5 Environmental Factors and Objectives

5.1 Identification of Key Environmental Factors

Environmental factors relate to parts of the environment that may be impacted by an aspect of a Proposal. The EPA has 14 environmental factors, which are organised into five themes: Sea, Land, Water, Air, and People.

The ESD approved by the EPA on 14 August 2024 provided an outline of preliminary Key Environmental Factors that are relevant to this Proposal. The preliminary key factors and their relevance to the Proposal is outlined in Table 5-1.

A description of environmental factors not considered as Key Environmental Factors for these Proposal is provided in Section 6.1.

Table 5-1: Key Environmental Factors Relevant to the Proposal

Theme	EPA Factor	Relevance to the Proposal
Land	Flora and vegetation	• Impacts to State-listed threatened, priority, and conservation significant flora species and ecological communities; • Impacts to regionally and locally significant vegetation; • Impacts to old growth forests and ecological linkages; • Clearing of native vegetation; • Potential spread of disease and weeds; and • Rehabilitation of cleared areas.
	Terrestrial fauna	• Impacts to habitat for threatened and conservation significant fauna species, including Black Cockatoos; • Impacts to short-range endemic invertebrates; • Habitat fragmentation; and • Rehabilitation to provide fauna habitat.
	Terrestrial environmental quality	• Impacts to soil quality and stability from clearing and drilling activities; • Management of soil during and after mining operations and rehabilitation to restore soil quality; • Soil salinisation as a result of mining-induced saline groundwater rise; • Disturbance of potential ASS; • Erosion of post-mining landforms; and • Contamination from spills and/or leaks from storage and handling of hazardous materials and waste.
Water	Inland waters	• Impacts to surface water and groundwater resources; • Impacts to Public Drinking Water Source Areas and water catchments; • Impacts to wetlands, waterways, and associated buffers; and • Potential contamination of water resources.
Air	Greenhouse gas emissions	• Emissions from mining operations and vegetation clearing; and • Requirement for Greenhouse Gas Environmental Management Plan.
People	Social surroundings	• Impacts to Aboriginal cultural heritage sites and values; • Impacts to visual amenity and recreational values; • Noise, dust, and light emissions affecting nearby communities; and • Impacts to European heritage sites.

5.2 Key Environmental Factor – Flora and Vegetation

This section discusses flora and vegetation values that occur or may have the potential to occur in the Huntly and Willowdale Mine DEs with a focus on:

- Regionally and locally significant vegetation;
- State-listed Threatened and Priority Ecological Communities (TECs/PECs);
- Groundwater Dependent Ecosystems;
- Old Growth Forests;
- Ecological linkages and wildlife corridors;
- Protected areas or conservation areas under the *Conservation and Land Management Act 1984* and the Forest Management Plan 2024-2033;
- Local and regional reserves identified in planning schemes and strategies;
- Retained or protected areas under existing Ministerial Statement;
- State-listed Threatened, Priority, and conservation significant flora (including locally endemic flora, flora associated with restricted habitats, range-end populations, novel species, specific /subspecies with unique taxonomical features);
- Threats to flora and vegetation, such as *Phytophthora* dieback, climate change and fire;
- Areas previously cleared and rehabilitated by the Alcoa;
- Proposed rehabilitation and efficiency;
- Knowledge and survey gaps which are to be addressed within Assessment 2253; and
- Quantification of significant residual impacts in line with the Residual Impact Significance Model and WA Environmental Offsets Guideline (2014, or any subsequent revisions).

5.2.1 EPA Objective

The EPA's environmental objective of the factor Flora and Vegetation is:

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

For the purposes of EIA, the ERD follows the EPA definition of flora as native vascular plants and vegetation as groupings of different flora patterned across the landscape (EPA, 2016a).

In the context of the EPA objective, ecological integrity is defined as "*the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements*" (EPA, 2016a).

5.2.2 Relevant Policy and Guidance

5.2.2.1 Legislation

- *Biodiversity Conservation Act 2016 (WA)* (BAM Act)*;*
- *Environment Protection and Biodiversity Conservation Act 1999 (Cth);*
- *Biosecurity and Agriculture Management Act 2007 (WA); and*
- *Conservation and Land Management Act 1984 (WA).*

5.2.2.2 EPA Policy and Guidance

- Environmental Factor Guideline – Flora and Vegetation (EPA, 2016a);

- Environmental outcomes and outcomes-based conditions – Interim guidance (EPA, 2021c);
- Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016b);
- Guidance Statement No. 6 – Rehabilitation of Terrestrial Ecosystems (EPA, 2006);
- Instructions on how to prepare an Environmental Review Document (EPA, 2024c); and
- Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans (EPA, 2024b).

5.2.2.3 Commonwealth Policy and Guidance

- Significant Impact Guidelines 1.1 – Matters of National Environmental Significance (DoE, 2013a);
- *Environment Protection and Biodiversity Conservation Act 1999* Environmental Offsets Policy (DSEWPC, 2012a);
- Threat abatement plan for disease in natural ecosystems caused by *P. cinnamomi* (DEE, 2018a);
- Threat abatement plan for competition and land degradation by rabbits (DEE, 2016);
- Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs *(Sus scrofa)* (DEE, 2017);
- Australian Weeds Strategy 2017-2027 (Invasive Plants and Animals Committee, 2017);
- Regional Forest Agreement for the South-West Forest Region of Western Australia (Commonwealth of Australia, 2019);
- Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community (DEE, 2016);
- Approved Conservation Advice for Clay Pans of the Swan Coastal Plain [DSEWPC (2012)];
- Commonwealth Listing Advice on Claypans of the Swan Coastal Plain (Threatened Species Scientific Committee, 2012);
- National Recovery Plan for the Clay pans of the Swan Coastal Plain Ecological Community (DBCA, 2019a);
- Approved Conservation Advice for *Corymbia calophylla – Kingia australis* woodlands on heavy soils of the Swan Coastal Plain (DEE, 2017a);
- Commonwealth Listing Advice on *Corymbia calophylla – Kingia australis* woodlands on heavy soils of the Swan Coastal Plain (Endangered Species Scientific Committee, 2000);
- Approved Conservation Advice for *Corymbia calophylla – Xanthorrhoea preissii* woodlands and shrublands of the Swan Coastal Plain (DEE, 2017b);
- Commonwealth Listing Advice on *Corymbia calophylla – Xanthorrhoea preissii* woodlands and shrublands of the Swan Coastal Plain (Endangered Species Scientific Subcommittee, 2000);
- Approved Conservation Advice for the *Empodisma* peatlands of southwestern Australia (DCCEEW, 2023);
- Approved Conservation Advice (incorporating listing advice) for the Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain ecological community (DEE, 2019);
- Draft survey guidelines for Australia's Threatened Orchids (DoE, 2013);

- Slender *Andersonia* (*Andersonia gracilis*) Interim Recovery Plan 2006–2011. Interim Recovery Plan No. 228 (2006);
- Approved Conservation Advice for *Anthocercis gracilis* (Slender Tailflower) (DAWE, 2008a);
- Approved Conservation Advice for *Dryandra mimica* (Summer Honeypot) (DEWHA, 2008h);
- Grand Spider Orchid (*Caladenia huegelii*) Recovery Plan (DEC, 2009a);
- Approved Conservation Advice for *Diuris drummondii* (Tall Donkey Orchid) (DAWE, 2008b);
- Approved Conservation Advice for *Diuris micrantha* (Dwarf Bee-orchid) [DAWE (DAWE, 2008c)];
- Approved Conservation Advice for *Diuris purdiei* (Purdie's Donkey-orchid) (DEWHA, 2008b)];
- Glossy-leafed Hammer Orchid (*Drakaea elastica*) Recovery Plan (DEC, 2009b);
- Approved Conservation Advice for *Drakaea micrantha* (Dwarf Hammer-orchid) (DEWHA, 2008c);
- Conservation Advice for *Eucalyptus* x *balanites* (Cadda Road Mallee) (DAWE, 2021);
- Approved Conservation Advice for *Grevillea flexuosa* (Zig Zag Grevillea) (DEWHA, 2008f);
- Conservation Advice *Lasiopetalum pterocarpum* (wing-fruited *lasiopetalum*) (Threatened Species Scientific Committee, 2017a);
- Wing-fruited *Lasiopetalum* (*Lasiopetalum pterocarpum ms*) Interim Recovery Plan 2003-2008. Interim Recovery Plan No. 134 (CALM, 2003);
- Approved Conservation Advice for *Tetraria australiensis* (Southern *Tetraria*) (DEWHA, 2008d);
- Approved Conservation Advice for *Synaphea stenoloba* (Dwellingup *Synaphea*) (DEWHA, 2009d);
- Approved Conservation Advice for *Synaphea* sp. Fairbridge Farm (D. Papenfus 696) (Selena's *Synaphea*) (DEWHA, 2009b);
- Approved Conservation Advice for *Synaphea* sp. Pinjarra (R.Davis 6578) (Club-leafed *Synaphea*) (DEWHA, 2009c);
- Conservation Advice *Synaphea* sp. Pinjarra Plain (A.S. George 17182) (Threatened Species Scientific Committee, 2018a);
- Conservation Advice *Synaphea* sp. Serpentine (G.R. Brand 103) (Threatened Species Scientific Committee, 2018b);
- Approved Conservation Advice for *Thelymitra stellata* (Star Sun-orchid) (DEWHA, 2008e); and
- Verticordia *fimbrilepis* subsp. *fimbrilepis* Interim Recovery Plan 2010-2015. Interim Recovery Plan No. 304 (DEC, 2010).

