expected to significantly impact terrestrial environmental quality. Seepage from topsoil and overburden stockpiles is to be managed through neutralisation and isolation during mine operation in a sufficient manner that significant impacts are unlikely. Hydrocarbon spills are able to be mitigated such that significant impacts are unlikely.

The key risks to terrestrial environmental quality is the disturbance of ASS, seepage from solar drying ponds, process plant and the wastewater treatment plant and erosion from active or rehabilitated structures, topsoil stockpiles and overburden. The design and operation of all of these items will be regulated under Part V of the EP Act and the Mining Act.

The implementation of design and operations mitigation measures, and regulation under Part V of the EP Act and the Mining Act, are expected to ensure that the Proposal does not significantly impact this factor. The EPA objective for this factor is therefore able to be met.

9 SOCIAL SURROUNDINGS

9.1 EPA Objective

The EPA Objective for this key environmental factor is to protect social surroundings from significant harm.

9.2 Policy and Guidance

Relevant EPA and Commonwealth Government guidance documents for social surroundings are summarised in Table 51.

Table 51: Policy and guidance relevant to the Social Surroundings key environmental factor

Policy and Guidance	How guidance has been considered
WA Government	
Key EPA documents	
Statement of Environmental Principles, Factors and Objectives (EPA, 2021b)	This document was considered in the preparation of this ERD and to inform EIA. It was used identify the Key Environmental Factors likely to be impacted by the Proposal and the EPA's objective for each factor.
Statutory Guidelines for Mine Closure Plans (DMIRS, 2020b);	This document has been considered in the design and planning of the Proposal, it has also been considered in the preparation of mitigation measures and a preliminary MCP for the Proposal.
EIA (Part IV Divisions 1 and 2) Administrative Procedures (EPA, 2021e)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
EIA (Part IV Divisions 1 and 2) Procedures Manual (EPA, 2021a)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
Instructions on how to prepare EP Act Part IV Environmental Management Plans (EPA, 2021f)	This document was considered in the preparation of the Dust Management Plan (Ramboll, 2022b; Appendix 25) and has been considered in the development of a Social Cultural Heritage Management Plan (in preparation).
Guidance Statement No. 3: Separation Distances between Industrial and Sensitive Land Uses (EPA, 2005)	This document was considered in the preparation of this section (Section 9) of the ERD and in the Dust Management Plan.
Relevant EPA Factor Guidelines	
Environmental Factor Guideline – Social Surroundings (EPA, 2016l)	This document was considered in the preparation of this section (Section 9) of the ERD.
Relevant EPA Technical Guidance	
Guidance Statement 41 – Assessment of Aboriginal Heritage (EPA, 2004c)	This document was considered in the preparation of this section (Section 9) of the ERD.
Other Policy and Guidance	
Environmental Protection (Noise) Regulations 1997	This document was considered during the assessment of Proposal noise emissions (LGA, 2022) and in the preparation of this section (Section 9) of the ERD.
Aboriginal Heritage Act 1972 (WA) (AH Act)	This document was considered during the preparation of this section (Section 9) of the ERD.

Policy and Guidance	How guidance has been considered
Aboriginal Cultural Heritage Act 2022 (ACH Act)	This document was considered during the preparation of this section (Section 9) of the ERD.
National Environment Protection Measure for Ambient Air Quality (National Environment Protection Council (NEPM), 2021)	This document was considered during the assessment of Proposal dust emissions.
State Environment Protection Policy (Ambient Air Quality) (Government of Victoria, 2001)	This document was considered during the assessment of ambient dust at the Proposal.
DWER draft guidelines for dust emissions (DWER, 2021b)	This document was considered during the assessment of Proposal dust emissions.
DPLH Position Statement: Dark sky and astrotourism (DPLH, 2020)	This document was considered during the assessment of Proposal light emissions.
A guideline for managing the impacts of dust and associated contaminants from land development sites, contaminated sites remediation and other related activities (DEC, 2011)	This document was considered during the preparation of this section (Section 9) of the ERD.
Commonwealth Government	
Key Documents	
Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act) (DotEE, 2016a)	This document was considered in the preparation of this ERD and while undertaking EIA.
Environmental Management Plan Guidelines (DotE, 2014a)	This document was considered in the preparation of the Dust Management Plan (Ramboll, 2022b; Appendix 25).
Environmental Management Plan Guidelines - template (DotE, 2018)	This document was considered in the preparation of the Dust Management Plan (Ramboll, 2022b; Appendix 25).
EPBC Act Condition Setting Policy (DAWE, 2020a)	This document was used as guidance for the likely regulation of Proposal impacts.
EPBC Act Outcomes-based conditions policy (DotE, 2016a)	This document was used as guidance for the likely regulation of Proposal impacts.
Relevant Technical Guidance	
Engage Early - Guidance for proponents on best practice Indigenous engagement for environmental assessments under the EPBC Act (DotE, 2016b)	This document was used as guidance for assessment and management of physical and social impacts on Aboriginal Heritage.
NSW Government	
Other Policy and Guidance	
Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (NSW EPA, 2016)	This document was considered during the preparation of this section (Section 9) of the ERD.

9.3 Receiving Environment

The section below has been sourced from the following reports:

- Assessment of Aboriginal Heritage Values and Traditional Uses (Horizon Heritage Management (Horizon), 2020; Appendix 26);

- Archaeological and Ethnographic Site Identification Survey of the Proposed Atlas Project Area with Yued Traditional Owners (Terra Rosa Consulting (Terra Rosa); 2022, Appendix 27);
- Environmental Noise Survey (Lloyd George Acoustics (LGA) 2021; Appendix 28);
- Environmental Noise Assessment (LGA, 2022; Appendix 29); and
- Air Quality Impact Assessment (Ramboll, 2022a; Appendix 30).

9.3.1 Survey Effort

Aboriginal Heritage Values and Traditional Uses

Image commissioned Horizon to undertake an Aboriginal heritage values and traditional uses assessment to understand the extent and characteristics of any known and likely Aboriginal heritage values at the Proposal). The extent of the assessment was to contextualise and demonstrate the importance of these Aboriginal cultural sites, features and materials.

Assessment by Horizon addressed the following:

- Identify whether any registered Aboriginal heritage sites occur within or in close proximity to the Proposal;
- Provide a contextual assessment of the general Aboriginal heritage values of the area;
- Identify any features at the Proposal that may:
    - Be ethnographic sites;
    - Have a higher likelihood of the presence of archaeological sites;
    - Be of high value for bush tucker or bush medicine; and
- Provide recommendations as appropriate to minimise impacts to Aboriginal heritage values.

Aboriginal Heritage Survey

Image commissioned Terra Rosa Consulting (Terra Rosa) to undertake an archaeological and ethnographic site identification heritage survey at the Proposal. The heritage survey was carried out over three excursions between 31 August 2021 and 26 March 2022 with endorsement of the South West Aboriginal Land and Sea Council (SWALSC), who were the representatives for the Yued Traditional Owners (TOs).

The archaeological and ethnographic heritage survey was conducted to a site identification standard in accordance with Section 18 AH Act requirements, and to satisfy obligations outlined in the activity notice. The aims of a site identification survey were to:

- Identify Aboriginal sites (as defined under Section 5 of the AH Act) within the requested survey area;
- Document the heritage values of the site comprehensively enough to provide the Department of Planning, Lands and Heritage (DPLH) and the Aboriginal Cultural Materials Committee (ACMC) with a fair understanding of the site's importance and significance under Section 5 and Section 39 of the AH Act; and
- Provide Image with relevant and informed heritage management recommendations for heritage values identified within the requested survey area.

Legislation and Heritage Agreement

Under Section 17 of the AH Act, it is an offence to disturb an Aboriginal site without prior written Ministerial consent to do so as provided under Section 16 and 18 of the AH Act. This applies regardless of whether an Aboriginal site is registered. Heritage assessments of proposed development areas were conducted to identify the location and extent of sites to ensure they can be appropriately managed in accordance with the legislative requirements of the AH Act.

An Indigenous Land Use Agreement (ILUA) is held by Yued TOs under the South West Native Title Settlement (the Settlement). Heritage surveys were undertaken with the endorsement of SWALSC, representatives for the Yued TOs.

Desktop Surveys

A desktop assessment was completed prior to the field survey to understand the extent of heritage research undertaken within the survey area to date. This research relies largely on the Register of Sites maintained by the DPLH, which is a catalogue of heritage places previously recorded within the area and submitted to the DPLH.

Prior to field work, the DPLH's Aboriginal Heritage Inquiry System (AHIS) was consulted to learn whether any heritage surveys have previously been conducted, and whether any registered Aboriginal sites or other heritage places (OHPs) exist in the area.

Any relevant unpublished material (heritage reports not registered with the DPLH) was also reviewed prior to field work and included in the heritage assessment results where relevant.

The reviewed material was summarised to provide the survey team with an understanding of the cultural landscape context of the survey area.

Field Survey

Mine Development Envelope

The heritage field survey was conducted over three separate field trips from 31 August 2021 to 26 March 2022. Prior to the survey, Terra Rosa's heritage consultants and Image representatives conducted a survey briefing to provide the Yued TOs with information about the purpose, scope, and proposed method of the heritage survey. The results of the desktop survey were also discussed to provide the survey team with contextual information on what heritage values are known to exist within the survey areas. The proposed method was approved by the Yued TOs present.

The briefing was conducted alongside the Image representatives, who provided technical information relating to the proposed works. The discussions included consideration for future Social Surroundings consultations for the Proposal.

The survey involved a combination of workshop meetings between the Yued TOs, the Terra Rosa heritage consultants and Image representatives, alongside targeted visits to key places of archaeological and ethnographic heritage concern, and pedestrian transects of the Heritage Survey Area (collective of Areas A, B, C and D; Figure 104). Systematic pedestrian transects were completed with survey team members spaced up to 30 m apart (depending on the terrain). Targeted visual and pedestrian inspection was used to assess the ethnographic and archaeological heritage values of the survey areas. Ethnographic consultation with the Yued TOs focused on the importance and significance of these places and the connection with the broader Yued cultural landscape. Separate consultations with only the Yued TOs and the Terra Rosa heritage consultants were held to ensure that the Yued TOs could privately discuss any Aboriginal heritage and Social Surroundings concerns.

In addition to the systematic pedestrian survey, investigation bores and associated sumps installed in and around the resource footprint were subject to targeted archaeological and ethnographic survey (Figure 104). This additional focus was to determine cultural significance of this work given the proximity to Mount Jetty Creek and Bibby Creek, two areas of cultural concern to the TOs.

Any heritage places identified during any of the survey were recorded to site identification standard.

Potential heritage sites that were unlikely to meet the legislative definition of an Aboriginal heritage site as defined under Section 5 of the AH Act were assessed in consultation with the Yued TOs as 'Areas of Cultural Concern'. A detailed description of methods used to describe different site types is provided in Appendix C of Terra Rosa (2022; Appendix 27).

At the end of each fieldtrip a debrief was conducted to discuss the results of the heritage survey, and to offer the Yued TOs an opportunity to provide additional comments on the heritage places identified, the effectiveness of the methods used, and their recommendations for the management of cultural heritage values in the area.

External Infrastructure Development Envelope

Targeted surveys of sections of the EIDE were undertaken by the Yued TOs and Terra Rosa consultants. These locations include two of the five potential production bores, and associated monitoring bores, and were surveyed on 26 March 2022 (trip 3/3; Figure 104). The monitoring and production bore locations were surveyed due to their proximity to a historically significant stock run, as identified by the TOs.

Coordinates Capture

All coordinates provided in Terra Rosa (2022) and the spatial data package accompanying it were obtained with a Garmin hand-held GPS and a Samsung Galaxy tablet, using the GDA datum (Terra Rosa, 2022). All grid references are projected in MGA Zone 50, unless otherwise stated. Dependent on external conditions, these units afford an optimal spatial accuracy of ± 5 m.

Report Review

A draft version of the Terra Rosa (2022) report was reviewed by Yued TOs before it was provided to Image. This review ensured that culturally sensitive information was appropriately indicated, and that the recommendations provided were made in accordance with any existing agreements.

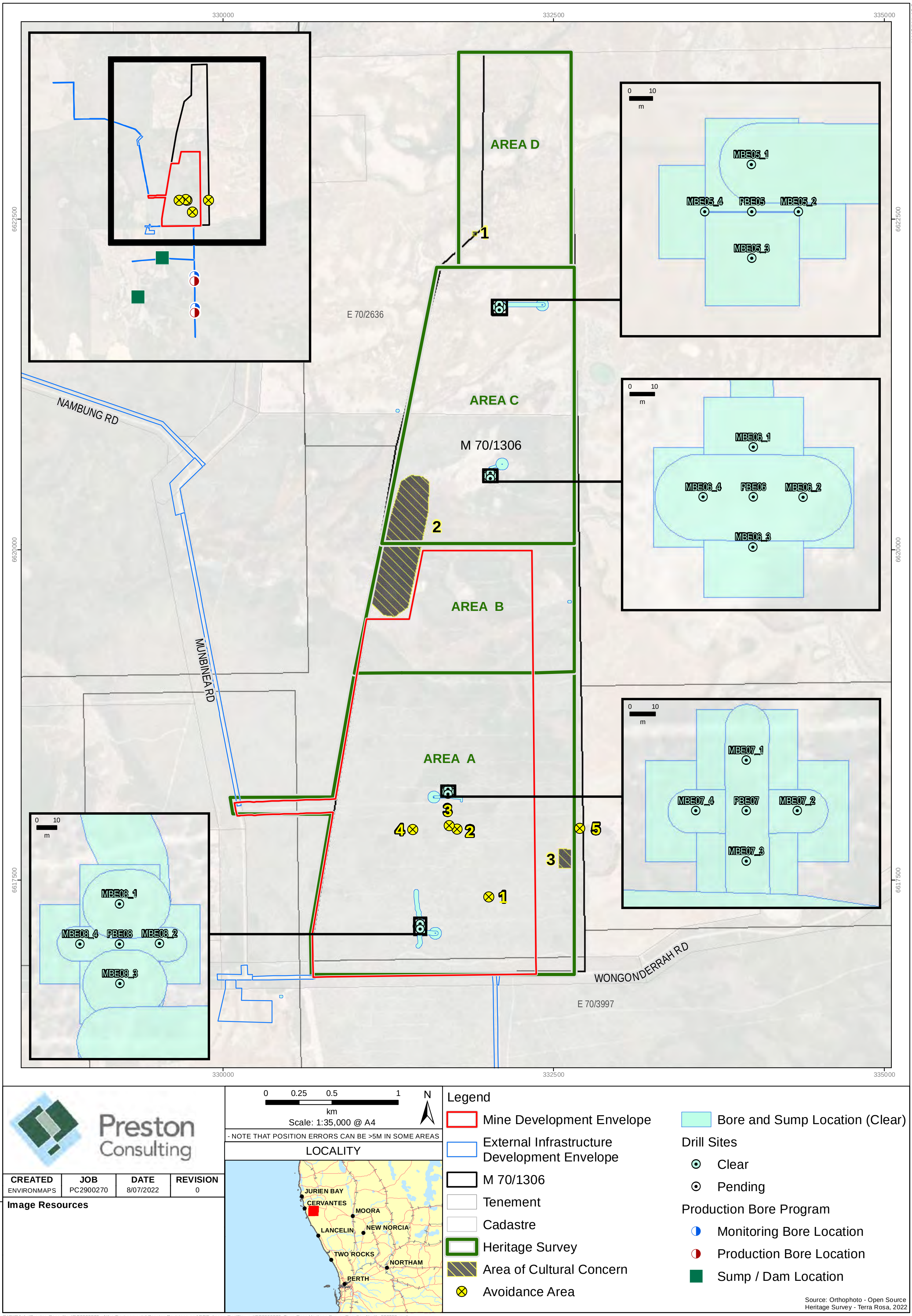


Figure 104: Terra Rosa Heritage Survey Areas and Survey Results around the MDE

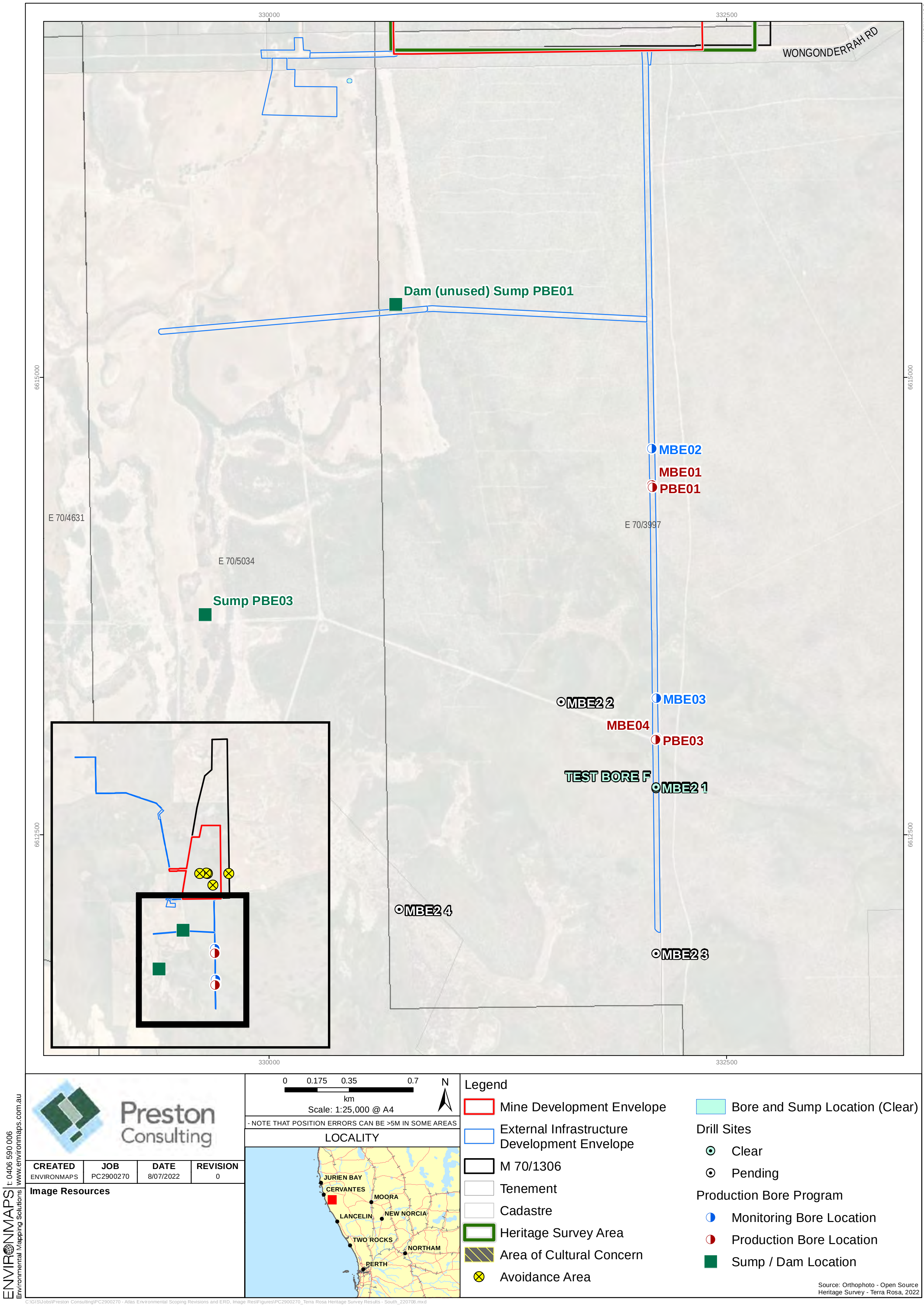


Figure 105: Terra Rosa Survey Results of the Water Supply Locations

Air Quality Assessment

Ramboll Australia Pty Ltd (Ramboll) were engaged to undertake an air quality assessment to predict the potential dust deposition rates and ambient air quality impacts in the vicinity of the Proposal.

Ramboll (2022) identified five sensitive receptors (all residences) associated with the Proposal, shown in Figure 106.

Background Noise Survey

Lloyd George Acoustics (LGA; 2021) was engaged to record and assess background noise levels at the Proposal to inform the Environmental Noise Assessment (LGA, 2022) for the Proposal.

Background noise monitoring was undertaken between 22 – 29 January 2021 to characterise the existing noise levels at two locations surrounding the Proposal. The first noise logger (North; 8780F7) was located approximately 3 km northwest of the MDE and the second logger (South; 8780F4) was located approximately 1 km southwest of the MDE at Nambung Station Stay.

The locations of the loggers are described in Table 52 and shown in Figure 107.

Table 52: Noise Logger Details at the Proposal

Logger	Description	Easting (MGA94, Zone 50)	Northing (MGA94, Zone 50)
8780F7	Logger North: 3121 Munbinea Road, Nambung	330,359	6,623,091
8780F4	Logger South: 2269 Wongonderrah Road, Nambung	329,657	6,616,154

Noise measurements were undertaken in accordance with the Environmental Protection (Noise) Regulations 1997 (Noise Regulations), specifically in relation to Noise Regulations 19, 20, 22 and 23, and Schedule 4 which detail the specifications for noise logging equipment.

Meteorological conditions over the time of the background noise survey were obtained from the Bureau of Meteorology's Lancelin (Defence) site. It is noted this weather station is located 28 km south of the site and closer to the coastline, and therefore may not reflect the actual weather conditions on site.

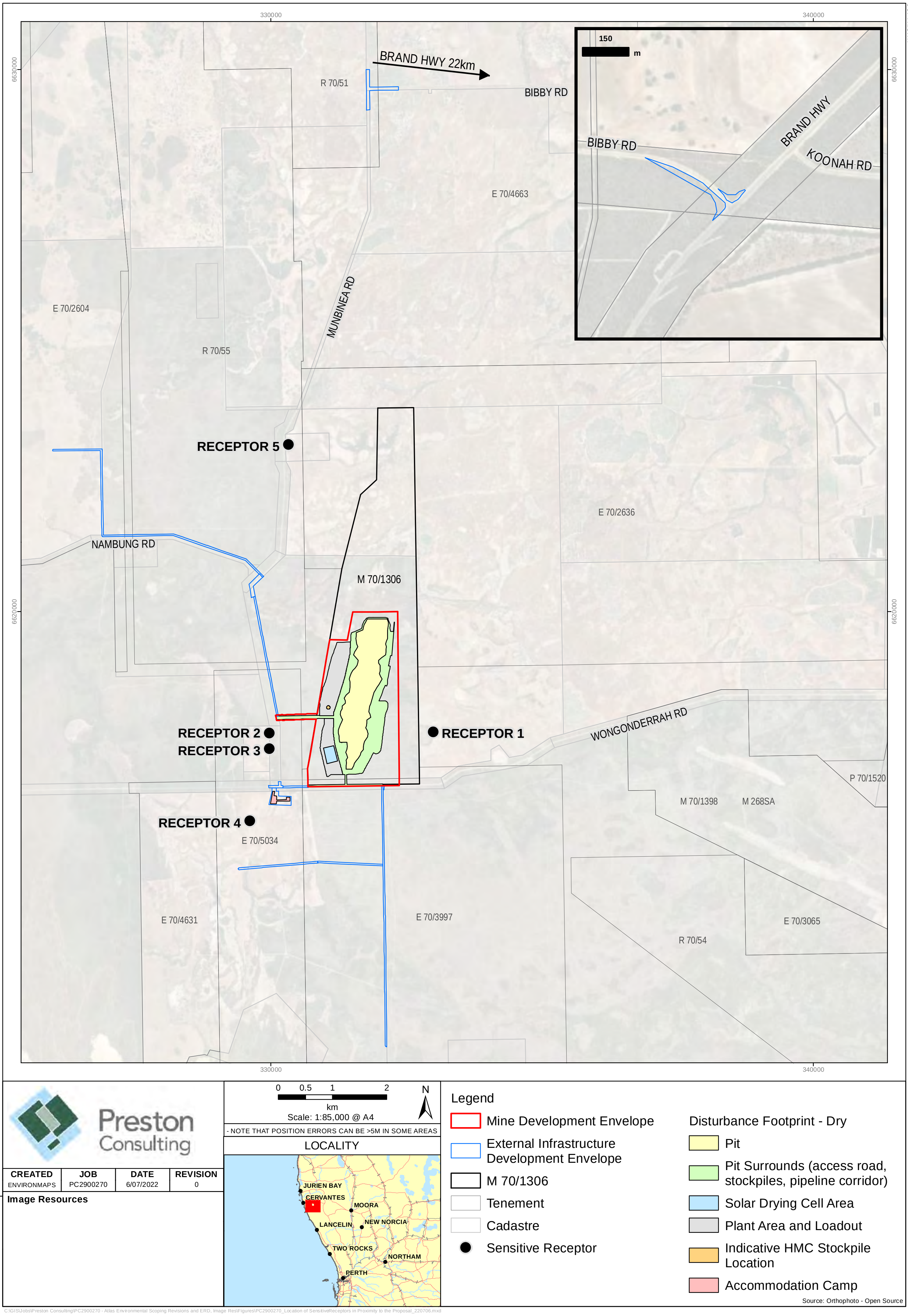


Figure 106: Locations of sensitive receptors in proximityto the Proposal

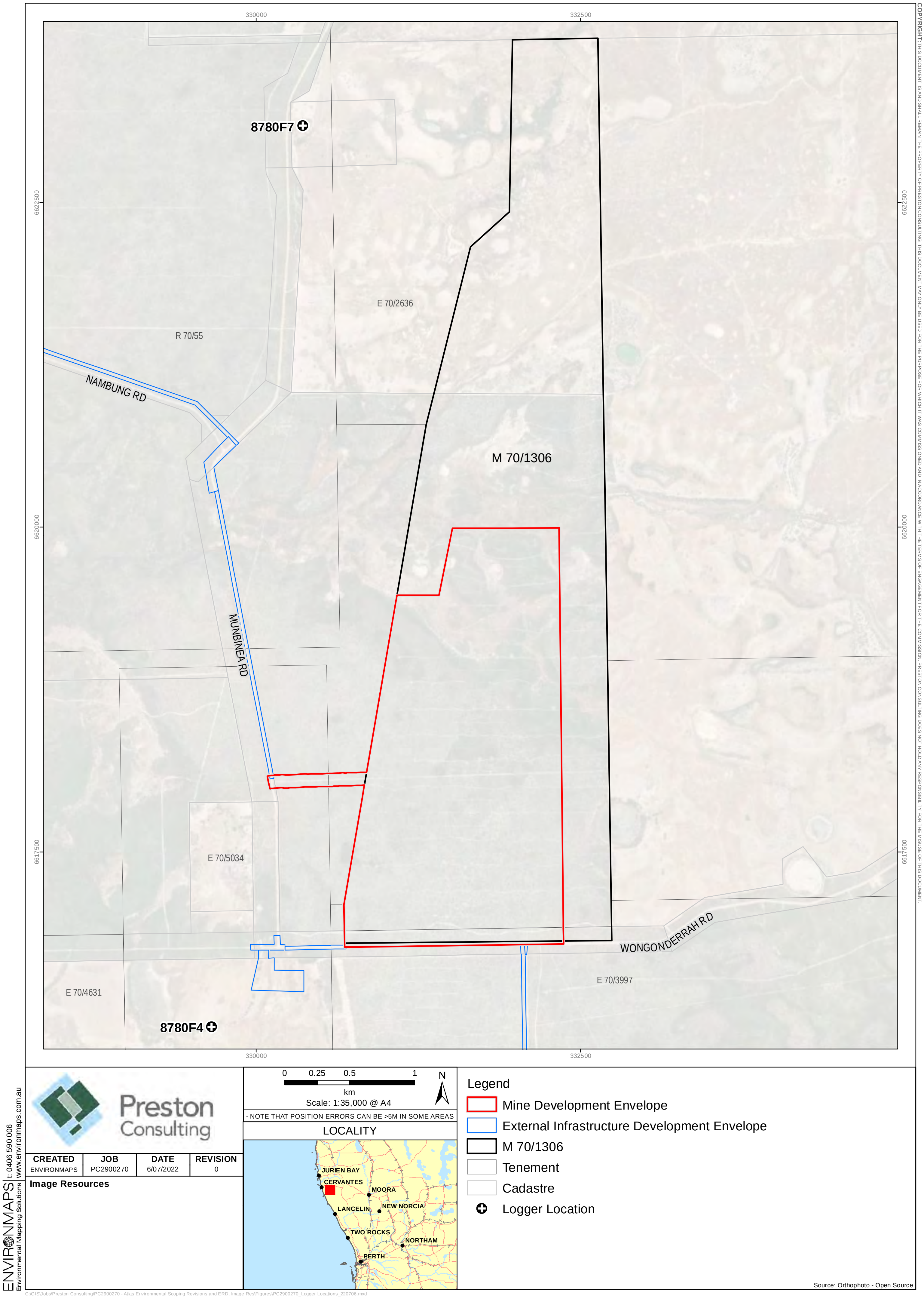


Figure 107: Noise Monitoring Locations at the Proposal

9.3.2 Aboriginal Heritage

Native Title rights and interests comprise either the exclusive right to possession, occupation, use and enjoyment of the relevant land or a set of non-exclusive rights which include, among others, the right to maintain and protect places of significance. The existence of a native title claim (NTC) is seen as sufficient to establish an Aboriginal person's 'right to speak' about heritage issues. The Yued 'Noongar' people are the TOs associated with the land that underlies the Proposal, holding a registered Native Title claim since 1997. 'Yued' refers to a Noongar language or dialectal group north of Perth, with the Yued NTC covering the City of Wanneroo, Shire of Chittering, Shire of Coorow, Shire of Dalwallinu, Shire of Dandaragan, Shire of Gingin, Shire of Goomalling, Shire of Moora, Shire of Toodyay, Shire of Victoria Plains and the Shire of Wongan-Ballidu.

Desktop Assessment

The desktop Assessment of Aboriginal Heritage Values and Traditional Uses completed by Horizon (2020) established that no significant sites or known registered Aboriginal heritage sites had been previously identified within the Development Envelopes. A number of sites and landscape features associated with significant mythological and heritage associations were however identified in the general locality.

Five Registered Aboriginal sites were identified between 15 – 25 km from the Proposal and eight DPLH Other Heritage Places were identified within Yued Country within reasonable proximity of the Proposal (up to 15 km), which demonstrated that important Aboriginal cultural places, features and materials are present in the area.

Identification Heritage Survey

Terra Rosa (2022) split the mine survey area into four Areas (A, B, C, & D; Figure 104) in which heritage surveys were undertaken. These areas included the entirety of the MDE as well as adjacent areas to the north and east. From these surveys, Areas of Cultural Concern (1-3) and Avoidance Areas (1-5) were identified by the Yued TOs and Terra Rosa (2022; Figure 104). The five avoidance areas identified by the Yued TOs are outlined in Figure 104, and include Avoidance Area 5 which is outside of the Mine Survey Area. Avoidance Areas 1 – 4 are individual Moojar (*Nuytsia floribunda*) trees that hold spiritual and cultural significance and are often recognised as potential burial sites.

No DPLH Registered Aboriginal sites, DPLH OHPs or Heritage Sites were identified during the survey. One isolated artefact was identified within Area A area and is discussed further below, alongside Areas of Cultural Concern identified by the Yued TOs.

Area of Cultural Concern 1 (Footprint)

An Area of Cultural Concern (Area of Cultural Concern 1) was identified within Area D area and comprises of a potential imprint of a human footprint. The footprint is believed, by the Yued TOs, to have been created by their Yued ancestors. Area of Cultural Concern 1 could not be recorded as a heritage site under Section 5 of the AH Act, but remains of significance to the Yued TOs. Area of Cultural Concern 1 is outside the MDE.

Area of Cultural Concern 2 (Ephemeral Lakes)

An Area of Cultural Concern was identified comprising *Kara Gabbi* and Y*ongah Gabbi,* two ephemeral lakes that are named after the fauna found in the respective locations. These two ephemeral lakes are said to be the main heritage features of a previously identified potential heritage site at Nambung Flats. Additional assessment was completed around the Nambung Flats potential heritage site and found not to meet the classification of an Aboriginal heritage site under Section 5 of the AH Act.

The Yued TOs outlined that the areas surrounding Area of Cultural Concern 2 are held of high value due to their unique and aesthetically pleasing characteristics. The Yued TOs explained Area of Cultural Concern 2 and surrounds were likely to have been traversed by Yued ancestors while travelling along waterways to meet neighbouring language groups, such as those from Amangu Country to the northeast. Area of Cultural Concern 2 is outside the MDE.

Area of Cultural Concern 3 (Stone Arrangement)

A Stone Arrangement was recorded by Terra Rosa (2022) and the Yued TOs. The site is located in Area A area and was subject to intensive pedestrian inspection, however, no surface artefacts were visible. Area of Cultural Concern 3 is deemed not to constitute a heritage site under Section 5 of the AH Act, nonetheless the area remains of significance to the Yued TOs. Area of Cultural Concern 3 is outside the MDE.

Bibby Creek and Mount Jetty Creek

The health of water places is of utmost importance to the Yued TOs who believe the *Waugal* (rainbow serpent recognised by Noongar as the giver of life) still reside within permanent water sources.

The water courses of Bibby Creek and Mount Jetty Creek also hold contemporary social, cultural, and aesthetic significance for the Yued TOs. During the survey, the Yued TOs recalled visiting these places for fishing and camping activities, and spoke about the importance of Bibby Creek as a permanent water source used historically by Yued people. The known use of local resources by the Yued TOs was made evident during the survey as they discovered turtle shell, prompting a Yued Elder to share his cultural knowledge of hunting and fishing. The Yued TOs expressed the need for these water courses to be protected from activities that may impact the ecological and cultural values of these places.

External Infrastructure Development Envelope

Two of the five potential production bore sites were visited by Terra Rosa (2022). Surveys found that within these areas, no DPLH Registered Aboriginal heritage sites, OHPs, isolated artefacts, Areas of Cultural Concern or Avoidance Areas were identified.

9.3.3 Traditional Uses

Yued Noongar people once lived on the land that underlies the Proposal, and feedback has been sought from Horizon (2020), in relation to traditional uses of the land for bush tucker or medicine within or adjacent to the Proposal. Although traditional bush tucker and medicine are not clearly legislated like other cultural values (e.g., engravings, ceremonial, mythological values), bush tucker and medicine is nevertheless an important connection to country and culture that still plays a part in the lives of many Yued Noongar people. Hunting and food (*merenj*) gathering activities is a way for contemporary Yued Noongar people to continue to share cultural knowledge and knowledge of country.

It is likely the entire Proposal area was utilised by past Yued Noongar people as a resource area for food and dietary sustenance. Yued Noongar people have traditionally hunted and gathered food based upon patterns of weather according to six seasons, which determine the abundance of fauna and flora resources available. Yued Noongar people know when it is the season for harvesting by signs in nature, and have always taken care to ensure the continued existence of animal and plant species. Vegetable foods collected and eaten by the Noongar included roots, bulbs, tubers, seeds, nuts, fruit and fungus. Other main sources of food most readily available to Yued Noongar people would have been mammals, birds and their eggs, most reptiles, frogs (*kooyar*), fish, turtle (*yarkan*), freshwater crayfish (*gilgi*e) and insects (e.g., larvae of beetles).

Low-lying swamp wetlands and watercourse areas present in the assessment area were the focus of Noongar hunting and gathering activities, even in drier times. Frogs, turtles, gilgie and water fowl could be sourced from freshwater waterways, swamps and pools. Nearby wetlands such as Cooljarloo Swamp, Coomado Swamp and Kooyar have been previously identified by Noongar people as cultural heritage sites, partly for their resource (food and water) availability. Other heritage places like Wongonderrah Camp and Muralang Pool Camp (outside the Development Envelopes) have also been previously identified which demonstrates that Yued Noongar in contemporary times choose to live on their traditional country.

The southern portion of the Survey Area remains in a predominantly natural native vegetation state with minimal disturbance, exhibiting features which could have been used for bush tucker and medicine. Within Banksia woodland areas Noongar people could find fruits or berries with ethnobotanical and cultural significance to Noongar people such as bush tomato, edible roots and leaves, flower nectar (Banksia, Dryandra, Hakea varieties), seeds and gum (Acacia varieties) and native honey (Eucalyptus). The WA Christmas tree (*Nuytsia floribunda*) commonly found in Banksia woodlands holds special significance to Noongar people and is known as *moojar* the Noongar spirit tree, with the spirits of dead ancestors resting in the branches. Flowering Banksia plants are a food source attracting birds, insects and small marsupials which could then be sourced by Noongar people, and are also used to determine seasonal outlooks with the onset of summer established by the early or late flowering. Other potential fauna food species that could be found in the Development Envelopes include wallabies, grey kangaroos, snakes (pythons), lizards (goanna and bobtail) and small marsupials (like the Quenda). It is likely many species of birds occur in the woodlands area with emus (*weitj*), bush turkey (Australia Bustard), cockatoos and parrots (refer to Section 6.3 for more information on the fauna assemblage at the Proposal).

The wood from Acacia could be used to make spears, boomerangs, fighting sticks and digging tools. Bark was used to construct watertight huts covered with thatches of grass trees to protect against the cold and wind. The gum from grass trees was used to haft hammers and the seeds of various trees and plants were harvested for flour to use in dampers. Sweet gum was collected from the cracks in the branches and trunks of Acacia for eating or to use as medicine for skin aliments and burns.

To deal with ailments, Noongar people regularly used a range of remedies, which included medicinal plants. As documented by Hansen (2016), Banksia flowers were drunk to relieve coughs and sore throats, or for a sweet refreshing drink. Pigface crushed leaves were used to treat diarrhoea, dysentery, and stomach cramps, and as a gargle to relieve sore throats and mild bacterial or fungal infections of the mouth. The juice of the leaves was used externally, much like aloe vera, as a salve. The Noongar people also ate the fruit as a food. Jam Wattle gum was eaten to treat diarrhoea and ease congestion, while the flowers were crushed and the vapours inhaled to relax the mind for a good night's sleep or made into weak infusions as a wash to aid healing. Eucalyptus leaves were used for to cure headaches by inhaling vapours from the crushed leaves, by rubbing the crushed leaves on the head and by sleeping in the smoke from a fire. Coughs and colds were relieved by inhaling the vapours from the crushed leaves of specific plants, especially eucalypts. Goanna and Emu fat were highly prized for the healing of painful joints while ailing health was treated by eating cooked bobtail (*yoorn*), goanna and echidna (*nyingarn*).

9.3.4 European Heritage and Cultural Values

No European Heritage sites are located within or in close proximity to the Proposal. Sites within the region include Frederick Smith Creek and Nambung Station.

Frederick Smith Creek is the longest tributary of the Nambung River, named after 'Frederick Smith' who was the first white man to die in Lancelin. He was involved with explorer George Gray on his expedition along the WA coast. Frederick Smith fell ill from exhaustion during the final days of the expedition and died in 1839 (DCLM, 1998).

Nambung Station is of European Heritage value due to the Fredrick Smith Well located within the Station, along with Frederick Smith Creek that runs through the Station. Frederick Smith Well was named after the aforementioned Fredrick Smith and is a water hole that was used for watering the stock passing along the Old Northern Stock Route (Nambung Station, n.d.).

9.3.5 Recreational Uses

The following factors were used to determine the potential recreational uses of the Development Envelope and surrounds:

- Availability of public access;
- Evidence of public access; and
- Evidence of public camping or bushwalking.

There is very little evidence of the MDE being used for public recreation. The MDE lacks features that would be sought after for recreational use such as walking / biking trails or campsites. A lack of aesthetic geological features further contributes to little public recreational use.

9.3.6 Local Residents and Community

Five residences (#2269 Wongonderrah Road, #3121 Munbinea Road, Avery Homestead, Farmhouse N, Farmhouse S.) are within 5 km of the Proposal (Table 53; Figure 106). All residences are primarily working farm properties. #2269 Wongonderrah Road has been purchased by Image and the remaining properties are privately owned.

Table 53: Approximate Distance of Local Residences to Proposal

Local Residence	Approximate Distance to Mine Pit (km)	Approximate Distance to Process Plant (km)
#2269 Wongonderrah Road	1.9	2.6
#3121 Munbinea Road	3.5	4.4
Avery Homestead	1.2	1.7
Farmhouse N	1.3	1.1
Farmhouse S	1.4	1.4

9.3.7 Background Noise Survey

Noise data logged at 30-minute intervals over the duration of the survey at the North and South locations for L_{A90}, L_{A10} and L_{Amax} noise levels are shown graphically on Figure 108 and Figure 109. Averaged wind speed recorded at BOM's Lancelin (Defence) station (Site ID: 009280) are included as a reference point. Data from the north location is limited to 3.5 days due to a logger malfunction.

Assuming the Proposal will operate 24 hours a day, 7 days a week, the focus of the data analysis was on the night-time period (10:00 pm – 07:00 am).

North Logger

From the time history data on Figure 108, the noise levels recorded generally follow a day-night pattern, whereby night-time noise levels are lower than during the day. At night-time, background noise levels did not drop below 30 dB L_{A90} during the recording period. This is somewhat unexpected given the rural setting of the monitoring location. Analysis of the audio files between midnight and 4:00 am only identified recordings of intermittent wildlife. The lowest L_{A90} level recorded at the north logger was 30.7 dB, recorded on two separate nights between 3:00 am and 4:45 am. During the recording period noise levels increased rapidly each day from 6:00 am (38 - 61 dB L_{A10}). The L_{A10} levels were mostly affected by local sources such as wildlife and resident's noise. Local wildlife noise occurring near the logger microphone also influenced L_{Amax} levels.

South Logger

From the time history data on Figure 109, the noise levels recorded follow a similar day-night pattern, whereby night-time noise levels are lower than during the day.

At this location, night-time background noise levels averaged 20 dB L_{A90} with outlying events (30 - 40 dB L_{A90}) associated with bird calls and wind gusts occurring over three separate nights. The south logger recorded the lowest L_{A90} level of 19 dB between 2:00 - 4:30 am on a single night. This level coincides with the noise floor of the instrument (i.e. lowest noise level measurable). Similar to the north location, noise levels increased rapidly from 6:00 am due to wildlife noises and other local noises associated with the Nambung Station Stay. The L_{A10} noise levels ranged between 36 - 71 dB L_{A10} over the recording period. The L_{A10} levels were also mostly affected by local noise sources such as wildlife, caravan park management activities and wind noise.