5.2.2.4 Other guidance

- *Corymbia calophylla* – *Kingia australis* woodlands on heavy soil (Swan Coastal Plain Community type 3a – (Gibson, Keighery, Keighery, Burbidge, & Lyons, 1994), Interim Recovery Plan 2000-2003 (English & Blyth, 2000a);

- *Corymbia calophylla* – *Xanthorrhoea preissii* woodlands and shrublands (Swan Coastal Plain Community type 3c -Gibson *et al.* 1994), Interim Recovery Plan 2000-2003 (English & Blyth, 2000b);
- Cadda Road Mallee (*Eucalyptus balanites*) Interim Recovery Plan 2004-2009) (Patten, Broun, Evans, & Willers, 2004);
- Wing-fruited Lasiopetalum (*Lasiopetalum pterocarpum ms*) Interim Recovery Plan 2003-2008 (Stack & English, 2003);
- Selena's *Synaphea* (*Synaphea* sp. Fairbridge Farm) Interim Recovery Plan 2007-2012. Interim Recovery Plan No. 236 (DEC, 2007);
- Club-leafed *Synaphea* (*Synaphea* sp. Pinjarra) Interim Recovery Plan No. 118 (Stack, Evans, & English, 2002);
- Assessment of Matters Pertaining to Renewal of the Regional Forest Agreement for the South-West Forest Regional of Western Australia DBCA (DBCA, 2019b);
- Forest Management Plan 2024-2033 (Conservation and Parks Commission, 2023);
- Managing *Phytophthora* Dieback in Bushland (Dieback Working Group, 2015); and
- Management of *Phytophthora* Dieback in Extractive Industries (Dieback Working Group, 2005).

Alcoa have applied the Environmental Factor Guideline – Flora and Vegetation (EPA, 2016a) to the activities described within the Huntly and Willowdale Mine DEs; further detail is provided in the Flora and Vegetation Management Plan (Appendix 11).

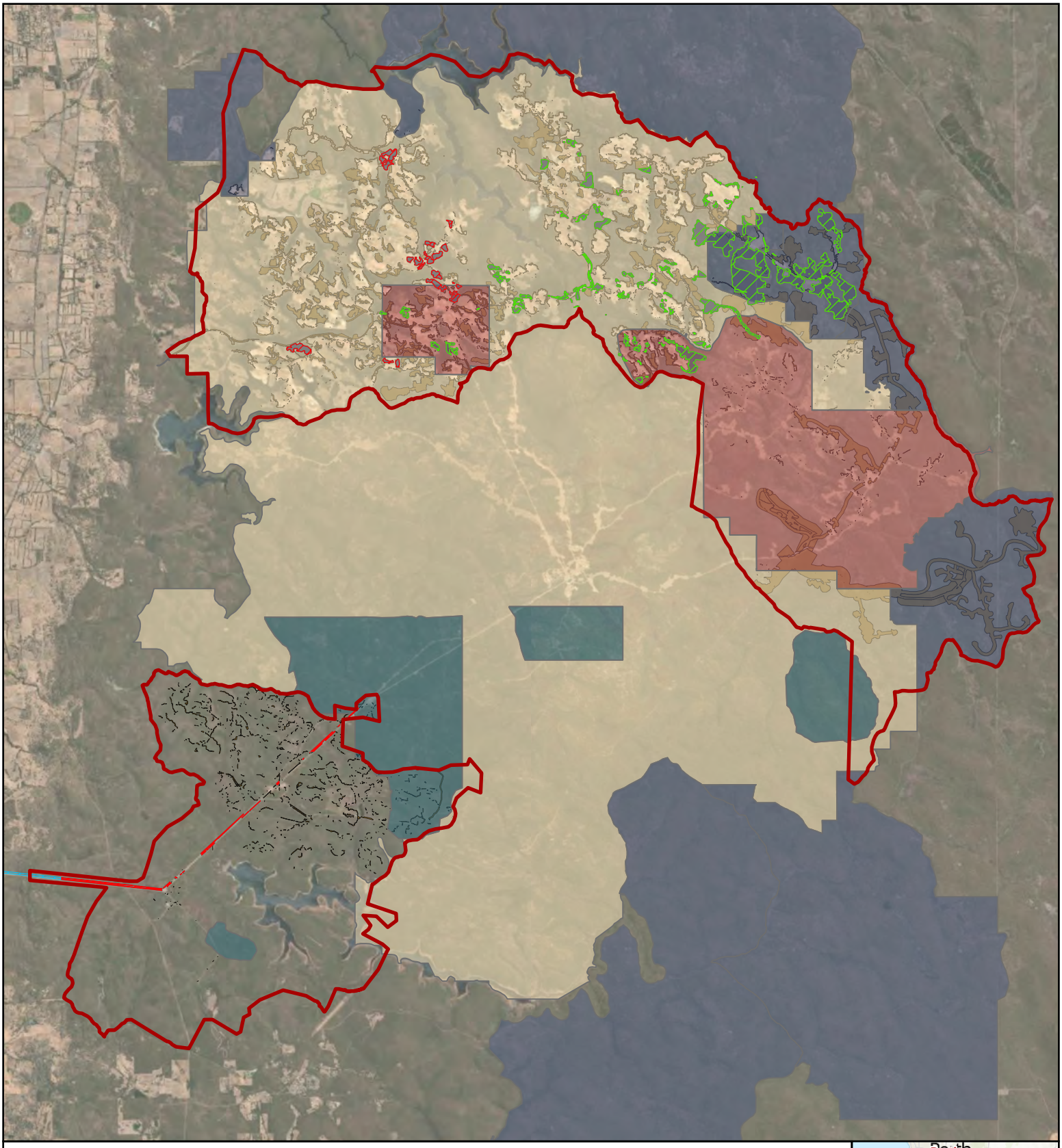
Alcoa have taken steps to identify and apply protection measures to areas of conservation significant flora and vegetation, such as the measures identified in Section 5.2.7 to avoid or minimise impacts to Threatened and Priority flora species and vegetation and other significant flora and vegetation values.

5.2.3 Receiving Environment

5.2.3.1 Previous Studies and Research

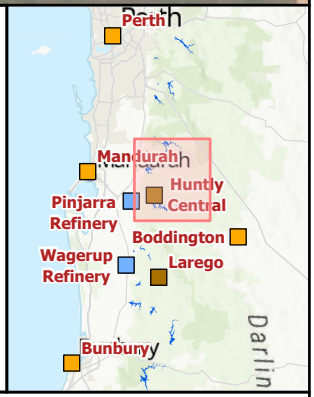
Flora and vegetation surveys and research have been undertaken across portions of the Mine DEs and surrounding areas by several ecological consultants (primarily by Mattiske Consulting) since the early 1980s (Mattiske Consulting, 2024e) (Appendix 14). The survey reports are summarised in Mattiske (2024e), with the findings used to support the Proposal and provide confidence in the current state of knowledge within the Mine DEs and surrounding area. Prior to the publishing of Florabase (Western Australian Herbarium, 1998) and the TPFL database hosted by the DBCA, the definition of and details on significant species listed at a State level was not readily available (Mattiske Consulting, 2024e).

The following Figure 5-1 and Figure 5-2 show the locations of field surveys relevant to the Proposal. An overview of the baseline flora surveys relevant to the Proposal is shown in Table 5-2. Lastly, Table 5-3 provides an overview of the Targeted flora surveys relevant to the Proposal.



Legend

- Huntly Mine DE
- Targeted Surveys
  - 2023, Biologic Environmental Survey
  - 2023, Eco Logical Australia Pty Ltd
  - 2023, Ecologia Environment
  - 2023, Mattiske Consulting Pty Ltd
- Mattiske Consulting Pty Ltd Baseline Surveys
  - Historic Mapping
- 1992 - 1994
- 1993
- 1994
- 2005
- 2009
- 2011
- 2019
- 2020
- 2021
- 2022
- 2023
- 2024
- Proposed Disturbance Footprint



Bauxite Mining on the Darling Range 2023 to 2027
(Assessment 2385) Environmental Review Document

Figure 5-1 Previous flora and vegetation surveys relevant to the Proposal - Huntly Mine DE

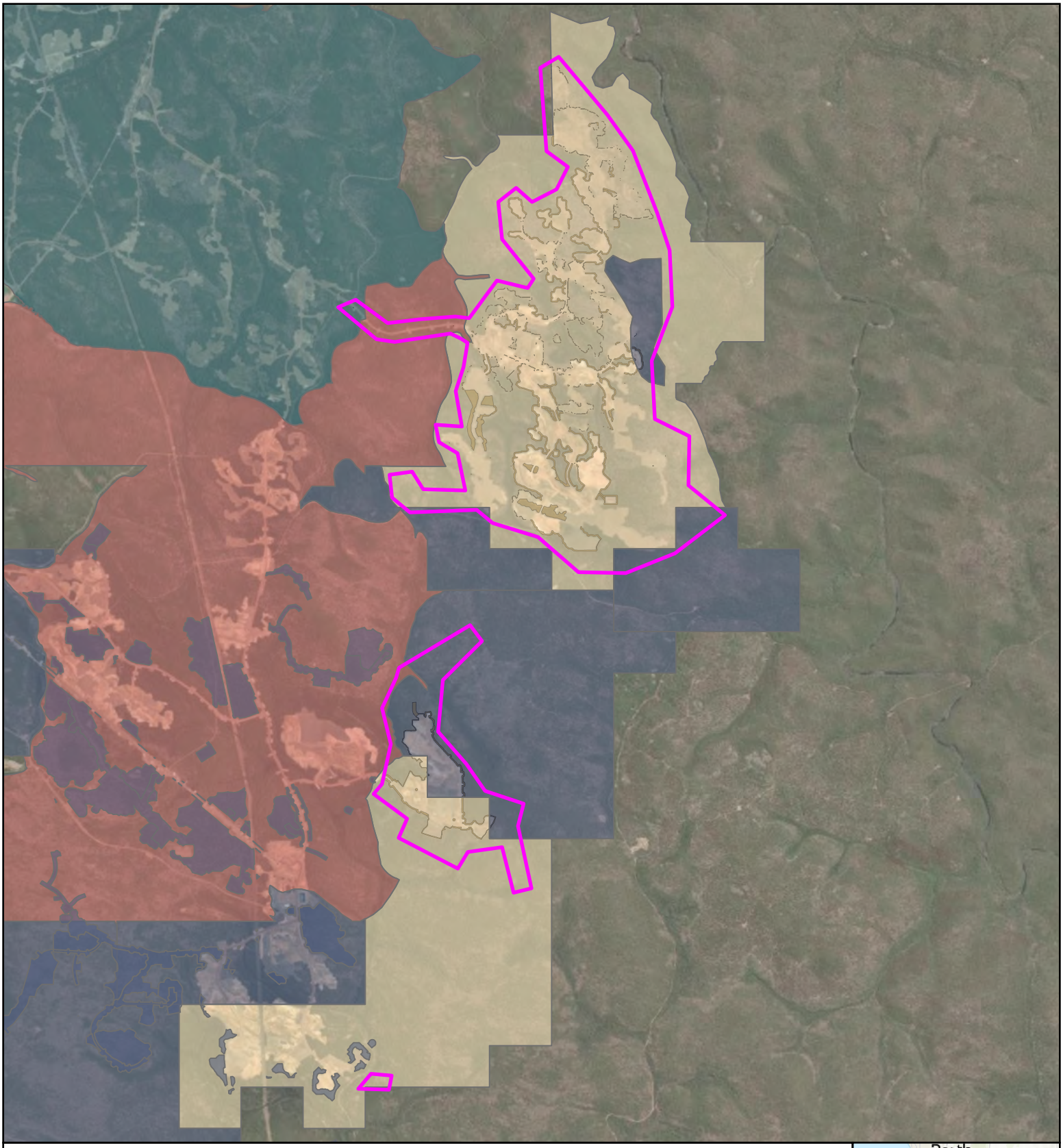
Kilometres
0 2 4 6 8 10 12

Scale: 1:174,000 at A4

Date Printed: 5/05/2025

N

Alcoa



Bauxite Mining on the Darling Range 2023 to 2027 (Assessment 2385) Environmental Review Document

Figure 5-2 Previous flora and vegetation surveys relevant to the Proposal - Willowdale Mine DE

Kilometres

0 0.9 1.8 2.7 3.6 4.5 5.4

Scale: 1:75,060 at A4

Date Printed: 5/05/2025

N

Alcoa

5.2.3.2 Desktop Studies

Desktop assessments were conducted prior to previous field surveys. The *NatureMap* search (DBCA, 2007) (replaced by Dandjoo biodiversity data platform in 2023; however, Threatened and Priority flora records remain unavailable in Dandjoo) and the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act) Protected Matters Search Tool (PMST) (DCCEEW, 2024b) databases were used to identify the possible occurrence of Threatened and Priority flora taxa and TECs and PECs in the survey area ((Mattiske Consulting, 2024e); Appendix 14).

The Western Australian Herbarium database and DBCA databases of Threatened and Priority flora and ecological communities [DBCA (2024b)] were searched for records within or in the vicinity of the survey area. Database searches were generally conducted within a 20 km radius of a point centred with a survey area. Historical documentation and vegetation mapping of the Northern Jarrah Forest IBRA (Interim Biogeographic Regionalisation for Australia v7) subregion (NJF) that provide resource material for the floristics and vegetation of the survey areas were reviewed (see Mattiske (2024e); Appendix 14).

5.2.3.3 Baseline Surveys

Baseline flora and vegetation mapping commenced in the early 1980s. The baseline (SVT) methodology used consistently for these surveys ((Mattiske Consulting, 2024e); Appendix 14) is based on Heddle et al (1980) and involved sites pre-selected on a 120 m x 120 m grid (with additional sites as needed to cover finer scale changes or when encountering perceived differing vegetation types, or restricted/unusual vegetation between the grid points.). Site data recorded included location, topography/slope aspect, soil type, outcropping, logging history, fire history, and potential for dieback occurrence. At each site flora species were ranked by relative abundance and physiological stress, using the scale of Havel (1975a; 1975b). Site data were then used to define SVTs for each survey site. SVTs may be combined to form Vegetation Types (VTs), which are then used, in combination with aerial imagery and field observations, to map the vegetation of the survey area (see Section 5.2.4.2). (Mattiske, 2021a).

Opportunistic records of Threatened, Priority, or key weed species were made whilst walking between survey sites. Key weed species are those listed as Weeds of National Significance (WoNS) (Centre for Invasive Species Solutions, n.d.) or Declared Pest plants declared under the *Biosecurity and Agriculture Management Act 2007* (BAM Act).

A significant amount of field study was completed using the SVT methodology prior to the publishing of the EPA's *Environmental Factor Guideline – Flora and Vegetation* (EPA, 2016a) and *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA, 2016b). Survey methodology developed prior to 2016 and used extensively through the NJF was continued in baseline surveys through to 2024. Mattiske Consulting (2021a) explain that "*to deviate from such an approach and rely on other approaches would negate the effort to date and the ability to align the findings with other areas in the Northern Jarrah Forest*."

In contrast, the methodology for Detailed flora and vegetation surveys (required if the desktop study finds that the area supports a high diversity of flora or vegetation, restricted landforms or vegetation units, significant flora or vegetation, if the related proposal is in a region that has been subject to minimal survey effort, or the scale and nature of the potential

impacts are likely to be significant) (EPA, 2016a), includes multiple quadrats located at representative points throughout each vegetation type identified through desktop assessment and/or reconnaissance field survey. The number of quadrats required will be dependent on the diversity of vegetation units present, heterogeneity within these vegetation units, the size of the vegetation units mapped and the size of the survey area, with a minimum of three quadrats required to be sampled in each vegetation unit. Opportunistic collections, systematic transects and targeted inspections of potential habitat are also required to verify that the survey area has been well characterised and important values identified (EPA, 2016a).

Although the baseline (SVT) survey methodology differs from the detailed flora and vegetation survey methodology prescribed by the EPA's Technical Guidance document (EPA, 2016b), the approach was discussed by Mattiske Consulting with representatives of the EPA, DWER, and DBCA prior to the 2020 Myara North survey and it was acknowledged that "*the continuation of the site-vegetation approach ensures a consistent delineation of the biodiversity values … and provides adequate information to support impact assessment*" (Mattiske, 2021a).

Some of the baseline surveys were conducted outside the primary survey period (Spring i.e., 01 September to 30 November) recommended by the EPA (2016b). However, it is important to recognise that vegetation mapping outside the Spring months can still be undertaken, as the baseline mapping methodology relies on key indicator species, which are perennial species that persist through all seasons (Mattiske Consulting, 2024b).