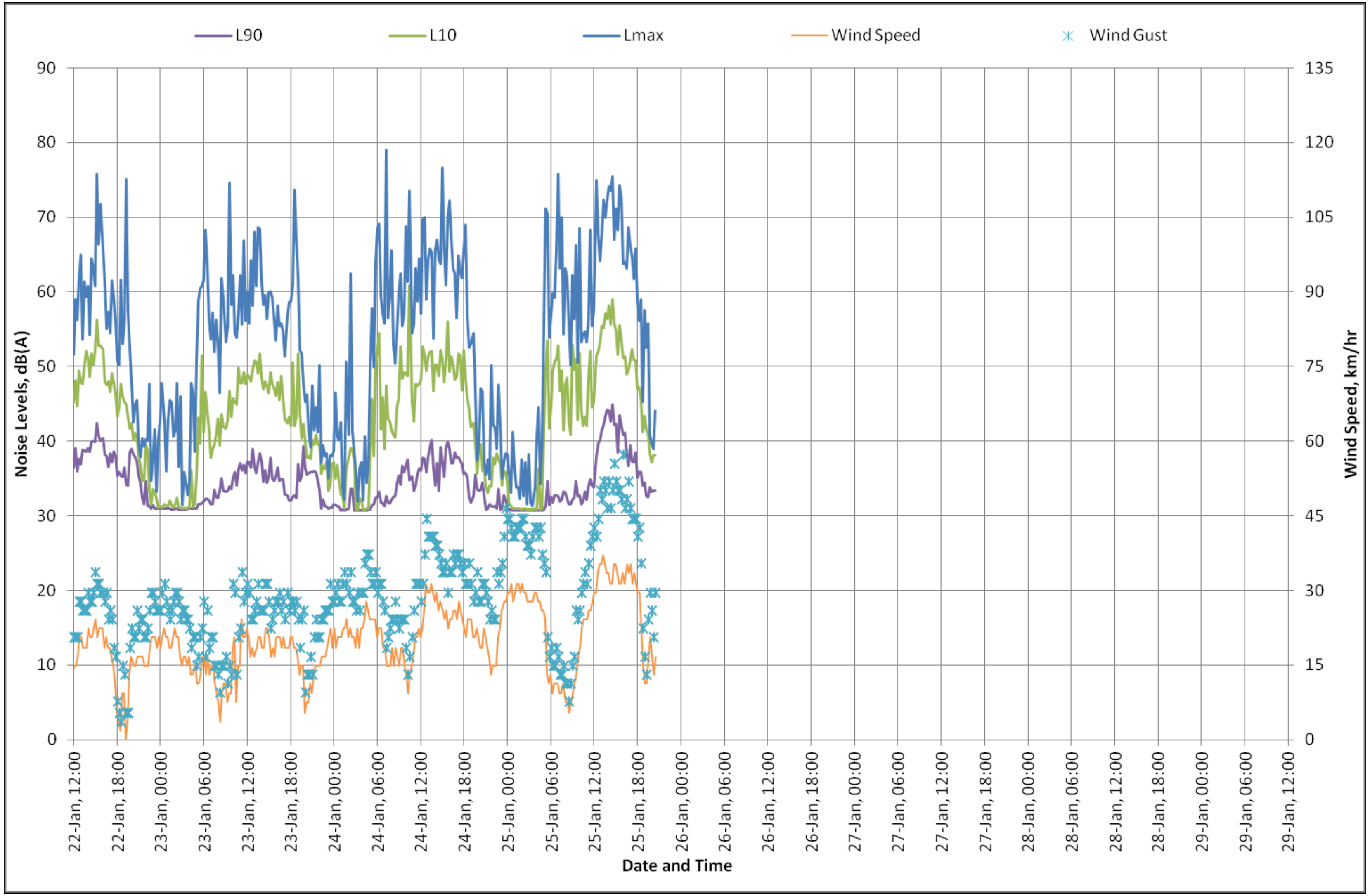


Figure 108: Background Noise Levels at the North Location (8780F7)

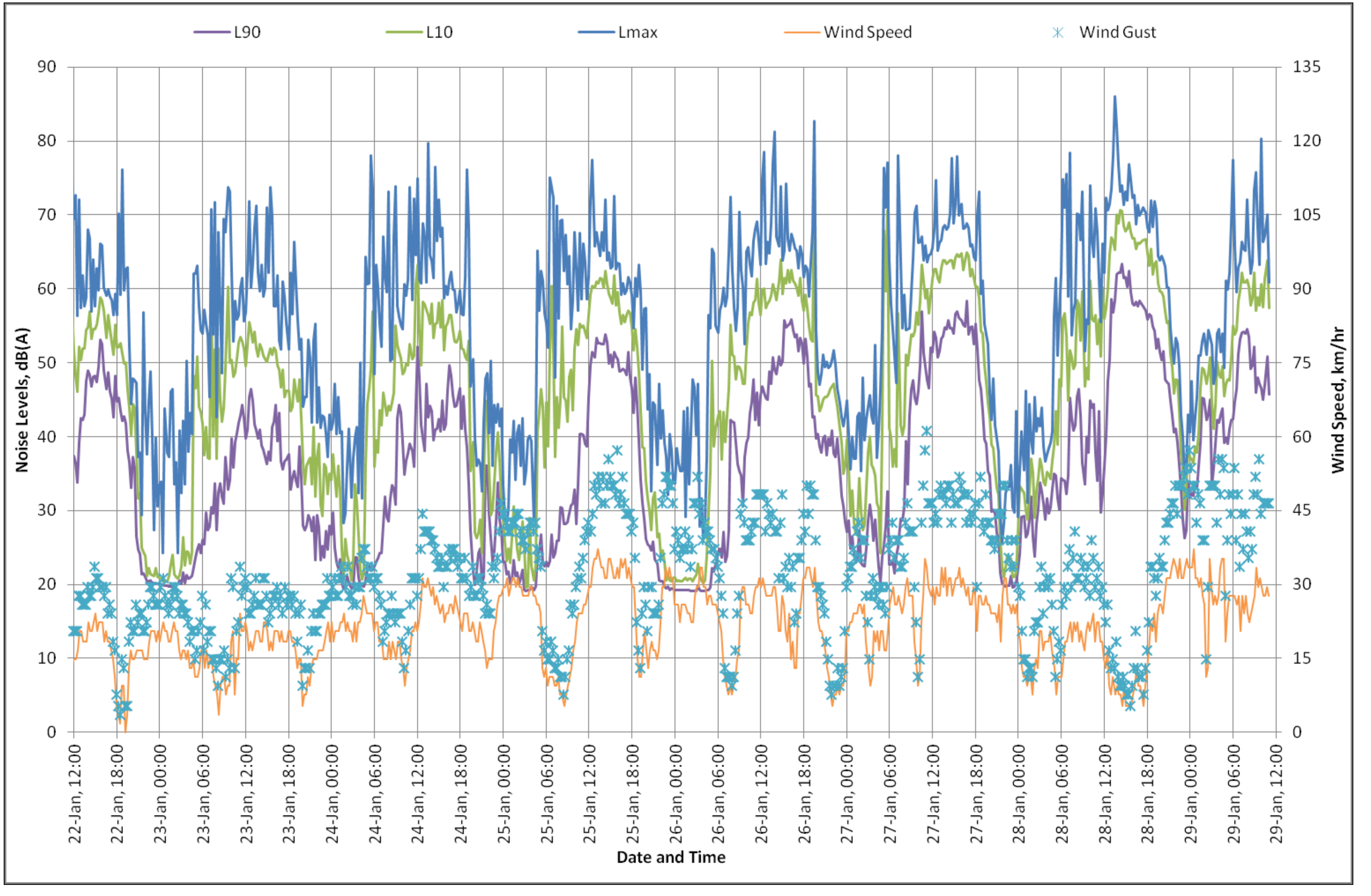


Figure 109: Background Noise Levels at the South Location (8780F4)

9.3.8 Social Values

From the information provided above, the following social values were determined to require assessment for this factor:

- Areas of Aboriginal cultural and heritage significance;
- Land used for traditional purposes; and
- Local residents and community.

9.4 Potential Impacts

Table 54 defines the potential impacts (direct, indirect and cumulative) on the social values for this factor in a local and regional context. These impacts are informed by the results of studies described in Section 9.3.

Table 54: Potential impacts on social surroundings

Social value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
Areas of Aboriginal cultural and heritage significance 3 areas of cultural concern and 4 avoidance areas were recorded during surveys. Bibby Creek and Mount Jetty Creek were noted to hold contemporary social, cultural, and aesthetic significance for the TOs.	No direct impact to areas of cultural concern, Bibby Creek or Mount Jetty Creek. Disturbance of up to 4 avoidance areas	Amenity impacts (dust and noise) to 2 areas of cultural concern and 1 avoidance area, located close to the Proposal. Altered access to land. Altered hydrology	No other proposals are currently known to be impacting any of the areas of cultural concern or avoidance areas. The surrounding area however has been heavily impacted by agriculture.	Disturbance of up to 4 avoidance areas and, in addition to losses incurred during clearing for agriculture. Potential indirect impacts to 2 areas of cultural concern, 1 avoidance area and Bibby and Mount Jetty Creeks
Land use for traditional purposes Bush tucker and bush medicine species are known to occur in and around the Proposal.	Clearing of up to 292 ha of native vegetation within the MDE and 26 ha in the EIDE.	Amenity impacts (dust and noise), weeds and dieback. Altered access to land.	No other proposals are impacting land used for traditional purposes within close proximity to the Proposal. The surrounding area however has been heavily impacted by agriculture.	Clearing of up to 318 ha and potential indirect impacts in addition to losses incurred during clearing for agriculture.
Local Residents and Community 5 sensitive receptors (residences) have been identified as residing within Proximity to the Proposal. The Proposal lies in proximity to Nambung National Park.	Noise and dust emissions from construction and operation.	Reduction in visual amenity. Increased traffic movements. Light emissions	Local residents and community are not currently impacted by noise or dust emissions or other amenity impacts from other proposals.	Noise and dust emissions from construction and operation. Reduction in visual amenity. Increased traffic movements. Light emissions.

9.5 Assessment of Impacts

9.5.1 Aboriginal Heritage

Field surveys conducted by Terra Rosa (2022) identified one isolated artefact which was brought to the attention of Image Resources, along with areas of cultural concern and avoidance areas.

Direct Disturbance

The Proposal has been designed to avoid Bibby Creek, Mount Jetty Creek and areas of cultural concern (all are located outside the DEs; Figure 104) and as such these areas will not be disturbed by the Proposal. Image Resources has reviewed the location of the avoidance areas; which are Moojar (*Nuytsia floribunda*) trees that hold spiritual and cultural significance and are often recognised as potential burial sites. One of the avoidance areas was able to excluded from the MDE. The MDE however contains the remaining four 'avoidance areas', and these cannot be avoided as they lie within the boundary of the mine pit. The heritage report noted that "in a situation where a Moojar tree cannot be avoided during the course of Image Resources' proposed works, Yued TOs must be present to collect the seeds from the tree and monitor any disturbance, including sub-surface disturbance, that may occur through the removal of the tree." (Terra Rosa, 2022). Image Resources intends to continue consultation with the Yued People in relation to these trees.

Amenity (Dust and Noise)

The Proposal will result in dust and noise emissions for several years during the construction, operational and rehabilitation phase. These emissions may result in a decrease in amenity for TOs when visiting the areas of cultural concern, avoidance areas, Bibby Creek or Mount Jetty Creek. The level of emissions will vary depending on the location of the mine pit at that point in time but noise from the Proposal will generally be detectable at least at the closer locations. Further details on predicted dust and noise emissions are provided in Section 9.5.3.

Land Access

The Proposal has been designed to avoid Bibby Creek, Mount Jetty Creek and areas of cultural concern and one Moojar (*Nuytsia floribunda*) avoidance area (all are located outside the DEs; Figure 104). None of these areas will be blocked by the Proposal therefore access will not be restricted.

Changes to Hydrological Regimes

Both Bibby Creek and Mount Jetty Creek have the potential to be indirectly impacted by the Proposal through changes to hydrological regimes. The Proposal however was redesigned to avoid any disturbance or diversions of drainage lines and therefore the potential impacts on Bibby Creek and Mount Jetty Creek are negligible. Further information is provided in Section 7.5. With the implementation of mitigation measures and controls described in Section 7.6, the Proposal is not expected to result in any significant hydrological impacts to Bibby Creek and Mount Jetty Creek.

9.5.2 Land Used for Traditional Purposes

Direct Disturbance

The Proposal will result in the clearing and progressive rehabilitation of up to 292 ha of native vegetation within the MDE and 26 ha of native vegetation within the EIDE. It is likely these areas were used by past Yued Noongar people as a resource area for food and dietary sustenance and is currently available for bush tucker or medicine. Rehabilitation will reinstate many of the values (and bush tucker and medicine species can be included in the seed mix) however it will take some time before values are close to pre-mining levels.

The loss of native vegetation is in addition to the extensive loss of vegetation due to agriculture, particularly to the east of the Proposal.

At a regional scale, the disturbance for the Proposal will occur entirely within vegetation association 1030, which retains 64.0% of the pre-European extent (88,950 ha of 139,013 ha). The Proposal will disturb 0.36% of the remaining vegetation association, or 0.23% of the pre-European extent. This minor reduction is unlikely to significantly reduce the availability of similar land available for traditional uses in the region.

Amenity (Dust and Noise)

The Proposal will result in dust and noise emissions for several years during the construction, operational and rehabilitation phase. These emissions may result in a decrease in amenity for TOs when utilising the surrounding land for traditional uses. The level of emissions will vary depending on the location of the mine pit at that point in time but noise from the Proposal will generally be detectable around the DEs. Further details on predicted dust and noise emissions are provided in Section 9.5.3.

Weeds and Dieback

As detailed in Section 5.5, the Proposal may introduce or spread weeds and / or dieback which may affect the quality of vegetated land used for traditional uses. Mitigation measures are proposed in Section 5.6 to address these risks and ensure the quality of land used for traditional uses is not impacted.

Land Access

The development envelopes are located within the Yued Indigenous ILUA. The Proposal will include some restrictions to parts of land within the development envelopes that would otherwise be available for traditional purposes. Areas within the development envelopes that are being actively mined or are under rehabilitation will not be accessible by the public however, exceptions will be made for Traditional Owners where safe to do so. Image has committed to maintaining and improving Traditional Owners' access to land for traditional purposes wherever possible and safe to do so.

The Proposal is therefore unlikely to significantly restrict access to land for traditional purposes.

9.5.3 Local Residents and Community

Potential impacts to amenity for local residents and the community include noise and dust emissions from construction and operation, alterations to land access and visual impacts. The Proposal is located 1.2 km away from the nearest sensitive receptor and approximately 13 km away from the closest major road (Indian Ocean Drive; west of the Proposal).

Sensitive Receptors

EPA Guidance Statement No. 3 (EPA, 2005) provides advice on the use of generic separation distances (buffers) between industrial and sensitive land uses to avoid conflicts between incompatible land uses. The generic separation distances are a tool to assist in the determination of suitable distances between industry and sensitive land uses where industry may have the potential to affect the amenity of a sensitive land use. Where the separation between the industrial and sensitive land uses is greater than the generic distance, there will not usually be a need to conduct site-specific technical analyses to determine the likely area of amenity impacts due to emissions from the industry. These generic separation distances are also referenced in the Guideline for Dust Emission, released as a draft for external consultation by DWER in July 2021 (DWER, 2021b).

The EPA (2005) definition for sensitive land use – land use sensitive to emissions from industry and infrastructure, residential development, hospitals, hotels, motels, motels, hostels, caravan parks, schools, nursing homes, childcare facilities, shopping centres, playgrounds and some public buildings. Some commercial, institutional and industrial land uses which require high levels of amenity or are sensitive to particular emissions may also be considered "sensitive land uses."

Under the separation distances guidance (EPA, 2005), the Proposal is best described as an 'Extractive Industry – sand and limestone extraction', involving no grinding or milling works. The corresponding generic buffer distance that is recommended is 300 - 500 m, depending on size. All sensitive receptors are located more than 1.2 km away from the Proposal

The location of sensitive land uses (sensitive receptors) in the area is presented in Figure 106. Note that Receptor R1 is now owned by Image Resources and is no longer considered a receptor for this assessment.

Nambung National Park

The Proposal lies approximately 1 km beyond the eastern edge of the Nambung National Park, and approximately 10 km north-east of the Pinnacles Visitors Centre. Visitors to the Pinnacles and the broader Nambung National Park would also be considered receptors.

Noise

Implementation of the Proposal is expected to result in the emissions of noise. Key Proposal activities with the potential to emit noise include:

- Extraction operations;
- Fixed plant (Feed Preparation Plant (FPP) and Wet Concentrator Plant (WCP));
- Overburden removal; and
- Vehicle movements (Haul Trucks).

Environmental Noise Assessment

Lloyd George Acoustics Pty Ltd (LGA) were engaged to undertake an environmental noise assessment (LGA, 2022; Appendix 29) to model and assess the noise emissions from Proposal.

Computer modelling has been used to predict noise levels at each nearby receiver. LGA's model includes the influence of wind and atmospheric stability. Input data required in the model includes meteorological information, topographical data, ground absorption and source sound power levels.

Meteorological Information

Baseline meteorological information to inform the assessment was selected to represent worst-case conditions for noise propagation, as presented in Table 55. At wind speeds greater than that outlined below, sound propagation may be further enhanced, however background noise from the wind itself and from local vegetation is likely to be elevated and dominate the ambient noise levels.

It is generally considered that compliance with the assigned noise levels needs to be demonstrated for 98% of the time, during both day and night periods, for the month of the year in which the worst-case weather conditions prevail.

Table 55: Modelling meteorological conditions

Parameter	Night period (1900 – 0700)	Day period (0700 – 1900)
Temperature (°C)	15	20
Humidity (%)	50	50
Wind Speed (m/s)	3	4
Wind Direction*	All	All
Pasquil Stability Factor	F	E

*Note that the modelling package used allows for all wind directions to be modelled simultaneously.

Topographical Data

Topographical data was based on that publicly available from *Google* in the form of spot heights, noting the topography is relatively flat between sources and receivers. The topography was then manually adjusted where warranted for the various stages of pit development.

Ground Absorption

Ground absorption varies from a value of 0 to 1, with 0 being for an acoustically reflective ground (e.g., water or bitumen) and 1 for acoustically absorbent ground (e.g., grass). In this instance, a value of 0.6 has been used as an average across the Survey Area, for example; wet sandy soil as would occur in winter times.

Source Sound Levels

The sound power levels used in the modelling are provided in Table 3-2 of LGA (2022; Appendix 29). Noise data of operational activities was gathered from LGA's library for similar projects, except for the FPP, WCP and haul trucks. Image supplied haul truck noise data, in addition to noise data for the FPP and WCP, which are based on measurements of equivalent infrastructure at Image's Boonanarring Project. Further assumptions include:

- Source levels represent L_{10} noise level;
- The WCP was modelled as a point source located 5 m above ground level;
- Gensets were positioned near the WCP area, source heights at 2 m above ground level;
- The FPP was modelled as a point source located 3 m above ground level;
- The Gensets, FPP and WCP are generally grouped as "fixed plant" in the noise results; and
- Mobile plant sources were modelled as point sources 2 m above local ground level with the exception of the HMC and haul trucks which were modelled at 3 m.

Description of Day and Night Operations

The Proposal will operate continuously (24 hours a day), however operations will be limited at night to comply with safety requirements. Overburden removal is planned during the day only, as this activity is better performed with daylight as it utilises heavy earthmoving machinery. At night, site operations will generally be limited to the extraction and processing of the ore. To account for these differences, separate day and night noise impact scenarios have been modelled for each general pit extraction area (south, middle and north; Figure 110). Noise emissions have been modelled to represent the worst-case scenario in each of these extraction areas by modelling noise emissions from the pit topography at the initial mining depth (top of the ore layer).

Day Period Operations

It is expected that several operations will occur simultaneously. For instance, at the start of the pit development, only overburden operations are anticipated. Once overburden at the start of the pit has been removed full production can start within the pit, while overburden removal is still occurring in the adjacent areas. It is also understood that overburden will be used as backfill for the pits which may occur concurrently with production and extraction. Minor intermittent operations are expected to occur during the day period, such as pipeline positioning, vegetation clearing and odd jobs using smaller mobile plant (loader and excavator) for short periods. For the purposes of studying long-term noise impacts, these have been excluded.

To represent the conservative scenario noise levels over time, ore mining and overburden have been modelled as occurring simultaneously during the day period.

All mobile plant were assumed to operate at existing ground level or 'top of ore' level as a worst-case scenario. Haul trucks were taken to travel from the excavation area to the soil stockpiles and to the FPP stockpile area.

Table 56 presents the predicted sources of noise at each receptor (including R1 which is now owned by Image Resources) and overall levels for each pit stage (Figure 110). Figure 111 - Figure 113 depicts the predicted overall and haul truck noise levels as a contour map for each stage.

Table 56: Pit Area- day period (0700 – 1900) operations noise levels (dB L_{A10})

Receiver	Extraction Operations	Fixed Plant	Overburden Removal	Haul Trucks	Overall
South Area					
R1	31	25	28	39	**40**
R2	12	17	13	19	**21**
R3	34	31	35	41	**43**
R4	34	35	33	43	**45**
R5	35	33	33	43	**44**
Middle Area					
R1	25	25	23	35	**36**
R2	17	17	17	27	**27**
R3	31	31	35	42	**44**
R4	31	35	30	42	**44**
R5	31	33	29	42	**43**
North Area					
R1	19	25	19	31	**33**
R2	22	17	21	31	**32**
R3	30	31	30	40	**41**
R4	26	35	27	39	**41**
R5	25	34	25	28	**40**

The most significant noise source is the Fixed Plant, contributing up to 35 dB L_{A10} to all scenarios. Operations in the South and Middle Areas will result in the highest noise levels at all receptors except R2.

Noise from mining operations across all pit areas will comply with day period assigned noise levels from Regulation 8 of the Noise Regulations.

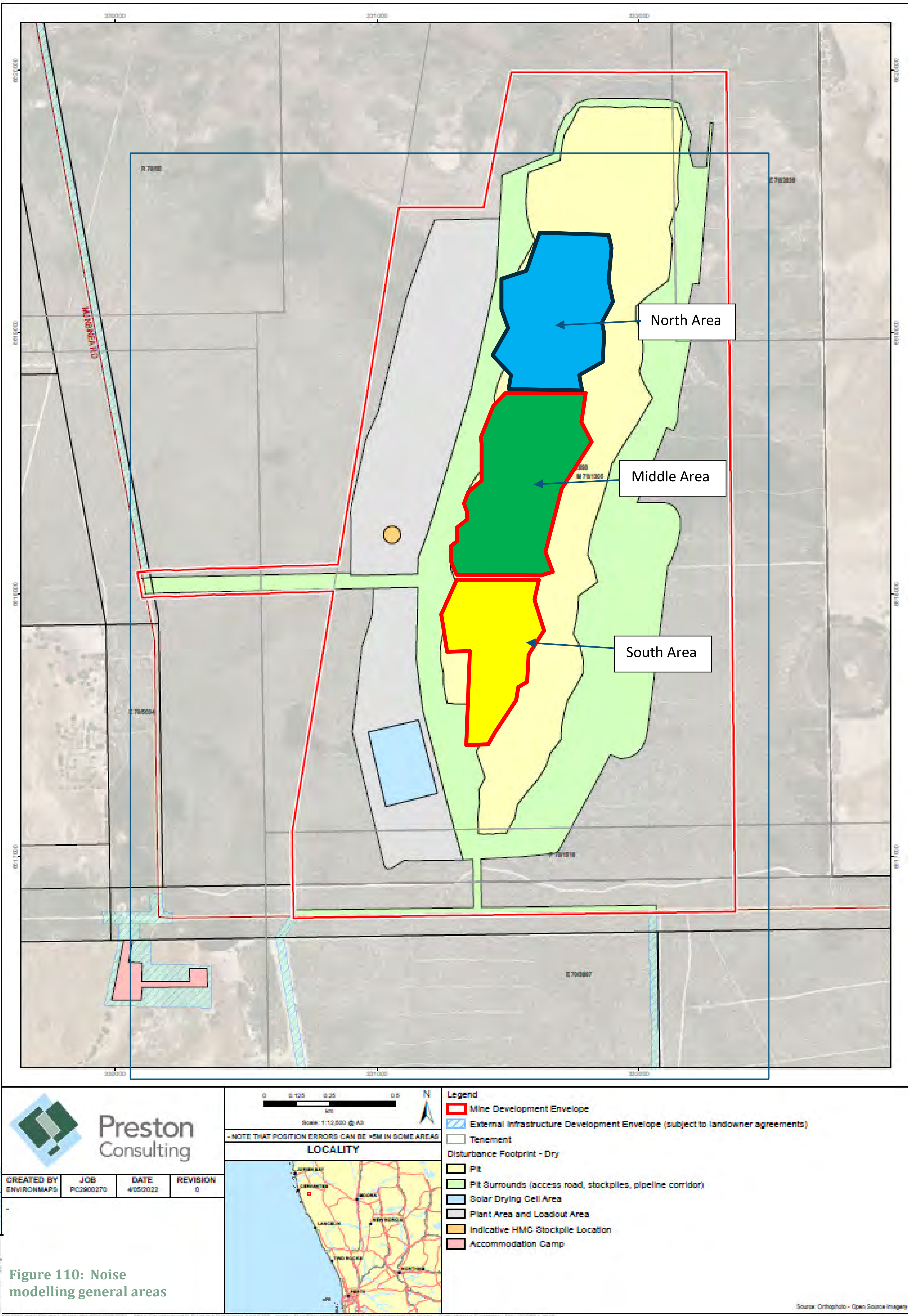


Figure 110: Noise modelling general areas

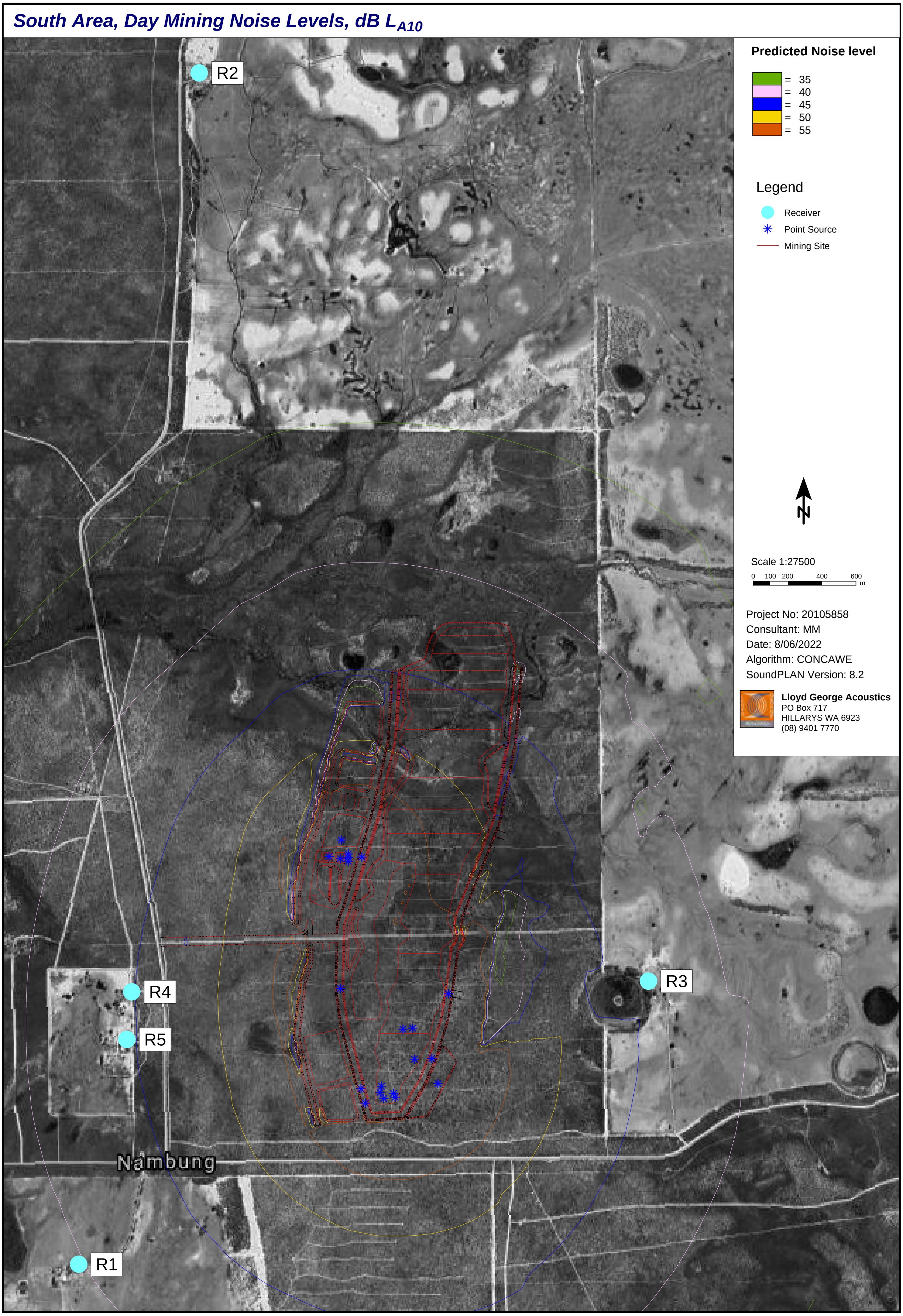


Figure 111: South area – day period operations noise levels (dB LA10)

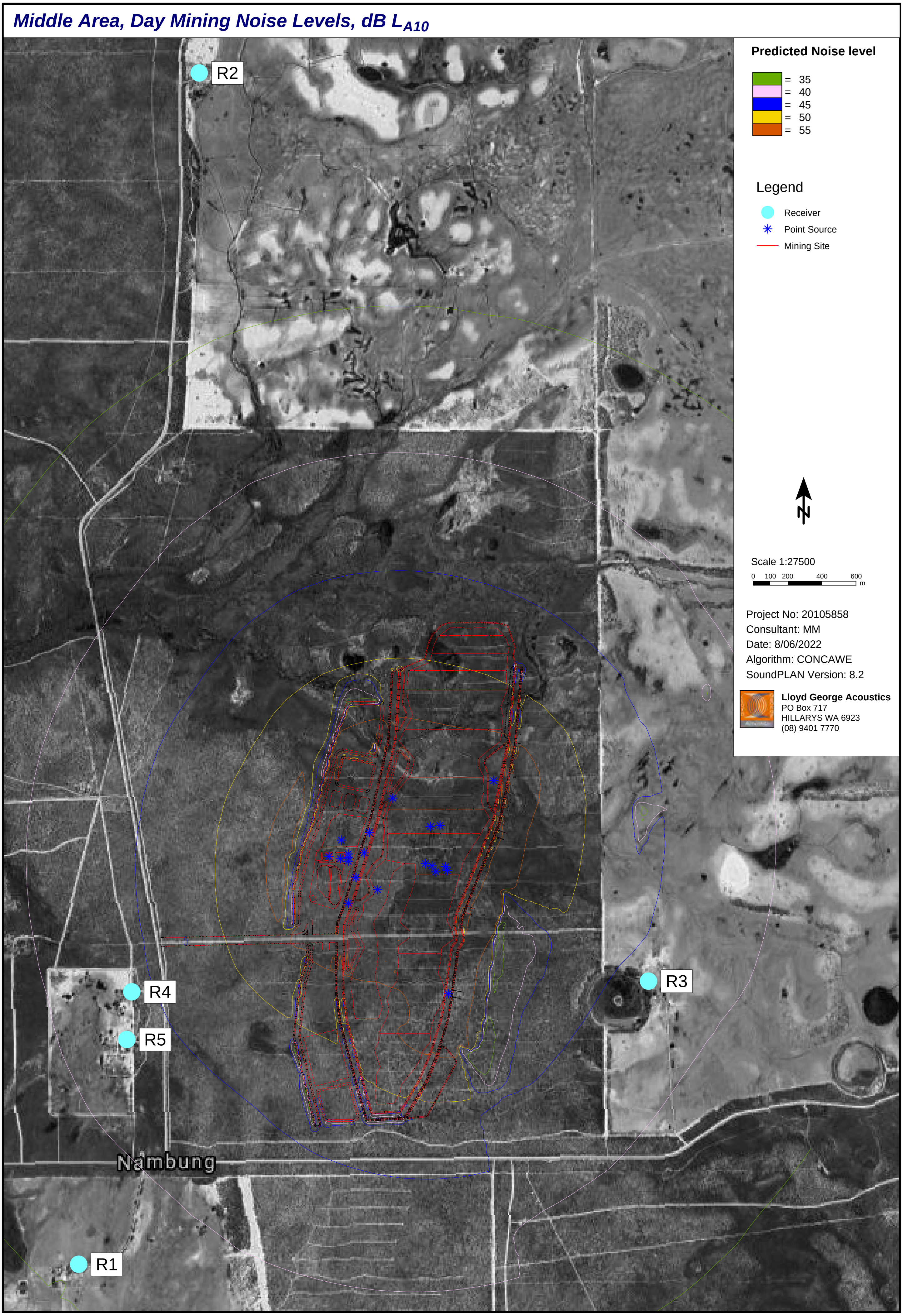


Figure 112: Middle area – day period operations noise levels (dB LA10)

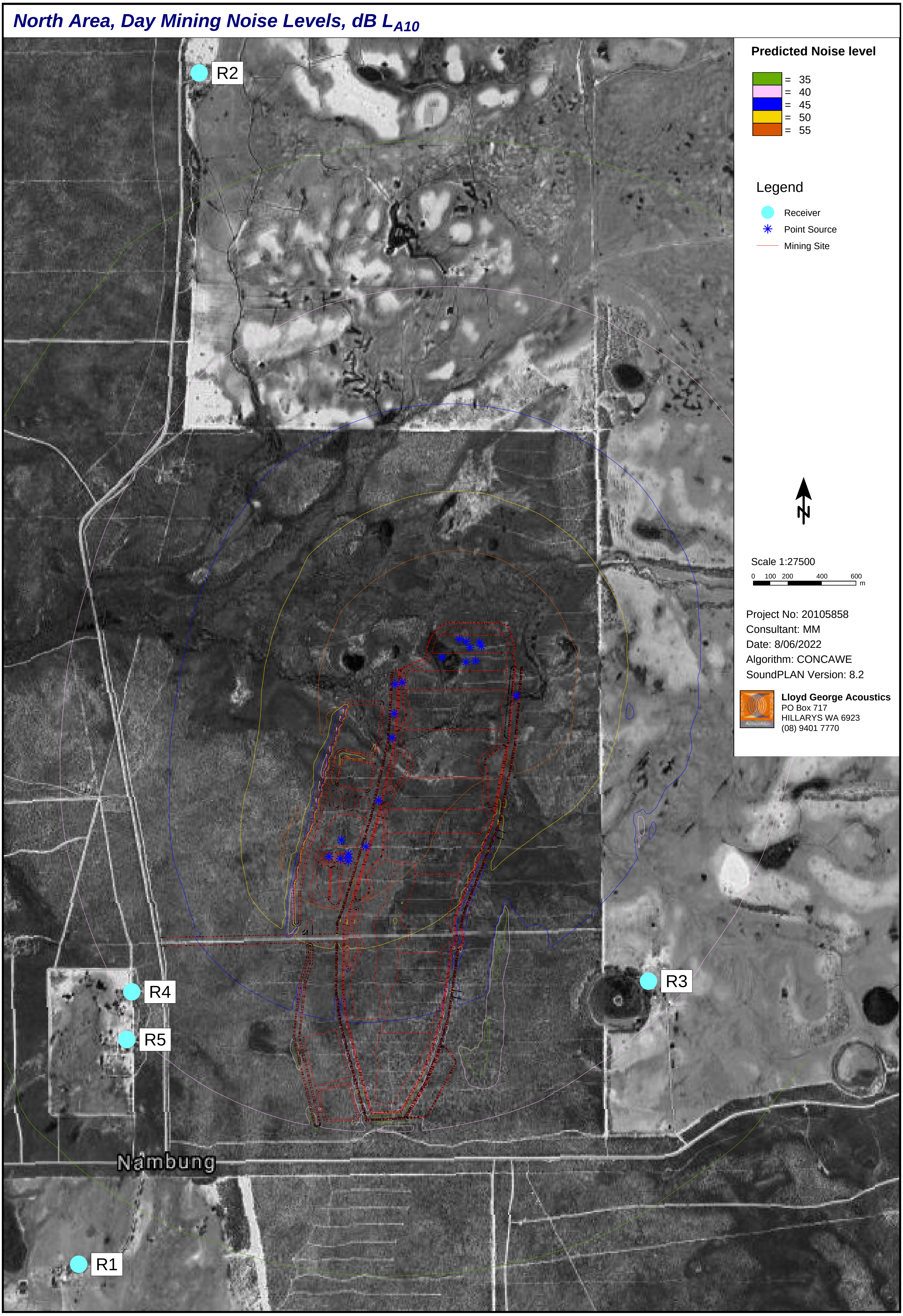


Figure 113: North area – day period operations noise levels (dB LA10)

Night Period Operations

Night period operations differ from day period operations in that they do not include overburden removal / backfilling work. As per the day period operations, mobile plant were assumed to operate at existing ground level and "top of ore" level as a worst-case scenario. Haul trucks were taken to travel the same path and in the same volumes as during the day period, as a conservative estimate.

Table 57 presents the predicted overall and haul truck noise levels for each pit stage (Figure 110). Figure 114 - Figure 116 depict the predicted overall noise levels as a contour map for each stage.

Table 57: Pit Area - Night period (1900 - 0700) Operations Noise Levels (dB L_{A10})

Receiver	Extraction Operations	Fixed Plant	Haul Trucks	Overall
South Area				
R1	31	25	37	**33**
R2	12	17	24	**22**
R3	34	31	41	**42**
R4	34	35	43	**44**
R5	35	34	43	**44**
Middle Area				
R1	25	25	35	**36**
R2	17	17	26	**27**
R3	31	31	42	**43**
R4	32	35	43	**44**
R5	31	34	42	**43**
North Area				
R1	19	25	34	**35**
R2	22	17	31	**31**
R3	30	31	40	**41**
R4	26	35	42	**43**
R5	25	34	41	**42**

From the results in Table 57, it can be seen the overall noise levels are generally dominated by the haul trucks on the surface at all the receivers. It is noted that this is the same level as for the day period, as the trucks are conservatively assumed to move the same material at all times. With the exception of receptor R2 the north area pit stage is predicted to be of lesser noise impact compared to other stages. This is likely due to distance between R3 - R5 and the truck haulage paths.

The results in Table 57 demonstrated that additional noise mitigation was required for evening and night time operations in order to comply with the Noise Regulation limits of 40 and 35 dB L_{A10} respectively. This mitigation is as per the recommendations in LGA (2022):

- Haul trucks will only be used if they have a sound power level no greater than 108 dB(A). This could be achieved with haul trucks fitted with noise controls such as 'HushPaks' and would result in noise levels in the order of 9 dB less at the most exposed receivers. This would result in compliance with Evening and Sunday time periods; and

- Where night-time running is required (10 pm to 7 am) haul truck movements will be altered and reduced. This could be achieved by additional stockpiling during the day such that the FPP can be loaded continuously with ore without the need for haul trucks to deliver direct from the pit. Truck paths will also be assessed in greater detail when known in future (e.g., using a time history method as used for the HMC Trucks) to determine a maximum night time fleet size.

HMC Trucks

As ore is processed, up to three HMC Trucks visit the site daily to cart it off site. An access road of approximately 750 m length is proposed to connect the mine site to public roads. This will be an unsealed road, with a speed limit of 60 km/h. As the empty trucks enter the site compound, a 25 km/h speed limit is assumed, where upon the trucks are loaded with processed ore and then leave via the same road and onto Munbinea Road.

A study of noise impacts of these trucks has been completed, using a time-history method which allows for a moving source at known speeds. From this analysis, noise levels can be determined at the nearest receivers, in this case R4 and R5, for the L_{max}, L_1 and L_{10} parameters in a 4-hour representative assessment period. Table 4-7 of LGA (2022) outlines the results of this analysis, assuming all trucks arrive in succession, taking four minutes to traverse the road and park on site, ten minutes to load, and four minutes to return to the public road.

Table 58 provides an example time history chart of the noise levels as received at R4 being the closest to the access road entry. Figure 117 shows a contour noise plot (non-cumulative) of the truck source following a path to site (to be used for illustrative purposes only).

Table 58: Assessment of HMC truck haulage noise levels, L_{A1} dB

Receiver	Truck Moving, L_{A1}	Day Assigned Noise Level	Evening Assigned Noise Level	Night Assigned Noise Level
R1	23	55	50	45
R2	9	55	50	45
R3	24	55	50	45
R4	43	55	50	45
R5	38	55	50	45

Above results for HMC Truck haulage shows compliance at all times with the Noise Regulations. HMC Truck noise emissions are not considered tonal due to the range in RPMs and as an L_1 the 8 dB rule applies.

Summary

The noise modelling demonstrates that compliance with the Noise Regulations can be achieved provided noise mitigation is implemented at the Proposal. Noise mitigation is committed to in Section 9.6 and is expected to form part of the Works Approval and Licence conditions under Part V of the EP Act.

It is noted that the Noise Regulations focus on nuisance noise rather than whether the noise is detectable. The area surrounding the Proposal is rural and while noise levels are often elevated from wind and fauna, there will be periods where the Proposal will be able to be heard from receptor locations, for example outside on still nights, including potentially at the very eastern edge of Nambung National Park. Image Resources has committed to continued discussions with the landholders regarding this impact and will work with them to minimise the amenity impacts associated with noise emissions as much as practicable.

No noise from the Proposal is expected to be detectable at the Pinnacles or any other areas heavily utilised by visitors within Nambung National Park.

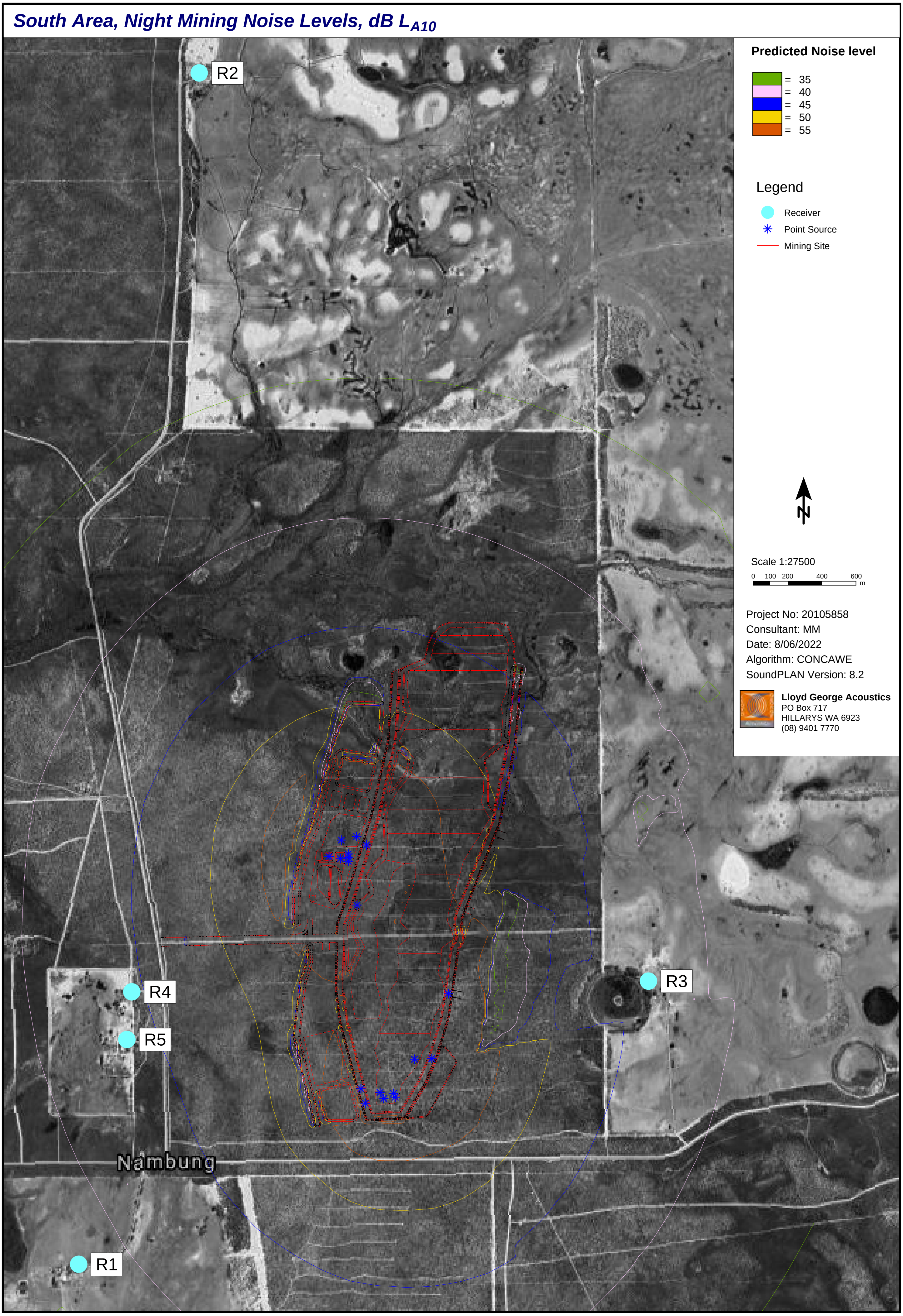


Figure 114: South Area – Night period Operations Noise Levels (dB LA10)

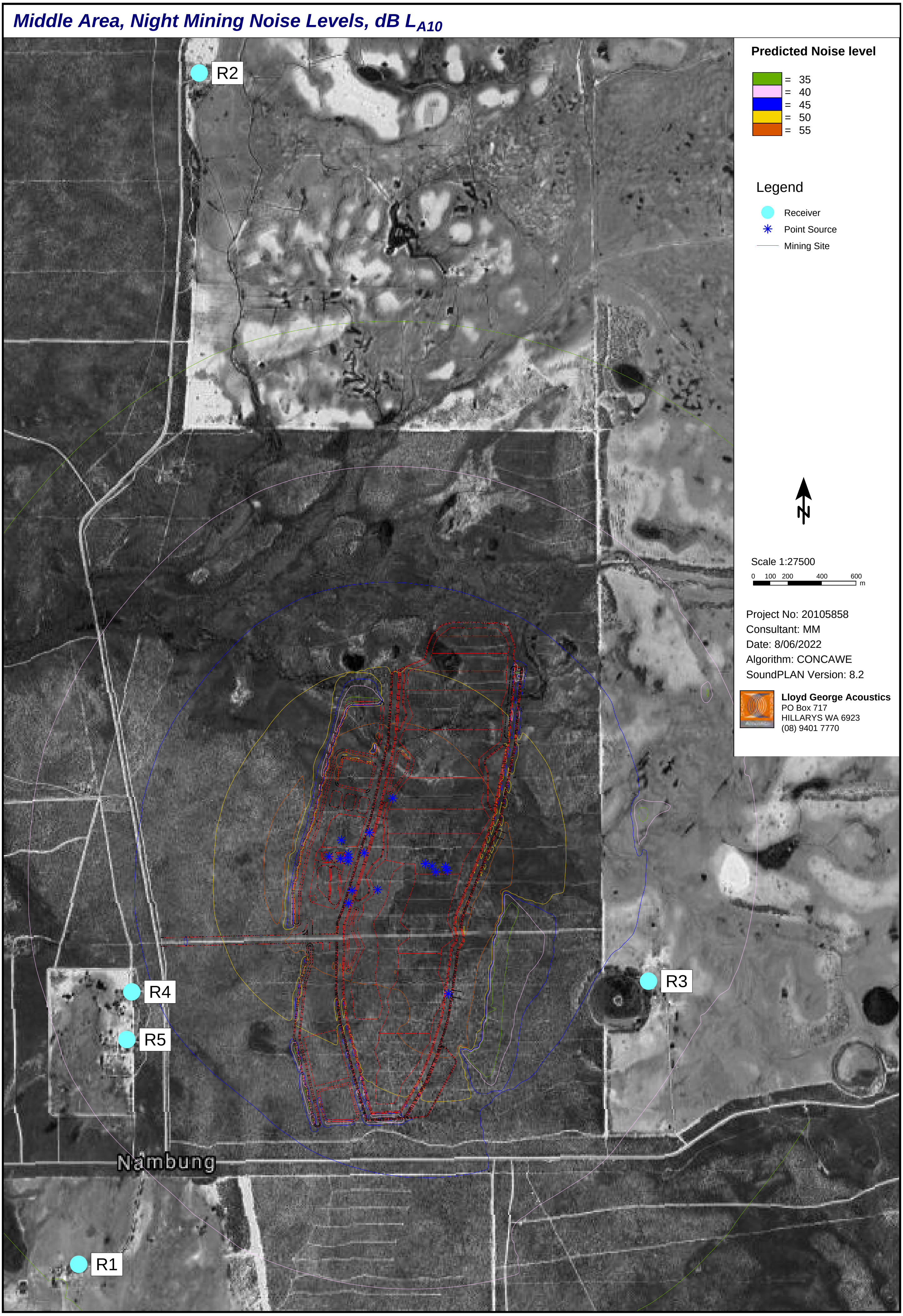


Figure 115: Middle Area – Night period Operations Noise Levels (dB LA10)

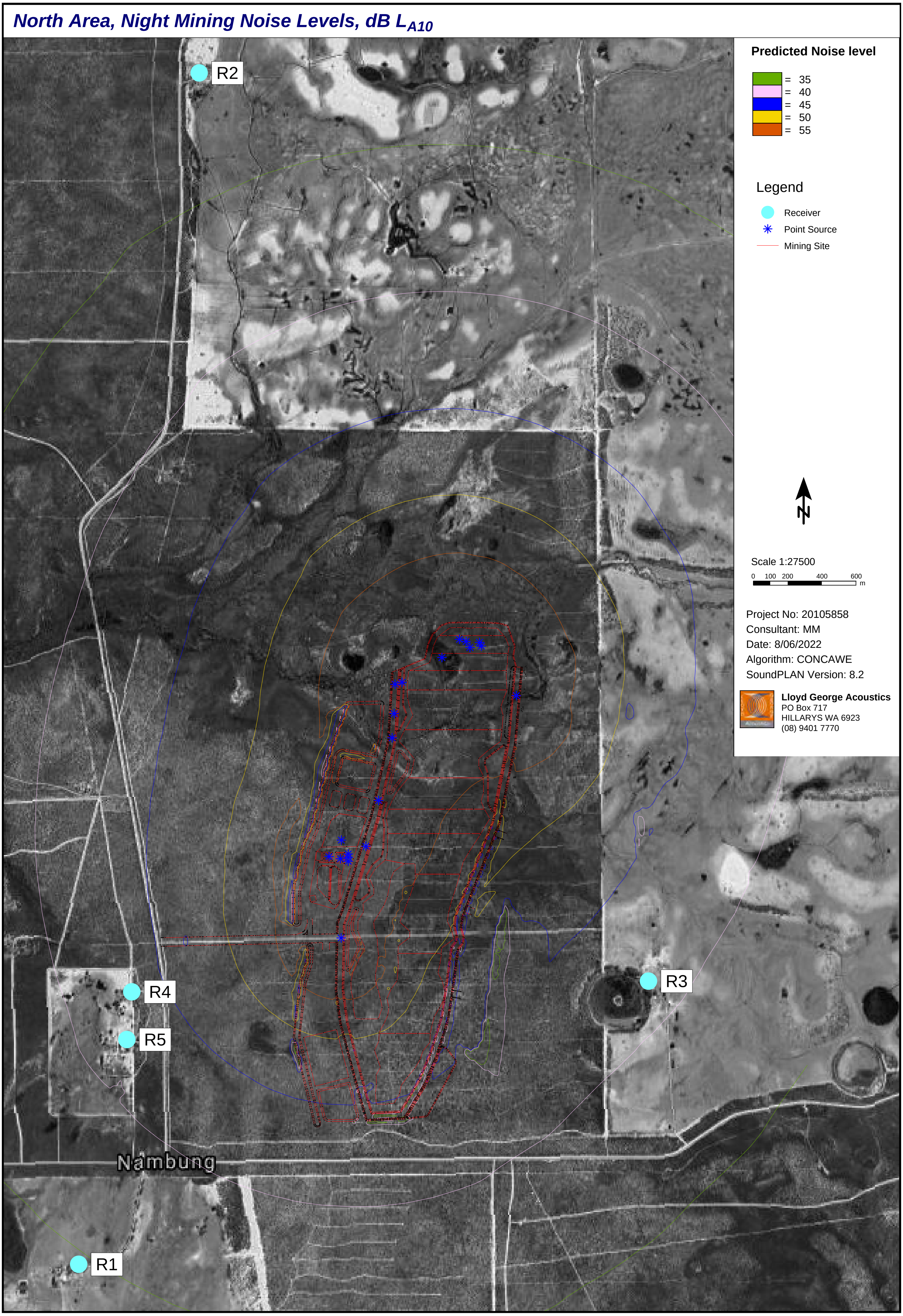


Figure 116: North Area – Night period Operations Noise Levels (dB LA10)

Figure 4-8 HMC Haulage Noise Levels, dB L_{A1}

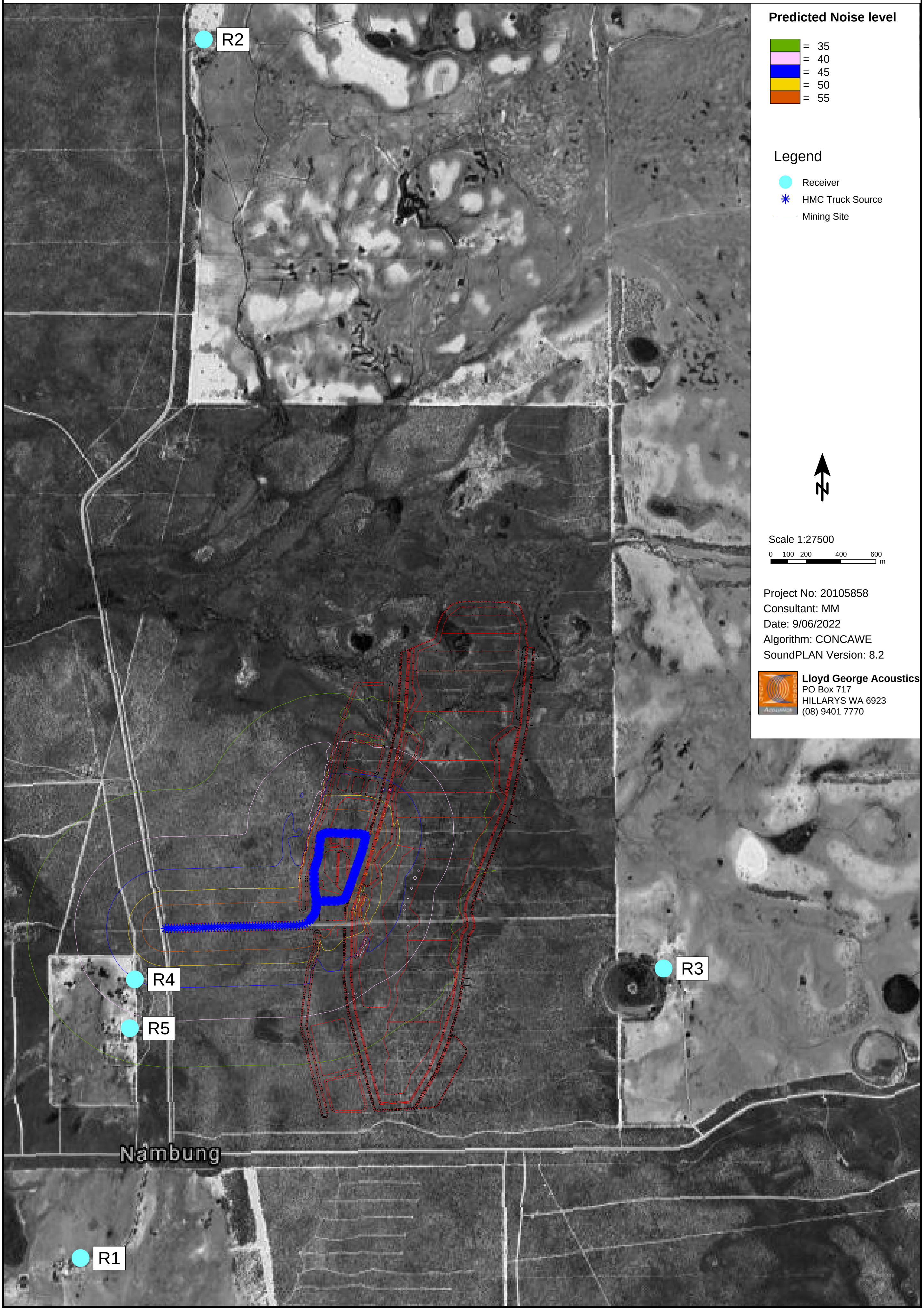


Figure 117: HMC Haulage Noise Levels (dB LA1)

Dust / Particulates

Ambient Air Quality Standards

Particulate matter (PM) is generally defined as particles that can remain suspended in the air by turbulence for an appreciable length of time. PM can consist of a range of matter including crustal material, pollens, sea salts and smoke from combustion products. PM is commonly defined by the size of the particles including the following:

- Total suspended particulates (TSP), which is all PM with an equivalent aerodynamic particle diameter below 50 µm;
- PM_{10} is the portion of TSP that is below 10 µm in equivalent aerodynamic diameter; and
- $PM_{2.5}$ is the portion of PM_{10} that is below 2.5 µm in equivalent aerodynamic diameter.

Mineral sands at the Proposal consist in the form of zircon, rutile, leucoxene and ilmenite. The physical properties of these minerals (i.e., hardness and SG) generally make it less susceptible to dust generation from particle attrition and wind erosion. Dust at the Proposal is of a similar colour to the underlying soils in the area and is therefore less likely to be of concern in terms of adverse amenity impacts from dust deposition.

TSP is normally associated with amenity and nuisance impacts. PM_{10} and $PM_{2.5}$ are generally associated with potential health impacts as particles this size and below may enter the lungs.

Table 59 contains the relevant criteria for particulate matter. The standards are based on the following guidelines:

- "National Environment Protection Measure (NEPM) for Ambient Air Quality" by the National Environment Protection Council (NEPC, 2021).

Note that a variation to the $PM_{2.5}$ standards has been proposed for implementation in 2025.

Table 59: Relevant Air Quality Standards

Pollutant	Averaging Period	Unit	Ambient Air Concentration	Proposed Variation in 2025	Reference
Particles as PM_{10}	24-hour	µg/m³	50	-	(NEPC, 2021)
	Annual	µg/m³	25	-	(NEPC, 2021)
Particles as $PM_{2.5}$	24-hour	µg/m³	25	20	(NEPC, 2021)
	Annual	µg/m³	8	7	(NEPC, 2021)

Particulate Deposition

DWER has published draft guidelines for dust emissions which outline standards for dust deposition. These guidelines are designed to consider potential amenity impacts, such as dust depositing on fabrics and buildings. The use of these guidelines serves as a reference to the potential magnitude of the impacts associated with dust deposition.

The DWER guidelines are based on studies undertaken on coal dust deposition in the Hunter Valley in NSW by the National Energy Research and Demonstration Council (NERDC, 1988). While the dust deposition guideline is expressed as g/m²/month, the draft DWER guidelines, have indicated that the monthly average deposition (to be compared against the guideline value) is to be determined from data spanning no less than one year, to account for seasonal variations (Table 60).

Table 60: Amenity Dust Deposition Criteria

Pollutant	Averaging Period	Criteria (g/m^2)/month
Deposited Dust	Annual (Increase)	2
	Annual (Total)	4

The DWER guidelines advise that the criteria for the maximum increase in deposited dust of 2 g/m^2/month is applicable when baseline data on deposited dust exists, while the total deposited dust criteria of 4 g/m^2/month criteria is applied when no baseline data exists.

Air Dispersion Modelling

The CALPUFF modelling system was utilised to undertake air dispersion modelling. CALPUFF is a multi-layer, multi-species, non-steady-state puff dispersion model. It utilises three-dimensional wind fields to simulate the effects of the temporal and spatial meteorological conditions on pollutant transport, transformation and removal. CALPUFF also allows for three-dimensional characterisation of land use and surface characteristics such as height and density of vegetation.

Detailed structure and constituents of Air Dispersion Modelling developed by Ramboll is listed below and detailed in Appendix 30:

- Meteorological data;
- Existing dust levels;
- Model parameterisation;
- Particle size distribution;
- Emission factors; and
- Emission sources and estimated emissions.

For the purpose of the assessment, Ramboll considered two scenarios:

- Conventional open-pit mining procedures are limited to day shift only (0600 to 1800); and
- Conventional open-pit mining procedures are conducted in double shifts over 24 hours.

The identified dust and particulates sources for the air quality assessment of the Proposal are:

- Dozing activities;
- Front-end load (FEL) operations;
- Excavation and removal of topsoil, overburden and ore;
- Pits backfill process;
- Topsoil, overburden and ore transfers;
- Overburden, topsoil, ore and HMC stockpiles;
- Wind erosion of exposed areas;
- Recovering clay fines from solar cells;
- Truck loading and unloading; and
- Haulage of HMC, ore and overburden.

Particulate Concentrations

The maximum predicted 24-hour average and annual concentrations at key receptors for PM_{10} and $PM_{2.5}$ in isolation are presented in Table 61 which show a comparison between the two scenarios. Table 62 shows the cumulative predicted annual average concentrations of PM_{10} and $PM_{2.5}$ for both scenarios. The five receptors are presented as the key sites of focus for analysis of predicted concentrations. Contour plots for 24-hour and annual average concentrations of PM_{10} and $PM_{2.5}$ under both scenarios are presented in Ramboll (2022).

The maximum predicted 24-hour average PM_{10} concentration for the day shift scenario in isolation is 5.6 µg/m^3 at Receptor 3 (R3) and 11.8 µg/m^3 for the double shift scenario in isolation, occurring at Receptor 2 (R2). These values are well below the criteria of 50 µg/m^3, representing 11% and 24% of the criteria respectively. The maximum predicted 24-hour average $PM_{2.5}$ concentration for the day shift scenario in isolation is 2.4 µg/m3 at R3 and 4.7 µg/m^3 at R2 for the double shift scenario. These values are also well below the criteria of 25 µg/m^3, representing 10% and 19% of the criteria respectively.

The maximum predicted annual average PM_{10} concentration for the day shift scenario in isolation is 0.8 µg/m^3 and 1.8 µg/m^3 for the double shift scenario, both occurring at R2. These values are below the criteria of 25 µg/m^3, representing 3% and 7% of the criteria respectively. The maximum predicted annual average $PM_{2.5}$ concentration for the day shift scenario in isolation is 0.3 µg/m^3 and 0.7 µg/m^3 double shift scenario at R2. These values are below the criteria of 8 µg/m^3, representing 3% and 8% of the criteria respectively.

The results of the modelling indicate that the predicted concentrations for the double shift scenario are overall greater than the predicted concentrations for the day shift scenario, however still well below guideline criteria.

Background concentrations were calculated from monitored data at the Atlas site. The 70th percentile of the 24-hour averages was included as background in this assessment to calculate the cumulative emissions. Results of the cumulative concentrations are presented in Table 62, with all concentrations remaining below the guidelines. The predicted maximum 24-hour average cumulative concentrations for PM_{10} and $PM_{2.5}$ were 45% and 35% of the guideline respectively. While the cumulative annual concentration was 50% of the guideline for PM_{10} and 59% of the guideline for $PM_{2.5}$.

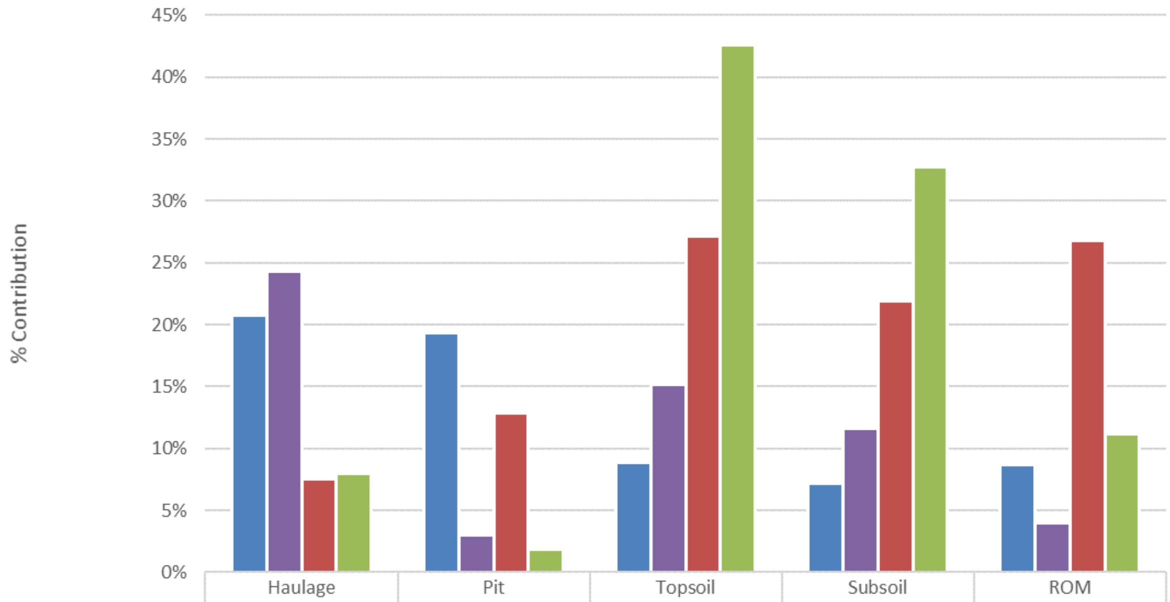
The maximum predicted concentrations at any of the key receptor locations were predicted to occur at either R2 or R3. Figure 118 and Figure 119 show the percentage contribution of different activities to the annual predicted concentrations at R2 and R3 respectively. It is noted haulage is the main contributor to PM_{10} annual concentrations, whereas activities conducted at the topsoil and subsoil stockpiles are the main contributors to $PM_{2.5}$ annual concentrations at both R2 and R3.

Table 61: Predicted GLCs for 24-hour and annual averaging periods in isolation

Pollutant	Averaging Period	Guideline (µg/m³)	Concentration(µg/m³)					% of Guideline				
			R1	R2	R3	R5	R5	R1	R2	R3	R5	R5
Day Shift Operations Scenario												
PM_{10}	24-Hour	50	3.6	4.1	5.6	2.4	2.3	7%	8%	11%	5%	5%
	Annual	25	0.3	0.8	0.7	0.2	0.3	1%	3%	3%	1%	1%
$PM_{2.5}$	24-Hour	25	1.2	2	2.4	0.9	0.6	5%	8%	10%	4%	3%
	Annual	8	0.1	0.3	0.2	0.1	0.1	1%	3%	3%	1%	1%
Double Shift Operations Scenario												
PM_{10}	24-Hour	50	9.9	11.8	10	5.7	7.2	20%	24%	20%	11%	14%
	Annual	25	0.8	1.8	1.5	0.5	1.3	3%	7%	6%	2%	5%
$PM_{2.5}$	24-Hour	25	4.4	4.7	3.8	2	1.3	18%	19%	15%	8%	5%
	Annual	8	0.3	07	0.5	0.2	0.2	4%	8%	7%	2%	3%

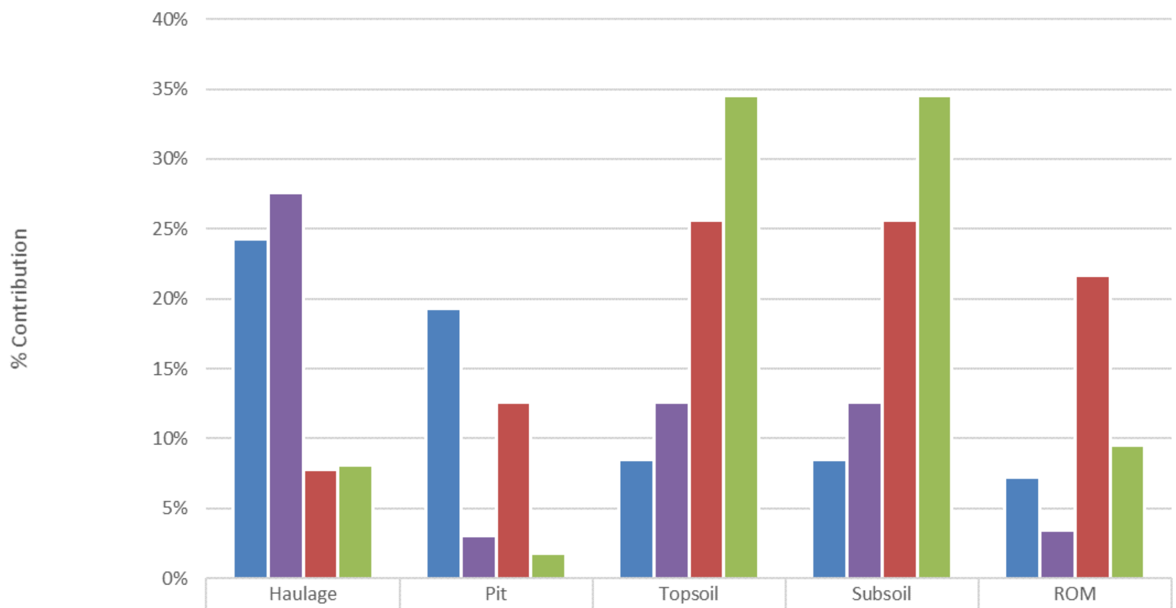
Table 62: Cumulative GLCs for 24-hour and annual average periods

Pollutant	Averaging Period	Guideline (µg/m³)	Concentration(µg/m³)					% of Guideline				
			R1	R2	R3	R5	R5	R1	R2	R3	R5	R5
Day Shift Operations Scenario												
PM_{10}	24-Hour	50	14.3	14.8	16.3	13.1	13.0	29%	30%	33%	26%	26%
	Annual	25	11	11.5	11.4	10.9	11.0	44%	46%	46%	44%	44%
$PM_{2.5}$	24-Hour	25	5.3	6.0	6.5	4.9	4.7	21%	24%	26%	20%	19%
	Annual	8	4.1	4.3	4.3	4.1	4.1	52%	54%	53%	51%	51%
Double Shift Operations Scenario												
PM_{10}	24-Hour	50	20.6	22.5	20.7	16.4	17.9	41%	45%	41%	33%	63%
	Annual	25	11.5	12.5	12.2	11.2	12.0	46%	50%	49%	45%	48%
$PM_{2.5}$	24-Hour	25	8.5	8.7	7.9	6.1	5.4	34%	35%	31%	24%	21%
	Annual	8	4.3	4.7	4.6	4.2	4.3	54%	59%	57%	53%	53%



	Haulage	Pit	Topsoil	Subsoil	ROM
PM10 Day Shift	20.8%	19.4%	8.8%	7.1%	8.7%
PM10 Double Shift	24.3%	3.0%	15.1%	11.6%	4.0%
PM25 Day Shift	7.5%	12.8%	27.1%	21.9%	26.8%
PM25 Double Shift	8.0%	1.8%	42.6%	32.8%	11.2%

Figure 118: Percentage contribution to predicted annual average concentrations at Receptor 2



	Haulage	Pit	Topsoil	Subsoil	ROM
PM10 Day Shift	24%	19%	9%	9%	7%
PM10 Double Shift	28%	3%	13%	13%	3%
PM25 Day Shift	8%	13%	26%	26%	22%
PM25 Double Shift	8%	2%	34%	34%	10%

Figure 119: Percentage contribution to predicted annual average concentrations at Receptor 3

Modelling Sensitivity Analysis

A sensitivity analysis was conducted to determine potential impacts from uncontrolled wind erosion at the site. The analysis indicated elevated concentrations of particulates could occur if wind erosion of exposed areas and haulage were not adequately controlled. It was noted that short-term impacts of PM_{10} and $PM_{2.5}$ levels could be expected during periods of high wind (>6.5 m/s) if sources of wind erosion were not controlled appropriately.

Image Resources has committed to the implementation of air quality monitors coupled with alarms that will trigger when an elevated concentration threshold is surpassed to ensure the appropriate management of sources of dust. Further details on the control of dust from the site will be detailed in the site dust environmental management plan (DEMP).

The sensitivity analysis also indicated that uncontrolled emissions from haulage could result in elevated concentrations of particulates. Image has committed to the application of a chemical suppressant on internal haul roads. The sensitivity analysis indicated there is a risk of elevated concentrations at R5 if haulage of HMC through Munbinea Rd is not properly managed.

Particulate Deposition

Modelling results for dust deposition for the day shift scenario operations are presented in Table 63. The dust deposition criteria of 2 $g/m^2/month$ for Image operations in isolation has been assumed for this assessment based on standards set by the DWER draft guidelines published in 2021.

Ramboll (2022) determined that the maximum predicted impacts at any location of the Proposal for the two scenarios were below the 9 $g/m^2/month$ rate highlighted by Doley and Rossato (2010) as potentially impacting plant growth.

The maximum predicted deposition rate for the day shift scenario is 0.10 $g/m^2/month$ at R2. All predicted deposition values for the day shift scenario operations fall under the adopted criteria with levels at R2 representing 5% of the guideline.

The maximum predicted deposition rate for double shift scenario operations is 0.2 $g/m^2/month$ at R2 representing 10% of the criteria. All predicted deposition values for the wet scenario operations fall under the adopted criteria.

Table 63: Predicted dust deposition rates at key sensitive receptors

Receptor	Criteria ($g/m^2/month$)	Day Shift Scenario		Double Shift Scenario	
		Dust deposition ($g/m^2/month$)	% of Criteria	Dust deposition ($g/m^2/month$)	% of Criteria
R1	2	0.03	2%	0.05	3%
R2	2	0.10	5%	0.20	10%
R3	2	0.08	4%	0.16	8%
R4	2	0.02	1%	0.04	2%
R5	2	0.06	3%	0.17	8%

Visual Amenity

The Proposal does not lie high in the landscape and does not include significantly high structures, however portions of the Proposal may be visible to the surrounding receptors, either in the short-term or over the three year life of the Proposal. No permanent visual amenity impacts are predicted however as the pits will be backfilled and the land shaped to match natural surrounding at closure.

Image Resources has committed to continued discussions with the landholders regarding this impact and will work with them to minimise visual amenity impacts as much as practicable.

The Proposal will not be visible from the Pinnacles or other areas frequently utilised by visitors to the Nambung National Park.

Increased Traffic

The Proposal will require the following traffic movements on local roads:

- Heavy and light vehicle construction vehicles;
- Operational workforce vehicles; and
- HMC trucks, typically three return trips per day.

The Proposal has been revised to include a small accommodation camp. This camp was included to remove impacts to the local community associated with workforce accommodation and in particular traffic. By keeping a majority of the workforce close to the Proposal the number of additional vehicles movements on local roads is kept to a minimum.

Image Resources is in regular discussions with the Shire of Dandaragan regarding the use of public roads to ensure traffic impacts are minimised.

Light Emissions

The Proposal is a relatively small-scale mining operation however night works are proposed and therefore some lighting will be required. The primary light sources will be the processing areas, with safety lighting around work areas. Image Resources is aware of the low light environment that surrounds the Proposal, and is committed to ensuring the Proposal light emissions are minimised as much as practicable while maintaining a safe work area. Lighting design will be reviewed close to the commencement of the Proposal to ensure they do not result in excessive light glow. Initial lighting commitments are provided in Section 9.6.

9.6 Mitigation

Image has mitigated the potential impacts to this factor according to the mitigation hierarchy; avoid, minimise, rehabilitate. Offsets are not expected to be required for this factor.

9.6.1 Avoid

The key avoidance mechanism implemented by Image was the extensive revision of the development envelopes and the infrastructure layout to avoid all areas of cultural concern, Bibby Creek and Mount Jetty Creek from the Development Envelopes, via S43A of the EP Act. This revision was undertaken after consultation with the Yued Noongar People about the significance of these sites. In addition one avoidance area was also able to be excluded from the Development Envelopes.

9.6.2 Minimise

The following mitigation measures are proposed to ensure that direct and indirect impacts to social surroundings are minimised:

1. **Obtain and comply with Works Approval and Licence issued under Part V of the EP Act**. A Works Approval and Licence for mineral sands mining or processing will be required for the Proposal. The Works Approval and Licence will ensure that mitigation measures are implemented to reduce noise and dust risks associated with the Proposal;
2. **Negotiate Access Agreement with Yued People;**
3. **Develop a Social Cultural Heritage Management Plan in consultation with the Yued People, which will include the following components (among others)**:
    a. Cultural awareness training will be included in site inductions, to ensure all personnel are made aware of their obligations under the Social Cultural Heritage Management Plan and ACH Act;
    b. Access to Country is to be maintained wherever possible and safe to do so, including for traditional uses;
    c. If human remains, skeletal materials that may be human or materials that may be a human grave are uncovered, then Image and its contractors will stop work immediately and the materials and the area will be left undisturbed. The Yued People will be informed immediately;
    d. Aboriginal Heritage surveys across areas proposed to be cleared (majority already completed);
    e. Boundaries of areas to be cleared or disturbed will be identified by GPS coordinates and maps of boundaries will be provided to dozer operators;
    f. The disturbance footprint will be developed to the minimum required to ensure safe and adequate construction and operation;
    g. Inclusion of bush tucker and medicine species in the site rehabilitation, potentially including Moojar trees;
    h. Encourage participation by the local indigenous population in land management activities within and surrounding the Proposal, e.g., environmental monitoring and rehabilitation activities (such as seed collection);
4. **If required, obtain and comply with approvals under the ACH Act for any Aboriginal Heritage sites (or Other Heritage Places that are likely to be sites) that are to be disturbed (none expected);**
5. **Development and Implementation of a Noise Management Plan.** Including noise management measures such as construction of noise bunds, operational restrictions, vehicle specifications as well as monitoring and reporting programs to demonstrate compliance;
6. **Implementation of the DMP(Ramboll, 2022b; Appendix 25).** Including dust management measures, a dust monitoring program and performance criteria to determine compliance;
7. **Conduct regular consultation with surrounding landholders regarding amenity impacts**. Any comments will be investigated to determine if changes can be made to reduce these impacts during construction, operation and closure; and
8. **Minimise light emissions**. At the detailed design stage, each significant light sources will assessed in terms of its purpose, location and intensity in order to minimise light spill.

9.6.3 Rehabilitate

Throughout the implementation of the Proposal the mine pit will be progressively mined and rehabilitated. This includes physically landforming the site and replanting vegetation to ensure surface safe site access and water regimes are not significantly altered. At the completion of the Proposal the site will be rehabilitated. The interim MCP provided in Appendix 2 identifies rehabilitation and closure tasks and associated management and monitoring to be undertaken during the closure phase, including:

- Materials balance for closure and rehabilitation demonstrating the quantities, availability and management for all rehabilitation materials;
- Identified knowledge gaps to be filled prior to closure;
- Closure tasks; and
- Completion criteria, monitoring and reporting during closure.

The key rehabilitation measures from the MCP that relate to social surroundings are summarised below:

1. Re-establish vegetation that provides a self-generating ecosystem comprising local native vegetation which resembles the surrounding environment as closely as practical;
2. Direct seeding of flora species identified by the Yued People as being of cultural use or significance (i.e., bush tucker and medicine flora, Moojar (*Nuytsia floribunda*) trees);
3. Land will be made physically safe, stable and non-polluting;
4. Soil profile will be re-established to support native vegetation growth;
5. The site will be left in a safe, stable, non-polluting and tidy condition with no remaining plant or infrastructure that is not required post-mining use or agreed used by other stakeholders;
6. All bores, pipes, tanks and other ancillary infrastructure will be decommissioned and made safe or else legal responsibility will be assumed by a third party; and
7. Disturbed surfaces rehabilitated to facilitate agreed upon post-mining land use (expected to be predominantly native vegetation.

The MCP will be submitted to DMIRS for assessment and approval under the Mining Act prior to the construction of the Proposal and will be reviewed and revised every three years.

9.7 Predicted Outcome

The EPA's environmental objective for this factor is to "protect social surroundings from significant harm" (EPA, 2016l).

The Proposal has incorporated extensive avoidance, minimisation and rehabilitation measures into the Proposal design and operational processes to ensure that the social surroundings are protected from significant harm. The Proposal is expected to result in only minor impacts to local residents and the community given the setback distances of the Proposal to the nearest sensitive receptors and implementation of mitigation measures. Continued consultation is planned to ensure impacts are kept as low as practicable. As a result of the above, the Proposal is not expected to result in significant 'harm' to this social value.

Image Resources has conducted extensive Aboriginal Heritage, archaeological, ethnographic and work area clearance investigations on proposed disturbance areas. Disturbance to Bibby Creek, Mount Jetty Creek and all areas of cultural concern identified during those surveys have been avoided during Proposal design, eliminating direct impacts. Indirect impacts are possible; however, they are expected to be managed by licencing under Part V of the EP Act and approval under the Mining Act. Based on the above, the Proposal is not expected to result in significant harm to Aboriginal Heritage.

The Proposal will result in clearing of native vegetation within the development envelopes. This clearing is to be progressively rehabilitated. The extent of clearing is not considered significant at a regional scale. The Proposal will result in restrictions to some of the land within the development envelopes. Restricted areas are to be limited to areas that are under rehabilitation, are actively being mined or contain infrastructure, therefore the proposed restricted areas will be relatively small. Image Resources has also committed to maintaining access to land for the Yued People, and minimising disturbance within any areas that may be used for traditional purposes. As a result, the Proposal is not expected to significantly impact land used for traditional purposes.

Based on the above, Image Resources considers that the Proposal can be implemented such that there are no significant residual impacts to this factor, and the EPA objective can be met.

10 HUMAN HEALTH

10.1 EPA Objective

The EPA Objective for this key environmental factor is to protect Human Health from significant harm.

10.2 Policy and Guidance

Relevant EPA and Commonwealth Government guidance documents for Human Health are summarised in Table 64.

Table 64: Policy and guidance relevant to the Human Health key environmental factor

Policy and Guidance	How guidance has been considered
Western Australian Government	
Key EPA documents	
Statement of Environmental Principles, Factors and Objectives (EPA, 2021b)	This document was considered in the preparation of this ERD and to inform EIA. It was used to identify the Key Environmental Factors likely to be impacted by the Proposal and the EPA's objective for each factor.
EIA (Part IV Divisions 1 and 2) Administrative Procedures (EPA, 2021e)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
EIA (Part IV Divisions 1 and 2) Procedures Manual (EPA, 2021a)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
Instructions on how to prepare EP Act Part IV Environmental Management Plans (EPA, 2021f)	This document was considered in the preparation of the Radiation Management Plan (RMP), prepared to support this ERD.
Relevant EPA Factor Guidelines	
Environmental Factor Guideline – Human Health (EPA, 2016m)	This document was considered in the preparation of this section of the ERD.
Relevant EPA Technical Guidance	
Monitoring naturally occurring radioactive material (NORM) – pre-operational monitoring requirements, Managing NORM in mining and mineral processing – Guideline NORM-3.1 (Department of Mines and Petroleum, 2010a)	This document was used as guidance for the baseline pre-mining radiation survey conducted for the Proposal, during the preparation of the RMP, and in the preparation of this ERD.
Controlling NORM – management of radioactive waste, Managing NORM in mining and mineral processing – Guideline NORM-4.2 (Department of Mines and Petroleum, 2010b)	This document was used as guidance during the preparation of the RMP for the Proposal.

Policy and Guidance	How guidance has been considered
Commonwealth Government	
Key Documents	
Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act) (DotEE, 2016a)	This document was considered in the preparation of this ERD and while undertaking EIA.
Environmental Management Plan Guidelines (DotE, 2014a)	This document was considered in the preparation of the RMP, prepared to support this ERD.
Environmental Management Plan Guidelines - template (DotE, 2018)	This document was considered in the preparation of the RMP, prepared to support this ERD.
EPBC Act Condition Setting Policy (DAWE, 2020a)	This document was used as guidance for the EIA for the Proposal.
EPBC Act Outcomes-based conditions policy (DotE, 2016a)	This document was used as guidance for the EIA for the Proposal.
Relevant Technical Guidance	
Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (Australian Radiation Protection and Nuclear Safety Agency; ARPANSA, RPS-9, 2005)	This document was used as guidance in the formation and adoption of the radiation protection practice at the Proposal, in the design of the RMP and in the preparation of this ERD.
National Directory for Radiation Protection (ARPANSA, RPS-6, 2021)	This document was considered in the preparation of this section of the ERD.
Managing naturally occurring radioactive material (NORM) in mining and mineral processing. NORM–2.2: Preparation of a radiation management plan – mining and processing (DMP, 2010c)	This document was used as guidance during the preparation of the RMP for the Proposal.
Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards (International Atomic Energy Agency; IAEA, GSR Part 3, 2014)	This document was considered in the preparation of the RMP for the Proposal.
Application of the Concepts of Exclusion, Exemption and Clearance (IAEA, RS-G-1.7, 2004)	This document was considered during the preparation of the RMP for the Proposal.
Code of Practice for the Safe Transport of Radioactive Material (ARPANSA, 2008)	This document was used as guidance in the preparation of the RMP for the Proposal.

10.3 Receiving Environment

10.3.1 Survey Effort

Image commissioned Calytrix Consulting Pty Ltd (Calytrix) to conduct a baseline radiation pre-mining survey of the Atlas deposit Calytrix, 2021; Appendix 31). Gamma radiation (μSv / hr) and Radon/Thoron (Bq / m^2) monitoring was performed over tenement M70/1305 (the tenement that contains the Atlas deposit) from 20 - 24 September 2021. Monitoring was undertaken in accordance with requirements detailed in *Managing naturally occurring radioactive material (NORM) in mining and mineral processing – guideline. NORM 3.1. Monitoring NORM – pre-operational monitoring* (the NORM guidelines; Department of Mines and Petroleum (DM&P), 2010).

Gamma Radiation Survey

Calytrix (2021) conducted a baseline gamma radiation survey at the Proposal, recording a total of 588 measurements over M70/1305. These included 40 measurements taken at the proposed WCP and HMC stockpiles locations, across an approximate 50 m x 50 m grid. The remaining 548 gamma radiation measurements were taken over 80 - 120 m intervals over the rest of the surveyed area.

Gamma radiation measurements were undertaken with a RadEye B20 monitor held 1 m above ground level, and a reading was taken averaged over 10 - 20 seconds. The locations of gamma radiation measurements were recorded with handheld GPS and are detailed in Figure 120.

Radon and Thoron Survey

Calytrix (2021) recorded a total of 117, 20-minute samples for thoron and radon at five monitoring locations across M70/1305 (Figure 121). At the five monitoring locations, 23 readings were recorded at sites 2 – 5, with 25 readings taken at site 1. A SARAD RTM1688-2 monitor was used to measure thoron and radon readings (Bq / m^2) within a 20 minute period, including:

- Measurement range;
- Average measurement; and
- Geometric mean.

To allow for the accurate calculation of averages where a zero value was recorded for radon and thoron concentrations, the values were replaced by 1.5 Bq / m^3 (minimum detection limit of a SARAD RTM1688-2 monitor).

10.3.2 Alignment with Technical Guidance

Calytrix (2021) conducted a radiation pre-mining baseline survey primarily in accordance with DM&P's *Managing naturally occurring radioactive material (NORM) in mining and mineral processing – guideline. NORM 3.1. Monitoring NORM – pre-operational monitoring* (DM&P, 2010). State and Commonwealth legislation and guidelines were also considered where relevant.