Table 5-2: Baseline and other Flora and Vegetation Studies Relevant to the Proposal

Field survey Year Range	Author(s)	Study Region(s)	Summary of Methods / Results	Location and in relation to the Proposal	Appendix
Historic surveys – reports, maps and data not available for this ERD					
1983, 1992, 1993	E.M. Mattiske & Associates	Jarrahdale, Chappell, Kingsbury Drive, Collie	Baseline studies using 120 x 120 m grid surveys. Flora and Site Vegetation Types (SVTs). Focus on novel species, range extensions, and Priority species.	N/A	N/A
1985, 1988, 1991, 1992-1993	E.M. Mattiske & Associates	Del Park, Bates, Jones, Huntly	Baseline studies using 120 x 120 m grid surveys. Flora and SVTs. Emphasis on novel species and Priority species.	Parts of Del Park and Huntly	N/A
1992	E.M. Mattiske & Associates	South Jarrahdale, Chandler and Kingsbury Drive Areas	VTs A total of 23 VTs were defined and mapped in the northern section of the Myara North DE (see Table 5-6 for descriptions) The dominant VTs were P, PS, S, SP, ST and SW, which together covered some 66.3% of the survey area reflecting the dominance of lateritic soils supporting varying types of *Eucalyptus marginata – Corymbia calophylla* with mosaics of *Allocasuarina fraseriana.* The more restricted sites associated with swamps (types A, C, AC, AW and AX and variants) or granite outcrops (types G, RG and R) covered less than 11% and 1% of the area respectively.	N/A	N/A
N/A	E.M. Mattiske & Associates	White Region	N/A	N/A	N/A
N/A	E.M. Mattiske & Associates	McCoy Region	N/A	N/A	N/A

Field survey Year Range	Author(s)	Study Region(s)	Summary of Methods / Results	Location and in relation to the Proposal	Appendix
1994, 2009, 2012, 2019, 2021, 2022	E.M. Mattiske & Associates, Mattiske Consulting	Huntly, O'Neill, Myara, Myara North	Baseline and desktop studies. Focus on SVTs and novel species. Studies included regional context for managed forest and conservation areas.	Parts of Huntly, Myara and O'Neill	N/A
1993, 1994	E.M. Mattiske & Associates	Willowdale	Baseline studies using 120 x 120 m grid surveys. Emphasis on novel species and Priority species.	Parts of Willowdale	N/A
1988 to 1994, 1996 to 2006	E.M. Mattiske & Associates, Mattiske Consulting	Wucalup, Cameron, Gordon, Jacup	Monitoring transects Assessment of creek lines and valley systems.	N/A	N/A
2005 to 2014, 2016 to 2021	Mattiske Consulting	Huntly, Myara, Willowdale	Rehabilitation area assessments at 9 and 15 months. Data collection and monitoring plots assistance.	Parts of Huntly, Myara, Willowdale	N/A
2012 (Sep)	Mattiske C onsulting	Flora and Vegetation of Myara Survey Area	A flora and vegetation study over the Myara region was completed in 2012. This report was compiled from field data collected from 2008, 2009, 2010, 2011 and 2012. A total of 590 vascular plant taxa from 70 plant families and 217 genera were recorded within the Myara survey area. Of these, 35 were introduced flora species. No Threatened flora were recorded. Six Priority flora, *Acacia drummondii subsp. affinis* (P3), *Calothamnus rupestris* (P4 in 2012, no longer listed as Priority), *Cyathochaeta* teretifolia (P3), *Senecio leucoglossus* (P4), *Stylidium ireneae* (P4) and *Stylidium longitubum* (P4), were recorded. 23 VTs were defined and mapped within the Myara survey area (see Table 5-6 for descriptions). None of these were	Parts of Myara	N/A

Field survey Year Range	Author(s)	Study Region(s)	Summary of Methods / Results	Location and in relation to the Proposal	Appendix
			identified to be TECs or PECs as listed under the EPBC Act or BC Act.		
2019 (Jun)	Mattiske	Flora & Vegetation Assessment of the Huntly Expansion Areas	A flora and vegetation study over the Myara region was completed in 2019. • A total of 239 vascular plant taxa, representative of 110 genera and 49 families, were recorded within the eastern Huntly expansion survey areas. A total of four introduced flora species were recorded within the eastern Huntly expansion survey areas. • Identified three different Priority 4 flora species under the BC Act: *Grevillea pimeleoides, Lasiopetalum cardiophyllum* and *Senecio leucoglossus.* No Threatened flora were recorded. 23 VTs were defined and mapped within the Myara survey area (see Table 5-6 for descriptions). None of these were identified to be TECs or PECs as listed under the BC Act or EPBC Act.	Parts of Myara	N/A
1994-2024	Mattiske Consulting	Willowdale, Keats, Wucalup, Vaquita, Squig,	Baseline and desktop studies. Focus on SVTs, novel species, and Priority species. Regional context for managed forest and conservation areas. Assessment of Flora and Vegetation Values	Parts of Willowdale	N/A
Modern surveys – reports, maps and data available for this ERD					
2021 (Jun-Nov)	Mattiske Consulting (2021a)	Myara North	Desktop study, baseline flora and vegetation survey over 18,541 ha. A total of 681 vascular plant taxa were recorded within the survey area. No Threatened flora species and 14 Priority flora were recorded: • *Andersonia sp. Saxatilis* (F. & J. Hort 3324)(CR under the BC Act) • *Paracalaena gracilicordata* (P1) • *Paracalaena granitica* (P1)	To the north and immediately adjacent to the Huntly Mine DE (Myara-O'Neil portion	Appendix 15

Field survey Year Range	Author(s)	Study Region(s)	Summary of Methods / Results	Location and in relation to the Proposal	Appendix
			• *Grevillea ornithopoda* (P2) • *Acacia drummondii* subsp. *affinis* (P3) • *Acacia horridula* (P3) • *Andersonia sp. Audax* (F. Hort, B. Hort & J. Hort 3179) (P3) • *Conospermum scaposum* (P3) • *Stackhousia sp.* Red-blotched corolla (A. Markey 911) (P3) • *Cyanothamnus tenuis* (P3) • *Hemigenia platyphylla* (P4) • *Pimelea rara* (P4) • *Stylidium ireneae* (P4) • *Stylidium scabridum* (P4) Eight recorded taxa were noted to be range extensions to current records. One Declared Pest plant species was recorded (**Gomphocarpus fruticosus*). A total of 32 VTs were mapped within the survey area (see Table 5-6 for descriptions). Approximately 48% of the vegetation within the survey area was given a condition rating of Very Good or Excellent, using a scale adapted from Keighery (1994) and Trudgen (1988) and modified to adjust to “forest areas”. No TECs occur in the survey area. Following the field survey, one PEC, *Granite communities of the northern Jarrah Forest* (P3), was considered likely to occur within the survey area. Approximately 25% of the survey area was mapped as corresponding to potential Groundwater Dependent Ecosystems (GDEs), using vegetation complexes and VTs.^ A small section of Old Growth Forest mapped by DBCA intersects the southwestern boundary of the survey area. No additional areas within the survey area that could potentially be un-mapped Old Growth Forest were recorded.		

Field survey Year Range	Author(s)	Study Region(s)	Summary of Methods / Results	Location and in relation to the Proposal	Appendix
2021 (Nov)	Mattiske Consulting (2021b)	Holyoake	Desktop study, baseline flora and vegetation survey over 12,036 ha. A total of 328 vascular plant taxa were recorded within the survey area. No Threatened flora species and six Priority flora were recorded: • *Bossiaea modesta* (P2) • *Hakea oldfieldii* (P3) • *Hemigenia microphylla* (P3) • *Thysanotus anceps* (P3) • *Senecio leucoglossus* (P4) • *Stylidium ireneae* (P4) No key weed species were recorded. A total of 21 VTs were mapped within the survey area (see Table 5-6 for descriptions). Approximately 67% of the vegetation within the survey area was given a condition rating of Very Good or Excellent. No TECs occur in the survey area. Assessments concluded that no PECs occur within the Holyoake survey area. Approximately 19% of the survey area was mapped as corresponding to potential GDEs, using vegetation complexes and VTs.^ No Old Growth Forest mapped by DBCA occurs in the survey area. No additional areas within the survey area that could potentially be un-mapped Old Growth Forest were recorded.	Adjacent to the Huntly Mine DE (between the two portions).	Appendix 16
2023 (Apr-May)	Mattiske Consulting (2023a)	Kingsbury West	Desktop study, baseline flora and vegetation survey over 983 ha. A total of 236 vascular plant taxa were recorded within the survey area. No Threatened flora species and no Priority flora were recorded. No key weed species were recorded. A total of 20 VTs were mapped within the survey area (see Table 5-6 for descriptions). The majority of the vegetation of	Eastern portion of the survey area intersects the Huntly Mine DE (Myara-O'Neil portion)	Summarised in Appendix 14

Field survey Year Range	Author(s)	Study Region(s)	Summary of Methods / Results	Location and in relation to the Proposal	Appendix
			the survey area was assessed as being in Excellent condition. No TECs occur in the survey area. Assessments concluded that no PECs occur within the Kingsbury West survey area. Potential GDEs were identified using vegetation complexes and VTs.^ No Old Growth Forest mapped by DBCA occurs in the survey area.		
2023 (Jun)	Mattiske Consulting (2023b)	Spion	Desktop study, baseline flora and vegetation survey over 486 ha. A total of 177 vascular plant taxa were recorded within the survey area. No Threatened flora species and one Priority flora species was recorded: • *Grevillea prominens* (P3) No key weed species were recorded. A total of 15 VTs were mapped within the survey area (see Table 5-6 for descriptions). The vegetation of the survey area was assessed as being in Very Good condition, aside from one very small, cleared area. No TECs occur in the survey area. Assessments concluded that no PECs occur within the Spion survey area. Potential GDEs were identified using vegetation complexes.^ No Old Growth Forest mapped by DBCA occurs in the survey area. Counts of habitat trees and stumps infer that some parts of the survey area may potentially have had lower logging rates, which could indicate the presence of Old Growth Forest.	Adjacent to Willowdale Mine DE (Keats and Wills portions)	Summarised in Appendix 14

Field survey Year Range	Author(s)	Study Region(s)	Summary of Methods / Results	Location and in relation to the Proposal	Appendix
2023 (Jun-Aug)	Mattiske Consulting (2023c)	Warrington	Desktop study, baseline flora and vegetation survey over 1,134 ha. A total of 238 vascular plant taxa were recorded within the survey area. No Threatened flora species and two Priority flora species were recorded: • *Grevillea prominens* (P3) • *Senecio leucoglossus* (P4) No key weed species were recorded. A total of 15 VTs were mapped within the survey area (see Table 5-6 for descriptions). The vegetation of the survey area was assessed as being in Very Good condition. No TECs occur in the survey area. Assessments concluded that no PECs occur within the Warrington survey area. Potential GDEs were identified using vegetation complexes only.^ No Old Growth Forest mapped by DBCA occurs in the survey area. Counts of habitat trees and stumps infer that some parts of the survey area may potentially have had lower logging rates.	West of Willowdale Mine DE (Tasman portion)	Summarised in Appendix 14
2023 (Aug-Sep) including 2009, 2012 results	Mattiske Consulting (2024a)	ONeil Transport Corridor	Desktop study, baseline flora and vegetation survey over 2,593 ha incorporating reviewed results from 2009-2012 plus additional mapping in 2023. A total of 122 vascular plant taxa were recorded in 2023. No Threatened flora species and two Priority flora were recorded: • *Hibbertia hortiorum* (P1) • *Senecio leucoglossus* (P4) No key weed species were recorded. A total of 17 VTs were mapped within the survey area (see Table 5-6 for descriptions). Vegetation condition was considered to be Excellent, except in rehabilitation areas.	Northeast portion of the survey area intersects the Huntly Mine DE (O'Neil portion)	Summarised in Appendix 14 and as seen in Appendix 78

Field survey Year Range	Author(s)	Study Region(s)	Summary of Methods / Results	Location and in relation to the Proposal	Appendix
			No TECs occur in the survey area. Assessments concluded that no PECs occur within the O'Neil Transport Corridor survey area. Potential GDEs were identified using vegetation complexes only.^ No Old Growth Forest mapped by DBCA occurs in the survey area.		
2024 (Jan-Mar) including 2009, 2012 results	Mattiske Consulting (2024b)	O'Neil, Huntly Mine	Desktop study, baseline flora and vegetation survey over 10,414 ha incorporating reviewed results from 2009-2012 plus additional mapping in 2023-24. A total of 353 vascular plant taxa were recorded in 2024. No Threatened flora species and four Priority flora were recorded: • *Hibbertia ambita* (P1) • *Hibbertia hortiorum* (P1) • *Grevillea dissectifolia* (P3) • *Senecio leucoglossus* (P4) No key weed species were recorded. A total of 27 VTs were mapped within the survey area (see Table 5-6 for descriptions). Vegetation condition was considered to be Excellent, except in rehabilitation areas. No TECs occur in the survey area. Assessments concluded that no PECs occur within the O'Neil survey area. Potential GDEs were identified using vegetation complexes only.^ No Old Growth Forest mapped by DBCA occurs in the survey area.	Huntly Mine DE (O'Neil portion)	Summarised in Appendix 14 and as seen in Appendix 79

Field survey Year Range	Author(s)	Study Region(s)	Summary of Methods / Results	Location and in relation to the Proposal	Appendix
2023 (August and December)	Ecologia (2024a)	Myara Mine	Desktop assessment and targeted flora survey over 673.81 ha completed primarily in Spring 2023 (late August and early December). No Threatened flora species and three Priority flora were recorded: • *Tetratheca phoeni* (P2) • *Senecio leucoglossus* (P4) • *Stylidium ireneae* (P4) No key weed species were recorded.	Huntly Mine DE (Myara portion)	Appendix 17
2024 (Desktop only)	Ecologia (2024b)	Myara Mine	Desktop assessment of the likelihood of occurrence of significant flora over total area 126 ha. Four species were assessed as 'Highly Likely' based on the potential presence of suitable habitat and records occurring within 500 m of the survey area, most of which were recorded during the recent surveys: • *Pimelea rara* (P4) • *Senecio leucoglossus* (P4) • *Tetratheca phoenix* (P2) • *Thysanotus anceps* (P3) Three taxa were assessed as 'Likely' based on the potential presence of suitable habitat and records occurring 0.5–2 km from the survey area: • *Acacia drummondii* subsp. *affinis* (P3) • *Grevillea pimeleoides* (P3) • *Hibbertia hortiorum* (P1) Seventeen taxa were assessed as 'Unlikely' as, although suitable habitat is potentially present, they were not recorded during the recent nearby targeted surveys. This includes one Threatened species, *Grevillea flexuosa*. The remaining 31 taxa were assessed as 'Unlikely' as suitable habitat is unlikely to be present; these are mostly	Huntly Mine DE (Myara-O'Neil portion)	Appendix 18

Field survey Year Range	Author(s)	Study Region(s)	Summary of Methods / Results	Location and in relation to the Proposal	Appendix
			taxa confined to granite outcrops, wetlands, or streamzone habitats.		

^Definition of potential GDEs is discussed further in Section 5.2.4.4.

5.2.3.4 Targeted Surveys

In addition to opportunistic observations of conservation significant flora and key weeds made during baseline surveys, Pre-clearance Targeted flora, and key weed surveys have been undertaken over 2023 and 2024 within the Huntly Mine DE and areas surrounding both Mine DEs, as shown in Figure 5-1 and Figure 5-2. The relevant desktop assessment and Targeted Flora and Weed Survey Reports are provided in Appendix 14 to Appendix 22 inclusive.

Pre-clearance Targeted flora and key weed surveys were undertaken during the period when most targeted flora and species were in flower (i.e., Spring), as recommended by the EPA (2016b), using systematic traverses spaced at 10-20 m to identify the presence or absence of conservation significant or key weed species. Survey tracks logs are provided in the relevant FCAs under the State Agreement Administrative Framework. Traverse spacing is considered adequate to detect the majority of the targeted species, as approximately three-quarters of the conservation significant flora assessed as having potential to occur within the Mine DEs (Appendix 18) are trees, shrubs or sedges and able to be observed from 10 m away.

When target species were found, the survey was modified to delineate the extent of the population within the survey area.

A total of 86 (77%) of the 111 identified conservation significant flora assessed as having potential to occur within the Mine DEs (Appendix 18) have flowering periods that overlap the recommended September to November primary survey period; 11 species flower outside the Spring period and data on flowering periods were not available for 14 species.

5.2.3.5 Other Studies

Detailed transect and plot surveys have been conducted within specific habitats (e.g., valley systems and granite outcrops), for vegetation rehabilitation monitoring and for areas associated with direct and indirect impacts (e.g., vegetation associated with haul road crossings) ((Mattiske Consulting, 2024e); Appendix 14).

A total of 50 permanent vegetation monitoring plots have been established within the Huntly Mine DE, with none inside the Willowdale Mine DE (Mattiske (2024e); Appendix 14). The permanent plot data were not available for this ERD.

5.2.3.6 Knowledge and survey gaps

Mattiske's (2024e) map of survey coverage across the Mine DEs (Figure 5-1 and Figure 5-2) shows that the majority of the Myara-O'Neil portion of the Huntly Mine DE has baseline vegetation mapping coverage; this is consistent with available VT mapping (Section 5.2.4.2) which covers 97.2% of the Myara-O'Neil portion.

Available VT mapping (Section 5.2.4.2) covers 37.5% of the Huntly-Del Park portion, although information on when this mapping was completed is not available.

The entirety of the Willowdale Mine DE has baseline survey coverage mapped with a combination of historic surveys and those undertaken in the 2000s; VT mapping (Section 5.2.4.2) covers 99.3% of the Willowdale Mine DE (Mattiske Consulting, 2024e).

Data for the following areas were either not available for this ERD, or there was no field survey coverage:

- Only 37.5% of the Huntly-Del Park portion of the Huntly Mine DE has VT mapping (Section 5.2.4.2) available. Mattiske (2024e) note that vegetation surveys were completed in this portion from 1979 through the 1990s, but the data is not available digitally.
- Only 2.0% of the Huntly Mine DE has been covered by Targeted flora surveys (Figure 5-1 and Figure 5-2), therefore limited information on conservation significant flora occurrences and population sizes is available. It is noted that variable likelihood of occurrence information is included in various reports, therefore a summary of ecological reports and consolidated Likelihood of Occurrence (LOO) (Appendix 14 & 24, respectively) were prepared for the Proposal Mine DE. The LOO will be revised as further surveys are completed or technical information is available. However, it is noted the pre-clearance Targeted surveys are proposed for flora and vegetation values, with the survey outcomes currently included within the State Agreement Administrative Framework. Avoidances will occur as per relevant Management Plans, mitigations and outcomes.
- No recent (2020 onwards) baseline vegetation and no Targeted flora surveys have been conducted within the Willowdale Mine DE.
- Limited vegetation mapping associated with TECs, PECs and GDEs.