The gamma radiation assessment was designed and conducted in accordance with Section 2.3.1 of the NORM Guidelines, which recommends the use of grid intervals of 100 m x 100 m for background gamma radiation monitoring, and 50 m x 50 m intervals "in areas where processing plants that may be a source of emissions are proposed, and where the increase in concentration of radionuclides may take place" (DM&P, 2010). The survey assessment of radon and thoron at M70/1305 was conducted in accordance with recommendations in the NORM Guidelines.

The RMP was prepared in accordance with requirements of the regulation Subdivision 3B – Radiation in mines of the Work Health and Safety (Mines) Regulations 2022. The Guideline *Managing naturally occurring radioactive material (NORM) in mining and mineral processing. NORM–2.2: Preparation of a radiation management plan – mining and processing* (DM&P, 2010,) [1] was followed to the maximum practicable extent.

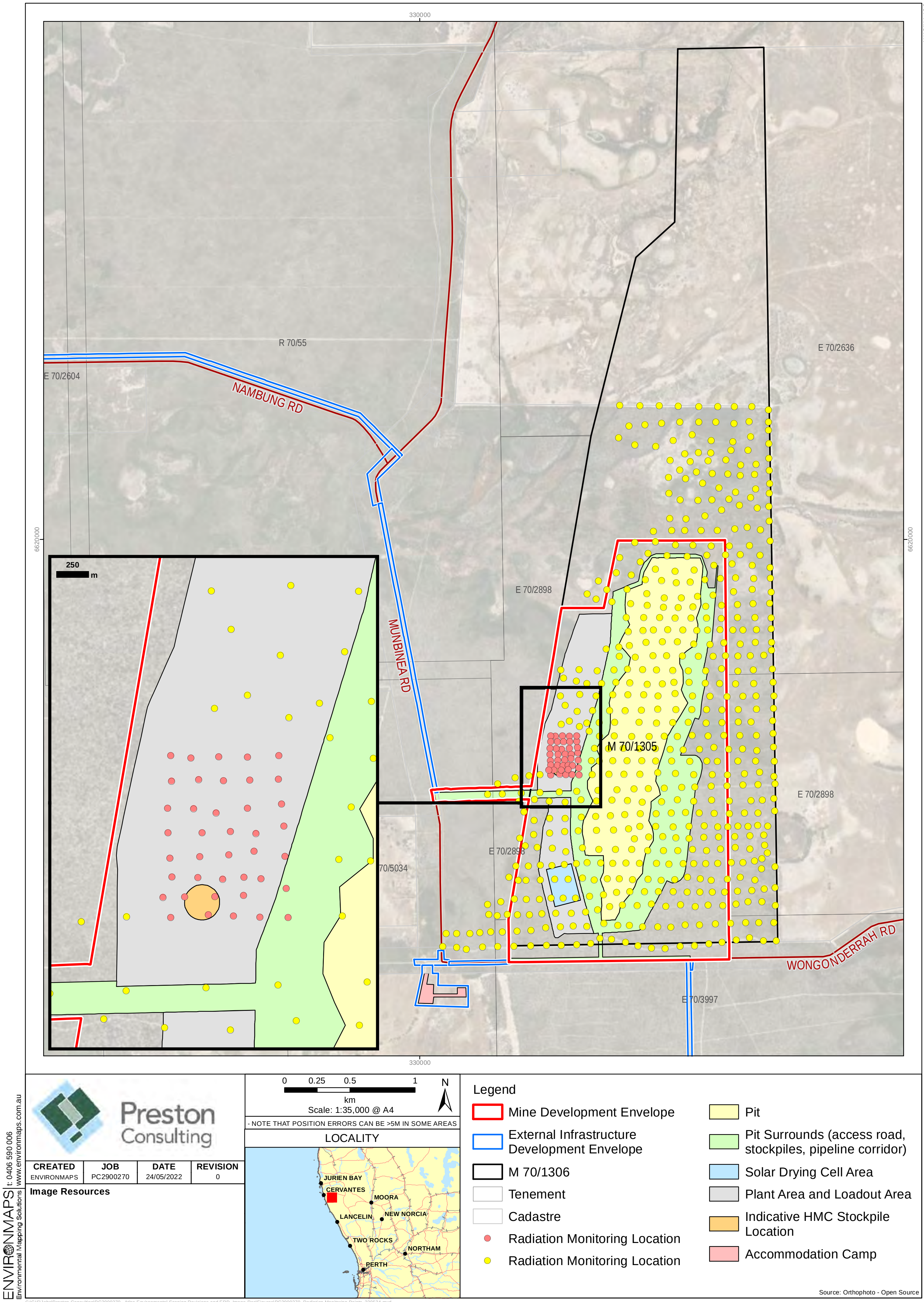


Figure 120: Gamma radiation pre-mining monitoring locations at the Proposal

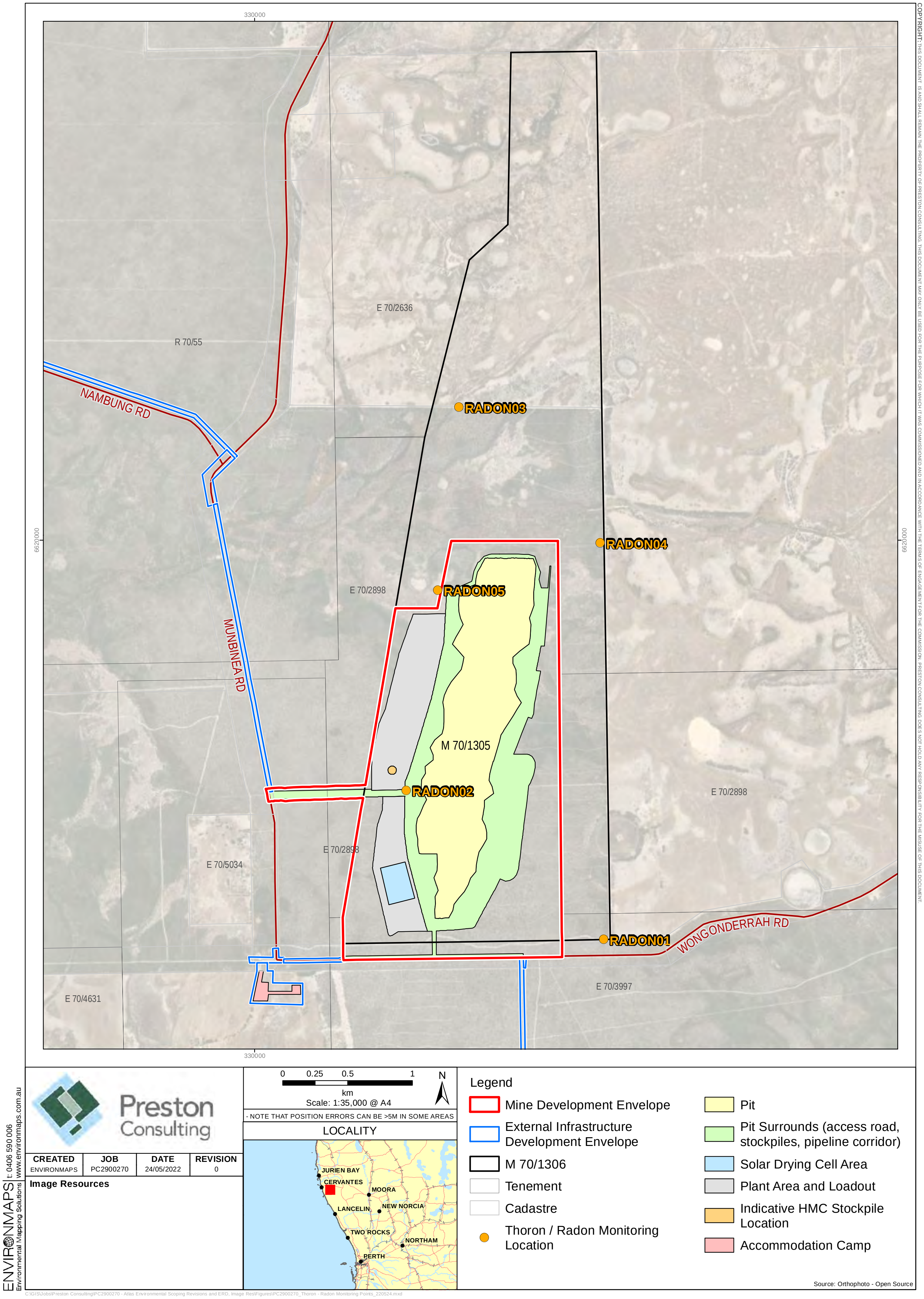


Figure 121: Radon and thoron pre-mining monitoring locations at the Proposal

10.3.3 Survey Findings

Gamma Radiation Survey

Gamma radiation measurements taken by Calytrix (2021) for the Proposal ranged between 0.04 – 0.12 µSv / hr at the proposed WCP and HMC stockpile locations, producing an average measurement of 0.08 µSv / hr (±0.02). Across the rest of M70/1305, gamma radiation ranged between 0.04 – 0.15 µSv / hr, (average 0.09 µSv / hr ±0.02), allowing the calculation of a geometric mean of 0.09 µSv / hr (average 0.09 µSv / hr ±0.02) for all measurements.

A summary of gamma radiation measurements, and a comparison with measurements taken at Image's nearby Boonanarring mineral sands mine (between 2017 – 2021) are detailed in Table 65.

Table 65: Average gamma radiation measurements taken across M70/1305 (Calytrix, 2021)

Survey area	Number of measurements	Range (µSv / hr)	Average (µSv / hr)
WCP and HMC stockpile areas	40	0.04 – 0.12	0.08 ±0.02
Remainder of M70/1305	548	0.04 – 0.15	0.09 ±0.02
Summary for all areas within M70/1305	**588**	**0.04 – 0.15**	**0.09 ±0.02**
Pre-mining surveys at the Boonanarring mineral sands mine, for comparison, 2017-2021	*1,153*	*0.03 – 0.19*	*0.09 ±0.02*

Radon and Thoron Survey

Surveys at the five monitoring points within M70/1305 produced a geometric mean of 3.5 Bq / m³ (average range 7.5 ±10.8) for radon and 4.6 Bq / m³ (average range 9.2 ±11.2) for thoron. These readings were determined to be lower than those compared with similar measurements taken at Image's nearby Boonanarring mineral sands mine for both radon (geomean 8.9 Bq / m³, average range 12.1 ±9.9) and thoron (geomean 6.8 Bq / m3, average range 10.8 ±11.3).

A summary of the radon and thoron measurements observed by Calytrix (2021) is detailed in Table 66.

Table 66: Summary of radon and thoron measurements taken across M70/1305 (Calytrix, 2021)

GPS Location		No of readings	Radon (Bq/m³)			Thoron (Bq/m³)		
mE	mN		Range	Average	Geomean	Range	Average	Geomean
332,687	6,616,925	25	1.5 – 39.5	9.6 ±11.7	4.4	1.5 – 41.2	10.1 ±10.5	5.9
331,168	6,618,073	23	1.5 – 65.4	10.9 ±16.6	4.3	1.5 – 48.5	14.7 ±14.9	7.0
331,574	6,621,024	23	1.5 – 36.0	7.6 ±8.2	4.4	1.5 – 32.6	4.2 ±6.4	2.8
332,660	6,619,979	23	1.5 – 27.2	4.7 ±6.9	2.6	1.5 – 23.7	9.4 ±10.2	4.5
331,410	6,619,615	23	1.5 – 19.7	4.5 ±6.4	2.5	1.5 – 44.7	7.4 ±9.6	3.9

GPS Location		No of readings	Radon (Bq/m³)			Thoron (Bq/m³)		
mE	mN		Range	Average	Geomean	Range	Average	Geomean
Summary		**117**	**1.5 – 65.4**	**7.5 ±10.8**	**3.5**	**1.5 – 48.5**	**9.2 ±11.2**	**4.6**
Pre-mining surveys at the Boonanarring site, for comparison, 2017 - 2021		*56*	*3.0 – 43.0*	*12.1 ±9.9*	*8.9*	*3.0 – 44.0*	*10.8 ±11.3*	*6.8*

10.4 Potential Impacts

The following issues are noted in the EPA's Environmental Factor Guideline; Human Health, as having potential to impact upon human health;

- Mining, processing and/or storage of radioactive minerals or ores;
- Transport and storage of radioactive materials; and
- Industrial processes that result in the build-up and release of radioactive substances or emissions.

The potential impacts of radiation exposure to humans occurs primarily via the following pathways:

- Gamma irradiation and absorption, from a person being in close proximity to material with elevated radioactive levels;
- Inhalation of radon decay products and thoron decay products;
- Inhalation of radionuclides in dust;
- Radiation exposure to the public on the post-closure rehabilitated landform.

Table 67 defines the potential impacts (direct, indirect and cumulative) on the environmental values for this factor in a local and regional content.

Table 67: Potential Impacts to Human Health

Environmental value	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
Health of workers at the Proposal.	Radiation exposure.	No indirect impacts.	No other proposals are located in proximity to the Proposal that could cause human health impacts.	Radiation exposure.
Health of residents in proximity to the Proposal.	Radiation exposure.	No indirect impacts.	No other proposals are located in proximity to the Proposal that could cause human health impacts.	Radiation exposure.

10.5 Assessment of Impacts

10.5.1 Workers at the Proposal

The Proposal will involve mining the Atlas deposit, a mineral sands deposit which contains naturally-occurring Uranium (U) and Thorium (Th) within heavy minerals (approximately 8.1% of the ore reserve). The decay series of naturally-occurring ^{238}U and ^{232}Th contain gamma-emitting radionuclides are a potential source of external radiation/hazard when present in elevated concentrations. The temporary stockpiling and transport of HMC for the Proposal therefore has the potential to cause elevated radiation exposures of workers during operations.

These impacts were assessed for risk to workers and public including:

- Radionuclides in fugitive dust and in radon (^{222}Rn) and thoron (^{220}Rn);
- Direct exposure to the external gamma radiation from HMC stockpiles and in certain sections of the plant; and
- Indirect exposure where radionuclides in fugitive dust enter the body via inhalation, ingestion, and wounds, or by absorption through the skin.

Inhalation of radionuclides in fugitive dust is expected to be an insignificant pathway at the Proposal. The mineral grain is large and heavy, minimising the possibility of suspension in air for considerable distances. Furthermore, ore bearing heavy mineral sand is transported in the form of a wet slurry, from the stage of primary screening in the open pit, further eliminating the possibility of exposure by dust emission.

Radon is not expected to be generated in measurable amounts due to the relatively low content of uranium in the HMC. Thoron is expected to be detectable but the exposures are expected to be insignificant due to low thorium concentrations in the HMC and the very short half-life of thoron (only 56 seconds).

Workers direct exposure to the external gamma radiation from HMC stockpiles and in certain sections of the plant is therefore expected to be the dominant pathway of exposure at the Proposal. However, the relatively low concentrations of thorium and uranium in the HMC is considered unlikely to result in exposure of workers to levels exceeding 10% of the annual radiation exposure limit of 20 mSv / year. Radiation from the Proposal is therefore unlikely to result in any notable health impacts to workers.

10.5.2 Residents in Proximity to the Proposal

The effective dose limits for the public and occupational people are outlined in Schedule 1 of '*Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing*' (RPS-9) as published by the Australian Radiation Protection and Nuclear Safety Agency (2005). The dose limit for the general public is 1 mSv in a year, averaged over a 5-year period, if a higher value of effective dose occurs in a single year. 1 mSv is equivalent to an average exposure of 0.114 µSv if the person was present within the MDE for every hour of the year. The average gamma radiation within the MDE was measured at only 0.09 ±0.02 µSv / hr, and given the closest residence is approximately 1,200 m from the mine pit, radiation exposures will remain well below the dose limits in RPS-9. Radiation from the Proposal is therefore unlikely to result in any notable health impacts to surrounding residents.

10.6 Mitigation

Image has mitigated the potential impacts to this factor according to the mitigation hierarchy; avoid, minimise, rehabilitate. Offsets are not expected to be required for this factor.

10.6.1 Avoid

The radiation at the Proposal is naturally-occurring and occurs within the ore, therefore there are few opportunities to completely avoid this impact. The focus is therefore to minimise exposure levels such that they are not significant.

10.6.2 Minimise

The following mitigation measures are proposed to ensure that direct and indirect impacts to human health are minimised:

1. **Compliance with the following regulatory requirements:**
    a. Work Health and Safety (Mines) Regulations 2022 (WA);
    b. Radiation protection guidelines developed by the Resources Safety Division of the DM&P, now DMIRS); and
    c. The Chamber of Minerals and Energy of WA (2010-2021) [1].
2. **Implementation of the RMP (Appendix 32) including the following institutional controls:**
    a. A suitably qualified Radiation Safety Officer (RSO) will be appointed and be responsible for the implementation of the RMP for the Radiation Protection Monitoring Programme;
    b. A suitably qualified mine air quality officer will also be appointed to ensure that all air monitoring is undertaken in accordance with the Australian Standards and West Australian guidelines;
    c. Different areas on site will be designated and signposted as necessary;
    d. Regular surveys of the pit, plant, HMC storage and waste/tailings disposal areas and limiting of access to these areas (supervised and/or controlled areas); and
    e. Employee inductions for all workers upon commencement and once every two years thereafter.
3. **Implement Records Management and Reporting as outlined in the RMP;**
4. **Dust suppression and cleaning techniques will be used as defined in Section 9.6;**
5. **Implement spill management procedures to ensure spilt ore or concentrate is contained quickly;**
6. **Conduct training and enforce internal radiation exposures and mitigation techniques on a personal level, including:**
    a. Wearing suitable PPE;
    b. Washing hands before eating;
    c. Regular cleaning of work areas where there is a build up of dust or mud; and
    d. Changing out of work clothing at the end of a shift or before leaving the site and regular washing of clothing.

10.6.3 Rehabilitate

Throughout the implementation of the Proposal the site will be progressively backfilled as the mine progresses, allowing for continuous rehabilitation. This includes returning of the sand tails to the pit void after cycloning and pumping of clay fines to solar drying ponds before being placed back in the pit void. At the completion of the Proposal the site will be rehabilitated. An interim MCP (Appendix 2) has been developed to accompany this ERD and will be revised and submitted prior to construction in accordance with DMIRS Guidelines (2020a; 2020b). The MCP will describe the rehabilitation and closure of the Proposal, and associated management and monitoring proposed during the closure phase including:

- Materials balance for closure and rehabilitation demonstrating the quantities, availability and management for all rehabilitation materials;
- Identified knowledge gaps to be filled prior to closure;
- Closure tasks; and
- Completion criteria, monitoring and reporting during closure.

The key rehabilitation measures from the MCP that relate to human health are summarised below:

1. Backfill and rehabilitated areas will be monitored to ensure the radiation levels do not exceed levels measured in the baseline surveys;
2. Surface gamma radiation levels are to be consistent with either pre-mining levels, analogue site levels or as specified by DMIRS;
3. Any identified site contamination is to be reported in accordance with the CS Act; and
4. No contaminated soils at the Project post-closure.

The MCP will be submitted to DMIRS for assessment and approval under the Mining Act prior to the construction of the Proposal and will be reviewed and revised every three years in accordance with DMIRS (2020b).

10.7 Predicted Outcome

The EPA's environmental objective for this factor is "to protect human health from significant harm" (EPA, 2016m).

Radiation has been identified as being one of the hazards associated with mining of mineral sands ore at the Proposal. However, with the application of appropriate measures to control and minimise radiation exposure, the radiation hazard level is low. While some exposures to radiation are expected to be detectable, it is believed that neither personnel, nor members of the public, nor the environment would be harmed by radiation from the Proposal. In each and every case radiation levels will be well within the accepted radiation safety standards.

Image has conducted extensive radiation (baseline) surveys to inform the Proposal, alongside a RMP as stipulated in RPS-9 (Australian Radiation Protection and Nuclear Safety Agency, 2005). Predicted levels of gamma radiation and airborne radioactivity concentrations associated with different materials and areas at the Proposal have been modelled against conservative assumptions of the amount of time this exposure may actually take place.

In accordance with Subdivision 3B – Radiation in mines of the Work Health and Safety (Mines) Regulations 2022, a RMP will need to be approved by DMIRS prior to commencement of mining at the Proposal. Calytrix Consulting Pty Ltd (Calytrix; 2021) have therefore developed a RMP to address the overall management of radiation in relation to the safety, occupational health and environmental aspects of the Proposal. Its successful implementation will ensure achievement of the legislative standards on radiation protection for company employees, contractors, the general public and the environment arising from mining, processing, storage, transport, waste management and transport operations.

The RMP is currently based on pre-mining assumptions and draws from experience of similar mining and processing operations, such as Image's Boonanarring Mineral Sands Project. The RMP will undergo revision as the Proposal develops and more relevant data becomes available. Further revisions will be undertaken when mining commences and statistically valid measurements of actual radiation levels and exposures of personnel will be available. The RMP will additionally be reviewed every two years and will be revised should future mining or processing methods change significantly.

Image has additionally incorporated extensive avoidance, minimisation and rehabilitation measures into the Proposal design and operational processes to ensure that human health is protected from significant harm. The Proposal is expected to result in negligible impacts to Proposal personnel and local residents. As a result of the above, the Proposal is not expected to result in significant 'harm' to human health.

11 OTHER KEY ENVIRONMENTAL FACTORS

EPA has determined that there are no other Key Environmental Factors relevant to the Proposal. All factors previously noted by the WA EPA as requiring assessment have been considered and included in this ERD, with the assessment of the factor Subterranean Fauna detailed within the Terrestrial Fauna Section (Section 6).

12 OFFSETS

Offsets are the last of the four steps in the mitigation hierarchy (Avoid, Minimise, Rehabilitate and Offset). They are only applied to counterbalance residual significant impacts when the other steps have already been applied to a Proposal.

Image has commissioned numerous environmental surveys and studies for the Proposal. Assessment of these surveys and research has enabled Image to determine key environmental values requiring protection at the Proposal, including significant fauna habitat, flora and vegetation, and areas of Aboriginal cultural value. Changes to the Proposal design have been made by Image to avoid and minimise significant impacts to the key environmental factors during Proposal construction and operations, and include a large reduction in the size of the Mine Development Envelope (511 ha reduction) and proposed Disturbance Footprint (78 ha reduction) to:

- Avoid:
  - Disturbance of areas of cultural concern identified in recent Aboriginal heritage surveys and consultation with the Yued People (Traditional Owners);
  - Disturbance of the Mt Jetty and Bibby Creek lines;
  - Disturbance of significant flora and fauna habitat;
- Minimise:
  - The extent of direct and indirect impacts to native vegetation including Banksia Woodlands TEC / PEC and Groundwater Dependant Ecosystems;
  - Impacts to Priority flora;
  - Impacts to Carnaby's Cockatoo foraging habitat;
  - Groundwater abstraction volumes and the extent of groundwater drawdown;
  - Emissions (air and greenhouse gas); and
  - Impacts to amenity through the reduction of local traffic from shift workers communing to site (24 hours/day).

The application of these avoidance and minimisation mechanisms in Proposal design and operations has meant that impacts to key environmental values have been significantly reduced. Image understands that this conclusion is in part based on studies, and as such monitoring has been committed to in order to verify the study outputs.

The WA Environmental Offsets Guidelines (EPA, 2014a) states:

> "In general, significant residual impacts include those that affect rare and endangered plants and animals (such as declared rare flora and threatened species that are protected by statute), areas within the formal conservation reserve system, important environmental systems and species that are protected under international agreements (such as Ramsar listed wetlands) and areas that are already defined as being critically impacted in a cumulative context. Impacts may also be significant if, for example, they could cause plants or animals to become rare or endangered, or they affect vegetation which provides important ecological functions".

12.1 Summary of Significant Residual Impacts

The assessments conducted in Sections 5 – 11 have utilised the findings of the numerous surveys and studies completed for the Proposal. Image has assessed the residual impacts of the Proposal against the residual impact significance model provided in the WA Environmental Offsets Guidelines (EPA, 2014a). The findings of this assessment are provided in Table 68.

Two residual impacts were determined likely to remain significant after the implementation of proposed avoidance, minimisation and rehabilitation measures;

1. The disturbance of Banksia Woodlands TEC / PEC; and
2. The disturbance of Carnaby's Cockatoo foraging habitat.

The extent of these impacts is detailed in the sections below.

Banksia Woodlands of the Swan Coastal Plain TEC / PEC

As previously noted, two vegetation units identified during flora surveys at the Proposal meet the criteria to be characterised as Banksia Woodlands TEC / PEC. The *Banksia* woodlands were mostly continuous over a large area of sand plain but occurred in smaller 'patches' amongst and around the floodplain area.

The residual impacts to Banksia Woodlands TEC / PEC are considered to remain significant, despite the avoidance, minimisation and rehabilitation measures proposed. Rehabilitation methods are relatively well-established for Banksia woodlands, however Image acknowledges the effort and complexity involved with achieving the desired outcomes of re-establishing a functional and sustainable ecological community, and that success cannot be guaranteed. The conservative position is therefore that the residual impacts associated with the disturbance to the Banksia Woodlands TEC / PEC is considered to be significant given the conservation status of this ecological community, and the cumulative losses of this TEC / PEC throughout the SCP.

Up to 218.83 ha of Proposal Banksia Woodlands TEC / PEC disturbance will be rehabilitated as the mining front progresses, or at the completion of the Proposal. The Proposal will therefore result in a loss of 218.83 ha of this ecological community for up to an estimated 15 years, until rehabilitated areas have qualities that align with this TEC / PEC (i.e. up to five years of construction and operations, and an estimated ten years of rehabilitation). After this period the community will not be of the same quality, however the quality is predicted to improve gradually over time.

A small area (0.05 ha) is likely to remain cleared permanently as it will form part of the Bibby Road / Brand Highway intersection.

The residual impacts are therefore predicted to be:

- A loss of 218.83 ha of predominantly Excellent - Pristine quality Banksia Woodlands TEC / PEC for a period of 11 - 15 years;
- A permanent loss of 0.05 ha of Good to Excellent quality Banksia Woodlands TEC / PEC; and
- A reduction in the quality of 218.83 ha of the Banksia Woodlands TEC / PEC after rehabilitation (in comparison to pre-mining quality).

Carnaby's Cockatoo Foraging Habitat

Carnaby's Cockatoo was recorded in the survey areas and is listed as Endangered under the EPBC Act and BC Act. It is primarily threatened by the loss and fragmentation of breeding and foraging habitat as a result of vegetation clearing (EPA, 2019). While no Carnaby's Cockatoo breeding trees were identified, the majority of the development envelopes was identified as containing very high quality foraging habitat for this species. After the implementation of avoidance, minimisation and rehabilitation mitigation measures, the residual impacts to Carnaby's Cockatoo foraging habitat, summarised as: Loss of up to 289 ha of very high value Carnaby's Cockatoo foraging habitat for a period of 15 years (up to five years construction and operation plus ten years before rehabilitation is suitable for foraging by Carnaby's Cockatoo).

Table 68: Assessment against residual impact significance model

Relevant Part IV Environmental Factors	Vegetation and Flora						
					Terrestrial Fauna		
Part V Clearing Principles	**c -** Rare flora	**d -** TECs	**e -** Remnant vegetation	**f -** Wetlands and waterways	**h -** Conservation areas	**a -** High biological diversity	**b -** Habitat for fauna
Residual impact that is environmentally unacceptable and cannot be offset	No residual impacts are considered to meet these criteria						
Significant residual impacts that will require an offset – *all significant residual impacts to species and ecosystems are protected by statute or where the cumulative impact is already at a critical level*	No residual impacts are considered to meet these criteria: • No Threatened Flora records are located within the survey areas • Impacts to Priority Flora are not considered significant	Residual impacts to Banksia Woodlands TEC / PEC are considered likely to meet these criteria. The residual impacts are predicted to be: • A loss of 218.83 ha of predominantly Excellent - Pristine quality Banksia Woodlands TEC / PEC for a period of 11 - 15 years; • A permanent loss of 0.05 ha of Good to Excellent quality Banksia Woodlands TEC / PEC; and A reduction in the quality of 218.83 ha of the Banksia Woodlands TEC / PEC after rehabilitation (in comparison to pre-mining quality).	No residual impacts are considered to meet these criteria – all remaining vegetation have 65% or more of their pre-European extent remaining and impacts will be 0.4% of vegetation association 1030	No residual impacts are considered to meet these criteria as no wetlands or waterways that are protected by statute lie within the development envelopes or would be indirectly impacted by the Proposal	No residual impacts are considered to meet these criteria as no conservation areas that are protected by statute lie within the development envelopes or would be indirectly impacted by the Proposal	No residual impacts are considered to meet these criteria. Locally significant vegetation is known to have high diversity, however the residual impacts on these areas are not considered significant given the area of intact habitat that will remain outside the development envelopes	Residual impacts to Carnaby's Cockatoo foraging habitat are considered likely to meet these criteria. The residual impacts are predicted to be: Loss of up to 289 ha of very high value Carnaby's Cockatoo foraging habitat for a period of 15 years.
Significant residual impacts that may require an offset – *any significant residual impacts to potentially threatened species and ecosystems, areas of high environmental value or where the cumulative impact may reach critical levels if not managed*	No residual impacts are considered to meet these criteria – refer above	No other residual impacts are considered to meet these criteria – refer above	No residual impacts are considered to meet these criteria – refer above	No residual impacts are considered to meet these criteria – refer above	No residual impacts are considered to meet these criteria – refer above	No residual impacts are considered to meet these criteria – refer above	No other residual impacts are considered to meet these criteria – refer above
Residual impacts that are not significant	No Threatened Flora listed under the EPBC Act or BC Act were recorded in the development envelopes. Twenty Priority Flora species were recorded within the Proposal development envelopes (Table 19). Of these, nine had a large proportion of their local records that were located outside the development envelopes and therefore impacts were not considered significant: 1. 76% of *Grevillea thelemanniana* subsp. Cooljarloo (BJ Keighery 28B) (P1); 2. 87% of *Calectasia palustris* (P2); 3. 89% of *Chordifex reseminans* (P2); 4. 85% of *Angianthus micropodioides* (P3); 5. 91% of *Babingtonia urbana* (P3); 6. 98% of *Desmocladus nodatus* (formerly *Onychosepalum nodatum*) (P3); 7. 86% of *Isopogon panduratus* subsp. *palustris* (P3); 8. 86% of *Schoenus pennisetis* (P3); and 9. 73% of *Thysanotus glaucus* (P4). Four Priority Flora species, returned a relatively low number of records within the	No other residual impacts are considered to meet this criteria – refer above	Clearing of 318 ha of general remnant vegetation is not considered to be a significant residual impact (noting other associated values are discussed separately in this table)	Indirect impacts to wetland and waterways are not considered to be a significant residual impact	No residual impacts are considered to meet these criteria or any other criteria above	Residual impacts on vegetated areas are not considered significant given the area of intact habitat that will remain outside the development envelopes	Fauna habitats in the Proposal area are well represented locally and regionally and do not support species that are considered restricted to the area.

	development envelopes when compared to the number of regional records: 1. *Acacia benthamii* (P2); 2. *Anigozanthos humilis* subsp. *chrysanthus* (P4); 3. *Conostylis pauciflora* subsp. *euryrhipis* (P4); and 4. Schoenus *griffinianus* (P4). Eight Priority Flora species had larger proportions of total records within the study area: *1. Levenhookia preissii* (P1); *2. Schoenus badius* (P2); *3. Conospermum scaposum* (P3); *4. Hensmania stoniella* (P3); *5. Jacksonia carduacea* (P3); *6. Eryngium pinnatifidum* subsp. Palustre (G. J. Keighery 13459) (P3); *7. Stylidium aceratum* (P3); and *8. Stylidium longitubum* (P4). Based on the individual assessments of these species in Section 5.5.2 the Proposal is unlikely to significantly impact the regional extent of these species but local impacts are likely and will require mitigation. In summary, no significant residual direct, indirect or cumulative impacts to significant flora are anticipated as a result of the Proposal. Potential impacts to significant flora (Priority flora species) will be avoided and minimised through implementation of the Final Infrastructure Design Plan.						

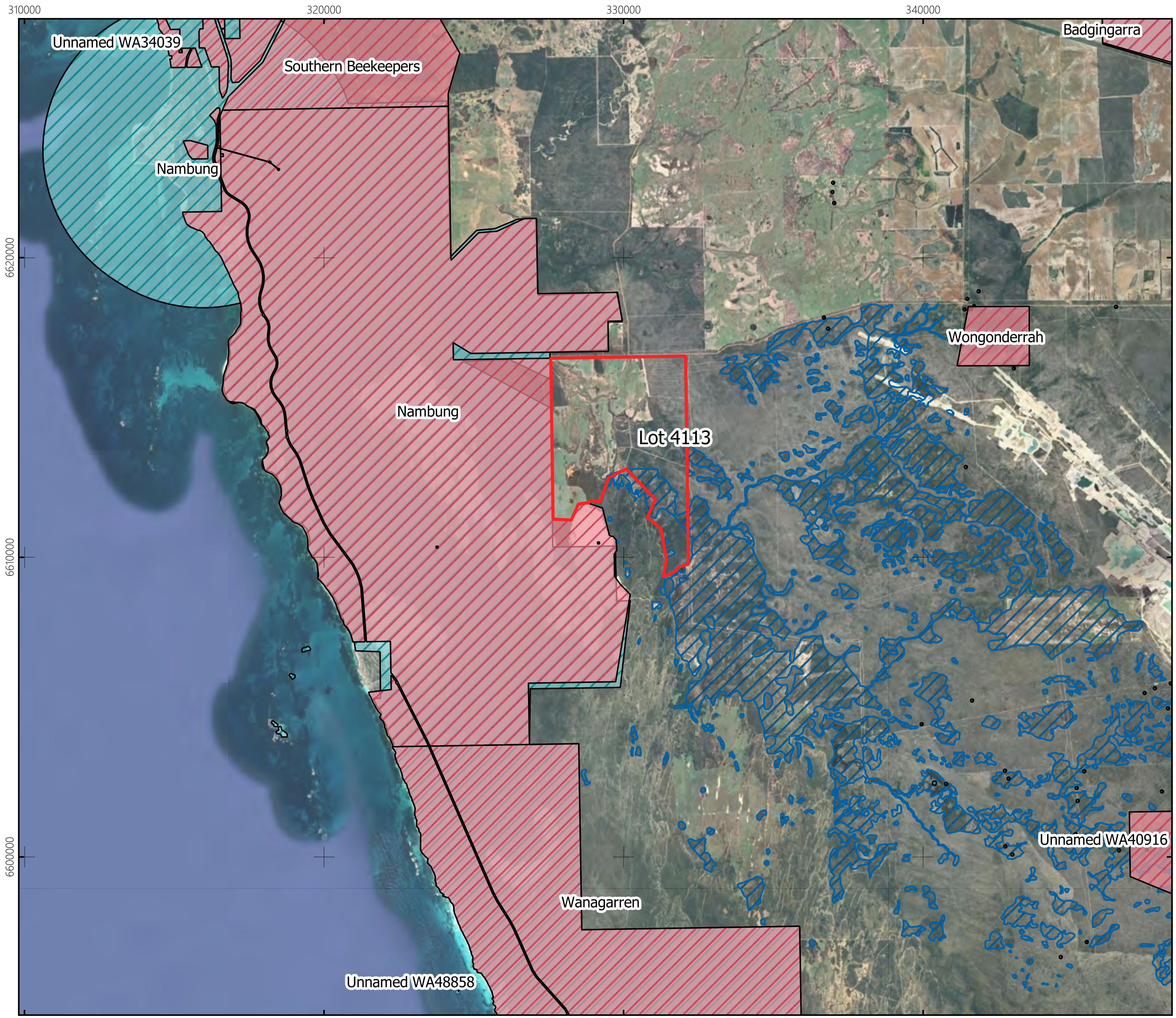
12.2 DETAILS OF PROPOSED OFFSETS – OPTION 1

To counterbalance the residual impact of the Proposal, Image is currently presenting two options. The final option will be determined pending detailed consultation and ecological and economic consideration. For Option 1 Image proposes to conserve and actively manage two properties that contain the impacted values:

- Lot number 4113, located immediately south of the Proposal MDE, on the opposite side of Wongonderrah Road (Figure 122); and
- Lot number 501, located approximately 75 km south east of the Proposal, on the eastern boundary of Moore River National Park and approximately 15 km south of Regans Ford (Figure 123).

Spectrum (2022a; Appendix 10) conducted surveys of Lots 4133 and 501 to determine the offset values of both properties with regards to Carnaby's Cockatoo foraging habitat and presence and condition of the Banksia Woodlands TEC / PEC.

Both properties were identified as containing excellent quality Banksia Woodland TEC / PEC vegetation, connectivity with adjoining remnant vegetation and conservation estate, a scarcity of weeds, and lack of evidence of *Phytophthora cinnamomi* adding value to the TEC. High quality Carnaby's Cockatoo foraging habitat was also identified at both sites, and potential breeding trees were identified at Lot 501. A summary of the offset values assessment is provided in the sections below, and is sourced from Spectrum (2022a) unless otherwise referenced.



Legend

- Survey Area - Lot 4113
- Principal Road
- Secondary Road
- Directory of Important Wetlands
- Environmentally Sensitive Areas - DWER 2019
- Conservation Estates

N

0 1.5 3 4.5 6 km

Scale 1:175,000 @ A4

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum ECOLOGY • SPATIAL

Author: NP Date: 06-08-2021

Location of the Survey Areas - Lot 4113

Atlas Project - Offset Property Assessment

Figure 122: Location of proposed Lot 4133 offset site

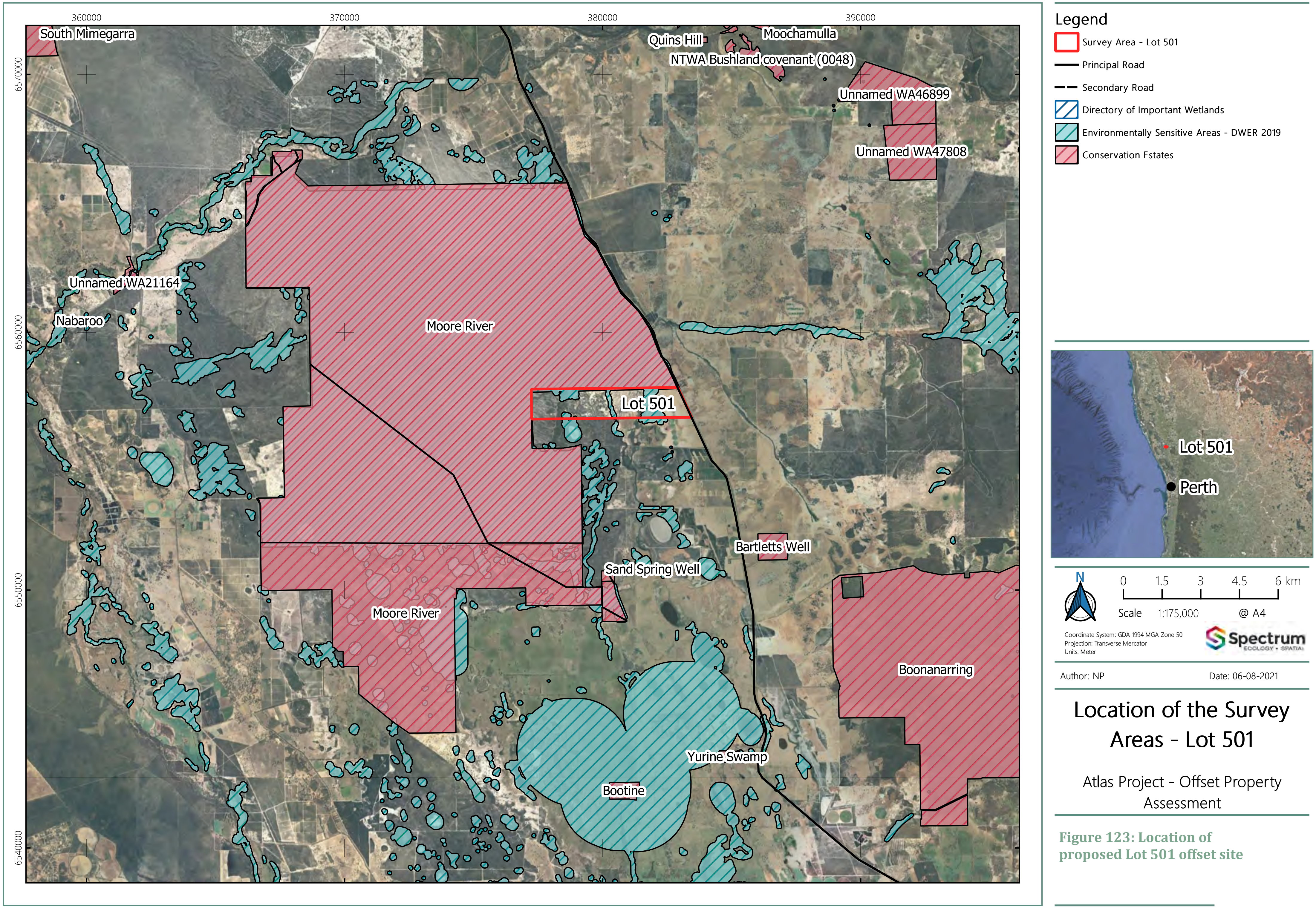


Figure 123: Location of proposed Lot 501 offset site

12.2.1 Values and Quality of the Offset Sites

Vegetation condition

Lot 4133

The Banksia Woodlands TEC / PEC was confirmed across much of the eastern half of Lot 4113 with a mapped extent of 615.05 ha (26.6% of the Survey Area). Another 26.68 ha (1.1% of the Survey Area) was inferred to be Banksia Woodlands TEC / PEC based on aerial mapping however this area was inaccessible during the survey period due to flooded tracks.

Banksia Woodlands TEC / PEC vegetation was identified as in Excellent condition with vegetation structure intact throughout according to the criteria described in EPBC Act *(s 266B) Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community* (DotEE, 2016d). Banksia Woodlands TEC / PEC at the property was identified to directly connect to remnant native vegetation to the north, east and south of the property and Nambung National Park to the west.

Disturbance identified included exploration tracks, and some weed incursion on the western perimeter bordering cleared agricultural land, however this incursion was considered low by a non-aggressive weed species. A small patch was assessed to be in a Good condition due to the loss of vegetation structure from clearing and grazing, and a high presence of weeds. Evidence of Banksia Woodlands recruitment was found in historical exploration tracks. There was no evidence of *Phytophthora cinnamomi* observed on the property.

Banksia Woodlands TEC / PEC mapped at Lot 4113 is shown in Figure 124.

Lot 501

Banksia Woodlands TEC / PEC was mapped to an extent of 175.56 ha, equating to 25.4% of the property. The vegetation was assessed to be in an Excellent condition with vegetation structure intact throughout, direct connectivity to remnant vegetation to the north, west and south of the property including Moore River National Park to the north and west, evidence of recruitment in historically cleared areas, a scarcity of weeds and absence of evidence of *Phytophthora cinnamomi*.

Disturbance at Lot 501 included tracks, historic clearing on the eastern ends of the TEC (noted to be regenerating) and grazing by goats.

Banksia Woodlands TEC / PEC mapped at Lot 501 is shown in Figure 125.