Additionally, the following data types were either not collected or were not available:

- Data on vegetation condition, using the Keighery (1994) scale, within the Mine DEs.
- Data on species richness from the 50 permanent vegetation monitoring plots established within the Huntly Mine DE.

Limited information on indirect impacts to flora and vegetation values is available, in particular impacts from dust emissions and altered hydrological/hydrogeological regimes.

The assessment of flora and vegetation values within the Mine DEs has been based on available information and data and, where information and data gaps affect analysis, results or interpretation, this has been noted.

Table 5-3: Targeted flora and vegetation studies and research relevant to the Proposal (Appendix 15 to Appendix 22 inclusive)

Month/ Year	Author	Study Name	Summary of key methods/findings	Location and in relation to the Proposal	Area (ha)
Aug-Nov 2023	Ecologia Environment (2024a)	Huntly Mine Pre-Clearance Surveys – Threatened Flora and Declared Weeds 2023	Targeted searches for conservation significant flora species, as well as WoNS and Declared Pests, were conducted along systematic transects at 20 m or 10 m spacings within the survey area. No Threatened flora species listed under the EPBC Act or the BC Act were recorded. Three Priority species were recorded within the survey area: • *Tetratheca phoenix* (P2) – 151 individuals • *Senecio leucoglossus* (P4) – 29 individuals • *Stylidium ireneae* (P4) – 10 individuals There were no WoNS or Declared Pests recorded.	Huntly – inside the Huntly Mine DE – numerous small areas in Myara part of Myara-O'Neil portion	674
Oct-Nov 2023	Eco Logical Australia Pty Ltd (2024)	Willowdale Targeted Flora Survey – Spring 2023	The targeted flora survey involved personnel walking systematic transects, spaced approximately 20 m apart, where terrain, vegetation and safe access allowed. No Threatened flora species listed under the EPBC Act or the BC Act were recorded within the project area. Three Priority flora species listed by DBCA were recorded within the project area, namely: • *Netrostylis sp. Nannup* (P.A. Jurjevich 1133) (P1) – One individual plant was recorded at one point location • *Grevillea prominens* (P3) – 11 plants were recorded at 11 point locations • *Senecio leucoglossus* (P4) – broadly distributed across eastern and southern portions of the project area, with a total of 2,063 individual plants recorded at 348 point locations One flora species recorded within the project area, *Boronia stricta*, represented a northeast range extension of approximately 125 km. A total of 30 individual B. stricta plants were recorded across five point locations. Two Key weed species were recorded during the field survey: • Blackberry (**Rubus* sp.) (WoNS, Declared Pest) – 310 plants at 31 point locations • Arum lily (**Zantedeschia aethiopica*) (Declared Pest) – one plant at one point location	Willowdale – outside the Willowdale Mine DE – numerous small areas nearby W of Wills and W of Tasman	801
Oct-Nov 2023	Biologic Environmental Survey (2024b)	Alcoa Huntly-Myara Targeted Flora Survey	Targeted flora surveys involved botanists walking grid lines 10 to 20 m apart while searching for significant flora and significant weed species. No Threatened flora species were recorded in this survey. Four Priority listed flora species were recorded from the Survey Area, which included: • *Acacia horridula* (P3) (21 individuals from eight locations); • *Thysanotus anceps* (P3) (nine individuals from nine locations); • *Senecio leucoglossus* (P4) (819 individuals from 162 locations); and • *Stylidium ireneae* (P4) (two individuals from one location) No environmentally significant weeds (WoNS or Declared Pest plants) were recorded during the field surveys.	Huntly – inside the Huntly Mine DE – numerous small areas in Myara part of Myara-O'Neil and conveyor inside Huntly-Del Park	111
Dec 2023	Mattiske Consulting Pty Ltd (2024c)	Threatened and Priority Flora search for Pinjarra refinery conveyor project area	The targeted search was undertaken by botanists walking traverses at 10 m spacing. Introduced flora were not included in the search. No Threatened species were recorded within or in proximity to the Myara conveyor. Two Priority species were recorded: • *Calothamnus graniticus* subsp. *leptophyllus* (P4) – 77 individuals from 6 point locations • *Cyanothamnus tenuis* (P4) – 31 individuals from 7 point locations	Huntly – partly (7.4 ha) inside the Huntly Mine DE – W end of conveyor Huntly-Del Park	13

5.2.3.7 Summary of Receiving Environment

A summary of the receiving environment with respect to flora and vegetation is as follows:

- The NJF subregion has moderate species richness (400–600 species per km^2), with higher species richness (500–600 species per km^2) in the high to moderate rainfall zone in the west.
- Four TECs listed by DBCA are known to occur in the NJF and 43 flora species listed as Threatened by DBCA are known to occur in a similar area (DBCA Perth Hills district).
- Alcoa has significant scientific knowledge of the Northern Jarrah Forest, attained through extensive research and having operated in Huntly since 1972 and Willowdale since 1984. There is a substantial amount of contextual baseline and background data gathered over that time that can be applied to the mining areas.
- Alcoa has conducted baseline flora and vegetation surveys over portions (survey data coverage available is 82.3%) of the Huntly Mine DE and the Willowdale Mine DE (99.3%) since the 1970s, which has enabled understanding of the local flora and vegetation.
- The vegetation of the Huntly and Willowdale Mine DEs is typical of the NJF IBRA subregion in which they are located; it has been impacted by timber harvesting, *Phytophthora* dieback, changing fire regimes, and changing climate.
- The majority of the NJF (77.6% of mapped area) and the Mine DEs (84.2%) are estimated to be at a juvenile to immature forest structure stage (assuming maturity as early as 70 years); with only 0.2% of the Huntly Mine DE and none of the Willowdale Mine DE being covered in Old Growth Forest compared with 2.6% of the mapped portion of the NJF.

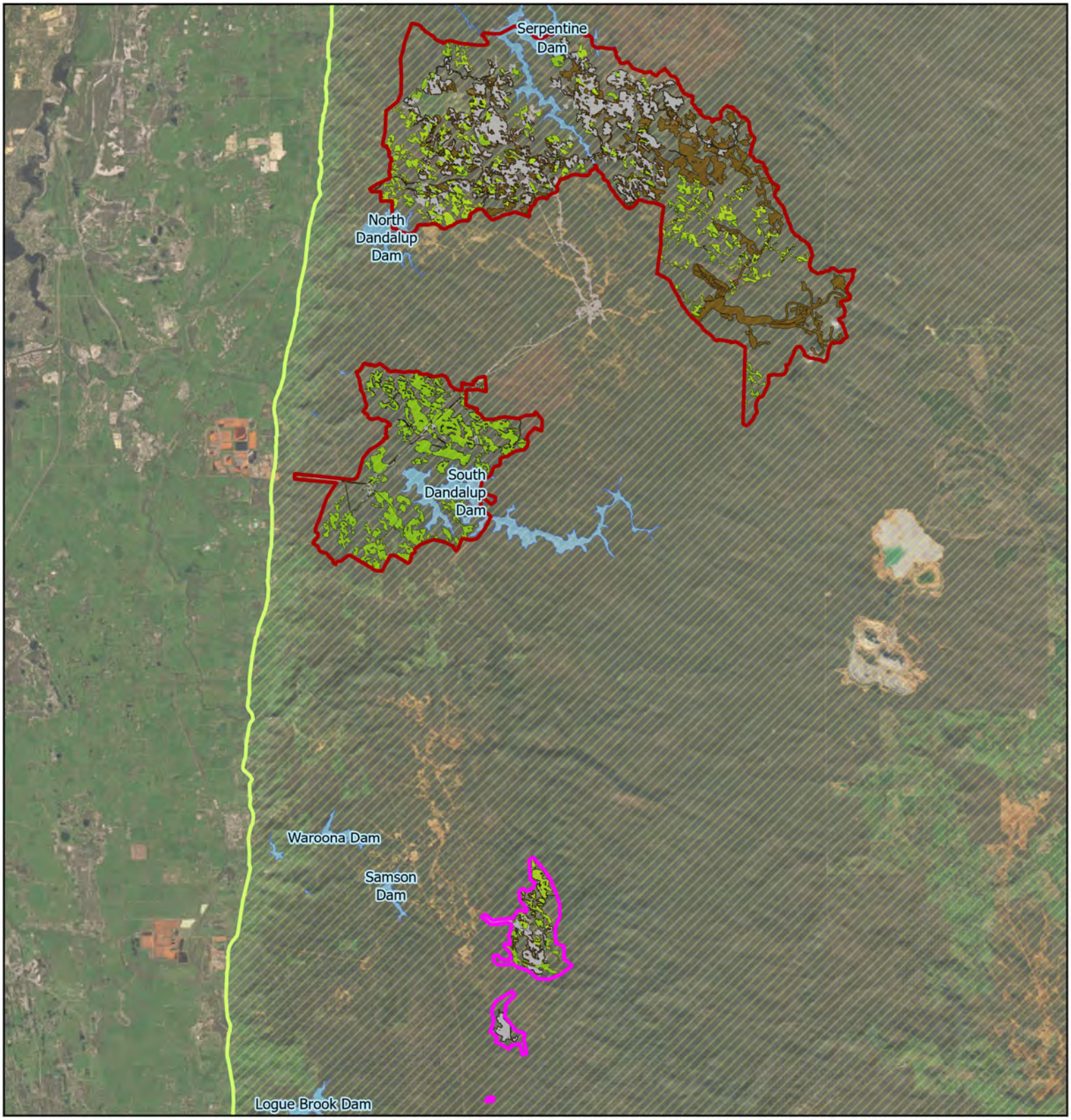
5.2.4 Receiving Environment – Vegetation

5.2.4.1 Regional Vegetation

The Proposal is located within the Southwest Botanical Province as mapped by Beard (1990), within the Jarrah Forest bioregion and NJF IBRA subregion (Figure 5-3). The NJF subregion covers approximately 1.90 million ha and is broadly characterised by Jarrah (*Eucalyptus marginata*) forest on ironstone gravels and Marri-Wandoo (*Corymbia calophylla – E. wandoo*) woodlands on loamy soils, with *sclerophyll* understoreys.

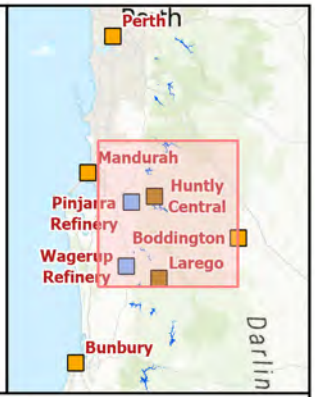
Dell and Havel (1989) broadly classified the Jarrah Forest as an open forest in its northern extent and as a tall forest in its southern extent. In lower rainfall areas, towards the east, trees decrease in size, forming woodlands or low forests.

The NJF subregion retains over approximately 1.1 million ha (58% of the pre-European extent) of native vegetation. Approximately 69% of the 1.1 million ha of native vegetation is within DBCA managed lands in the west and south (GoWA, 2019). Substantial clearing has occurred for agriculture in the north and east, as well as urban rural residential areas in the Perth Hills (e.g., Gidgegannup, Mundaring, Roleystone, and Kalamunda).



Legend

- Huntly Mine DE
- Willowdale Mine DE
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Reservoirs
- IBRA sub-region (Northern Jarrah Forest)



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-3 Huntly and Willowdale Mine DEs and Northern Jarrah Forest IBRA Sub-Region

Kilometres

0 4 8 12 16 20 24

Scale: 1:320,000 at A4

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Alcoa

5.2.4.1.1 Pre-European Vegetation Associations

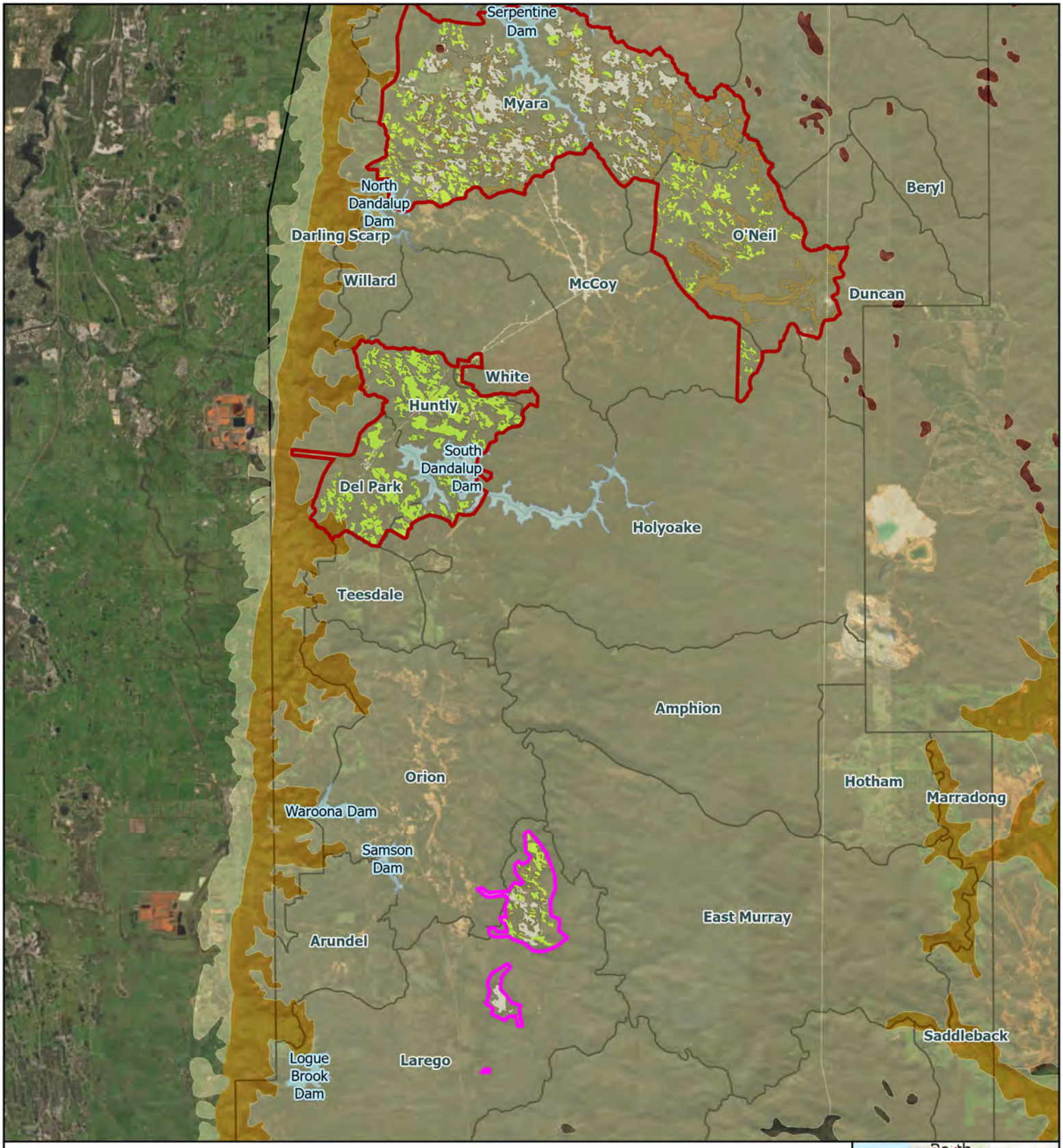
Beard (1979) mapped the pre-European vegetation (1:250,000 scale) over the NJF as comprising 44 vegetation associations. The vegetation associations within the Mine DEs are shown in Table 5-4 and Figure 5-4.

The Huntly Mine DE is predominantly (98.5% of the DE) and the Willowdale Mine DE entirely covered by vegetation association West Darling 3, which comprises medium forest of Jarrah and Marri. The remainder of the Huntly Mine DE is covered by associations East Darling 3 (medium forest of Jarrah and Marri), West Darling 4 (medium forest of Jarrah, Marri and Wandoo) and West Darling 128 (bare rock).

West Darling 3 is the most widespread vegetation association across the NJF subregion, with its current extent comprising approximately 38% of the subregion. Approximately 86% of the pre-European vegetation extent of West Darling 3 remains, with approximately 17% of the current extent protected for conservation (Government of Western Australia, 2019a).

Table 5-4: Pre-European vegetation associations

Vegetation association	Area in Huntly Mine DE (ha)	Proportion of Huntly Mine DE (%)	Area in Willowdale Mine DE (ha)	Proportion of Willowdale Mine DE (%)	Pre-European extent in NJF (ha)	Current extent in NJF (ha)	Proportion remaining (%)	Proportion of current extent protected for conservation (%)
East Darling-3	399	1.0	-	-	303,496	241,876	79.7	12.8
West Darling-3	38,456	98.5	2,137	100.0	485,010	416,422	85.9	17.1
West Darling-4	164	0.4	-	-	49,604	25,643	51.7	19.3
West Darling-128	28	0.1	-	-	1,450	1,402	96.7	64.6

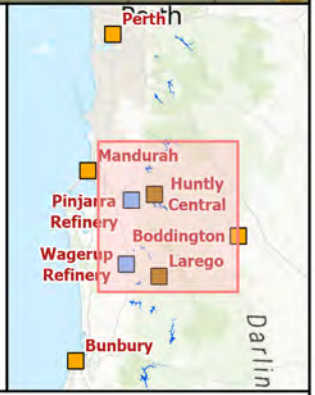


Legend

- Huntly Mine DE
- Willowdale Mine DE

Pre-European Vegetation

- 3: Forest
- 4: Woodland southwest
- 128: Rock
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Reservoirs
- Mining Regions



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-4 Pre-European Vegetation Associations - Mine DEs

Kilometres

0 4 8 12 16 20 24

Scale: 1:320,000 at A4

Date Printed: 26/02/2025

N

Alcoa

5.2.4.1.2 Vegetation Complexes

Heddle, Loneragan and Havel (1980) defined and described the dominant pre-European vegetation of the Darling System in a series of vegetation complexes, which was updated by Mattiske and Havel (1998) as part of a biodiversity assessment to inform the development of the Regional Forest Agreement 1999 (RFA). The 36 vegetation complexes mapped within the NJF cover 1.59 million ha and provide more detailed delineation of vegetation over the NJF subregion than the state-wide mapping of vegetation associations. The Dwellingup upland complexes cover the greatest proportion of the mapped area within the NJF (0.39 million ha; 24.4%).