Foraging Values

Lot 4113

The Spectrum (2022a) assessment of Banksia Woodlands and heath identified a total of 937.65 ha of Carnaby's Cockatoo foraging habitat, representing 40.5% of Lot 4133 (Figure 126). Evidence of Carnaby's Cockatoo foraging activities was recorded under *Banksia prionotes, B. sphaerocarpa, B. menziesii* and *B. ilicifolia* trees throughout foraging habitat, however no evidence was identified in cleared paddocks, samphire wetlands and drainage lines where these *Banksia* species weren't located.

There were no potential breeding trees recorded within Lot 4133. Introduced pine trees recorded along the driveway and in a stand in the centre of the property may provide night roosting habitat. Flocks of Carnaby's Cockatoos numbering between two and 34 were regularly observed flying over the Survey Area.

The identified habitat for the Carnaby's Cockatoo was assessed as follows:

- Starting score:
    - 7 (high quality) Banksia woodland and heath habitat dominated by proteaceous plant species including *Banksia attenuata, B. menziesii, B. prionotes, B. ilicifolia, B. sphaerocarpa,* and *Hakea triacantha.*
- Additions:
    - +3 is within the Swan Coastal Plain.
- Subtractions:
    - -1 is >12 km from a known breeding location; and
    - -1 is >12 km from a known roosting location.

The overall scoring of the habitat for the Carnaby's Cockatoo has therefore been rated as eight (high quality) based on the above criteria.

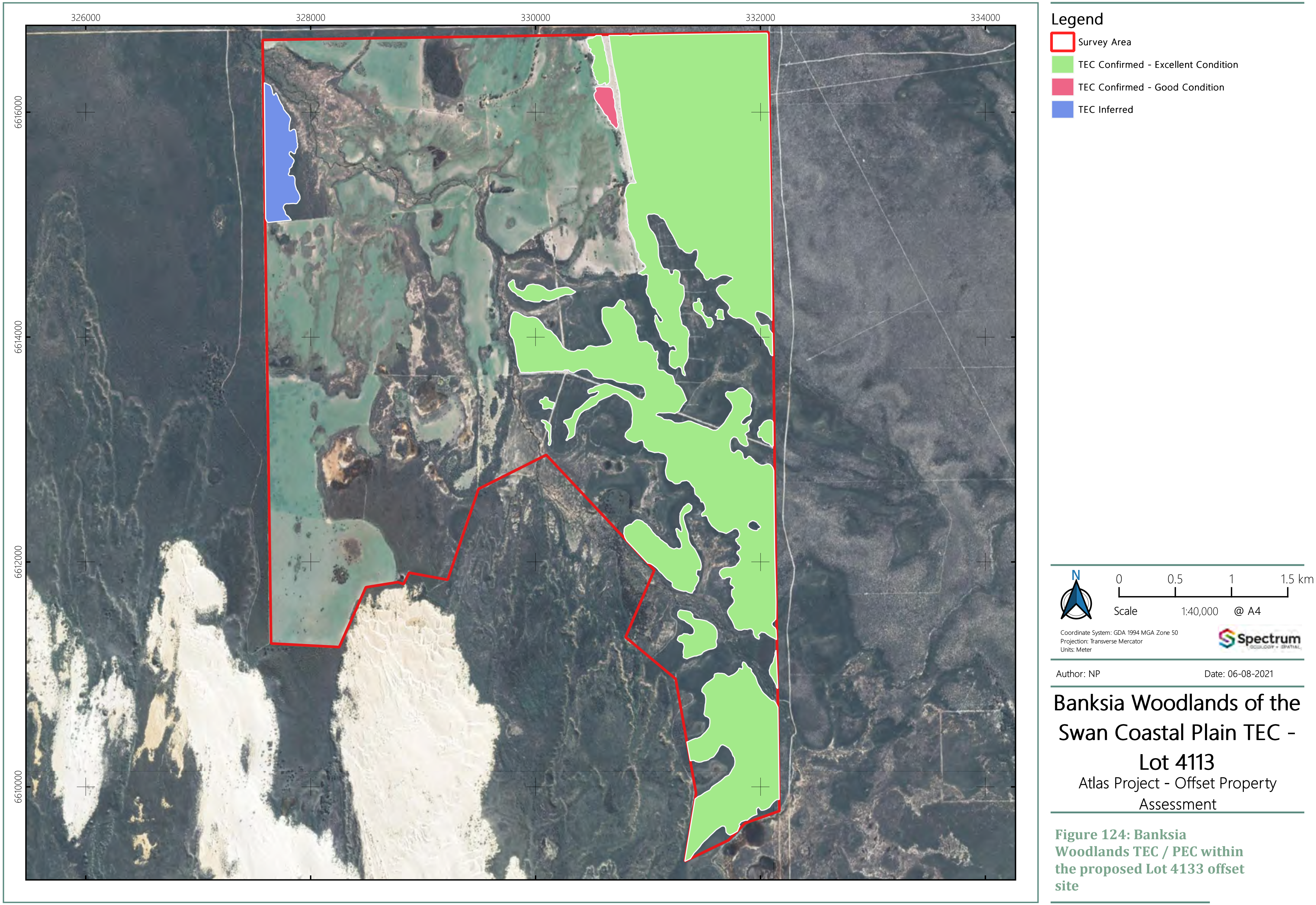
Lot 501

Native Banksia woodlands, open *Corymbia calophylla/Eucalyptus todtiana* woodland and heath in the west of the Lot 501 were identified as suitable foraging habitat for Carnaby's Cockatoo, resulting in a mapped extent of 467.96 ha or 67.7% of the property. Five Marri trees were identified as potential breeding trees (DBH >500 mm) however no suitable nesting hollows were observed (although one tree contained small hollows which may develop into suitable nesting hollows in the future). Pairs of Carnaby's Cockatoos were observed flying over the Survey Area on two occasions.

The identified habitat for the Carnaby's Cockatoo was assessed as follows:

- Starting score:
    - 7 (high quality) being Banksia woodland habitat that dominated by proteaceous species including *Banksia attenuata, B. menziesii, B. prionotes, B. ilicifolia, B. telmatiaea, B. littoralis, Hakea triacantha, H varia* and *H. lissocarpha.* Native eucalypts including *Corymbia calophylla* and *Eucalyptus todtiana* were abundant.
- Additions:
    - +3 is within the Swan Coastal Plain.
- Subtractions:
    - -1 is >12 km from a known roosting location.

The overall scoring of the habitat for the Carnaby's Cockatoo has therefore been rated as nine (high quality) based on the above criteria. The extent of Carnaby's Cockatoo foraging habitat within the Offset Area is shown in Figure 127.



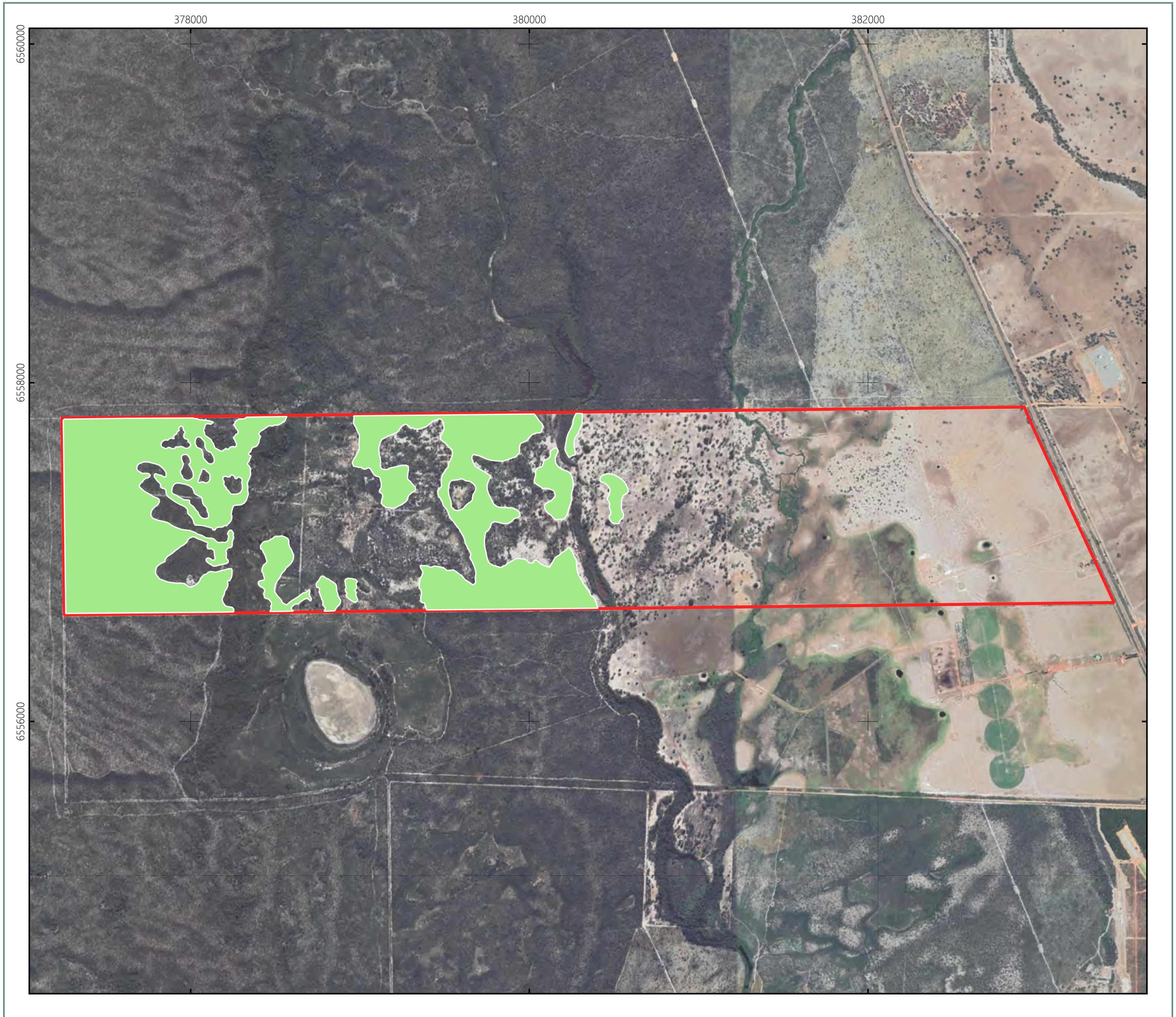
Author: NP

Date: 06-08-2021

Banksia Woodlands of the Swan Coastal Plain TEC - Lot 4113

Atlas Project - Offset Property Assessment

Figure 124: Banksia Woodlands TEC / PEC within the proposed Lot 4133 offset site



Legend

Survey Area

TEC Confirmed - Excellent Condition

N

0 0.3 0.6 0.9 km

Scale 1:30,000 @ A4

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum

Author: NP

Date: 06-08-2021

Banksia Woodlands of the Swan Coastal Plain TEC - Lot 501

Atlas Project - Offset Property Assessment

Figure 125: Banksia Woodlands TEC / PEC within the proposed Lot 501 offset site

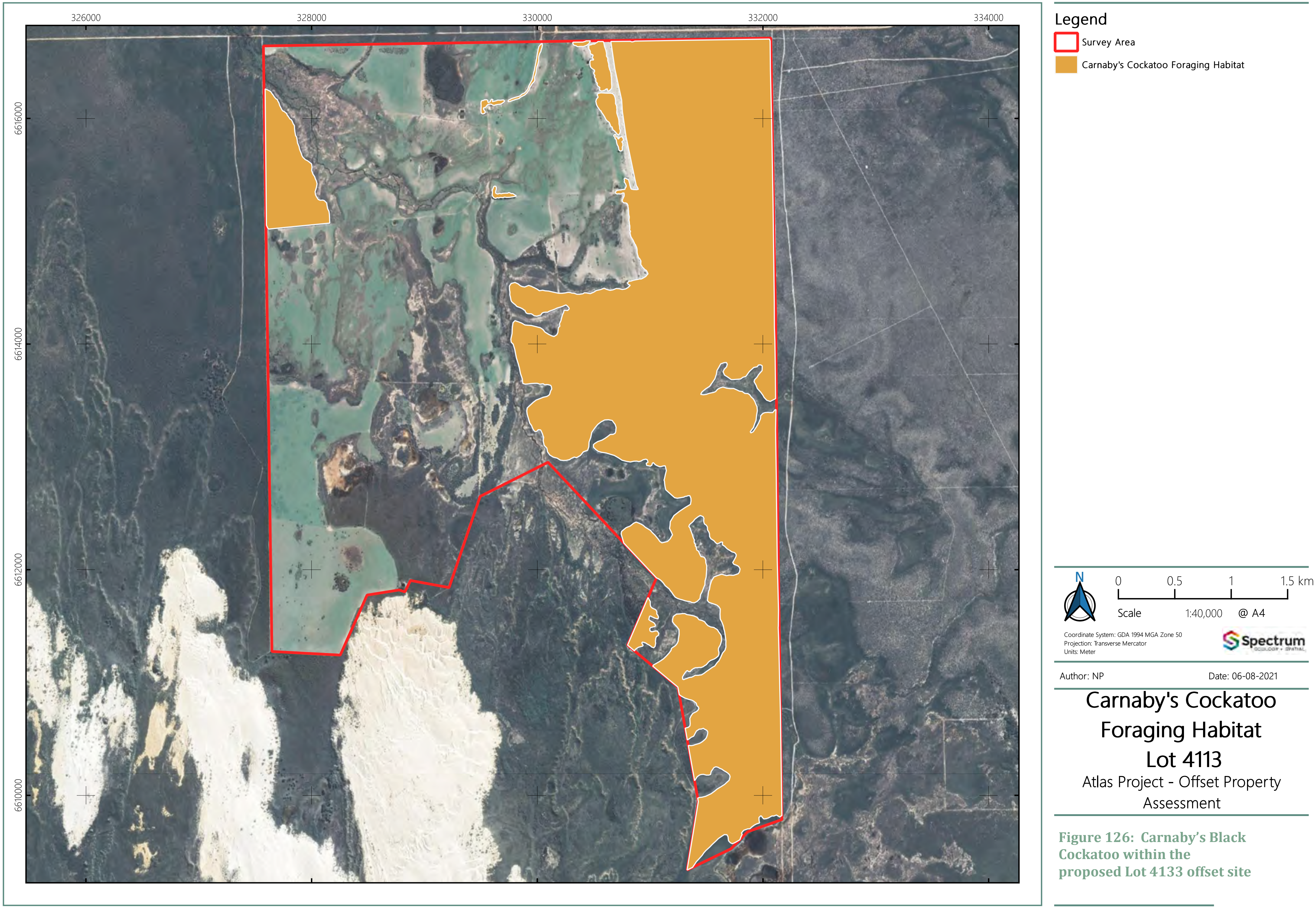
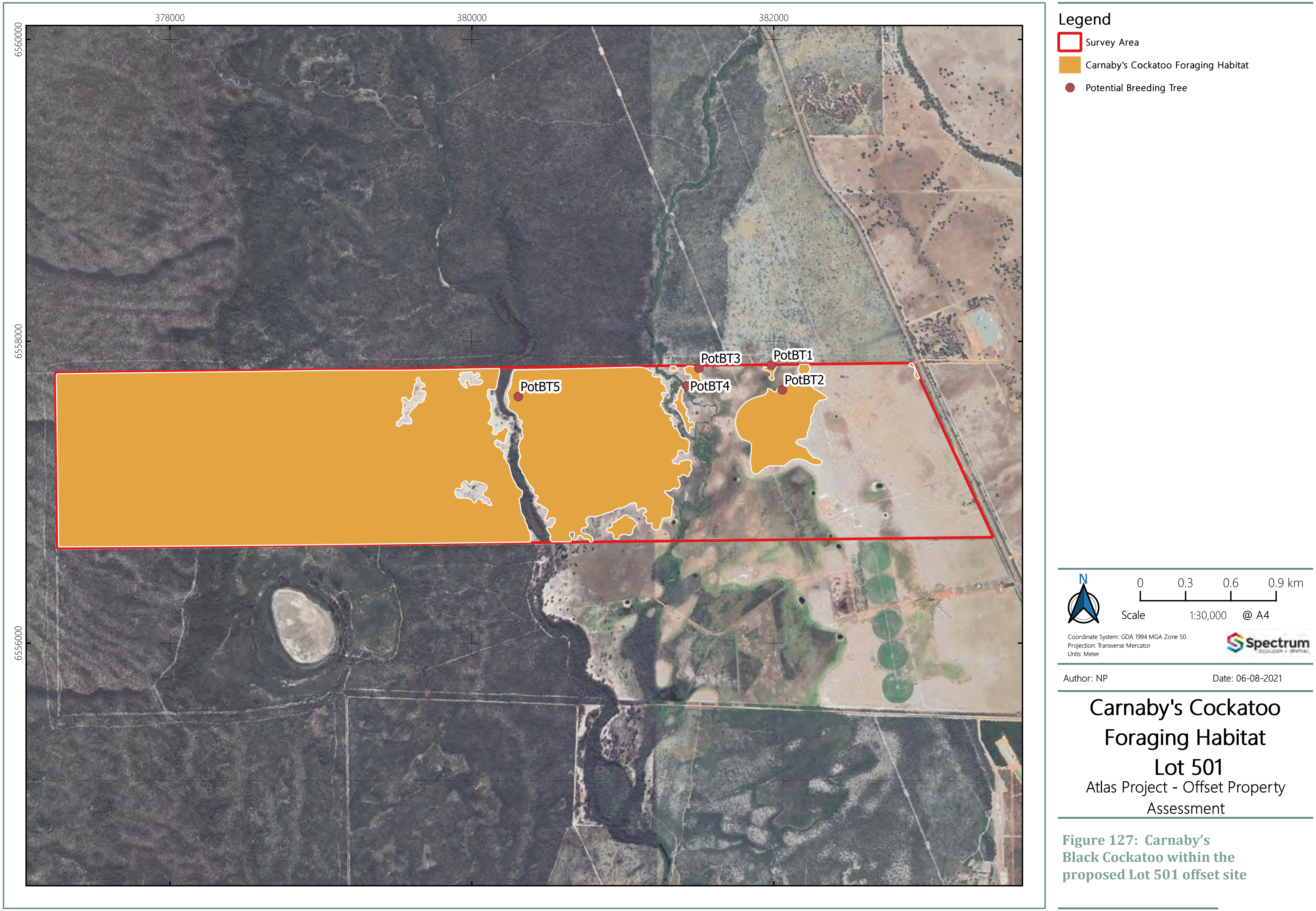


Figure 126: Carnaby's Black Cockatoo within the proposed Lot 4133 offset site



Author: NP

Date: 06-08-2021

Carnaby's Cockatoo Foraging Habitat Lot 501

Atlas Project - Offset Property Assessment

Figure 127: Carnaby's Black Cockatoo within the proposed Lot 501 offset site

12.2.2 Management of Offset Sites

Image proposed to protect and maintain the entire mapped extents of Banksia Woodlands TEC / PEC and Carnaby's Cockatoo foraging habitat across both sites to offset the residual impacts of the Proposal. The combined offset properties will therefore include:

- 817.29 ha of Excellent quality Banksia Woodlands TEC / PEC (641.73 ha at Lot 4113 and 175.56 ha at Lot 501); and
- 1,405.6 ha of High quality Carnaby's Cockatoo foraging habitat (937.65 ha at Lot 4113 and 467.96 ha at Lot 501).

Offsets include protection and maintenance activities to maintain (and potentially improve) the condition of the native vegetation and reduce the risk of potential degradation and loss. Protection and maintenance activities proposed include but are not limited to:

1. Demarcation of the offset sites;
2. Access restrictions into vegetated areas to minimise damage from off-road vehicles;
3. Erection of signs to identify the boundaries of the offset sites;
4. Regular monitoring for signs of weed propagation, spread of dieback and changes in vegetation condition and foraging value;
5. Removal / treatment of weeds and treatment of dieback affected areas (if present);
6. Implementing the DMP (Appendix 7);
7. Regular monitoring for signs of feral animals (including Fox, Cat, Dog, Pig, Rabbit); and
8. Feral animal trapping and management with a particular focus on Foxes and Cats.

Implementation of the management mechanisms listed above is expected to protect the offset sites from any impacts that may lower the quality of the Banksia Woodlands TEC / PEC or the foraging value to Carnaby's Cockatoo and ensure that the offset values are available in the long-term. The protection mechanisms listed above may have the added benefit of reducing predator numbers and improving the quality of foraging habitat.

12.2.3 Protection of Offset Site

Image is proposing to use both Lots 4133 and 501 for the long-term preservation of 817 ha of Banksia Woodlands TEC / PEC, 1,405.6 ha of Carnaby's Cockatoo foraging habitat and up to 37 ha of revegetated Banksia Woodlands TEC / PEC. Image will work with DBCA, DCCEEW and EPA Services to determine the most appropriate method of providing long-term conservation protection for the offset sites.

Management of the offset sites is proposed to be undertaken for a minimum of 20 years. Image intends to either fund DBCA to undertake this work or engage an experienced landcare contractor.

12.2.4 Summary Table

Table 69 describes the measures proposed to offset the residual impacts to Banksia Woodlands TEC / PEC and Carnaby's Cockatoo foraging habitat.

Table 69: Proposed offsets summary

Objective & intended outcome	Offset actions	Details	Success criteria	Governance / Responsibilities	Timing	Risks and contingency measures	Monitoring	Reporting
To counterbalance the significant residual impacts to 236.2 ha of Banksia Woodlands TEC / PEC	Protect and maintain 817 ha of Excellent condition Banksia Woodlands TEC / PEC within the offset sites	Image is proposing to use long-term land conservation to offset the residual impact to up to 236.2 ha of Banksia Woodlands TEC / PEC, by protecting and maintaining 817 ha of Excellent quality Banksia Woodlands TEC / PEC at Lots 4113 and 501 for a minimum of 20 years. Image will manage and pay costs for the maintenance and protection of the proposed offset commensurate with the protection mechanisms in Section 12.2.2. The offset would adequately offset the impacts associated with the loss of availability of up to 225 ha of Banksia Woodlands TEC / PEC (Section 12.5) Image intends to pay costs to DBCA or commission experienced contractors to complete the work with direction and advice from Image ecological consultants. The size of the Offset Area has been calculated based on the vegetation quality of the chosen offset sites, in order to satisfy the minimum 90% offset criteria within DSEWPaC (2012a; Appendix 34) and 100% offset criteria in DWER (2021b; Appendix 33).	817 ha of Excellent Banksia Woodlands TEC / PEC protected and maintained that would satisfy the minimum 100% offset criteria in DWER (2021c) and almost satisfy the minimum 90% offset criteria in DSEWPaC (2012a). Initial and ongoing management works are completed in accordance with Section 12.2.2. Banksia Woodlands TEC / PEC is maintained or improved at Lots 4113 and 501.	Image: • Preservation of offset sites • Funding of upfront and ongoing management costs for preservation • Ultimate responsibility for the conservation of the environmental values of the offset sites Environment Manager: • Overseeing the monitoring, management and reporting on the status of environmental values of the offset sites Site Manager: • Onsite implementation of the protection and management mechanisms Technical Officers: • Carrying out routine monitoring and management of the offset sites	Offset established and initial management costs provided within 12 months of implementation of the Proposal. Ongoing management for a minimum of 20 years.	Dieback: • Restriction of access • Education of contractors carrying out firebreak and fencing maintenance • Application of Phosphite to affected vegetation (or other methods in consultation with DBCA) Weeds: • Targeted control of high impact weed species that may be present or may become established • Weed hygiene controls during site management and firebreak and fencing maintenance Grazing and feral animals: • Monitor current use • Targeted control of high impact feral animal species if required Unauthorised access (rubbish dumping, timber cutting, 4WD): • Installation of fences where appropriate around the vegetation to restrict all off-road vehicle access (including bikes)	Annual monitoring to confirm offset values are being protected. Weed, dieback, boundary and firebreak monitoring / inspections every three months (i.e. weed infestations, feral animal use, fence lines, firebreaks, dieback).	Initial report of management actions completed prior to implementation. Annual report of management actions and monitoring results.
To counterbalance the significant residual impacts to 289 ha of high-value Carnaby's Cockatoo foraging habitat	Protect and maintain 1,405.6 ha of high value Carnaby's Cockatoo foraging habitat within the Offset Area	Image is proposing to use a long-term land conservation offset to offset the residual impact to up to 289 ha of high-value Carnaby's Cockatoo foraging habitat, by protecting and maintaining 1,405.61 ha of high quality Cockatoo foraging habitat at Lots 4113 and 501 for a minimum of 20 years. Image will manage and pay costs for the maintenance and protection of the proposed offset commensurate with the protection mechanisms in Section 12.2.2. The offset would adequately offset the impacts associated with the loss of availability of 289 ha of Cockatoo foraging habitat (Section 12.5) Image intends to pay costs to DBCA or commission experienced contractors to complete the work with direction and advice from Image ecological consultants. The size of the Offset Area has been calculated based on the vegetation quality of the chosen offset sites, in order to satisfy the minimum 90% offset criteria within DSEWPaC (2012a; Appendix 34) and minimum 100% offset criteria within DWER (2021c; Appendix 33).	1,405.61 ha of high value Carnaby's Cockatoo foraging habitat protected and maintained that would satisfy the minimum 90% offset criteria within DSEWPaC (2012a; Appendix 34) and minimum 100% offset criteria within DWER (2021c; Appendix 33). Initial and ongoing management works are completed in accordance with Section 12.2.2. Carnaby's Cockatoo foraging habitat values are maintained or improved at Lots 4113 and 501.	Image: • Preservation of offset sites • Funding of upfront and ongoing management costs for preservation • Ultimate responsibility for the conservation of the environmental values of the offset sites Environment Manager: • Overseeing the monitoring, management and reporting on the status of environmental values of the offset sites Site Manager: • Onsite implementation of the protection and management mechanisms Technical Officers: • Carrying out routine monitoring and management of the offset sites	Offset established and initial management costs provided within 12 months of implementation of the Proposal. Ongoing management for a minimum of 20 years.	Dieback: • Restriction of access • Education of contractors carrying out firebreak and fencing maintenance • Application of Phosphite to affected vegetation (or other methods in consultation with DBCA) Weeds: • Targeted control of high impact weed species that may be present or may become established • Weed hygiene controls during site management and firebreak and fencing maintenance Grazing and feral animals: • Monitor current use • Targeted control of high impact feral animal species if required Unauthorised access (rubbish dumping, timber cutting, 4WD): • Installation of fences where appropriate around the vegetation to restrict all off-road vehicle access (including bikes)	Annual monitoring to confirm offset values are being protected. Weed, dieback, boundary and firebreak monitoring / inspections every three months (i.e. weed infestations, feral animal use, fence lines, firebreaks, dieback). Annual monitoring of foraging use of the site Carnaby's Cockatoo.	Initial report of management actions completed prior to implementation. Annual report of management actions and monitoring results.

12.3 Details of Proposed Offsets – Option 2

To counterbalance the residual impact of the Proposal, Image is currently presenting two options. The final option will be determined pending detailed consultation and ecological and economic consideration. For Option 2 Image proposes to conserve and actively manage one property that contains the impacted values:

- Lot number 4113, located immediately south of the Proposal MDE, on the opposite side of Wongonderrah Road (Figure 122).

As discussed in Section 12.5, the proposed offset site is sufficient to offset the residual impacts of 175 ha of the maximum 236.2 ha of Banksia Woodlands TEC / PEC proposed to be disturbed (noting the TEC / PEC is the limiting factor when determining the offset value of this site). Image intends to review the required clearing of Banksia Woodlands TEC / PEC during detailed mine design to attempt to limit the clearing to the minimum required. Up to 200 ha of Banksia Woodland TEC / PEC revegetation is proposed across suitable areas of the offset site to account for any shortfalls. The area of revegetation will be proportional to the area of any disturbance above 175 ha, using the DSEWPaC (2012a) calculator provided in Appendix 34.

Spectrum (2022a; Appendix 10) conducted a survey of Lot 4133 to determine the offset values of both properties with regards to Carnaby's Cockatoo foraging habitat and presence and condition of the Banksia Woodlands TEC / PEC.

The property was identified as containing excellent quality Banksia Woodland TEC / PEC vegetation, connectivity with adjoining remnant vegetation and conservation estate, a scarcity of weeds, and lack of evidence of *Phytophthora cinnamomi* adding value to the TEC. High quality Carnaby's Cockatoo foraging habitat was also identified. A summary of the offset values assessment is provided in Section 12.2.1, and is sourced from Spectrum (2022a) unless otherwise referenced.

12.3.1 Management of Offset Site

Image proposed to protect and maintain the entire mapped extents of Banksia Woodlands TEC / PEC and Carnaby's Cockatoo foraging habitat across the site to offset the residual impacts of the Proposal. The offset property will therefore include:

- 641.73 ha of Excellent quality Banksia Woodlands TEC / PEC; and
- 937.65 ha of High quality Carnaby's Cockatoo foraging habitat.

Offsets include protection and maintenance activities to maintain (and potentially improve) the condition of the native vegetation and reduce the risk of potential degradation and loss. Protection and maintenance activities proposed include but are not limited to:

1. Demarcation of the offset site;
2. Access restrictions into vegetated areas to minimise damage from off-road vehicles;
3. Erection of signs to identify the boundaries of the offset site;
4. Regular monitoring for signs of weed propagation, spread of dieback and changes in vegetation condition and foraging value;
5. Removal / treatment of weeds and treatment of dieback affected areas (if present);
6. Implementing the DMP (Appendix 7);

7. Regular monitoring for signs of feral animals (including Fox, Cat, Dog, Pig, Rabbit); and
8. Feral animal trapping and management with a particular focus on Foxes and Cats.

Implementation of the management mechanisms listed above is expected to protect the offset site from any impacts that may lower the quality of the Banksia Woodlands TEC / PEC or the foraging value to Carnaby's Cockatoo and ensure that the offset values are available in the long-term. The protection mechanisms listed above may have the added benefit of reducing predator numbers and improving the quality of foraging habitat.

12.3.2 Protection of Offset Site

Image is proposing to use Lot 4133 for the long-term preservation of 641.73 ha of Banksia Woodlands TEC / PEC, 937.65 ha of Carnaby's Cockatoo foraging habitat and up to 200 ha of revegetated Banksia Woodlands TEC / PEC. Image will work with DBCA, DCCEEW and EPA Services to determine the most appropriate method of providing long-term conservation protection for the offset site.

Management of the offset sites is proposed to be undertaken for a minimum of 20 years. Image intends to either fund DBCA to undertake this work or engage an experienced landcare contractor.

12.3.3 Summary Table

Table 69 describes the measures proposed to offset the residual impacts to Banksia Woodlands TEC / PEC and Carnaby's Cockatoo foraging habitat.

Table 70: Proposed offsets summary

Objective & intended outcome	Offset actions	Details	Success criteria	Governance / Responsibilities	Timing	Risks and contingency measures	Monitoring	Reporting
To counterbalance the significant residual impacts to 175 ha of Banksia Woodlands TEC / PEC	Protect and maintain 641.73 ha of Excellent condition Banksia Woodlands TEC / PEC within the offset site	Image is proposing to use a long-term land conservation offset to offset the residual impact to up to 175 ha of Banksia Woodlands TEC / PEC, by protecting and maintaining 641.73 ha of Excellent quality Banksia Woodlands TEC / PEC at Lot 4113 for a minimum of 20 years. Image will manage and pay costs for the maintenance and protection of the proposed offset commensurate with the protection mechanisms in Section 12.2.2. The offset would adequately offset the impacts associated with the loss of availability of up to 175 ha of Banksia Woodlands TEC / PEC (Section 12.5) Image intends to pay costs to DBCA or commission experienced contractors to complete the work with direction and advice from Image ecological consultants. The size of the Offset Area has been calculated based on the vegetation quality of the chosen offset sites, in order to satisfy the minimum 90% offset criteria within DSEWPaC (2012a; Appendix 34) and DWER (2021c; Appendix 33).	641.73 ha of Excellent Banksia Woodlands TEC / PEC protected and maintained that would satisfy the minimum 90% offset criteria in DSEWPaC (2012a) and 100% offset criteria in DWER (2021c). Initial and ongoing management works are completed in accordance with Section 12.2.2. Banksia Woodlands TEC / PEC is maintained or improved at Lots 4113 and 501.	Image: • Preservation of offset sites • Funding of upfront and ongoing management costs for preservation • Ultimate responsibility for the conservation of the environmental values of the offset sites Environment Manager: • Overseeing the monitoring, management and reporting on the status of environmental values of the offset sites Site Manager: • Onsite implementation of the protection and management mechanisms Technical Officers: • Carrying out routine monitoring and management of the offset sites	Offset established and initial management costs provided within 12 months of implementation of the Proposal. Ongoing management for a minimum of 20 years.	Dieback: • Restriction of access • Education of contractors carrying out firebreak and fencing maintenance • Application of Phosphite to affected vegetation (or other methods in consultation with DBCA) Weeds: • Targeted control of high impact weed species that may be present or may become established • Weed hygiene controls during site management and firebreak and fencing maintenance Grazing and feral animals: • Monitor current use • Targeted control of high impact feral animal species if required Unauthorised access (rubbish dumping, timber cutting, 4WD): • Installation of fences where appropriate around the vegetation to restrict all off-road vehicle access (including bikes)	Annual monitoring to confirm offset values are being protected. Weed, dieback, boundary and firebreak monitoring / inspections every three months (i.e. weed infestations, feral animal use, fence lines, firebreaks, dieback).	Initial report of management actions completed prior to implementation. Annual report of management actions and monitoring results.
To counterbalance the significant residual impacts of up to 61.2 ha of Banksia Woodlands TEC / PEC	Revegetate 200 ha of Banksia Woodlands TEC / PEC within the offset sites	Image is proposing to use revegetation to offset the residual impact to up to 61.2 ha of Banksia Woodlands TEC / PEC, by revegetating currently cleared areas of Lot 4113 and monitoring / managing the revegetation for a minimum of 20 years. Image will manage and pay costs for the maintenance and protection of the proposed offset commensurate with the protection mechanisms in Section 12.2.2. The offset would adequately offset the impacts associated with the loss of availability of up to 61.2 ha of Banksia Woodlands TEC / PEC (Section 12.5) Image intends to commission experienced contractors to complete the work with direction and advice from DBCA and Image ecological consultants.	Image will be targeting to meet the 'Attributes of Restored Ecosystems' defined by Stevens *et al.,* 2016): 1. The restored ecosystem contains a characteristic assemblage of species that occur in the reference ecosystem and that provide appropriate community structure 2. The restored ecosystem consists of indigenous species to the greatest practical extent 3. All functional groups necessary for the continued development and / or stability of the restored ecosystem are represented, or if they are not, the missing groups have the potential to colonise by natural means 4. The physical environment of the restored ecosystem is capable of sustaining reproducing populations of the species necessary for its continued stability or development along the desired trajectory	As above	Revegetation commences within 24 months of implementation of the Proposal, assuming favourable climatic conditions. Ongoing management for a minimum of 20 years.	As above	Annual monitoring to confirm revegetation targets are being met. Revegetation, weed, dieback, boundary and firebreak monitoring / inspections every three months (i.e., growth criteria, weed infestations, feral animal use, fence lines, firebreaks, dieback).	Initial report of management actions completed prior to implementation. Annual report of management actions and monitoring results.

Objective & intended outcome	Offset actions	Details	Success criteria	Governance / Responsibilities	Timing	Risks and contingency measures	Monitoring	Reporting
		The size of the revegetation area has been calculated based on satisfying the minimum 90% offset criteria within DSEWPaC (2012a; Appendix 34) and DWER (2021c; Appendix 33).	5. The restored ecosystem apparently functions normally for its ecological stage of development, and there are no signs of dysfunction 6. The restored ecosystem is suitable integrated into a larger ecological matrix or landscape, with which it interacts through abiotic and biotic flows and exchanges 7. Potential threats to the health and integrity of the restored ecosystem from the surrounding landscape have been eliminated or reduced as much as practicable 8. The restored ecosystem is sufficiently resilient to endure the normal periodic stress events in the local environment that serve to maintain the integrity of the ecosystem 9. The restored ecosystem is self-sustaining to the same degree as its reference ecosystem and has the potential to persist indefinitely under existing environmental conditions					
To counterbalance the significant residual impacts to 289 ha of high-value Carnaby's Cockatoo foraging habitat	Protect and maintain 1,405.6 ha of high value Carnaby's Cockatoo foraging habitat within the Offset Area	Image is proposing to use a long-term land conservation offset to offset the residual impact to up to 289 ha of of high-value Carnaby's Cockatoo foraging habitat, by protecting and maintaining 1,405.61 ha of high quality Cockatoo foraging habitat at Lots 4113 and 501 for a minimum of 20 years. Image will manage and pay costs for the maintenance and protection of the proposed offset commensurate with the protection mechanisms in Section 12.2.2. The offset would adequately offset the impacts associated with the loss of availability of 289 ha of Cockatoo foraging habitat (Section 12.5) Image intends to pay costs to DBCA or commission experienced contractors to complete the work with direction and advice from Image ecological consultants. The size of the Offset Area has been calculated based on the vegetation quality of the chosen offset sites, in order to satisfy the minimum 90% offset criteria within DSEWPaC (2012a; Appendix 34) and 100% offset criteria in DWER (2021c; Appendix 33).	1,405.61 ha of high value Carnaby's Cockatoo foraging habitat protected and maintained that would satisfy the minimum 90% offset criteria in DSEWPaC (2012a) and 100% offset criteria in DWER (2021c). Initial and ongoing management works are completed in accordance with Section 12.2.2. Carnaby's Cockatoo foraging habitat values are maintained or improved at Lots 4113 and 501.	As above	Offset established and initial management costs provided within 12 months of implementation of the Proposal. Ongoing management for a minimum of 20 years.	As above	Annual monitoring to confirm offset values are being protected. Weed, dieback, boundary and firebreak monitoring / inspections every three months (i.e. weed infestations, feral animal use, fence lines, firebreaks, dieback). Annual monitoring of foraging use of the site Carnaby's Cockatoo.	Initial report of management actions completed prior to implementation. Annual report of management actions and monitoring results.

12.4 WA Offsets Template

Image has completed a WA Offsets Template as per the requirements of the WA Environmental Offsets Guideline (EPA, 2014a), provided in Table 71.

Table 71: WA offsets policy template

Existing Environment / Impact	Mitigation			Significant Residual Impact	Offset Calculation Methodology				
	Avoid and Minimise	Rehabilitation Type	Likely Rehabilitation Success		Type	Risk	Likely Offset Success	Time Lag	Offset Quantification
General flora and vegetation – Up to 318 ha of native vegetation clearing (292 ha within the MDE, and 26 ha in the EIDE). 126 ha of native vegetation cleared for the mine pit will be progressively rehabilitated during operations, and the remaining 192 ha is to be rehabilitated post-closure. Reduction in vegetation health due to indirect impacts	**Avoid** Development envelopes were revised to avoid: • 78 ha of native vegetation clearing • The Mt Jetty and Bibby Creek lines and associated riparian vegetation. **Minimise** • Implement industry best practice management measures for flora and vegetation • Implement the Rehabilitation Strategy • Implement preventive measures to minimise the risk and impact of hydrocarbon spills • Comply with Water Quality Protection Guidelines and guidance notes	126 ha of native vegetation cleared for the mine pit will be progressively rehabilitated during operations, and the remaining 192 ha is to be rehabilitated post-closure. Vegetation will be rehabilitated using traditional mine rehabilitation methods (with stripped topsoil and seeded with impacted species if required and suitable).	**Can the environmental values be rehabilitated / Evidence?** Yes, the values are predicted to be rehabilitated via respread of stockpiled topsoil and seed mix utilising best practice methods. **Operator experience in undertaking rehabilitation?** Image will utilise experienced operators to conduct the rehabilitation works, and given progressive rehabilitation is proposed this experience will improve further over the life of the Proposal **What is the type of vegetation being rehabilitated?** Low woodland or open low woodland: Other acacia, banksia, peppermint, cypress pine, casuarina, York gum *Acacia* spp., *Banksia* spp., *Agonis flexuosa*, *Callitris* spp., *Allocasuarina* spp., *Eucalyptus loxophleba*. **Time lag?** Up to two years for some species depending on rainfall events, up to ten years for some deeper-rooted species to become fully established **Credibility of the rehabilitation proposed (evidence of demonstrated success)** Credible, traditional mine rehabilitation methods are widely practised and there is clear evidence of demonstrated success.	No					
Priority Flora – Clearing of known individuals of 20 Priority Flora species. 126 ha of native vegetation cleared for the mine pit will be progressively rehabilitated during operations, and the remaining 192 ha is to be rehabilitated post-closure. Reduction in vegetation health due to indirect impacts	**Avoid** Development envelopes were revised to avoid: • *Grevillea sp. Cooljarloo* (B.J. Keighery 28 B) (P1) (1,284 individuals); • *Chordifex reseminans* (P2) (127 individuals); • *Angianthus micropodioides* (P3) (213,211 individuals); • *Babingtonia urbana* (P3) (133 individuals); • *Conospermum scaposum* (P3) (1,107 individuals); • *Desmocladus nodatus* (P3) (69 individuals); • *Eryngium pinnatifidum* subsp. Palustre (G.J. Keighery 13459) (P3) (459 individuals); • *Isopogon panduratus* subsp. *palustris* (P3) (1,643 individuals); • *Stylidium aceratum* (P3) (150 individuals); and	126 ha of native vegetation cleared for the mine pit will be progressively rehabilitated during operations, and the remaining 192 ha is to be rehabilitated post-closure. Vegetation will be rehabilitated using traditional mine rehabilitation methods (with stripped topsoil and seeded with impacted species if required and suitable).	**Can the environmental values be rehabilitated / Evidence?** Yes, the values are predicted to be rehabilitated via respread of stockpiled topsoil and seed mix utilising best practice methods. **Operator experience in undertaking rehabilitation?** Image will utilise experienced operators to conduct the rehabilitation works, and given progressive rehabilitation is proposed this experience will improve further over the life of the Proposal **What is the type of vegetation being rehabilitated?** Low woodland or open low woodland: Other acacia, banksia, peppermint, cypress pine, casuarina, York gum *Acacia* spp., *Banksia* spp., *Agonis flexuosa*, *Callitris* spp., *Allocasuarina* spp., *Eucalyptus loxophleba*. **Time lag?** Up to two years for some species depending on rainfall events, up to ten years for some deeper rooted species to become fully established **Credibility of the rehabilitation proposed (evidence of demonstrated success)**	No					

Existing Environment / Impact	Mitigation				Significant Residual Impact	Offset Calculation Methodology				
	Avoid and Minimise	Rehabilitation Type	Likely Rehabilitation Success			Type	Risk	Likely Offset Success	Time Lag	Offset Quantification
	• *Stylidium longitubum* (P4) (1,955 individuals). Smaller concentrations of *Levenhookia preissii* (P1), *Lepyrodia curvescens* (P2), *Hensmania stoniella* (P3), *Schoenus pennisetis* (P3), *Stylidium hymenocraspedum* (P3), *Anigozanthos humilis* subsp. *chrysanthus* (P4), *Schoenus griffinianus* (P4) and *Thysanotus glaucus* (P4) will also be avoided. **Minimise** • Implement industry best practice management measures for flora and vegetation • Conduct additional significant flora searches of final disturbance footprints • Ensure impacts to Priority Flora within the Access and Development Envelope do not exceed those predicted in Section **5.5.2** • Prepare a Significant Flora Management Plan • Implement rehabilitation measures detailed in the MCP (Appendix 2) • Implement preventive measures to minimise the risk and impact of hydrocarbon spills • Comply with Water Quality Protection Guidelines and guidance notes		Credible, traditional mine rehabilitation methods are widely practised and there is clear evidence of demonstrated success.							
General fauna species and habitat – Clearing of up to 318 ha of native fauna habitat, 183.6 ha for the life of the Proposal, 0.6 ha to remain cleared permanently for the Bibby Road / Brand Highway intersection and up to 122.3 ha will be progressively rehabilitated. Potential death or injury of fauna from vehicle strike or entrapment Some indirect impacts to fauna habitat health and fauna behavioural impacts	**Avoid** Image has conducted numerous ecological surveys and this information has been utilised to design the Proposal and its development envelope boundaries to avoid general fauna habitats including habitat types that may be used by significant fauna The Proposal utilises previously cleared areas where possible such as utilising existing tracks for access. **Minimise** • Implement industry best practice management measures for terrestrial fauna • Implement the Rehabilitation Strategy • Prepare and implement FHMP • Implement preventive measures to minimise the risk and impact of hydrocarbon spills • Comply with Water Quality Protection Guidelines and guidance notes	126 ha of native vegetation cleared for the mine pit will be progressively rehabilitated during operations, and the remaining 192 ha is to be rehabilitated post-closure. Vegetation will be rehabilitated using traditional mine rehabilitation methods (with stripped topsoil and seeded with impacted species if required and suitable).	**Can the environmental values be rehabilitated / Evidence?** Yes, the values are predicted to be rehabilitated via respread of stockpiled topsoil and seed mix utilising best practice methods. **Operator experience in undertaking rehabilitation?** Image will utilise experienced operators to conduct the rehabilitation works, and given progressive rehabilitation is proposed this experience will improve further over the life of the Proposal **What is the type of vegetation being rehabilitated?** Low woodland or open low woodland: Other acacia, banksia, peppermint, cypress pine, casuarina, York gum *Acacia* spp., *Banksia* spp., *Agonis flexuosa*, *Callitris* spp., *Allocasuarina* spp., *Eucalyptus loxophleba*. **Time lag?** Up to two years for some species depending on rainfall events, up to ten years for some deeper-rooted species to become fully established **Credibility of the rehabilitation proposed (evidence of demonstrated success)** Credible, traditional mine rehabilitation methods are widely practised and there is clear evidence of demonstrated success.		No					
SRE Fauna - 5 potential SRE fauna have been recorded	**Avoid** Image has conducted numerous ecological surveys and this information has been	126 ha of native vegetation cleared for the mine pit will be	**Can the environmental values be rehabilitated / Evidence?**		No					

Existing Environment / Impact	Mitigation			Significant Residual Impact	Offset Calculation Methodology				
	Avoid and Minimise	Rehabilitation Type	Likely Rehabilitation Success		Type	Risk	Likely Offset Success	Time Lag	Offset Quantification
within the development envelopes, including two potential SRE species *Maratus* 'BAR130' and *Antichiropus whistleri* recorded within the MDE however outside of the indicative disturbance areas. Potential death or injury of fauna from vehicle strike or entrapment Some indirect impacts to fauna habitat health and fauna behavioural impacts	utilised to design the Proposal and its development envelope boundaries to avoid the majority of potential SRE records. The Proposal utilises previously cleared areas where possible such as utilising existing tracks for access. **Minimise** • Implement industry best practice management measures for terrestrial fauna • Implement the Rehabilitation Strategy • Ensure no confirmed SREs are restricted to the disturbance footprint. • Prepare and implement FHMP • Implement preventive measures to minimise the risk and impact of hydrocarbon spills • Comply with Water Quality Protection Guidelines and guidance notes	progressively rehabilitated during operations, and the remaining 192 ha is to be rehabilitated post-closure. Vegetation will be rehabilitated using traditional mine rehabilitation methods (with stripped topsoil and seeded with impacted species if required and suitable).	Yes, the values are predicted to be rehabilitated via respread of stockpiled topsoil and seed mix utilising best practice methods. **Operator experience in undertaking rehabilitation?** Image will utilise experienced operators to conduct the rehabilitation works, and given progressive rehabilitation is proposed this experience will improve further over the life of the Proposal **What is the type of vegetation being rehabilitated?** Low woodland or open low woodland: Other acacia, banksia, peppermint, cypress pine, casuarina, York gum *Acacia* spp., *Banksia* spp., *Agonis flexuosa*, *Callitris* spp., *Allocasuarina* spp., *Eucalyptus loxophleba*. **Time lag?** Up to two years for some species depending on rainfall events, up to ten years for some deeper-rooted species to become fully established **Credibility of the rehabilitation proposed (evidence of demonstrated success)** Credible, traditional mine rehabilitation methods are widely practised and there is clear evidence of demonstrated success.						
Banksia Woodlands TEC / PEC Up to 236.2 ha of vegetation clearing (210.2 ha within the MDE, and 26 ha in the EIDE). 75.6 ha cleared for the mine pit will be progressively rehabilitated during operations, 0.05 ha will remain cleared permanently and the remainder is to be rehabilitated post-closure. Reduction in vegetation health due to indirect impacts	**Avoid** Image has conducted numerous ecological surveys and this information has been utilised to design the Proposal and its development envelope boundaries to avoid direct and indirect impacts to Carnaby's Cockatoo foraging and potential roosting habitat. The Proposal also utilises previously cleared areas where possible, such as locating the accommodation camp completely on cleared land, and utilising existing tracks. **Minimise** • Implement industry best practice management measures for Banksia Woodlands TEC / PEC • Implement rehabilitation measures detailed in the MCP (Appendix 2) • Prepare and implement FHMP and DMP • Implement preventive measures to minimise the risk and impact of hydrocarbon spills • Comply with Water Quality Protection Guidelines and guidance notes	Best practice rehabilitation methods for Banksia Woodlands, including the use of reference sites, monitoring of individual and species parameters, establishment and comparison with annual performance criteria and the consolidation of monitoring data in addition to standard rehabilitation methods such as topsoil respreading and reseeding with impacted species. Image will be targeting to meeting the 'Attributes of Restored Ecosystems' defined by SER (2004) in the Banksia Woodlands TEC / PEC rehabilitation areas	**Can the environmental values be rehabilitated / Evidence?** Rehabilitation methods are relatively well-established for Banksia woodlands, however Image acknowledges the effort and complexity involved with achieving the desired outcomes of re-establishing a functional and sustainable ecological community, and that success cannot be guaranteed **Operator experience in undertaking rehabilitation?** Image will utilise experienced operators to conduct the rehabilitation works, and given progressive rehabilitation is proposed this experience will improve further over the life of the Proposal **What is the type of vegetation being rehabilitated?** Banksia Woodlands TEC / PEC **Time lag?** Up to ten years depending on rainfall events **Credibility of the rehabilitation proposed (evidence of demonstrated success)** Some limitations have been noted with Banksia revegetation conducted in mine rehabilitation to-date. Proposed rehabilitation methods are detailed in Section 5.5.4 and the Interim MCP (Appendix 2).	Yes	Protection and maintenance of 817 ha (Option 1) or 641.73 (Option 2) of Banksia Woodlands TEC / PEC confirmed to occur in Excellent condition	Low – Image has identified sufficient area of Banksia Woodlands TEC / PEC suitable to be used as an offset.	<u>Can the values be defined and measured?</u> Yes - value to TEC / PEC can be measured <u>Operator experience/Evidence?</u> DBCA will manage the land or Image will utilise an experienced land management contractor <u>What is the type of vegetation being revegetated?</u> None - Image is protecting and maintaining existing Banksia Woodlands TEC / PEC	Protects and maintains critical area of TEC / PEC upon agreement – no time delay	Offset would ensure protection and maintenance of Excellent condition Banksia Woodlands TEC / PEC, which based on the Commonwealth calculator (DSEWPaC, 2012; Appendix 34) is considered to be suitable to offset the impacts associated with clearing of up to 225 ha (Option1) or 175 ha (Option 2) of long term impact to Banksia Woodlands TEC / PEC. This is considered adequate by DWER (2021)
					Revegetation of up to 200 ha (Option 2 only) of Banksia Woodlands TEC / PEC (proportional to amount of disturbance above 175 ha)	Medium / High – Image has land available on the offset sites however Some limitations have been noted with	<u>Can the values be defined and measured?</u> Yes - value to TEC / PEC can be measured <u>Operator experience/Evidence?</u> DBCA will manage the land or Image will utilise an experienced	Revegetation rates estimated at 10 years before community is sustainable.	Offset would ensure revegetation of Banksia Woodlands TEC / PEC, which based on the Commonwealth calculator (DSEWPaC, 2012; Appendix 34) is

Existing Environment / Impact	Mitigation			Significant Residual Impact	Offset Calculation Methodology				
	Avoid and Minimise	Rehabilitation Type	Likely Rehabilitation Success		Type	Risk	Likely Offset Success	Time Lag	Offset Quantification
						Banksia revegetation conducted in mine rehabilitation to-date.	land management contractor What is the type of vegetation being revegetated? Banksia Woodlands TEC / PEC (from cleared pasture)		considered to be suitable to offset the impacts associated with clearing of up to 61.2 ha (Option 2 only) of long term impact to Banksia Woodlands TEC / PEC. This is considered adequate by DWER (2021)
Carnaby's Cockatoo foraging habitat – Clearing of up to 289 ha of very high value Carnaby's Cockatoo foraging habitat, 182.4 ha of which will remain cleared for the life of the Proposal, and up to 122.3 ha that will be progressively rehabilitated Some indirect impacts to habitat health and behavioural impacts	**Avoid** Image has conducted numerous ecological surveys and this information has been utilised to design the Proposal and its development envelope boundaries to avoid direct and indirect impacts to Carnaby's Cockatoo foraging and potential roosting habitat. The Proposal also utilises previously cleared areas where possible, such as locating the accommodation camp completely on cleared land, and utilising existing tracks. **Minimise** • Implement industry best practice management measures for terrestrial fauna • Implement rehabilitation measures detailed in the MCP (Appendix 2) • Prepare and implement FHMP and DMP • Implement preventive measures to minimise the risk and impact of hydrocarbon spills • Comply with Water Quality Protection Guidelines and guidance notes	Best practice rehabilitation methods for Banksia Woodlands, including the use of reference sites, monitoring of individual and species parameters, establishment and comparison with annual performance criteria and the consolidation of monitoring data in addition to standard rehabilitation methods such as topsoil respreading and reseeding with impacted species. Image will be targeting to meeting the 'Attributes of Restored Ecosystems' defined by SER (2004) in the Banksia Woodlands TEC / PEC rehabilitation areas	**Can the environmental values be rehabilitated / Evidence?** Rehabilitation methods are relatively well-established for Banksia woodlands, however Image acknowledges the effort and complexity involved with achieving the desired outcomes of re-establishing a functional and sustainable ecological community, and that success cannot be guaranteed **Operator experience in undertaking rehabilitation?** Image will utilise experienced operators to conduct the rehabilitation works, and given progressive rehabilitation is proposed this experience will improve further over the life of the Proposal **What is the type of vegetation being rehabilitated?** Banksia woodlands of the Swan Coastal Plain TEC / PEC **Time lag?** Up to ten years for deeper-rooted foraging species **Credibility of the rehabilitation proposed (evidence of demonstrated success)** Some limitations have been noted with Banksia revegetation conducted in mine rehabilitation to-date. Proposed rehabilitation methods are detailed in Section 5.5.4 and the Interim MCP (Appendix 2).	Yes	Protection and maintenance of 1,405.61 ha (Option 1) or 937.65 (option 2) of high value Carnaby's Cockatoo habitat	Low – Image has identified sufficient foraging habitat within both properties suitable as an offset.	Can the values be defined and measured? Yes - value to species can be measured Operator experience/Evidence? DBCA will manage the land or will utilise an experienced land management contractor What is the type of vegetation being revegetated? None - Image is protecting and maintaining existing Carnaby's Cockatoo foraging habitat	Protects and maintains foraging habitat upon agreement – no time delay	Both offset options would ensure protection and maintenance of high value foraging habitat, which based on the Commonwealth calculator (DSEWPaC, 2012a; Appendix 34) is considered to be suitable to offset the foraging habitat impacts associated with the long-term impact to 289 ha of foraging habitat. This is considered adequate by DWER (2021) and exceeds the minimum 90% offset criteria within DSEWPaC, (2012a; Appendix 34)

12.5 Assessment against WA Offsets Calculator

Image proposes two options to offset impacts to 263.2 ha of Banksia Woodlands PEC:

- Option 1- by protecting and maintaining a minimum of 817 ha of Excellent quality Banksia Woodlands PEC within the Offset Area at Lots 4113 (641.73 ha) and 501 (175.56 ha); or
- Option 2- by protecting and maintaining a minimum of 641.73 ha of Excellent quality Banksia Woodlands PEC within the Offset Area at Lots 4113 and revegetating up to 200 ha of Banksia Woodlands PEC.

Image also proposes to offset impacts Carnaby's Cockatoo foraging habitat by protecting and maintaining:

- Option 1 - 1,405.6 ha (937.65 ha and 467.96 ha at Lots 4113 and 501 respectively) of high quality foraging habitat; or
- Option 2 - 937.65 ha at Lot 4113 of high quality foraging habitat.

The Commonwealth and WA Governments have similar offset calculators that allow a general assessment of the suitability of offsets in counterbalancing the residual impacts of a proposal. The calculators consider factors such as:

- The quality of the impacted area and offset sites (with and without the offset being applied);
- The likelihood that the offset sites will be disturbed(with and without the offset being applied);
- The size of the offset areas; and
- The likely change in quality with and without an offset.

The values used in the calculator, and the justification for the value, is provided in Table 72. Appendix 33 contains copies of these calculators for reference.

Table 72: Criteria used in WA Offsets Calculator

Criteria	Value used	Justification / Rationale
Quality of impacted area	9/10 for Banksia Woodlands PEC 8/10 for Carnaby's Cockatoo foraging habitat	Values taken from detailed survey reports
Quality of rehabilitation site	0/10	Site would have recently been cleared to implement the Proposal
Future quality of rehabilitation site without rehabilitation	0/10	Site would be unlikely to carry any score for Banksia Woodlands PEC or Carnaby's Cockatoo foraging habitat if not properly rehabilitated
Future quality of rehabilitation site with rehabilitation	4/10	Image acknowledges that rehabilitation of Banksia Woodlands PEC and Carnaby's Cockatoo foraging habitat is difficult, therefore a lower value was used
Time until ecological benefit	10 years	Rehabilitation is likely to take several decades before values are close to pre-mining levels, however after ten years some ecological benefit is considered likely
Confidence in rehabilitation result	80%	Image has given this a high confidence as the target quality is relatively low (i.e., 80% confidence of achieving only 4/10)
Quality of offset area	9/10 for Banksia Woodlands PEC	Values taken from survey reports

Criteria	Value used	Justification / Rationale
	8/10 for Carnaby's Cockatoo foraging habitat	
Future quality of offset site without offset	7/10	The site is partly cleared and risks of weeds and other incremental impacts is likely over the 20 year offset period
Future quality of offset site without offset	9/10	The site is partly cleared and risks of weeds and other incremental impacts could be mitigated or reduced over the 20 year offset period
Time until ecological benefit	1 year	1 year is the lowest value available, but Image intends to protect and maintain the offset from the commencement date of the Proposal
Confidence in offset result	80%	Predicted changes in quality are conservative therefore confidence is relatively high
Duration of offset	20 years	Image has proposed to preserve and maintain the offset site for a minimum of 20 years
Time until offset site secured	1 year	1 year is the lowest value available, but Image already owns the offset sites and intends to protect and maintain the offset from the commencement date of the Proposal
Risk of future loss of the offset site if offset was not in place	30%	20 year timeframe was used as per the duration of the offset listed above. Possibility the sites would be targeted for clearing given they are private agricultural lots.
Risk of future loss of the offset site if offset is in place	10%	20 year timeframe was used as per the duration of the offset listed above. Greatly reduced possibility that the sites would be targeted for clearing however can never be completely ruled out.

12.5.1 Option 1

The proposed offset sites have been assessed against the WA Offsets Calculator (DWER, 2021c; Appendix 33). The assessment was run in two separate calculations:

1. **Offset to counterbalance the disturbance of 236.2 ha of Excellent-Pristine Banksia Woodlands PEC.** 817 ha of Excellent quality Banksia Woodlands PEC was shown to be suitable to offset 152.3% of the residual impact; and
2. **Offset to counterbalance the disturbance of 289 ha of high-value Carnaby's Cockatoo foraging habitat.** 1,405.61 ha of high value foraging habitat is suitable to offset 276.3% of the residual impact.

As detailed above, using the WA Government offsets calculator the offset sites completely adequately offset the impacts to the Banksia Woodlands PEC. This differs from the EPBC calculator due to Banksia Woodlands being listed as a PEC under the BC Act and not a TEC, and because rehabilitation is incorporated into residual impact calculations in this calculator (DWER, 2021c; Appendix 33).

The proposed Offset Area is therefore deemed suitable to offset the significant residual impact of the Proposal on Banksia Woodlands TEC / PEC and Carnaby's Cockatoo foraging habitat as each calculation provides an offset value of at least 152% of the residual impact.

12.5.2 Option 2

The proposed offset site has been assessed against the WA Offsets Calculator (DWER, 2021c; Appendix 33). The assessment was run in two separate calculations:

1. **Offset to counterbalance the disturbance of 236.2 ha of Excellent-Pristine Banksia Woodlands PEC.** 641.73 ha of Excellent quality Banksia Woodlands PEC was shown to be suitable to offset 119.6% of the residual impact; and
2. **Offset to counterbalance the disturbance of 289 ha of high-value Carnaby's Cockatoo foraging habitat.** 937.65 ha of high value foraging habitat is suitable to offset 184.3% of the residual impact.

As detailed above, using the WA Government offsets calculator the offset site completely adequately offsets the impacts to the Banksia Woodlands PEC. This differs from the EPBC calculator due to Banksia Woodlands being listed as a PEC under the BC Act and not a TEC, and because rehabilitation is incorporated into residual impact calculations in this calculator (DWER, 2021c; Appendix 33).

The proposed Offset Area is therefore deemed suitable to offset the significant residual impact of the Proposal on Banksia Woodlands TEC / PEC and Carnaby's Cockatoo foraging habitat as each calculation provides an offset value of at least 119% of the residual impact.

12.6 Assessment against Environmental Offsets Principles

In WA, government decision making processes in relation to the use of environmental offsets are underpinned by six principles. These are set out in the Environmental Offsets Policy (EPA, 2011). The Proposal and proposed offset has been assessed against each of these principles, provided in Table 73.

Table 73: Assessment of the proposed offset against the six principles

No.	Principle	Assessment outcome
1	Environmental offsets will only be considered after avoidance and mitigation options have been pursued.	Image has applied the mitigation hierarchy by identifying measures to avoid, minimise and rehabilitate. Image's main action to meet this policy's requirements was site selection and design, which minimised development in areas of Banksia Woodlands PEC vegetation with potential Carnaby's Cockatoo foraging habitat, and reduced the development envelopes to the smallest size possible.
2	Environmental offsets are not appropriate for all projects.	It is acknowledged that offsets are not appropriate for all projects. As the Proposal will result in significant residual impacts on a threatened fauna species and PEC, an offset is considered to be appropriate.
3	Environmental offsets will be cost-effective, as well as relevant and proportionate to the significance of the environmental value being impacted.	The proposed offsets have been designed to be cost-effective by targeting the retention and conservation of existing remnant vegetation that is primarily in close proximity to the Proposal, meaning that much of the same equipment and personnel could be used for management. Potential Banksia Woodlands PEC vegetation and Carnaby's Cockatoo foraging habitat is proposed to be cleared during the implementation of the Proposal. The proposed Offset Area contains correlating Banksia Woodlands PEC vegetation and Carnaby's Cockatoo foraging habitat values that represent those that will be lost during the implementation of the Proposal. The use of the proposed offsets for the Proposal is considered to be relevant and proportionate to the significance of the environmental value being impacted.
4	Environmental offsets will be based on sound environmental information and knowledge.	The proposed offsets are aligned with EPBC Act (s 266B) Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community (DotEE, 2016d) and the Carnaby's Cockatoo Recovery Plan (DPaW, 2013). The protection and maintenance of the offset sites

No.	Principle	Assessment outcome
		will ensure its protection from development, and that it is managed to maintain its natural values in the long-term.
5	Environmental offsets will be applied within a framework of adaptive management.	The proposed offset sites will provide significant opportunities within the framework of adaptive management. Areas of neighbouring cleared land can potentially be used as a trial or pilot site for new approaches to revegetation. In consultation with DBCA or other land management specialists, Image will review the management mechanisms (Section 12.2.2) to ensure best practice management techniques are applied. Offsets have been designed to be adaptive, Image will undertake regular monitoring and reporting to assess the performance of protection mechanisms and identify areas for improvement. This allows information and knowledge captured during operation to be used in an adaptive manner for ongoing maintenance and protection.
6	Environmental offsets will be focused on longer term strategic outcomes.	The proposed offsets are aligned with EPBC Act (s 266B) Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community (DotEE, 2016) and the long-term strategy within the Carnaby's Cockatoo Recovery Plan (DPaW, 2013). The proposed offsets have been designed to offset the impacts of the Proposal from the outset. The protection and maintenance of the offset sites will ensure its protection from development, and that it is managed to maintain its natural values in the long-term.

12.7 Assessment of Proposed Offsets – EPBC Act

The Commonwealth Minister for the Environment determined that the Proposal (EPBC 2021/9056) is a controlled action under the EPBC Act as it is likely to have a significant impact on one or more MNES. It was determined that the proposed action is likely to have a significant impact on the following matters protected by the EPBC Act:

- 'Banksia woodlands of the Swan Coastal Plain' TEC – Endangered; and
- Carnaby's Cockatoo (*Zanda latirostris*) – Endangered.

The Proposal will be assessed as an 'accredited assessment' under Part IV of the EP Act. Section 87 of the EPBC Act makes provisions for the EPA to undertake this accredited assessment of the potential impacts to MNES on behalf of DCCEEW.

12.7.1 Commonwealth Environmental Offsets Guidelines

Offsets are defined as measures that compensate for the residual adverse impacts of an action on the environment. Where appropriate, offsets are considered during the assessment phase of an EIA under the EPBC Act.

The EPBC Act Environmental Offsets Policy (DSEWPaC, 2012a) states:

> "The term 'environmental offsets' refers to measures that compensate for the residual adverse impacts of an action on the environment. Offsets provide environmental benefits to counterbalance the impacts that remain after avoidance and mitigation measures. These remaining, unavoidable impacts are termed 'residual impacts'. For assessments under the EPBC Act, offsets are only required if residual impacts are significant.
>
> Offsets can help to achieve long-term environmental outcomes for matters protected under the EPBC Act, while providing flexibility for proponents seeking to undertake an action that will have residual impacts on those protected matters."

12.7.2 Assessment against EPBC Offsets Calculator

Image proposes two options to offset impacts to 263.2 ha of Banksia Woodlands PEC:

- Option 1- by protecting and maintaining a minimum of 817 ha of Excellent quality Banksia Woodlands TEC within the Offset Area at Lots 4113 (641.73 ha) and 501 (175.56 ha); or
- Option 2- by protecting and maintaining a minimum of 641.73 ha of Excellent quality Banksia Woodlands TEC within the Offset Area at Lots 4113 and revegetating up to 200 ha of Banksia Woodlands TEC.

Image also proposes to offset impacts Carnaby's Cockatoo foraging habitat by protecting and maintaining:

- Option 1 - 1,405.6 ha (937.65 ha and 467.96 ha at Lots 4113 and 501 respectively) of high quality foraging habitat; or
- Option 2 - 937.65 ha at Lot 4113 of high quality foraging habitat.

The Commonwealth and WA Governments have similar offset calculators that allow a general assessment of the suitability of offsets in counterbalancing the residual impacts of a proposal. The calculators consider factors such as:

- The quality of the impacted area and offset sites (with and without the offset being applied);
- The likelihood that the offset sites will be disturbed(with and without the offset being applied);
- The size of the offset areas; and
- The likely change in quality with and without an offset.

The values used in the calculator, and the justification for the value, is provided in Table 72. Appendix 34 contains copies of these calculators for reference.

Option 1

The proposed offset sites have been assessed against the EPBC Offsets Calculator (DSEWPaC (2012a; Appendix 34). The assessment was run in two separate calculations:

1. **Offset to counterbalance the disturbance of 236.2 ha of Excellent-Pristine Banksia Woodlands TEC.** 817 ha of Excellent quality Banksia Woodlands TEC was shown to be suitable to offset 86.13% of the residual impact; and
2. **Offset to counterbalance the disturbance of 289 ha of high-value Carnaby's Cockatoo foraging habitat.** 1,405.61 ha of high value foraging habitat is suitable to offset 164.97% of the residual impact.

Using the EPBC Act calculator, the offset sites contain sufficient areas of Banksia Woodlands TEC to adequately offset almost all of the total proposed disturbance (86.13%, or 225 ha of 236.2 ha) to this TEC, i.e., almost meets the minimum 90% offset criteria in DSEWPaC (2012a). Image notes that the EPBC Act calculator does not account for rehabilitation of the Proposal when determining residual impacts (i.e., it assumes the TEC would be cleared forever). Given the entire Proposal will be rehabilitated within five years this rehabilitation is considered to reduce the residual impacts such that the proposed offset should be considered acceptable.

The proposed offset sites are therefore considered suitable to offset the significant residual impact of the Proposal on Banksia Woodlands TEC and Carnaby's Cockatoo foraging habitat.

Option 2

The proposed offset sites have been assessed against the EPBC Offsets Calculator (DSEWPaC (2012a; Appendix 34). The assessment was run in two separate calculations:

1. **Offset to counterbalance the disturbance of 236.2 ha of Excellent-Pristine Banksia Woodlands TEC.** 641.73 ha of Excellent quality Banksia Woodlands TEC was shown to be suitable to offset 67.65% of the residual impact, and 200 ha of revegetation was shown to be suitable to offset 23.45% of the residual impact; and
2. **Offset to counterbalance the disturbance of 289 ha of high-value Carnaby's Cockatoo foraging habitat.** 937.65 ha of high value foraging habitat is suitable to offset 110.05% of the residual impact.

Using the EPBC Act calculator, the offset sites contain sufficient areas of Banksia Woodlands TEC to adequately offset a large proportion of the total proposed disturbance (67.65%, or 175 ha of 236.2 ha) to this TEC, i.e., is more than two thirds of the minimum 90% offset criteria in DSEWPaC (2012a).

Image intends to review the required clearing of Banksia Woodland TEC / PEC during detailed mine design to attempt to limit the clearing to the minimum required. Up to 200 ha of Banksia Woodland TEC / PEC revegetation is proposed across suitable areas of the offset site to account for the shortfall. The area of revegetation will be proportional to the area of the disturbance above 175 ha, using the DSEWPaC (2012a) calculator provided in Appendix 34.

Image notes that the EPBC Act calculator does not account for rehabilitation of the Proposal when determining residual impacts (i.e., it assumes the TEC would be cleared forever). Given the entire Proposal will be rehabilitated within five years this rehabilitation is considered to reduce the residual impacts such that the proposed offset should be considered acceptable.

The proposed offset site and revegetation is therefore considered suitable to offset the significant residual impact of the Proposal on Banksia Woodlands TEC and Carnaby's Cockatoo foraging habitat.

12.7.3 Offset Principles

Table 74 provides the overarching principles that are applied in determining the suitability of offsets. In assessing the suitability of an offset, government decision-making will be informed by scientifically robust information and incorporate the precautionary principle in the absence of scientific certainty and conducted in a consistent and transparent manner.

Table 74: EPBC Act overarching principles applied in determining the suitability of offsets

No.	Principle	Offset suitability
1	Offsets must deliver an overall conservation outcome that improves or maintains the viability of the protected matter	The protection of Banksia Woodlands TEC and Carnaby's Cockatoo foraging habitat is a direct offset for the impacts of the Proposal. Implementation of Management (12.2.2) and Protection (12.2.3) mechanisms will ensure that the offset sites will remain viable in the long-term. The proposed offset includes monitoring of the offset sites to determine the change in quality and value over time. Monitoring information will provide Image with a better understanding of the impacts that weeds, dieback and feral animals will have on Banksia Woodland TEC and Carnaby's Cockatoo foraging habitat. This information will be used to inform the protection and maintenance measures for the offset sites which

No.	Principle	Offset suitability
		are likely to result in an improvement to the viability of Banksia Woodland TEC and Carnaby's Cockatoo foraging habitat.
2	Offsets must be built around direct offsets but may include other compensatory measures	The proposed offsets are direct offsets.
3	Offsets must be in proportion to the level of statutory protection that applies to the protected matter	Image acknowledges the level of statutory protection that apply to the protected matter. This was considered when assessing the significance of the residual impacts. The scale of the proposed offsets takes into account these considerations.
4	Offsets must be of a size and scale proportionate to the residual impacts on the protected matter	The proposed offsets are significant in size and scale, proportionate to the predicted residual impacts.
5	Offsets must effectively account for and manage the risks of the offset not succeeding	The risk of the proposed offsets not succeeding is low. Proposed offsets include the protection and maintenance of existing native vegetation. Image has commissioned an extensive survey of the offset sites and owns the properties or is in the process of purchase. Maintenance measures specific to the proposed offset have been determined based on the assessment of potential impacts to Banksia Woodlands TEC and Carnaby's Cockatoo foraging habitat.
6	Offsets must be additional to what is already required, determined by law or planning regulations, or agreed to under other schemes or programs	The proposed offsets are in addition to that which is already required, determined by law or planning regulations, or agreed to under other schemes or programs. The offset site is not protected as conservation estate by any current legislation.
7	Offsets must be efficient, effective, timely, transparent, scientifically robust and reasonable	The proposed offset targets a portion of existing native vegetation representative of Banksia Woodlands TEC and Carnaby's Cockatoo foraging habitat. Image currently owns Lot 4113 and Lot 501 to maintain and manage the offset sites in the long-term. Implementation of the offset can commence at any time after the Proposal approval date (if approved). The proposed offset is considered to be effective, scientifically robust and reasonable.
8	Offsets must have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced	Image will be responsible for the protection and maintenance of the proposed offset. The offset sites may be transferred to DBCA, however if Image retains responsibility in the long-term then they have a corporate governance statement that sets out the main corporate governance policies and practices. Under this statement, Image has an environmental policy to ensure the integrity of the environment for all employees, contractors and external stakeholders associated with operations. The performance of the proposed offset will be monitored, the outcomes of this the monitoring will be reported on annually.

13 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

13.1 Controlled Action Provisions

DCCEEW determined that the relevant controlling provisions for the Proposal are:

- Listed threatened species and communities (Sections 18 and 18A of the EPBC Act); and
- Nuclear action' (Section 21 and 22A of the EPBC Act).

13.2 Policy and Guidance

The relevant policy and guidance for MNES includes:

- Carnaby's Cockatoo (*Zanda latirostris*) Recovery Plan (DPaW, 2013);
- Conservation Advice for *Conostylis dielsii* subsp. *teres* (TSSC, 2016a);
- *Environment Protection and Biodiversity Conservation Act 1999* - section 269A - Adoption of State Plans as Recovery Plans (21/10/2005);
- Environmental Management Plan Guidelines (DotE, 2018a);
- EPBC Act Condition Setting Policy (DAWE, 2020a);
- EPBC Act Environmental Offsets Policy (DSEWPaC, 2012a) – including the Offset Assessment guide;
- EPBC Act Outcomes-based conditions policy (DotE, 2016a);
- Carnaby's Cockatoo (*Calyptorhynchus latirostric*) Recovery Plan (DAWE, 2012);
- Fauna Profile: Carnaby's Cockatoo (DBCA, 2017);
- Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act, 1999) (DotEE, 2016a);
- National recovery plan for Malleefowl (Benshemesh, 2007);
- Other Minister of the Environment (Cth) approval decision making considerations;
- Referral guideline for 14 birds listed as migratory species under the EPBC Act *DRAFT* (DotE, 2015a);
- Significant Impact Guidelines: 1.1 – Matters of National Environmental Significance (DotE, 2013a);
- South Coast threatened birds recovery plan (DPaW, 2014);
- Survey guidelines for Australia's threatened birds (DEWHA, 2010);
- Threat abatement plan for competition and land degradation by rabbits (DotEE, 2016c);
- Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* (DotE, 2014b);
- Threat abatement plan for predation by feral cats (DotE, 2015b);
- Threat abatement plan for predation by the European red fox (DEWHA 2008a);
- Threat abatement plan for predation, habitat degradation, competition and disease transmission by unmanaged goats (DEWHA, 2008b);
- Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (DotEE, 2017b);
- Threatened (Declared Rare) and Priority List (DBCA, 2018); and

- Threatened Species Strategy – Year 3 Priority Species Scorecard (2018): Malleefowl *Leipoa ocellata* (National Environmental Science Program Threatened Species Research Hub, 2019).

13.3 Description of the Environment

A summary of surveys conducted to date and a detailed description of survey findings relevant to each of the MNES species and their respective habitats is provided in Section 5 (Flora MNES), and Section 6 (Terrestrial Fauna MNES). A summary of the findings is provided below.

13.3.1 Survey Effort

Flora and Vegetation

A number of flora and vegetation desktop and field surveys have been undertaken within and in close proximity to the development envelopes. These surveys include:

- Level 2 Flora and Vegetation Survey (360 Environmental, 2012c);
- Flora and Vegetation Survey for the Atlas Project (Morgan, 2022);
- Spring Biological Assessment – Bibby Road, Cooljarloo (360 Environmental, 2021); and
- Comprehensive and Broadscale Phytophthora Dieback Assessment of the Proposed Atlas Project (Terratree, 2020).

The information contained within the following sections has been sourced from the surveys listed above unless mentioned otherwise. Section 5.3 describes these surveys in detail.

Terrestrial Fauna

Spectrum (2022a) and 360 Environmental (2012c) conducted detailed fauna surveys of the MESA which included Targeted Black Cockatoo assessment in October 2020 and November 2011 respectively. A Basic fauna survey of the EISA was completed by Spectrum (2022a) in September 2021 in addition to a Basic fauna survey completed for the BBSA by 360 Environmental (2021) in September 2020, which also included a Black Cockatoo assessment. Targeted surveys were completed for Subterranean fauna (Bennelongia, 2021), the Graceful Sun-moth (360 Environmental, 2012a) and regional SRE extents (Spectrum, 2022b).

13.3.2 Recorded or Likely Species / Communities

A likelihood assessment of Threatened Flora and Fauna occurring within the Study Area has been conducted by Morgan (2022), 360 Environmental (2021 & 2022) and Spectrum (2022a). A summary of those identified as having a medium / moderate likelihood of occurrence or greater is provided in Table 75. Note that wetland species are not included in the list as the Proposal has avoided wetland areas identified in the surveys.

Table 75: Likelihood of MNES occurring within the survey areas

Species and conservation rating	Range/habitat preference	Likelihood of Occurrence
Threatened Flora and Vegetation		
Andersonia gracilis, Endangered	Flowers from September to November. Prefers white/grey sand, sandy clay, gravelly loam in winter-wet areas, near swamps. It has been recorded on the south side of Wongonderrah Road east of the survey area, in the heaths on palusplain wetlands (Morgan, 2022).	Not recorded, listed as being moderate to high for MESA and EISA and low for BBSA.
Anigozanthos viridis* subsp. *Terraspectans, Endangered	Flowers from August to September. Prefers grey sand, clay loam in winter-wet depressions. It was recorded at Cooljarloo in previous survey (Morgan, 2022).	Not recorded, listed as being Moderate to high for MESA and EISA and low for BBSA
Macarthuria keigheryi Endangered	Flowers from September to December or February to March. Prefers white or grey sand in low-lying, winter-wet dampland areas; margins of Banksia woodlands on Bassendean sands on low plains. Responds to fire and less abundant in long-unburnt areas. Difficult to find. Previously recorded in Cooljarloo area (Morgan, 2022; Woodman Environmental Consultancy).	Not recorded, listed as being Moderate to high to MESA and EISA and low for BBSA
Thelymitra stellata, Endangered	Flowers from October to November. Prefers sand, gravel, and lateritic loam. Its favoured habitat is lateritic loams of Jarrah forest near Perth and heath on rocky low hills further north (Brown *et al*., 2008; Morgan, 2022).	Not recorded, listed as being low for MESA and EISA and medium for BBSA
Banksia Woodlands of the SCP, TEC	N/A	Recorded within all survey areas
Terrestrial Fauna		
Carnaby's Cockatoo (*Zanda latirostris*), Endangered	The Carnaby's Cockatoo is endemic to the south-west of WA, with a widespread distribution. The species is highly mobile and displays a seasonal migratory pattern that is linked to breeding (Saunders, 1980 & 1990; Berry, 2008). Breeding takes place between late July and December and most breeding occurs in the inland parts of its distribution, in areas receiving between 300 - 750 mm of annual average rainfall (Saunders, 1974). During the non-breeding season (January - July) the majority of the birds move to the higher rainfall coastal regions of their range including the mid-west coast, Swan Coastal Plain and south coast (Saunders, 1980 & 1990; Berry, 2008; Saunders *et al.*, 2011; Johnstone *et al.,* 2011; DPaW, 2013).	Recorded, multiple individuals, flocks, and extensive evidence of foraging.
Fork-Tailed Swift (*Apus pacificus)* Marine, Migratory	In WA, there are sparsely scattered records of the Fork-tailed Swift along the south coast, ranging from near the Eyre Bird Observatory and west to Denmark. They are widespread in coastal and subcoastal areas between Augusta and Carnarvon, including some on nearshore and offshore islands. They are scattered along the coast from south-west Pilbara to the north and east Kimberley region, near Wyndham. There are sparsely scattered inland records, especially in the Wheatbelt, from Lake Annean and Wittenoom. They are found in the north and north-west Gascoyne Region, north through much of the Pilbara Region, and the south and east Kimberley. They are also recorded in the Timor Sea, both at sea and around islands such as the Ashmore Reef. Isolated records occur at Neale Junction in the Great Victoria Desert and on the Nullarbor Plain (Higgins, 1999).	Not recorded, may occur infrequently over any part of the MESA and EISA. (Recorded approximately 12 km west southwest of the Proposal (2013)).

Species and conservation rating	Range/habitat preference	Likelihood of Occurrence
Malleefowl (*Leipoa ocellate*), Vulnerable	In WA, Malleefowl are found in shrublands dominated by *Acacia*, and occasionally in woodlands dominated by *Eucalypts* such as *Wandoo E. wandoo, Marri Corymbia calophylla* and *Mallet E. astringens* (Storr, 1985, 1986 & 1987; Storr & Johnstone, 1988; Benshemesh & Malleefowl Preservation Group, 2001; Sanders *et al.,* 2003; Benshemesh, 2007). Parsons (2008) has recently examined the distribution of Malleefowl within the WA Wheatbelt. Malleefowl distribution was associated with landscapes that had lower rainfall, greater amounts of mallee and shrubland that occur as large remnants, and lighter soil surface textures. At a finer scale, Malleefowl occurrence was associated with mallee / shrubland and thicket vegetation with woodland representing poor habitat for the species. Parsons (2008) also examined the occupancy of small remnants in the wheatbelt and found that remnants occupied by Malleefowl typically possessed a greater amount of litter, greater cover of tall shrubs, greater abundance of food shrubs and a greater soil gravel content than those that were not occupied (Benshemesh, 2007).	Not recorded, suitable shrubland and heath habitat exists in MESA and EISA, though no individuals or secondary evidence in the form of nesting mounds (contemporary or historical) or tracks were observed. (Two records from Nambung National Park, 8 km west southwest of the Proposal (2012)).

13.3.3 Habitat Suitability for MNES

Seven fauna habitat types and two ecotones (mixed habitats) were recorded within the MESA and EISA (Spectrum, 2022a):

- Banksia Woodland;
- Pasture / cleared;
- Heath (Banksia);
- Samphire;
- Melaleuca;
- Banksia Woodland / Heath (Banksia);
- Ephemeral Wetland;
- Melaleuca / Samphire;
- Eucalypt Woodland;

These are described in detail in Section 6.3.9 and shown on Figure 62. Information relevant to Carnaby's Cockatoo has been replicated below given this species and significant habitat was recorded within the survey areas.

Carnaby's Cockatoo

The species has been recorded in small and large flocks moving through the local region and birds utilising Banksia Woodland habitats 6 km north of the MESA at the intersection of Munbinea Road and Bibby Road during the initial Basic fauna survey. Carnaby's Cockatoo were also recorded at three locations during the Basic fauna assessment of the EISA, and a large flock of up to 100 individuals were observed flying over Banksia woodland to the west of the Proposal, however a location could not be determined due to the distance from the observers (Spectrum, 2022a). Evidence of foraging was recorded by Spectrum (2022a) at an additional survey site where no Carnaby's Cockatoos were directly observed.

Previous Carnaby's Cockatoo assessments identified that only suitable foraging habitat occurs within the MESA. Two roost sites were identified within 12 km of the MESA and an additional seven roost sites are located in the surrounding region. The survey areas are all located just outside of the breeding range of Carnaby's Cockatoo, however the region is considered important foraging habitat.

The species was recorded within the BBSA. A number of individuals were observed foraging in Banksia and at another location a flock of Carnaby's Cockatoos were observed flying overhead. Evidence of Carnaby's Cockatoo was also seen at two other sites, with calls heard at one site and evidence of foraging (chewed Banksia) seen at the other site (360 Environment, 2021).

The species has been allocated a high likelihood of occurrence because suitable foraging habitat occurs across the survey areas including Banksia Woodland and Heath (Banksia) and the species has been recently recorded just outside of the MESA and within the BBSA.

Spectrum (2022a) defined and assessed potential Carnaby's Cockatoo habitat within the MESA and EISA. Suitable foraging habitat in the form of Banksia Woodland, Heath (Banksia), Banksia Woodland/Heath (Banksia) and Eucalypt Woodland was calculated to account for 864.3 ha (70.3%) of the MESA and EISA. The Eucalypt Woodland may also be considered potential roosting habitat though the habitat is located outside of the MESA and EISA and no Carnaby's Cockatoos were observed utilising the area for this purpose (Spectrum, 2022a). A total of 21.7 ha of Carnaby's Cockatoo foraging habitat was also recorded within the BBSA, and was identified to be very high quality. No potential breeding habitat was recorded within the BBSA, however the non-endemic trees (0.1 ha) were considered potential roosting habitat.

Using the scoring tool outlined in the Revised Draft Referral Guideline for Three Threatened Black Cockatoo Species (DotEE, 2017a), the identified habitat for the Carnaby's Cockatoo within the MESA and EISA was assessed by Spectrum (2022a) as follows:

Starting score:

- 7 (High Quality): proteaceus woodland and heathland dominated by Banksia species with some native *Eucalyptus rudis* woodland present.

Additions:

- +3 Is within the Swan Coastal Plain (important foraging area).

Subtractions:

- -1 Is >12 km from a known breeding location.

The overall scoring of the foraging habitat for the Carnaby's Cockatoo was rated as Nine (very high quality) based on the above criteria. Evidence and observations of Carnaby's Cockatoo foraging have been recorded and the species has been well documented using similar habitats across the surrounding region (Spectrum, 2022a). The MESA and EISA is located outside of the breeding range of Carnaby's Cockatoo, however the region is considered as important foraging habitat as juvenile cockatoos move into the area after fledging from breeding sites located to the east. Two roost sites were identified within 12 km of the MESA and EISA and an additional seven roost sites are located in the surrounding region (Figure 67).

Three Important Bird Areas for Carnaby's Cockatoo occur in the surrounding region (Dutson, Garnett and Gole, 2009; DPaW, 2013). Spectrum (2022a) summarises these as follows:

- Coomallo: Located approximately 40 km to the northeast of the Proposal, this area supports at least 1% of the Carnaby's Cockatoo breeding population (minimum of 40

breeding pairs) which nest in woodland remnants and isolated paddock trees and feed in native shrublands;
- Koobabbie: Located near Coorow and approximately 110 km northeast of the Proposal, supporting at least 1% of the Carnaby's Cockatoo breeding population (up to 32 breeding pairs), this large pastoral property has 254 ha of remnant Wandoo and Salmon Gum woodland vegetation. Fledglings have been recorded at Coomallo Creek and Beekeepers Nature Reserve; and
- Northern Swan Coastal Plain: Located between the Swan River and Moore River, this area supports 4,600 - 15,000 birds in the non-breeding season and a small number of pairs of breeding birds; this is the largest population of birds that gather in the non-breeding season.

Regionally, approximately 44,000 hectares of Carnaby's Cockatoo habitat occurs within the conservation reserves listed below with additional areas of Carnaby's Cockatoo habitat located outside of the conservation estates which are also utilised for foraging and nesting:
- Badgingarra National Park: 13,108 ha;
- Coomallo Nature Reserve: 8,807 ha;
- Southern Beekeepers Nature Reserve: 10,808 ha;
- Nambung National Park: 8,362 ha;
- Hill River Nature Reserve: 882 ha; and
- Un-named Conservation Park: 2,369 ha.

Breeding sites in the region surrounding the Survey Area include Three Springs, Coomallo, Carnamah, Coorow, Badgingarra and Moora regions which are vacated by the end of February each year. Adult Carnaby's Cockatoo and their fledglings fly west to coastal feeding habitat where they aggregate in flocks in the Kwongan heath and pine plantations (Saunders, 1980). Occasionally a flock of 60 - 100 birds remain in the Badgingarra National Park area into March-April (Ron Johnstone pers. comm., 2008) and from July through to September the Carnaby's Cockatoo population moves back to breeding sites (Williams *et al.*, 2017; Figure 68).

13.4 Relevant Impacts

Sections 5.4 and 6.3 of this ERD have assessed the potential impacts on MNES in detail. To avoid repetition, Table 76 summarises the findings of those assessments as applicable to MNES.

Table 76: Relevant impacts to MNES

Potential Impact	Assessment of Impacts	Relevant MNES
Direct disturbance / loss of habitat		
Up to 318 ha native vegetation disturbance within the development envelopes	**Nature and extent of impact:** Clearing of up to 292 ha of native vegetation (within the MDE) which a portion will be progressively rehabilitated as mining progresses. Clearing of up to 26 ha of native vegetation within the EIDE. **Unknown, unpredictable or irreversible impacts**: There is some uncertainty about the resultant quality of the rehabilitated vegetation, and the likely success of infill planting for Carnaby's Cockatoo foraging species. Impacts to Malleefowl are uncertain as this species has not been recorded in the survey areas however, it is likely to be an irregular visitor. No unknown impacts are predicted from this direct disturbance of habitat.	*Andersonia gracilis* *Anigozanthos viridis* subsp. *Terraspectans* *Macarthuria keigheryi* *Thelymitra stellata* Banksia Woodlands TEC

<table>
<tr><th>Potential Impact</th><th>Assessment of Impacts</th><th>Relevant MNES</th></tr>
<tr><td></td><td>Significance of impacts:
Impacts to species other than Carnaby’s Cockatoo are not considered significant. Threatened Flora have not been recorded despite targeted searches and Malleefowl and Fork-tailed Swift utilise widespread habitats and the rehabilitated habitats will be suitable for use by these species.
The residual impacts to the Banksia Woodland TEC and Carnaby’s Cockatoo foraging habitat are considered to be significant and can be summarised as:
1. Loss of 218.83 ha of this ecological community for up to an estimated 15 years, until rehabilitated areas have qualities that align with this TEC / PEC (i.e. up to five years of construction and operations, and an estimated ten years of rehabilitation).
2. Loss of up to 289 ha of very high value Carnaby’s Cockatoo foraging habitat for a period of 15 years (up to five years construction and operation plus ten years before rehabilitation is suitable for foraging by Carnaby’s Cockatoo).
Additional technical data:
• Section 6.3.9 provides detail on the fauna habitats recorded within the survey area
• Section 5.3.6 provides detail on the vegetation communities recorded in the survey area
• Morgan (2022) and 360 Environmental (2012b & 2021a) (Appendix 4, 3 & 5) provide further technical information on the vegetation communities within the survey areas
• Spectrum (2022a) and 360 Environmental (2012c & 2021a) (Appendix 10; 8 & 5) provide further technical information on the fauna habitats within the survey areas</td><td>Carnaby's Cockatoo (Zanda latirostris)
Fork-Tailed Swift (Apus pacificus)
Malleefowl (Leipoa ocellate)</td></tr>
<tr><td>Vehicle / earthmoving equipment strike</td><td>Nature and extent of impact:
There is a risk of fauna death or injury if fauna are struck by earthmoving equipment during clearing, mining or rehabilitation. The majority of fauna would be expected to flee the areas to be cleared as the equipment approaches. It is likely however that there will be some fauna injuries or deaths during these activities. Image will implement management measures to minimise this likelihood (refer to Section 6.5).
Although no Malleefowl mounds were identified during the surveys, there is a small risk of the disturbance of new Malleefowl mounds during earthmoving. Image will check for the presence of Malleefowl mounds prior to clearing if mounds are found and ensure no active mounds are disturbed until Malleefowl have left the mound.
Unknown, unpredictable or irreversible impacts:
Vehicle / earthmoving equipment strikes were able to be predicted.
No irreversible impacts are predicted from indirect impacts if mitigation measures are implemented.
Significance of impacts:
With appropriate vehicle strike mitigation measures in place, any vehicle / earthmoving impacts to MNES are likely to be extremely rare.
Additional technical data:
Section 2.2 provides detailed information on the Proposal, including equipment required.</td><td>Malleefowl (Leipoa ocellate)</td></tr>
<tr><td colspan="3">Indirect Impacts</td></tr>
<tr><td>Introduced fauna</td><td>Nature and extent of impact:
Introduced species were recorded in fauna surveys within the study areas including cats and foxes (Spectrum, 2022a). The Proposal has the potential to introduce additional species or increase the population of existing introduced species, through the following vectors:
• Food wastes at work areas; or
• Presence of cleared corridors that may be utilised by introduced fauna for access or predation.
The workforce will be relatively small, and the appropriate management and disposal of food wastes (refer to Section 6.5) will ensure that food wastes do not attract fauna to the area. No pets will be brought to site.
Roads can result in increases in predator activity by providing movement pathways or improved access for predatory hunting and travel (Raiter, 2016). There are some</td><td>Carnaby's Cockatoo (Zanda latirostris)
Fork-Tailed Swift (Apus pacificus)
Malleefowl (Leipoa ocellate)</td></tr>
</table>

Potential Impact	Assessment of Impacts	Relevant MNES
	minor roads within the mine site however the access road is likely to present the greatest risk. In order to counteract this risk feral animal controls are proposed to be implemented in consultation with DBCA (refer to Section 6.5). **Unknown, unpredictable or irreversible impacts**: No impacts would be considered unknown. The presence of introduced species is known as a result of fauna surveys. No irreversible impacts are predicted from this indirect impact. **Significance of impacts**: With the implementation of controls (refer to Section 6.5) potential introduced fauna impacts described above are expected to be able to be appropriately mitigated such that impacts are not significant on a local or regional scale. **Additional technical data:** Spectrum (2022a; Appendix 10) provide further technical information regarding introduced species and use of the study area.	
Alteration of behaviour as a result of noise, or light emissions.	**Nature and extent of impact:** The Proposal has a small operational footprint and will produce low levels of artificial light and noise emissions. The main source of noise and light emissions will be the WCP (24-hour operations), which covers only several hectares. Equipment moving within the mining area will produce noise emissions. It is expected that MNES will keep some distance from the mining area while operating. **Unknown, unpredictable or irreversible impacts**: Noise and light impacts from the Proposal are known and can be predicted. No irreversible impacts are predicted from this indirect impact. **Significance of impacts**: With the implementation of controls (refer to Section 6.5) potential increased risks to MNES from light or noise emissions are expected to be able to be appropriately mitigated such that impacts are not significant. **Additional technical data:** LGA (2022; Appendix 28) provides further technical information on the potential extent of noise emissions.	Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)
Alterations to fire regimes	**Nature and extent of impact:** Mining activities have the potential to ignite bushfires through hot work and other activities. **Unknown, unpredictable or irreversible impacts**: No impacts would be considered unknown. The frequency of fire is well known in the area and therefore predictable. An intense and uncontrolled fire could have irreversible impacts to local MNES populations. **Significance of impacts**: With appropriate firefighting and prevention management measures in place (Section 5.5 and 6.5), the development of the Proposal will provide improved access subsequent ability to fight fire outbreaks and prevent them from spreading. The potential for increased fire risk impacts is therefore expected to not be significant. **Additional technical data:** Section 5.5.1 provides detail regarding the impacts of fire on flora and vegetation. Section 6.5.3 provides more information of the impacts that a loss of foraging habitat has on the Carnaby's Cockatoo.	*Andersonia gracilis* *Anigozanthos viridis* subsp. *Terraspectans* *Macarthuria keigheryi* *Thelymitra stellata* Banksia Woodlands TEC Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)
Establishment or spread of weed species / populations	**Nature and extent of impact:** Weeds have the potential to outcompete and displace native vegetation if introduced or conditions are altered to favour their growth. Weeds may be spread and/or introduced by vehicles and equipment, resulting in soil and weed vegetative material being transported around site and being present on equipment entering and exiting site. 89 introduced species were identified during flora / vegetation surveys (Morgan, 2021a & b, 360 Environmental, 2021). None of these taxa are listed as WoNS. Given the presence of these weed species, weed management measures will be implemented	*Andersonia gracilis* *Anigozanthos viridis* subsp. *Terraspectans* *Macarthuria keigheryi* *Thelymitra stellata*

Potential Impact	**Assessment of Impacts**	**Relevant MNES**
	to prevent or minimise the spread of weeds and any increased competition with native species **Unknown, unpredictable or irreversible impacts**: This impact would be not be considered unknown, unpredictable or irreversible. **Significance of impacts**: With appropriate weed management measures in place Image will be able to prevent and minimise the spread of weed, mitigating competition with other species. Therefore, impacts to MNES arising from the establishment or the spread of weeds is considered to be minimal. **Additional technical data:** Morgan (2022) and 360 Environmental (2012b, 2021) (Appendix 4, 3 & 5) provide further technical information on the weed species present within the survey areas. Section 5.6 provides further detail on weed management measures that will be implemented.	Banksia Woodlands TEC
Lowering of groundwater table	**Nature and extent of impact:** Without mitigation the abstraction of groundwater for dewatering and water supply has the potential to lower groundwater levels in those areas. Some flora species may be affected if they can no longer access this groundwater for water supply. **Unknown, unpredictable or irreversible impacts**: Groundwater drawdown is to be mitigated to ensure it does not extend outside the disturbance footprint. If some unexpected short-term impacts occur it is likely that they will be reversible if addressed quickly. **Significance of impacts**: This impact may be significant if it is not mitigated adequately. **Additional technical data:** Morgan (2022) and 360 Environmental (2012b, 2021) (Appendix 4, 3 & 5) provide further technical information on the flora species and vegetation present within the survey areas. MWES (2022b; Appendix 18) provides further technical information on the groundwater hydrogeology of the survey areas. Proposed control measures are identified in Section 7.6.	*Andersonia gracilis* *Anigozanthos viridis* subsp. *Terraspectans* *Macarthuria keigheryi* *Thelymitra stellata* Banksia Woodlands TEC Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)
Hydrocarbon spills	**Nature and extent of impact:** Considering the small scale of operations planned for the Proposal, large-scale hydrocarbon spills are considered unlikely. Small hydrocarbon spills associated with hydraulics failures on machinery and refuelling spills may occur on occasion in operational areas. Spills generally result in a defined area of hydrocarbon-contaminated soil that can be remediated via passive means such as bioremediation. **Unknown, unpredictable or irreversible impacts**: This impact would be not be considered unknown, unpredictable or irreversible. **Significance of impacts**: With the implementation of controls this impact is unlikely to be significant. **Additional technical data:** Proposed control measures are identified in Section 5.6 and are designed to further reduce the risk of vegetation impacts from hydrocarbon spillage.	*Andersonia gracilis* *Anigozanthos viridis* subsp. *Terraspectans* *Macarthuria keigheryi* *Thelymitra stellata* Banksia Woodlands TEC Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)
Introduction or spread of dieback	**Nature and extent of impact:** The introduction of *P. cinnamomi* to the development envelopes could likely result in a significant vegetation decline. Given the risk of dieback, hygiene management measures will be implemented to prevent the introduction of dieback (Section 5.6). **Unknown, unpredictable or irreversible impacts**: This impact would be not be considered unknown, unpredictable or irreversible. **Significance of impacts**:	*Andersonia gracilis* *Anigozanthos viridis* subsp. *Terraspectans* *Macarthuria keigheryi* *Thelymitra stellata*

Potential Impact	Assessment of Impacts	Relevant MNES
	With the implementation of controls this impact is unlikely to be significant. **Additional technical data:** Terratree (2020; Appendix 6) provides further technical information on the extent of dieback within the survey areas.	Banksia Woodlands TEC Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)

13.5 Assessment against significant impact criteria for listed threatened species and ecological communities

Assessment against the significant impact criteria for each listed threatened species listed in Table 77 has been provided in the tables below. Where appropriate, some species have been assessed as a group if they share similar habitats and potential impacts.

Table 77: Threatened Flora

Significant impact criteria (Endangered)	Assessment of impacts to *Andersonia gracilis, Anigozanthos viridis* subsp. *Terraspectans, Macarthuria keigheryi Thelymitra stellata*
Lead to a long-term decrease in the size of a population	There are no known populations of any of these species within the development envelopes or in close proximity. The Proposal will therefore not lead to a long-term decrease in the size of any known populations.
Reduce the area of occupancy of the species	There are no known populations of any of these species within the development envelopes or in close proximity. The Proposal will therefore not reduce the area of known occupancy for these species.
Fragment an existing important population into two or more populations	There are no known populations of any of these species within the development envelopes or in close proximity. The Proposal will therefore not fragment any existing important populations into two or more populations.
Adversely affect habitat critical to the survival of a species	The habitat critical to the survival of *Andersonia gracilis* includes the remnant vegetation in which important populations occur, areas of similar habitat (i.e. winter-wet areas of black, sandy clay flats of open, low heath over sedges) - these areas provide potential habitat for natural range extension and/or for allowing pollinators or biota essential to the continued existence of the species to move between populations; and additional occurrences of similar habitat that may contain important populations of the species or be suitable for future translocations or other recovery actions intended to create important populations; and the local catchment for the surface and groundwater that maintains the habitat of the species. Habitat critical to the survival of *Macarthuria keigheryi* includes the area of occupancy of all known populations, areas of similar habitat surrounding known populations (low lying winter wet damp sands with *Banksia* and *Kingia australis* heathland or Banksia woodland) that provide potential habitat for natural range extension), remnant vegetation that surrounds and links populations (necessary to allow pollinators to move between populations), the local catchment area and ground water systems that maintain the damp-land habitat of the species, and additional occurrences of similar habitat that may contain the species or be suitable for future translocations. The approved conservation advice for *Anigozanthos viridis* subsp. *Terraspectans* and *Thelymitra stellata* does not identify any critical habitats. There are no habitats that are constrained to the development envelopes and none of these species have known populations in close proximity to the Proposal.
Disrupt the breeding cycle of a population	There are no known populations of any of these species within the development envelopes or in close proximity. The Proposal will therefore not disrupt the breeding cycle of any known populations
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	*Andersonia gracilis* is currently known from the Badgingarra, Dandaragan and Kenwick areas where it is found on seasonally damp, black sandy clay flats near or on the margins of swamps, often on duplex soils supporting low open heath vegetation with species such as *Calothamnus hirsutus*, *Verticordia densiflora* and *Kunzea recurva* over sedges (Department of Environment and Conservation, 2006). *Anigozanthos viridis* subsp. *Terraspectans* is endemic to WA. Insufficient data are available to determine the area of occupancy (DEC, 2008). This species appears to be in moderately healthy condition, but the populations have not been re-surveyed for a number of years. The distribution of *Anigozanthos viridis* subsp. *Terraspectans* is limited compared with the Green Kangaroo Paw, which can be found from north of Perth down to the southwest of WA (W.A. Herbarium, 2008). *Anigozanthos viridis* subsp. *Terraspectans* occurs in winter-wet depressions where it grows on grey sandy clay loam, or grey sand, in low post-fire regenerating heath. It is associated with species such as Slender-leaved Banksia (*Banksia leptophylla*), melaleucas (*Melaleuca* spp.), Compact Featherflower (*Verticordia densiflora*), coneflowers (*Conostylis* spp.) and sedges (Brown *et al.*, 1998; Patrick & Brown, 2001) (TSSC, 2008a). *Macarthuria keigheryi* is found in low-lying winter-wet damp, grey/white sands and grows in open patches with low tree canopy cover among heathland, jarrah (*Eucalyptus marginata*) and *Allocasuarina* / *Banksia* woodland at Welshpool and Kewdale; and *Banksia* / *Eucalyptus* woodland at the Dandaragan population. Associated species include *Kingia australis, Banksia attenuata*, *B. menziesii, Eremaea pauciflora, Nuytsia floribunda, Melaleuca seriata, Patersonia occidentalis* and

Significant impact criteria (Endangered)	Assessment of impacts to *Andersonia gracilis, Anigozanthos viridis* subsp. *Terraspectans, Macarthuria keigheryi Thelymitra stellata*
	Alexgeorgea nitens in the Welshpool/Kewdale area and *B. menziesii, B. attenuata, Eucalyptus todtiana* and *Nuytsia floribunda* in the Cooljarloo area (Brown *et al.,* 1998; Keighery 2001; Atkins 2006) (Department of Environment and Conservation, 2009). *Thelymitra stellata* grows in gravelly loam among low heath and scrub in *Eucalyptus marginata* and *E. wandoo* woodland, and in low heath on lateritic hill tops (Briggs & Leigh, 1996; Brown *et al.,* 1997; Patrick & Brown, 2001). This species occurs within the Avon, Northern Agricultural, Swan and South West (WA) Natural Resource Management Regions (TSSC, 2008b). None of the species listed above have been recorded within the Development Envelopes despite intensive targeted searches. The Proposal includes clearing of up to 318 ha of native vegetation. This will modify and decrease the availability or quality of habitat for these species for a period of time until rehabilitation is fully established. There are however no habitats that are constrained to the development envelopes and none of these species have known populations in close proximity to the Proposal. Fires are expected to be frequent in the area and the Proposal may increase the risk of fires starting as a result of machinery sparks, cigarettes and other sources. This risk will be reduced as far as practicable by the implementation of mitigation measures. The presence of fire-fighting equipment on site will allow small fires to be controlled before they become uncontrolled.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	**Weeds** Weeds have the potential to outcompete and displace flora species if introduced or conditions are altered to favour their growth. Weeds may be spread and/or introduced by vehicles and equipment, resulting in soil and weed vegetative material being transported around site and being present on equipment entering and exiting site. Image will implement weed management measures to ensure that the spread and introduction of weed species is minimised. **Feral Animals** The mining and rehabilitation methodology will not result in extensive areas of permanently cleared land. Mining will be rehabilitated progressively using traditional rehabilitation techniques and infill planting. It is unlikely that the Proposal will modify fauna behaviours to the extent that would further impact Threatened Flora species. Image proposes to develop and implement ongoing monitoring and control of feral animal populations within and surrounding the Proposal.
Introduce disease that may cause the species to decline	*Andersonia gracilis* is known to be highly susceptible to dieback disease (caused by *Phytophthora cinnamomi*), ranking 8 on a scale of 1 to 10 where 7 is considered a significant risk (Keighery, 1988). Initial tests using 17 seeds at the Threatened Flora Seed Centre (TFSC) support the information that it is highly susceptible to dieback disease (*Phytophthora cinnamomi*) (Department of Environment and Conservation, 2006). The main potential threat to *Anigozanthos viridis* subsp. *Terraspectans* is dieback caused by *Phytophthora cinnamomi*. The species' susceptibility to dieback is currently unknown, but a vigorous outbreak occurred near one population in 1989 and any further outbreaks may affect this population if the species is found to be susceptible (Brown *et al.,* 1998; Patrick & Brown, 2001) (TSSC, 2008a). There are no known diseases threatening *Macarthuria keigheryi* or *Thelymitra stellata* (Department of Environment and Conservation, 2009; TSSC, 2008b). Dieback hygiene and management measures / procedures will be implemented to prevent the introduction or spread of dieback as a result of construction and operation.
Interfere with the recovery of the species	The objectives of the *Slender Andersonia (Andersonia gracilis) Recovery Plan* (Department of Environment and Conservation, 2006) and the *National Recovery Plan for the Leighery's Macarthuria (Macarthuria keigheryi)* (Department of Environment and Conservation, 2009) are to "abate identified threats and maintain or enhance in situ populations to ensure the long-term preservation of the species in the wild". The Proposal will not affect in situ populations as none are located in close proximity to the Proposal. Mitigation measures are proposed to ensure that indirect impacts are not significant.

Significant impact criteria (Endangered)	Assessment of impacts to *Andersonia gracilis, Anigozanthos viridis* subsp. *Terraspectans, Macarthuria keigheryi* *Thelymitra stellata*
	Currently, there are no approved recovery plans in effect for *Anigozanthos viridis* subsp. *Terraspectans* or *Thelymitra stellata*. Nevertheless the Proposal is not expected to interfere with the recovery of any of these species. No known individuals have been recorded in close proximity to the Proposal, and measures are proposed to ensure successful rehabilitation such that habitat remains available for these species.

Table 78: Banksia Woodlands Threatened Ecological Community

Significant impact criteria (Endangered)	Assessment of impacts to Banksia Woodlands TEC
Reduce the extent of an ecological community	Despite the implementation of avoidance and minimisation measures the Proposal will require the disturbance of 210.2 ha of this TEC. These disturbed areas will be either progressively rehabilitated (mine pit) or rehabilitated at the end of the mine life. Since the 19th century, the region has been heavily cleared for agriculture, housing and associated infrastructure. In total, about 60% of the original extent of the TEC has been cleared. When native vegetation is cleared, habitat which was once continuous becomes divided into smaller separate fragments. This makes it harder for animals to roam or migrate and for plants to disperse. Many fragments of the TEC are small islands; isolated from each other by roads, houses and other developments. The remaining patches of the TEC are typically small over much of its range (more than 80% are less than 10 ha in size). Statewide, the Banksia Woodlands TEC covers over 335,000 ha and as such only 0.06% is predicted to be disturbed and rehabilitated by the Proposal. Nevertheless, as described above this disturbance is considered to 'reduce the extent' of this TEC.
Fragment or increase fragmentation of an ecological community	The disturbance of this TEC will occur in a north-south direction, however connecting portions of TEC will remain south of the Proposal, connecting eastern extents with those to the west (Figure 45). Some minor fragmentation will therefore occur but it is unlikely to be significant once rehabilitation has become established.
Adversely affect habitat critical to the survival of an ecological community	*Banksia Woodlands of the Swan Coastal Plain: a nationally protected ecological community* (Commonwealth of Australia, 2016) does not define 'habitat critical to the survival' for this TEC, therefore it is assumed the habitat within the boundaries of the TEC would be considered habitat critical to the TEC's survival. Despite the implementation of avoidance and minimisation measures the Proposal will require the disturbance of 210.2 ha of this TEC. These disturbed areas will be either progressively rehabilitated (mine pit) or rehabilitated at the end of the mine life. The Proposal is therefore likely to 'adversely affect habitat critical to the survival of this TEC'.
Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns	The Proposal is predicted to have negligible indirect environmental impacts outside the boundaries of the disturbance footprint. In order to achieve this outcome there are several key mitigation measures proposed, including groundwater drawdown limits and recharge strategies, avoidance of surface water flow areas, dust minimisation and fire, weed and dieback management. With the implementation of these controls the Proposal is considered unlikely to 'modify or destroy abiotic factors necessary for the TEC's survival".
Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a	With the implementation of mitigation measures (for example for fire, weeds and dieback) the Proposal is not predicted to result in any impacts that could cause a substantial change in the species composition of an occurrence of this TEC.

Significant impact criteria (Endangered)	Assessment of impacts to Banksia Woodlands TEC
decline or loss of functionally important species	
Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community	Despite the implementation of avoidance and minimisation measures the Proposal will require the disturbance of 210.2 ha of this TEC. These disturbed areas will be either progressively rehabilitated (mine pit) or rehabilitated at the end of the mine life, however these areas will remain of a lower quality than pre-mining conditions for many years. The Proposal is therefore likely to 'cause a substantial reduction in the quality or integrity of' a 210.2 ha portion of this TEC.
Interfere with the recovery of the ecological community	A recovery plan does not exist for this TEC however the approved conservation advice (DotEE, 2016d) identifies the following conservation objectives: • Protect the TEC using the EPBC Act; • Implement priority conservation actions: ○ Priority protection and restoration actions; ○ Research and monitoring priorities; and ○ Offsets. The Proposal is being assessed under the EPBC Act and the offset program proposed in Section 12 aligns with the priority conservation actions. Therefore while the Proposal does interfere with the recovery of this TEC, the proposed offsets are predicted to counterbalance that impact with outcomes that align with the approved conservation advice (refer to Section 12 for more detail).

Table 79: Carnaby's Cockatoo

Significant impact criteria (Endangered)	Assessment of impacts to Carnaby's Cockatoo
Lead to a long-term decrease in the size of a population	Carnaby's Cockatoo occurs widely throughout south-western WA, from the lower Murchison in the north and south to Esperance, and as far east as Forrestania (Storr and Johnstone, 1998). Clearing in the southern Wheatbelt has resulted in two genetically distinct subpopulations: a western and an eastern (White *et al.,* 2014). The western subpopulation is relevant to the Proposal, which breeds in the Avon-Wheatbelt, Geraldton Sandplains and Jarrah Forest IBRA bioregions, as far as Morawa in the north, and migrates to the Swan Coastal Plain during the non-breeding season, between January and June. It has been estimated that Carnaby's Cockatoo has disappeared from more than one-third of its historical breeding range because of extensive habitat loss in the Avon-Wheatbelt region (Saunders, 1990). Subsequently, the breeding distribution of Carnaby's Cockatoo has shifted westward through the Jarrah Forest region, where it now also breeds (Johnstone and Kirkby, 2008a; Storr and Johnstone, 1998). Black cockatoos are known to be mobile and widely-distributed, and the variation in flock compositions (for example, between breeding and non-breeding seasons). For black cockatoos, it is more appropriate to consider significance in terms of impacts on habitat rather than a resident population (DSEWPaC, 2012b). This assessment is provided below.
Reduce the area of occupancy of the species	The Banksia Woodland, Heath (Banksia) and Banksia Woodland/Heath (Banksia) habitat types would be considered an area of occupancy for this species as it provides feeding habitat, with Spectrum, (20221) classifying it as very high value foraging habitat. The Proposal will result in the disturbance of up to 289 ha of very high value Carnaby's Cockatoo foraging habitat, of which up to 289 ha of very high value foraging habitat will be rehabilitated (either progressively or at the completion of mine life).

Significant impact criteria (Endangered)	Assessment of impacts to Carnaby's Cockatoo
	During and after the mining stage of the Proposal the site will be rehabilitated to reinstate the flora and vegetation of areas that were disturbed. The mining pits will be progressively filled and rehabilitated to the pre-mining profile with the pre-existing land use reinstated as mining advances and actioned in accordance with the MCP. An interim MCP has been prepared to accompany this ERD (Appendix 2) which was developed according to DMIRS Guidelines (2020a; 2020b). Key rehabilitation measures captured within the MCP are summarised below: 1. All infrastructure will be removed from site; 2. All long-term disturbance areas will be respread with topsoil (or ripped and seeded if topsoil is no longer viable) and rehabilitated; 3. All earthmoving equipment will be cleaned free of any soil material to minimise the risk of weed or dieback introduction; 4. Rehabilitation specific to Carnaby's Cockatoo foraging habitat will be conducted in areas previously vegetated by similar habitat types, utilising best-practice methods; and 5. Carnaby's Cockatoo foraging species will be included in the rehabilitation seed mix if suitable. Image also proposes to develop a specific Banksia Woodland Rehabilitation Management Plan which will be developed and implemented prior to the disturbance of any Banksia Woodland TEC / PEC. This Plan will be an appendix to the final MCP and will draw on current rehabilitation practices for Banksia woodlands and is intended to be developed in consultation with DBCA and relevant rehabilitation experts. Management and monitoring is proposed to improve the performance of rehabilitation with regards to Carnaby's Cockatoo foraging values, and minimise indirect impacts to foraging habitats. The MCP will be submitted to DMIRS for assessment and approval prior to the construction of the Proposal and will be reviewed and revised at least every three years, or prior to closure, whichever is the earliest. It is estimated that rehabilitation of high value Carnaby's Cockatoo habitat will require ten years before rehabilitation is suitable for foraging by Carnaby's Cockatoo). After this period the foraging habitat will not be of the same quality, however the quality is predicted to improve gradually over time. There will therefore be unavoidable impacts to Carnaby's Cockatoo foraging habitat values within rehabilitated areas, however the health of these areas are predicted to improve closer to background over time. After the implementation of avoidance, minimisation and rehabilitation mitigation measures the residual impacts to Carnaby's Cockatoo foraging habitat are summarised as: Loss of up to 289 ha of very high value Carnaby's Cockatoo foraging habitat for a period of 15 years (up to five years construction and operation plus ten years before rehabilitation is suitable for foraging by Carnaby's Cockatoo).. These residual impacts are considered likely to temporarily reduce the area of occupancy of the species and are proposed to be counterbalanced by offsets (refer to Section 12).
Fragment an existing important population into two or more populations	The term 'important population' has not been defined for black cockatoos, due to the mobile and widely-distributed nature of these species, and the variation in flock compositions (for example, between breeding and non-breeding seasons). For black cockatoos, it is more appropriate to consider significance in terms of impacts on habitat rather than a resident population (DSEWPaC, 2012b). This assessment is provided below.
Adversely affect habitat critical to the survival of a species	The Carnaby's Cockatoo (*Zanda latirostris*) Recovery Plan (DPaW, 2013) identifies habitat critical to the survival of this species as being: • The eucalypt woodlands that provide nest hollows used for breeding, together with nearby vegetation that provides feeding, roosting and watering habitat that supports successful breeding • Woodland sites known to have supported breeding in the past and which could be used in the future, provided adequate nearby food and/or water resources are available or are re-established • In the non-breeding season the vegetation that provides food resources as well as the sites for nearby watering and night roosting that enable the cockatoos to effectively utilise the available food resources

Significant impact criteria (Endangered)	Assessment of impacts to Carnaby's Cockatoo
	Based on the above classification, Banksia Woodland, Heath (Banksia) and Banksia Woodland/Heath (Banksia) habitat types would be considered habitat critical to the survival of a species as it provides feeding habitat, with Spectrum (20221) classifying it as very high value foraging habitat. The Proposal will result in the disturbance of up to 289 ha of very high value Carnaby's Cockatoo foraging habitat, of which up to 289 ha of very high value foraging habitat will be rehabilitated (either progressively or at the completion of mine life). During and after the mining stage of the Proposal the site will be rehabilitated to reinstate the flora and vegetation of areas that were disturbed. The mining pits will be progressively filled and rehabilitated to the pre-mining profile with the pre-existing land use reinstated as mining advances and actioned in accordance with the MCP. An interim MCP has been prepared to accompany this ERD (Appendix 2) which was developed according to DMIRS Guidelines (2020a; 2020b). Key rehabilitation measures captured within the MCP are summarised below: 1. All infrastructure will be removed from site; 2. All long-term disturbance areas will be respread with topsoil (or ripped and seeded if topsoil is no longer viable) and rehabilitated; 3. All earthmoving equipment will be cleaned free of any soil material to minimise the risk of weed or dieback introduction; 4. Rehabilitation specific to Carnaby's Cockatoo foraging habitat will be conducted in areas previously vegetated by similar habitat types, utilising best-practice methods; and 5. Carnaby's Cockatoo foraging species will be included in the rehabilitation seed mix if suitable. Image also proposes to develop a specific Banksia Woodland Rehabilitation Management Plan which will be developed and implemented prior to the disturbance of any Banksia Woodland TEC / PEC. This Plan will be an appendix to the final MCP and will draw on current rehabilitation practices for Banksia woodlands and is intended to be developed in consultation with DBCA and relevant rehabilitation experts. Management and monitoring is proposed to improve the performance of rehabilitation with regards to Carnaby's Cockatoo foraging values, and minimise indirect impacts to foraging habitats. The MCP will be submitted to DMIRS for assessment and approval prior to the construction of the Proposal and will be reviewed and revised at least every three years, or prior to closure, whichever is the earliest. It is estimated that rehabilitation of high value Carnaby's Cockatoo habitat will require ten years before rehabilitation is suitable for foraging by Carnaby's Cockatoo). After this period the foraging habitat will not be of the same quality, however the quality is predicted to improve gradually over time. There will therefore be unavoidable impacts to Carnaby's Cockatoo foraging habitat values within rehabilitated areas, however the health of these areas are predicted to improve closer to background over time. After the implementation of avoidance, minimisation and rehabilitation mitigation measures the residual impacts to Carnaby's Cockatoo foraging habitat are summarised as: Loss of up to 289 ha of very high value Carnaby's Cockatoo foraging habitat for a period of 15 years (up to five years construction and operation plus ten years before rehabilitation is suitable for foraging by Carnaby's Cockatoo). These residual impacts are considered likely to adversely affect habitat critical to the survival of a species and are proposed to be counterbalanced by offsets (refer to Section 12).
Disrupt the breeding cycle of an important population	The development envelopes are unlikely to support breeding by Carnaby's Cockatoos (Spectrum, 2022a). There are no large trees (trees of sufficient size to provide nesting hollows) in the Survey Areas. The Proposal is therefore unlikely to disrupt the breeding cycle of an important population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that	As described above, after the implementation of avoidance, minimisation and rehabilitation mitigation measures the residual impacts to Carnaby's Cockatoo foraging habitat are summarised as: Loss of up to 289 ha of very high value Carnaby's Cockatoo foraging habitat for a period of 15 years (up to five years construction and operation plus ten years before rehabilitation is suitable for foraging by Carnaby's Cockatoo).

Significant impact criteria (Endangered)	Assessment of impacts to Carnaby's Cockatoo
the species is likely to decline	These residual impacts are considered likely to temporarily modify and decrease the availability or quality of habitat for this species, however not to the extent that the species is likely to decline, given the rehabilitation methods proposed and the availability of suitable habitat in the area.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	**Weeds** Weeds have the potential to outcompete and displace flora species if introduced or conditions are altered to favour their growth. Weeds may be spread and/or introduced by vehicles and equipment, resulting in soil and weed vegetative material being transported around site and being present on equipment entering and exiting site. Image will implement weed management measures to ensure that the spread and introduction of weed species is minimised. **Feral Animals** The mining and rehabilitation methodology will not result in extensive areas of permanently cleared land. Mining will be rehabilitated progressively where possible and infill planting will be used. It is unlikely that the Proposal will modify fauna behaviours to the extent that would further impact this species.
Introduce disease that may cause the species to decline	The Proposal is not expected to be a vector for any disease for Carnaby's Cockatoo. The Carnaby's Cockatoo (*Zanda latirostris*) Recovery Plan (DPaW, 2013) however identifies *Phytophthora cinnamomi* (dieback) as a threat to the habitat for this species. Dieback hygiene and management measures / procedures will be implemented to prevent the introduction or spread of dieback as a result of construction and operation.
Interfere with the recovery of the species	The Carnaby's Cockatoo (*Zanda latirostris*) Recovery Plan (DPaW, 2013) identifies the protection and management of important habitat as a key recovery action for this species. The Proposal will require the temporary disturbance of important habitat for this species (refer above) and as such may interfere with its recovery. This impact is proposed to be counterbalanced by offsets, which includes further protection and management of important habitat (refer to Section 12).

Table 80: Malleefowl

Significant impact criteria (Vulnerable)	Assessment of impacts to Malleefowl
Lead to a long-term decrease in the size of an important population of a species	An 'important population' is defined by the Significant Impact Guidelines 1.1 (DotE, 2013a) as a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are: • Key source populations either for breeding or dispersal; • Populations that are necessary for maintaining genetic diversity, and/or • Populations that are near the limit of the species range. The National Recovery Plan for Malleefowl *Leipoa ocellata* (Benshemesh, 2007) states that no particular populations or general areas can be described as being of greater importance for the long-term survival of Malleefowl than any other at this stage. No evidence of Malleefowl populations or individuals were identified within the development envelopes, therefore there is no known important population that may be impacted by the Proposal. Regardless of this, the Proposal will only have minor disturbance to the broad habitat of this species and indirect impacts are able to be easily mitigated with well-established controls (Section 13.6). The Proposal is therefore unlikely to lead to a long-term decrease in the size of an important population of this species.
Reduce the area of occupancy of an important population	As discussed above, no evidence of Malleefowl populations or individuals were identified within the development envelopes, therefore there is no known important population that may be impacted by the Proposal. Regardless of this, the Proposal will only have minor disturbance to the potential area of occupancy

Significant impact criteria (Vulnerable)	Assessment of impacts to Malleefowl
	of any populations that may be in the area, and indirect impacts are able to be easily mitigated with well-established controls (Section 13.6). The Proposal is therefore unlikely to lead to reduce the area of occupancy of an important population of this species.
Fragment an existing important population into two or more populations	No evidence of Malleefowl populations or individuals were identified within the development envelopes, therefore there is no known important population that may be fragmented into two or more populations impacted by the Proposal.
Adversely affect habitat critical to the survival of a species	Malleefowl occur in a wide range of habitat types and habitat critical to the survival of the species is known only in broad terms (Benshemesh, 2007). While suitable habitat exists within the development envelopes, this habitat is widespread throughout the area, including large areas within conservation reserves. The habitat within the development envelopes would be unlikely to be considered 'habitat critical to the survival' of this species.
Disrupt the breeding cycle of an important population	No Malleefowl mounds were recorded within the development envelopes and Image has committed to not disturb any new mounds that may be created or discovered while being used for breeding purposes. As discussed above, no evidence of Malleefowl populations or individuals were identified within the development envelopes, therefore there is no important population that is known to utilise the habitat within the development envelopes. The Proposal is therefore unlikely to disrupt the breeding cycle of an important population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The Proposal will result in the disturbance of up to 318 ha of potential Malleefowl habitat, 0.6 ha of which will remain permanently cleared, and up to 122.3 ha of habitat that will be cleared and rehabilitated (either progressively or at the end of the mine life). There will be unavoidable impacts to Malleefowl habitat health within rehabilitated areas, however the health of these areas are predicted to improve closer to background over time. Management and monitoring is proposed to prevent direct impacts to Malleefowl habitat, to improve the performance of rehabilitation and minimise indirect impacts to Malleefowl habitats (refer to Section 13.6) Based on the above the Proposal is considered unlikely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Weeds** Weeds have the potential to outcompete and displace flora species if introduced or conditions are altered to favour their growth. Weeds may be spread and/or introduced by vehicles and equipment, resulting in soil and weed vegetative material being transported around site and being present on equipment entering and exiting site. Image will implement weed management measures to ensure that the spread and introduction of weed species is minimised. **Feral Animals** The mining and rehabilitation methodology will not result in extensive areas of permanently cleared land. Mining will be rehabilitated progressively where possible and infill planting will occur. It is unlikely that the Proposal will modify fauna behaviours to the extent that would further impact this species.
Introduce disease that may cause the species to decline	There is no information on disease in wild Malleefowl populations although the species is susceptible to a range of common diseases in captive situations and may also be susceptible to exotic diseases, especially those found in other Galliformes (R. Woods pers. comm.). The Proposal is not expected to be a vector for any disease for this species.
Interfere substantially with the recovery of the species	The National Recovery Plan for Malleefowl *Leipoa ocellata* (Benshemesh, 2007) identifies the management of populations as a key recovery action for this species. The Proposal will not impact any known populations and the temporary reduction in habitat extent is limited in the context of the wide-ranging nature of this species. The Proposal is therefore considered unlikely to interfere substantially with the recovery of this species

13.6 Assessment against significant impact criteria for listed migratory species

One species listed as migratory under the EPBC Act was considered likely to occur in the vicinity of the Proposal (Fork-tailed Swift) on an infrequent basis. An assessment of the significance of impacts to the Fork-tailed Swift is provided in Table 81.

Table 81: Fork-tailed Swift

Significant impact criteria	Assessment of impacts
Potential to substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	An area of 'important habitat' for a migratory species is defined in the Significant Impact Guidelines 1.1 (DotE, 2013a) as habitat that is: a. Utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species, and/or b. Of critical importance to the species at particular life-cycle stages, and/or c. Utilised by a migratory species which is at the limit of the species range, and/or d. Within an area where the species is declining. The Fork-tailed Swift was only identified as a possible infrequent visitor to the area and the habitat within the development envelopes was not identified as meeting any of the above criteria. The Proposal is therefore considered unlikely to substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for this species.
Potential to result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species.	As described above, the Fork-tailed Swift was only identified as a possible infrequent visitor to the area and the habitat within the development envelopes was not identified as meeting any of the criteria for 'important habitat'. The Proposal is therefore considered unlikely to result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species.
Potential to seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	The Fork-tailed Swift is widespread in coastal and subcoastal areas between Augusta and Carnarvon, including some on nearshore and offshore islands. They are scattered along the coast from south-west Pilbara to the north and east Kimberley region, near Wyndham. There are sparsely scattered inland records, especially in the Wheatbelt, from Lake Annean and Wittenoom. They are found in the north and north-west Gascoyne Region, north through much of the Pilbara Region, and the south and east Kimberley. The habitat within the development envelopes is well represented in the surrounding area and is therefore unlikely to be significant habitat for Fork-tailed Swift breeding, feeding, migration or resting behaviour. The Fork-tailed Swift was also only identified as a possible infrequent visitor to the area and therefore the development envelopes are unlikely to contain an ecologically significant proportion of the population of this species.

13.7 Proposed Safeguards and Mitigation Measures

The proposed mitigation measures relevant to MNES are outlined in Table 82.

Table 82: Proposed mitigation measures

Mitigation Number	Key Mitigation	Detail	Species Affected	Timing	Location
Hydrological / Water Quality					
1.	Development envelopes designed to avoid key surface water features	The development envelopes have been designed to avoid the following: • Seasonal ponds; • Mount Jetty Creek; and • Bibby Creek.	Banksia Woodlands TEC Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	Construction	All
2.	Obtain and comply with Works Approval and Licence issued under Part V of the EP Act.	A Works Approval and Licence will be required for the Proposal, specifically for the FPP, slurry and return water pipeline and WCP. These infrastructure items present the highest surface water and groundwater pollution risks for the Proposal. Therefore, the Works Approval and Licence is the primary mechanism for ensuring the design and operation of the Proposal is conducted in a manner that minimises pollution impacts to inland waters. The Works Approval and Licence will ensure that the following mitigation measures are implemented at a minimum: 1. Routinely inspect the condition and performance of pipelines, containment systems and internal drainage structures, to ensure they are in acceptable condition and / or operating appropriately; 2. The following controls will be implemented to minimise the risk of impact from unintentional slurry pipeline spills: a. Pipeline will be fitted with leak detection (where there is potential to impact native vegetation); b. Flows will be shut off if leaks are detected; c. Pipeline will be inspected regularly, especially during extreme heat or fire events; d. Pipeline will be located off road surfaces to reduce the risk of vehicle collisions; and e. Where the pipeline has to cross a road, then it will be buried. Investigations will be conducted into the cause of any spills, and remedial actions will be taken to minimise the chance of reoccurrence;	Banksia Woodlands TEC Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	Construction and Operation	All
3.	Obtain and comply with a 5C Licence for groundwater abstraction	The 5C Licence is the primary mechanism for ensuring the groundwater abstraction is conducted in a manner that does not pose a significant risk to the Superficial, Yarragadee, Eneabba and/or Lesueur Aquifer or other users. The Licence application will be supported by H3 level hydrological investigations verifying that the proposed abstraction volumes will not result in drawdown impacts to wetlands, GDEs.	Banksia Woodlands TEC Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	Construction and Operation	All
4.	Implement Flood and Stormwater Controls	Allowing for contingencies, the required flood protection level was determined to be 41.5 m AHD (MWES, 20222d). Bunding to this elevation will be installed temporarily for the duration of the pre-strip mine and rehabilitation period for each mine block. Stormwater containment within the plant area will be applied to areas of potential contamination such as workshops, machinery lay-down etc. Precise locations will depend on the finalised site levelling, layout and utilisation	Banksia Woodlands TEC Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	Construction and Operation	All
5.	Implement measures to minimise the risk and impact of hydrocarbon spills	**Implement the following measures to minimise the risk and impact of hydrocarbon spills:** • Hydrocarbons will be stored either within a bunded area or within self-bunded tanks; • All spills will be controlled, contained and cleaned up as soon as practicable; • Service vehicles will be fitted with spill kits; • Spill kits will be located at all workshop and fuel storage areas; and • Environmental incident recording, investigation and reporting system.	Banksia Woodlands TEC Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	Construction and Operation	All
6.	Comply with WA Water Quality Protection Guidelines and guidance notes	Particularly in relation to the storage and use of hydrocarbons and other harmful chemicals, the design and operation of maintenance areas and facilities, the siting and operation of wastewater storage systems, and the handling and storage of other waste materials, including contaminated soils.	Banksia Woodlands TEC Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	Construction and Operation	All
7.	Implementation of the SWMP	The SWMP (Appendix 20) will include the following institutional controls: • Drainage diversions around the stockpiles and hardstands will retain stormwater locally; • Mine workings isolated from wetland water through the construction of mine bunds; • Pond freeboard and sediment basins will be designed for a minimum first flush capacity of nominally 25 mm; and • Monitoring of flood controls and water levels and quality.	Banksia Woodlands TEC Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	Construction and Operation	All
8.	Prepare a Final Infrastructure Design Plan	Prior to ground disturbance, which will provide further detail that demonstrates that the final locations of all Proposal infrastructure and related disturbance has been selected to avoid groundwater drawdown impacts outside of the disturbance footprint.	Banksia Woodlands TEC Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	Construction	All

Mitigation Number	Key Mitigation	Detail	Species Affected	Timing	Location
9.	Implementation of the DMS	The DMS will be implemented to manage the recharge of the Superficial Aquifer, to mitigate the impacts of groundwater drawdown on GDEs.	Banksia Woodlands TEC Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	Construction and Operation	All
10.	Ensure abstraction within the Mesozoic Aquifer System does not result in drawdown impacts to wetlands, GDEs	H3-level hydrological investigations will be completed verifying that the proposed abstraction volumes will not result in drawdown impacts.	Banksia Woodlands TEC Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	Construction and Operation	All
11.	Implement the GOS (Appendix 19)	The GOS includes detailed management and monitoring of the DMS, as well as typical monitoring and management measures required under RIWI Act approvals for groundwater abstraction. Monitoring of groundwater within the superficial and Mesozoic aquifer systems will be undertaken over the life of the Proposal. Monitoring will be conducted during operations and closure to identify changes in groundwater levels, water quality. Monitoring will be conducted to provide ongoing calibration of the DMS and to provide early detection of drawdown beyond specified limits and changes in water quality.	Banksia Woodlands TEC Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	Construction and Operation	All
Fauna					
1.	Implement industry best practice management measures for terrestrial fauna	• Vegetation clearing will be managed through internal ground disturbance procedures; • Boundaries of areas to be cleared or disturbed will be identified by GPS coordinates and maps of boundaries will be provided to dozer operator to minimise clearing; • Progressive clearing will be undertaken; • The disturbance footprint will be developed to the minimum required to ensure safe and adequate construction and operation; • Water or dust suppressants will be applied to disturbed areas and product transfer/storage areas as required to minimise dust generation; • Emergency response capabilities will be maintained to prevent fire outbreaks where possible; • Weed and dieback hygiene and management measures / procedures will be implemented to prevent spread of weeds / dieback and the introduction of new weed species as a result of construction and operation; • Fauna egress mechanisms will be installed in trenches, turkeys nests and solar drying ponds; • Low noise equipment will be used where practicable; • All incidents resulting in fauna injury or death will be reported internally; and • Vehicle speed limits will be set and enforced.	Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	All phases	All
2.	Prepare and implement a FHMP	The FHMP will include commitments to minimise impacts to fauna habitat, and in particular Carnaby's Cockatoo foraging habitat, including: • Commitments to minimise habitat disturbance during construction and operations; • Minimum infill planting or seeding requirements for species utilised for Carnaby's Cockatoo foraging in rehabilitation areas; • Annual monitoring of rehabilitation success, in particular the species utilised for Carnaby's Cockatoo foraging; • Reporting and recording of Carnaby's Cockatoo and other significant fauna sightings; • Reporting of introduced fauna sightings within rehabilitated areas; and • Annual Targeted fauna survey of rehabilitation areas to assess the usage characteristics of these areas against baseline sites.	Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	All phases	All
3.	Prepare a Final Infrastructure Design Plan	Prior to ground disturbance, which will provide further detail that demonstrates that the final locations of all Proposal infrastructure and related disturbance has been selected to avoid groundwater drawdown impacts outside of the disturbance footprint.	Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	Construction	All
4.	Implementation of the DMS	The DMS will be implemented to manage the recharge of the Superficial Aquifer, to mitigate the impacts of groundwater drawdown on GDEs.	Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	All phases	All
5.	Ensure abstraction within the Mesozoic Aquifer System does not result in drawdown impacts to wetlands, GDEs	H3-level hydrological investigations will be completed verifying that the proposed abstraction volumes will not result in drawdown impacts.	Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	All phases	All

Mitigation Number	Key Mitigation	Detail	Species Affected	Timing	Location
6.	Develop and implement a GOS (Appendix 19)	The GOS includes detailed management and monitoring of the DMS, as well as typical monitoring and management measures required under RIWI Act approvals for groundwater abstraction. Monitoring of groundwater within the superficial and Mesozoic aquifer systems will be undertaken over the life of the Proposal. Monitoring will be conducted during operations and closure to identify changes in groundwater levels, water quality. Monitoring will be conducted to provide ongoing calibration of the DMS and to provide early detection of drawdown beyond specified limits and changes in water quality.	Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	All phases	All
7.	Implement measures to minimise the risk and impact of hydrocarbon spills	• Hydrocarbons will be stored either within a bunded area or within self-bunded tanks; • All spills will be controlled, contained and cleaned up as soon as practicable; • Service vehicles will be fitted with spill kits; • Spill kits will be located at all workshop and fuel storage areas; and • Environmental incident recording, investigation and reporting system.	Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	All phases	All
8.	Comply with WA Water Quality Protection Guidelines and guidance notes	Particularly in relation to the storage and use of hydrocarbons and other harmful chemicals, the design and operation of maintenance areas and facilities, the siting and operation of wastewater storage systems, and the handling and storage of other waste materials, including contaminated soils.	Carnaby's Cockatoo (*Zanda latirostris*) Fork-Tailed Swift (*Apus pacificus*) Malleefowl (*Leipoa ocellate*)	All phases	All
Flora and Vegetation					
1.	Implement industry best practice management measures for flora and vegetation	• Vegetation clearing will be managed through internal ground disturbance procedures; • Boundaries of areas to be cleared or disturbed will be identified by GPS coordinates and maps of boundaries will be provided to the dozer operator to minimise clearing; • Progressive clearing will be undertaken; • The disturbance footprint will be developed to the minimum required to ensure safe and adequate construction and operation; • Water or dust suppressants will be applied to disturbed areas, mining areas and product transfer/storage areas as required to minimise dust generation; • Emergency and fire response capabilities will be maintained to respond to fire outbreaks where possible; • Weed and dieback hygiene and management measures / procedures will be implemented through the DMP to prevent spread of weeds and dieback and the introduction of new weed species as a result of construction and operation.	*Andersonia gracilis* *Anigozanthos viridis* subsp. *Terraspectans* *Macarthuria keigheryi* *Thelymitra stellata* Banksia Woodlands TEC	All phases	All
2.	Obtain and comply with Works Approval and Licence issued under Part V of the EP Act.	A Works Approval and Licence will be required for the Proposal, under the mineral sands mining category. The Works Approval and Licence is the primary mechanism for ensuring the design and operation of the Proposal is conducted in a manner that minimises pollution impacts to flora. The Works Approval and Licence will ensure that the following mitigation measures are implemented at a minimum: • Dust emissions are managed in accordance with a DEMP; • Routinely inspect the condition and performance of pipelines, containment systems and internal drainage structures, to ensure they are in acceptable condition and / or operating appropriately; • The following controls will be implemented to minimise the risk of impact from unintentional pipeline spills: ○ Pipeline will be fitted with leak detection (where there is potential to impact native vegetation); ○ Flows will be shut off if leaks are detected; ○ Pipeline will be inspected regularly, especially during extreme heat or fire events; ○ Pipeline will be located off access road surfaces to reduce the risk of vehicle collisions; ○ If the pipeline has to cross the access road then it will be buried; ○ Investigations will be conducted into the cause of any spills, and remedial actions will be taken to minimise the chance of reoccurrence;	*Andersonia gracilis* *Anigozanthos viridis* subsp. *Terraspectans* *Macarthuria keigheryi* *Thelymitra stellata* Banksia Woodlands TEC	Construction and Operation	Mining areas
3.	Implement the MCP	The MCP is provided in Appendix 2 and will be implemented during closure and rehabilitation of the Proposal.	*Andersonia gracilis* *Anigozanthos viridis* subsp. *Terraspectans* *Macarthuria keigheryi* *Thelymitra stellata* Banksia Woodlands TEC	Closure	Mining areas
4.	Implement measures to minimise the risk and impact of hydrocarbon spills	• Hydrocarbons will be stored either within a bunded area or within self-bunded tanks; • All spills will be controlled, contained and cleaned up as soon as practicable; • Service vehicles will be fitted with spill kits; • Spill kits will be located at all workshop and fuel storage areas; • Environmental incident recording, investigation and reporting system.	*Andersonia gracilis* *Anigozanthos viridis* subsp. *Terraspectans* *Macarthuria keigheryi* *Thelymitra stellata* Banksia Woodlands TEC	All phases	All
5.	Comply with WA Water Quality Protection	Particularly in relation to the storage and use of hydrocarbons and other harmful chemicals, the design and operation of vehicle maintenance areas and facilities, the siting and operation of wastewater treatment systems, and the handling and storage of other waste materials, including contaminated soils	*Andersonia gracilis*	All phases	All

Mitigation Number	Key Mitigation	Detail	Species Affected	Timing	Location
	Guidelines and guidance notes		*Anigozanthos viridis* subsp. *Terraspectans* *Macarthuria keigheryi* *Thelymitra stellata* Banksia Woodlands TEC		
6.	Implement the Dieback Management Plan	The Dieback Management Plan is provided in Appendix 7 and will be implemented during all phases of the Proposal.	*Andersonia gracilis* *Anigozanthos viridis* subsp. *Terraspectans* *Macarthuria keigheryi* *Thelymitra stellata* Banksia Woodlands TEC	All phases	All
Rehabilitation					
1.	Implement the MCP	At the completion of the Proposal the site will be further rehabilitated to reinstate the flora and vegetation of areas that were disturbed. A MCP will be required under the Mining Act and the key rehabilitation measures that relate to MNES are summarised below: • All infrastructure will be removed from site; • All long-term disturbance areas will be respread with topsoil (or ripped and seeded if topsoil is no longer viable) and rehabilitated; • All earthmoving equipment will be cleaned free of any soil material to minimise the risk of weed or dieback introduction; • Key TEC species will be included in the rehabilitation seed mix if suitable; and • All depressions will be shaped to prevent the formation of new semi-permanent water sources. The MCP will be submitted to DMIRS for assessment and approval prior to the construction of the Proposal and will be reviewed and revised at least every three years.	*Andersonia gracilis* *Anigozanthos viridis* subsp. *Terraspectans* *Macarthuria keigheryi* *Thelymitra stellata* Banksia Woodlands TEC Carnaby's Cockatoo Malleefowl Fork-tailed Swift	Closure	All

13.7.1 Principles of Ecologically Sustainable Development

Table 83 assesses the Proposal against the principles of ecologically sustainable development listed in Section 3A of the EPBC Act.

Table 83: Assessment against the principles of ecologically sustainable development

Principle	Assessment
(a) decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations	The Proposal is a short-term project that supports the ongoing demand for mineral sands. The environmental and social impacts associated with the Proposal are short-term and incremental (progressive clearing and rehabilitation), and rehabilitation is able to commence in a short timeframe.
(b) if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation	While Image has commissioned numerous ecological studies in order to inform the design of the Proposal, and there are several examples where measures have been taken to prevent environmental degradation, such as: • Removal of areas of significant flora and vegetation from the development envelopes; • Avoiding drainage lines; • Implementing groundwater recharge to avoid drawdown impacts; • Targeting deeper groundwater sources for external water supply; and • Disposing of the tailings and waste material in the mined out pits to remove the requirement for permanent external disposal facilities. Sufficient studies have been completed or are planned to ensure there is scientific certainty that unexpected environmental degradation would not occur.
(c) the principle of inter-generational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations	As stated above, the Proposal is a short-term small-scale project that provides minerals sands. The Proposal includes rehabilitation commitments and techniques specifically designed to ensure the health, diversity and productivity of the environment is reinstated close to background levels over time, with pit backfilling and no permanent constructed landforms.
(d) the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making	The conservation of biological diversity and ecological integrity was a fundamental consideration in decision-making when determining the mining and rehabilitation method for the Proposal, as well as the location of the disturbance areas.
(e) improved valuation, pricing and incentive mechanisms should be promoted	The Proposal is a short-term project that targets the high-grade portion of the deposit and allows Image to meet current demand, improving the valuation of the product.

13.8 Economic Impacts of the Proposal

The 2017 Feasibility Study for the Proposal identified that the Proposal earnings (before interest, taxes, depreciation, and amortization) are predicted to be $75 million of a three year period, resulting in $11 million in royalties paid. The Proposal is predicted to employ up to 140 personnel during construction and up to 110 personnel during operations.

14 HOLISTIC IMPACT ASSESSMENT

For each relevant Key Environmental Factor, the ERD provides a detailed assessment of the potential impacts associated with the Proposal, application of the mitigation hierarchy and the management strategies proposed. The Key Environmental Factors relevant to the Proposal include:

- Flora and Vegetation;
- Terrestrial Fauna;
- Inland Waters;
- Terrestrial Environmental Quality;
- Social Surroundings; and
- Human Health.

Each relevant Key Environmental Factor has been assessed separately in Sections 5 - 10. Linkages of varying strengths exist between the relevant Key Environmental Factors. The potential impacts of the Proposal have been considered in a holistic context and a conceptual model demonstrating links between key environmental factors is provided in Figure 128. A linkage is considered to be present if any two Key Environmental Factors share the same impact. The strength of the links are based on the significance of the impact and the interconnectivity of each Key Environmental Factor with another. Linkages are represented by lines, strong linkages are shown as solid black lines and weaker linkages are represented by grey dotted lines.

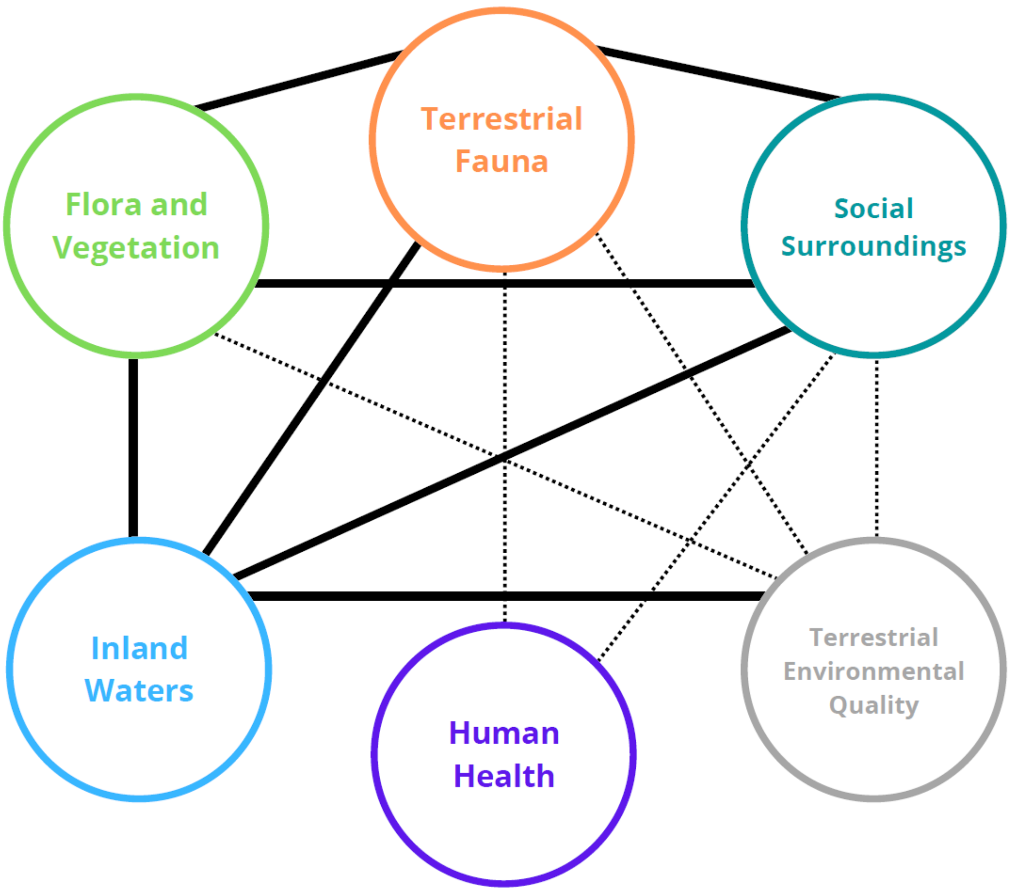


Figure 128: Conceptual model of linkages between Key Environmental Factors

Potential overarching impacts relevant to each Key Environmental Factor have been summarised in Table 84. While many potential impacts are shared between multiple factors, key impacts (those which have been identified as creating a strong linkage) have been identified with red ticks.

Table 84: Potential impacts shared by key environmental factors

Key Environmental Factor	Relevant Potential Impacts						
	Clearing	Dieback/ Weeds	Groundwater Abstraction	Contamination	Dust Emissions	Radiation Emissions	Noise
Flora & Vegetation	✓	✓	✓	✓	✓		
Terrestrial Fauna	✓	✓	✓	✓	✓	✓	✓
Inland Waters	✓		✓	✓			
Social Surroundings	✓	✓	✓	✓	✓	✓	✓
Human Health				✓		✓	
Terrestrial Environmental Quality				✓			

Clearing of native vegetation is identified as a key impact as it will directly impact three Key environmental factors. Clearing will impact the Flora and Vegetation and Terrestrial Fauna key environmental factors by removing or disturbing significant flora species, ecological communities and fauna habitat. Clearing will also impact the Social Surroundings factor by reducing the quality and availability of vegetation that may otherwise be used by the Yued People for bush tucker or bush medicine. Image also acknowledges that native vegetation values are related to the availability of faunal and botanical resources and represents a connection to Country.

While not a direct impact, the introduction and spread of dieback and weeds has the potential to impact three key environmental factors and therefore has also been considered as a key impact. Introduction and spread of dieback and weeds has the potential to impact the Flora and Vegetation and Terrestrial Fauna key environmental factors through mortality (flora) and a reduction in habitat extent and quality (flora and fauna). The introduction of dieback and weeds also impacts the Social Surroundings key environmental factor as it has the potential to result in plant deaths and a reduction in the quality and extent of native vegetation on Yued Country, including those that may be used for bush medicine or bush tucker.

The Proposal is not predicted to result in a significant impact to groundwater provided mitigation measures are in place. Regardless, groundwater abstraction has been identified as a key impact due to the significance of the linkage between Flora and Vegetation, Terrestrial Fauna, Inland Waters and Social Surroundings key environmental factors. Generally, water is recognised as being of high importance to Traditional Owners typically through mythological associations, significance in song lines and represents a connection to Country.

Image acknowledges that other impacts of the Proposal (contamination, dust and air emissions, radiation and noise) provide linkages between the other key environmental factors however these impacts are unlikely to be significant and therefore linkages are not considered to be as strong as the others mentioned above. All linkages have been considered in the design of the Proposal, application of the mitigation hierarchy and proposed management measures.

The Proposal is a project that allows progressive rehabilitation, in contrast to projects such as housing and infrastructure that require large areas to be cleared permanently.

The Proposal lies within the range of the Carnaby's Cockatoo (Endangered; BC Act and EPBC Act) and contains the Banksia Woodlands TEC / PEC. Several significant flora species were also identified within the survey areas. The Proposal has unavoidable impacts associated with vegetation clearing and habitat loss, therefore it was imperative that these impacts were avoided and minimised as far as practicable, and rehabilitation methods are best-practice.

Given the above, Image incorporated extensive avoidance and minimisation measures into the Proposal design. The Proposal that was originally referred to the EPA under Section 38 of the EP Act included the direct disturbance of up to 396 ha of native vegetation. Image has since reduced the extent of the Development Envelopes to exclude key environmental and cultural values as much as practicable, and as a result the extent of clearing of native vegetation has been reduced by 78 ha to 318 ha.

In addition to the above, Image has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes, the key measures being:

- The adoption of a progressive mining and immediate rehabilitation approach;
- The backfilling of mine pits, to avoid leaving an excavation at closure;
- The avoidance of wetland, riparian and drainage areas to the north of the Mine Development Envelope;
- Revising the Mine Development Envelope to avoid Priority Flora populations and areas of cultural significance; and
- The use of existing cleared areas where available (access corridors).

There are some potential impacts that require management and monitoring to ensure that the impacts are not significant. Many of these potential impacts are adequately regulated under other legislation:

- Slurry spills and leaks and process plant emissions will be regulated under Part V of the EP Act;
- Mine pit design, and general environmental management will be regulated through a Mining Proposal assessed under the Mining Act; and
- Closure and rehabilitation will be regulated through a MCP assessed under the Mining Act.

There are some potential impacts however that are expected to require limits or conditions in the Ministerial Statement, including:

- Limits on total permanent and temporary disturbance within each development envelope;
- A limit on groundwater abstraction volumes;
- The implementation of a Final Infrastructure Design Plan, which will ensure that impacts on Priority Flora, the Banksia Woodland TEC / PEC and Carnaby's Cockatoo foraging habitat are minimised as far as practicable;
- The implementation of management plans for dust, noise and radiation;
- The implementation of a Social Cultural Heritage Management Plan; and
- The implementation of an Offset Strategy.

Based on the above, and the assessment provided in Sections 5 - 10, the Proposal avoidance, minimisation and rehabilitation measures are expected to be able to meet the EPA's objectives for all potential key environmental factors, with the exception of Flora and Vegetation and Terrestrial Fauna.

Residual impacts to the Banksia Woodlands TEC / PEC and Carnaby's Cockatoo foraging habitat are considered to remain significant once mitigation measures are implemented. Offset measures are required to counterbalance these residual impacts to ensure that the EPA objective for Flora and Vegetation and Terrestrial Fauna can be met. Image has proposed offsets and assessed the suitability of the offset against the WA and EPBC offset guidance, provided in Section 12. Specifics of these offset measures will be reviewed and refined during the development of an Offsets Strategy (expected to be a Ministerial Condition) through discussions with DMIRS, DBCA, DCCEEW and EPA Services to ensure they meet the required outcomes and adequately counterbalance the residual impacts.

Image considers that the residual impacts to the Banksia Woodlands TEC / PEC and Carnaby's Cockatoo foraging habitat is able to be counterbalanced by the implementation of the offsets detailed in Section 12, such that the EPA's objectives are able to be met for all Key Environmental Factors.

15 CUMULATIVE ENVIRONMENTAL IMPACT ASSESSMENT

Image has conducted an assessment of the potential and residual environmental impacts for each Key Environmental Factor relevant to the Proposal. A cumulative environmental impact assessment was included to assess the successive, incremental and interactive impacts of the Proposal on the environment in addition to impacts from past, present and reasonably foreseeable future activities. The results of this assessment are summarised in the following sections. Impacts to Terrestrial Environmental Quality and Human Health were not considered significant in a cumulative context therefore they have not been included in the summary.

The surrounding area has been impacted by agriculture, residential land and linear infrastructure and this has been considered in the cumulative assessment. There is also one other operational project in close proximity considered relevant for assessing cumulative impacts of the Proposal; the Cooljarloo West Titanium Minerals Project (Cooljarloo West; proponent Tronox Management) located 20 km to the south east. Image is not aware of any other proposed projects within 25 km of the Proposal.

15.1 CLEARING OF NATIVE VEGETATION / HABITAT

Clearing of native vegetation and habitat is the primary impact from the Proposal on Flora and Vegetation, Terrestrial Fauna and Social Surroundings. Cumulative impacts from the Proposal are considered to include:

- 0.4% of the remaining native vegetation within 20 km;
- 0.4% of the current pre-European extent of Bassendean 1030 vegetation association;
- 0.06% of the state-wide mapped extent of the 'Banksia woodlands of the Swan Coastal Plain' TEC / PEC; and
- Less than 35% of mapped local high value Carnaby's Cockatoo foraging habitat.

Cumulative impacts on individual vegetation units and Priority flora species are quantified in Table 19.

Image has assessed the impacts of the Proposal against potential and existing cumulative clearing impacts, including the future impacts of the Cooljarloo West Titanium Minerals Project. Image has determined that the cumulative native vegetation clearing across the Proposal and Cooljarloo West is estimated to be 2,208 ha, representing:

- 2% of the remaining native vegetation extent within 25 km of the Proposal
- 2.9% of the remaining native vegetation extent within 20 km of the Proposal;
- 4.5% of the remaining native vegetation extent within 15 km of the Proposal; and
- 10.2% of the remaining native vegetation extent within 10 km of the Proposal.

It should be noted that an estimated 13,433 ha of vegetation association 1030 located within conservation estate, and the Southern Beekeepers Nature Reserve and Nambung National Park also lie in proximity to both proposals. These conservation reserves also contain similar habitat for significant fauna including Carnaby's Cockatoo.

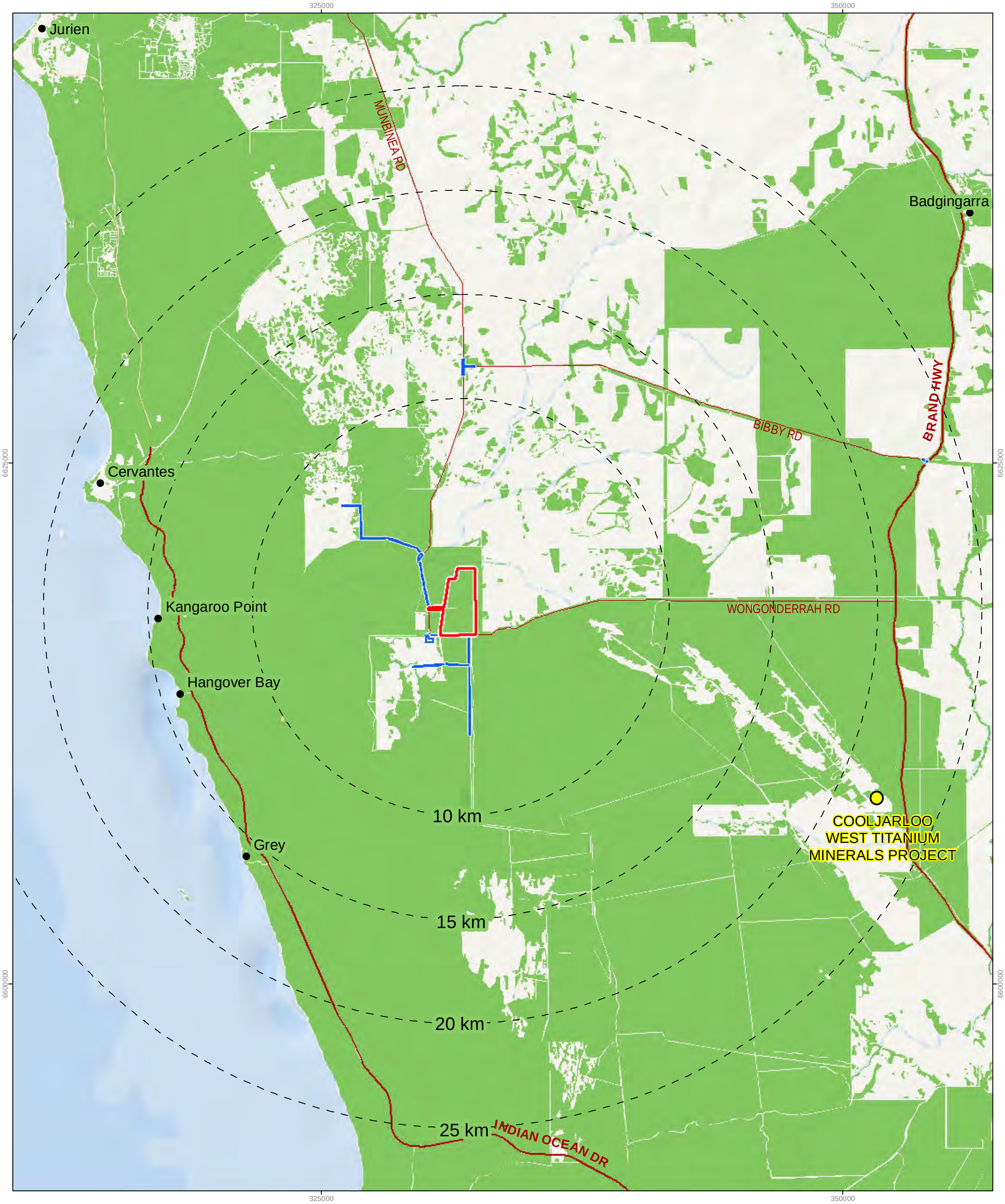
The ERD for the Cooljarloo West Titanium Minerals Project notes that the proposed 1,890 ha of native vegetation clearing includes Carnaby's Cockatoo foraging habitat, representing 7.2% of the total foraging habitat available within the total native vegetation extent assessed at the Project (27,960 ha) (Tronox, 2017). Using the same cumulative methodology above, up to a total of 2,174.2 ha of foraging habitat will be cleared across both proposals. Image will implement offsets to counteract the residual impact of the Proposal on Carnaby's Cockatoo foraging habitat (Section 12). Based on the provision of these offsets, Image considers that the implementation of the Proposal is not expected to significantly contribute to the cumulative impacts on Flora and Vegetation, Terrestrial Fauna or Social Surroundings.

15.2 ABSTRACTION OF GROUNDWATER

The Proposal will require dewatering from the Superficial / Tamala Limestone Aquifer within the Nambung subarea, estimated at up to 1.1 GL/yr during construction and 0.75 GL/yr during operations. The nearby Cooljarloo West Titanium Minerals Project is also licensed by DoW to abstract 3.27 GL/yr of groundwater from this system, producing a combined peak cumulative abstraction of up to 4.3 GL/yr. Given the Superficial / Tamala Limestone Aquifer has a groundwater abstraction allocation limit of 4 GL within the Nambung subarea, worst case estimates of the Proposal's abstraction from this system will result in an exceedance by 0.3 GL during construction. Image has therefore proposed significant mitigation schemes to ensure direct and indirect impacts to the Superficial / Tamala Limestone Aquifer are minimised (Section 7.6).

The Proposal will also require abstraction from the Mesozoic Aquifer System of up to 2.2 GL/yr via one or more borefields. Dependant on the outcomes of water supply investigations, this water supply will be abstracted from the Lesueur, Yarragadee and / or Eneabba aquifers. Cooljarloo West has again been identified as a nearby Project which is also licensed abstract the Mesozoic Aquifer System (via the Nambung Yarragadee Aquifer), resulting in a combined peak cumulative abstraction of up to 4.7 GL/yr. The groundwater abstraction allocation limit of Yarragadee Aquifer system in the Nambung subarea is 8.8 GL, resulting in a cumulative abstraction estimate of 53.4% of the total allocation should this option be chosen.

The Cervantes town water supply is the closest major borefield to the Proposal, and comprised of four shallow production bores that draw approximately 260 ML/yr of water from the unconfined Tamala Limestone aquifer. Image has also identified several privately owned bores and soaks in the local area, however is unable to obtain hydrogeological information from these locations. The cumulative potential abstraction rate of these locations and the proposed abstraction from Image is therefore predicted to be 4.8 GL per annum (Section 7.3.6).



Preston Consulting

CREATED	JOB	DATE	REVISION
ENVIRONMAPS	PC2900270	26/07/2022	0

Image Resources

0 1.5 3 6
km
Scale: 1:250,000 @ A4
N

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY

Legend
- Mine Development Envelope
- External Infrastructure Development Envelope
- Buffer (km)
- Native Vegetation

Source: Native Vegetation - DAFWA

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Figure 129: Cumulative disturbance (including the Cooljarloo West Titanium Minerals Project) within 25 km of the Proposal

GLOSSARY

Term	Meaning
µm	Micrometre
µS	Microseimens
µSv / hr	Micro-Sievert per Hour
^{220}Rn	Thoron
^{222}Rn	Radon
360 Environmental	360 Environmental Pty Ltd
AASS	Actual Acidic Sulphate Soils
ACA	Average Crustal Abundance
ACH Act	*Aboriginal Cultural Heritage Act 2021*
ACH Bill	*Aboriginal Cultural Heritage Bill 2021*
ACMC	Aboriginal Cultural Materials Committee
AEP	Average Exceedance Probabilities
AH Act	*Aboriginal Heritage Act 1972*
AHD	Australian Height Datum
AHIS	Aboriginal Heritage Inquiry System
AMR	Atlas Mineral Resource
ARI	Average Recurrence Intervals
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
ASS	Acid Sulphate Soils
ASSMP	Acid Sulphate Soils Management Plan
BAM Act	*Biosecurity and Agriculture Management Act 2007* (WA)
BBSA	Brand Highway-Bibby Road Survey Area
BC Act	*Biodiversity Conservation Act 2016* (WA)
BCE	Bamford Consulting Ecologists
BoM	Bureau of Meteorology
Bq / m^2	Becquerel per Square Metres
Bq / m^3	Becquerel per Cubic Metres
CALM	Conservation and Land Management
Calytrix	Calytrix Consulting Pty Ltd
CCM	Cattamarra Coal Measures
CD Tank	Constant Density Tank
cm	Centimetre
CO	Carbon Monoxide

Term	Meaning
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
CS Act	*Contaminated Sites Act 2003*
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Cth	Commonwealth
DAWE	Department of Agriculture, Water and the Environment
dB	Decibel
DBCA	Department of Biodiversity, Conservation and Attractions
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DCLM	*Department of Conservation and Land Management* (Now DBCA)
DEC	Department of Environmental Conservation (now DBCA)
DEM	Dust Extinction Moisture
DEMP	Dust Environmental Management Plan
DER	Department of Environmental Regulation
DEWHA	Department of Environment, Water, Heritage and the Arts (now DotEE)
DIDMS	Dieback Information Data Management System
DISER	Department of Industry, Science, Energy and Resources
DJTSI	Department of Jobs, Tourism, Science and Innovation (WA)
DM&P	Department of Mines and Petroleum (now DMIRS)
DMIRS	Department of Mines, Industry Regulation and Safety
DMP	Dieback Management Plan
DoE	Department of Environment
DoT	Department of Transport (WA)
DotE	Department of the Environment (now DAWE)
DotEE	Department of the Environment and Energy (now DAWE)
DoW	Department of Water (WA), now DWER
DPaW	Department of Parks and Wildlife (WA)
DPC	Department of the Premier and Cabinet (WA)
DPIRD	Department of Primary Industries and Regional Development (WA)
DPLH	Department of Planning, Lands and Heritage (WA)
dS/m	deciSiemens per metre
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (Commonwealth), (now DAWE)
DWER	Department of Water and Environmental Regulation
EC	Electrical Conductivity
eCEC	Effective cation exchange capacity
EIA	Environmental Impact Assessment

Term	Meaning
EIDE	External Infrastructure Development Envelope
EIS	Environmental Impact Statement
EISA	External Infrastructure Survey Area
EP Act	*Environmental Protection Act 1986* (Cth)
EPA	Environmental Protection Authority (WA)
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999* (Cth)
ERD	Environmental Review Document
ESD	Environmental Scoping Document
ESP	Exchangeable Sodium Percentage
F	Foraging
FCT	Floristic Community Types
FEL	Front End Loader
FEMD	*Forest and Ecosystem Management Division*
FHMP	Fauna Habitat Management Plan
FNA	File Notification Area
FPP	Feed Preparation Plant
g	Grams
$g/m^2/month$	mass of dust deposited per m^2 per month
GDEs	Groundwater Dependent Ecosystems
GL	Gigalitre
GL/yr	Gigalitre per year
GOS	Groundwater Operating Strategy
GPS	Global Positioning System
GSM	Graceful Sun-moth Survey
ha	hectares
HMC	Heavy Mineral Concentrate
Horizon	Horizon Heritage Management
hr	Hours
HSL	High Slimes
HydroConcept	HydroConcept Pty Ltd
IBRA	Interim Biogeographic Regionalisation for Australia
IBSA	Index of Biodiversity Surveys of Assessments
IFD	Rainfall Intensity Data
ILUA	Indigenous Land Use Agreement
Image	Image Resources NL
IUCN	International Union for Conservation of Nature

Term	Meaning
KBPL	Kewan Bond Pty Ltd
Kg/year	Kilogram per year
kL/yr	Kilolitre per year
km	kilometres
Km^2	Kilometres squared
kPa	Kilopascal
K_{sat}	Hydraulic conductivity
kt	Kiloton
kt CO_2-e	Kiloton Carbon dioxide equivalent
kt CO_2-e/yr	Kiloton Carbon dioxide equivalent per year
ktpa	Kilo-Tonnes Per Annum
L	Litres
L/sec	Litres per second
LAA	*Land Administration Act 1997* (WA)
LGA	Lloyd George Acoustics
LSL	Low Slimes
m	Metre
m AHD	Australian Height Datum
m BGL	Meters Below Ground Level
m RL	Meters Reduced Level
M^2	Square metres
M^3	Cubic metres
MAR	Managed Aquifer Recharge
Mattiske	Mattiske Consulting Pty Ltd
MCP	Mine Closure Plan
MDE	Mine Development Envelope
MDS	Multidimsensional scale
MDS	Multidimensional Scaling
Meq/100g	Millequivalents per 100 grams
MESA	Mine Envelope Survey Area
MFP	Mine Feed Plant
Mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Litre
MGA	Metric Rectangular Grid (Co-ordinate system; Geodetic CRS: GDA94)
Mine Earth	Mine Earth Pty Ltd
Mining Act	*Mining Act 1978* (WA)

Term	Meaning
ML	Mining Lease
MLA	Member of the Legislative Assembly
mm	Millimetres
MNES	Matters of National Environmental Significance
MOR	Modulus of Rupture
MRWA	Main Roads Western Australia
Mt	Million tonnes
Mtpa	Million tonnes per annum
MW	Megawatt
MWDC	Mid-West Development Commission
MWES	MWES Consulting Pty Ltd
MWPA	Mid-West Ports Authority
NEPC	National Environmental Protection Council
NEPM	National Environment Protection Measure
NERDC	National Energy Research and Demonstration Council
NO_2	Nitrogen dioxide
Noise Regulations	*Environmental Protection (Noise) Regulations 1997*
NORM	Naturally Occurring Radioactive Material
NOx	Nitrous oxides
NSHA	Noongar Standard Heritage Agreement
NTC	Native Title Claim
NVIS	National Vegetation Information System
OEHHA	(Californian) Office of Environmental health Hazard Assessment
OHP	Other heritage places
P	Priority
PASS	Potential Acidic Sulphate Soils
PEC	Priority Ecological Community
PER	Public Environmental Review
PFC	Percentage foliar cover
PFC	Percentage Foliar Cover
pH_f	pH
pH_{FOX}	Oxidised pH
PM	Particulate Matter
PMST	Protected Matters Search Tool
PoW	Program of Works

Term	Meaning
Preston Consulting	Preston Consulting Pty Ltd
Proposal	Atlas Project
PSD	Particle Size Distribution
R	Reserve
R1	(sensitive) Receptor 1
R2	(sensitive) Receptor 2
R3	(sensitive) Receptor 3
R4	(sensitive) Receptor 4
R5	(sensitive) Receptor 5
Ramboll	Ramboll Australia Pty Ltd
RCS	Respirable Crystalline Silica
RIWI Act	*Rights in Water and Irrigation Act 1914*
RMP	Radiation Management Plan
RNE	Register of the National Estate
ROM	Run-of-mine
RPS	RPS Group
RSO	Radiation Safety Officer
S43A	Section 43A
SCC	State Conservation Code
SCP	Swan Coastal Plain
S_{cr}	Chromium reducible sulphur
SEM	Scanning electron microscope
SMUs	Soil Management Units
SOC%	Soil Organic Carbon Percentage
SR	Supplementary Report
SRE	Short Range Endemic
SSI	Single Site Insertion
SWALSC	South-West Aboriginal Land and Sea Council
SWeRF	Size-weighted respirable fraction
T	Threatened
TDS	Total Dissolved Solids
TEC	Threatened Ecological Communities – plant communities listed as being threatened and legally protected under the *Biodiversity Conservation Act 2016* and / or the *Environment Protection and Biodiversity Conservation Act 1999*
Terra Rosa	Terra Rosa Consulting
Terratree	Terratree Pty Ltd
Th	Thorium

Term	Meaning
The Settlement	The South-West Native Title Settlement
TOs	Traditional Owners
TSP	Total suspended particles
TSSC	Threatened Species Scientific Committee
U	Uranium
UCL	Unallocated Crown Land
ug/kg	Microgram per kilogram
URS	URS Australia Pty Ltd
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
UWA	University of Western Australia
VDT	Vegetation Direct Transfer
VHS	Vegetation Health Services
WA	Western Australia
WA HIS	Western Australian Herbarium Identification Service
WAH	Western Australian Herbarium
WAM	West Australian Museum
WCP	Wet Concentrator Plant
WONS	Weeds of National Significance
XRD	X-ray diffraction
YMAC	Yamatji Marlpa Aboriginal Corporation
ΔpH	Change in pH
$\mu g/m^3$	Microgram per cubic metre

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