There are 11 vegetation complexes mapped within the Mine DEs, as presented in Table 5-5, Figure 5-5, and Figure 5-6.

The Mine DEs are predominantly covered by three Dwellingup complexes (Dwellingup-1, -2, and -4) on the uplands (48.5% of the Huntly Mine DE and 52.8% of the Willowdale Mine DE) and Yarragil complexes (22.8% of the Huntly Mine DE and 21.2% of the Willowdale Mine DE) on the slopes and valley floors. The uplands and slopes contain enriched bauxite and, therefore, these are the areas where mining is proposed.

Eight vegetation complexes mapped within the Mine DEs have potential to provide key habitat for conservation significant flora (Section 5.2.5.2) and may comprise conservation significant communities (Sections 5.2.4.3 and 5.2.4.4). The three key groups of complexes include:

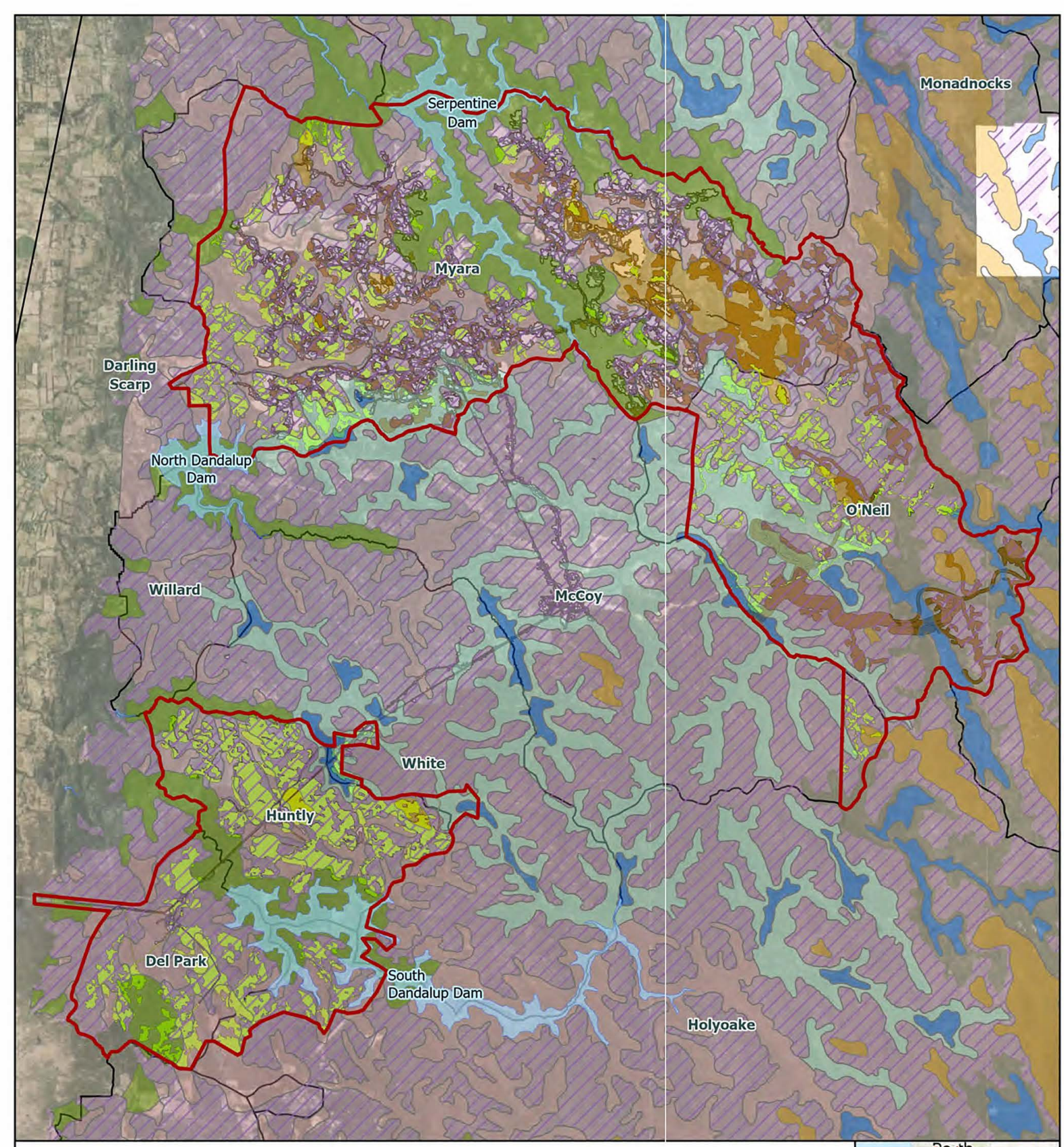
- The Swamp complex (1.9% of the Huntly Mine DE and 0.6% of the Willowdale Mine DE) occurs on seasonally wet or moist sand, peat, and clay soils within depressions and swamps on the Darling Plateau uplands. This complex may provide habitat for conservation significant flora and has potential to correspond with GDEs. It may be associated with occurrences of the '*Empodisma* peatlands of southwestern Australia' TEC (listed as Endangered under the EPBC Act).
- Valley floors and lower slopes within the Murray 1, Pindalup, Yarragil-1 and Yarragil-2 complexes (combined 43.3% of the Huntly Mine DE and 28.0% of the Willowdale Mine DE) may also be associated with GDEs.
- The Cooke (6.1% of the Huntly Mine DE and 18.7% of the Willowdale Mine DEs), and to a lesser degree the Darling Scarp DS2 (<0.1% of the Huntly Mine DE) and Helena 1 (0.2% of the Huntly Mine DE) complexes, are all associated with granite outcrops. Granite outcrops are a key component of the 'Granite communities of the northern Jarrah Forest' PEC (listed as Priority 3 [P3] by DBCA) and provide habitat for conservation significant flora species. These areas generally do not contain laterite and are therefore not subject to bauxite mining.

Ten of the 11 vegetation complexes found within the Mine DEs retain greater than 75% of their pre-European extent. The exception is the Darling Scarp DS2 complex, which has approximately 6.9% of its pre-European extent remaining (Government of Western Australia, 2019b). Darling DS2 forms a narrow strip at the base of the Darling Scarp, an area with significant amounts of agricultural clearing.

Table 5-5: Vegetation Complexes of the Southwest Forests

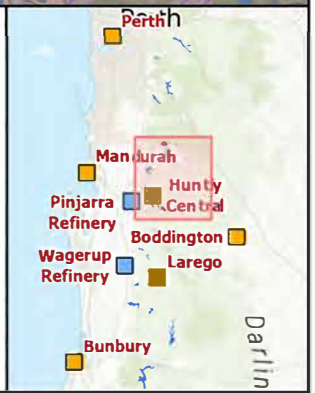
Vegetation complex	Description	Area in Huntly Mine DE (ha)	Proportion of Huntly Mine DE (%)	Area in Willowdale Mine DE (ha)	Proportion of Willowdale Mine DE (%)	Pre-European extent (ha)	Current extent (ha)	Proportion remaining (%)	Proportion of current extent protected for conservation (%)
Cooke, Ce	Darling Plateau Uplands: Mosaic of open forest of *Eucalyptus marginata* subsp. *marginata-Corymbia calophylla* (subhumid zone) and open forest of *Eucalyptus marginata* subsp. *thalassica-Corymbia calophylla* (semiarid and arid zones) and on deeper soils adjacent to outcrops, closed heath of *Myrtaceae-Proteaceae* species and lithic complex on granite rocks and associated soils in all climate zones, with some *Eucalyptus laeliae* (semiarid), and *Allocasuarina huegeliana* and *Eucalyptus wandoo* (mainly semiarid to perarid zones).	2,382	6.1	400	18.7	36,805	30,304	82.30%	18.60%
Darling Scarp, DS2	Darling Plateau Uplands: Mosaic of open forest of *Eucalyptus marginata* subsp. *marginata-Corymbia calophylla*, with some admixtures with *Eucalyptus laeliae* in the north (subhumid zone), with occasional Eucalyptus *marginata* subsp. *elegantella* (mainly in subhumid zone) and *Corymbia haematoxylon* in the south (humid zone) on deeper soils adjacent to outcrops, woodland of *Eucalyptus wandoo* (subhumid and semiarid zones), low woodland of *Allocasuarina huegeliana* on shallow soils over granite outcrops, closed heath of *Myrtaceae-Proteaceae* species and lithic complex on or near granite outcrops in all climate zones.	13	<0.1	-	-	32,466	32,466	100.00%	0.26%
Dwellingup, D1	Darling Plateau Uplands: Open forest of *Eucalyptus marginata* subsp. *marginata-Corymbia calophylla* on lateritic uplands in mainly humid and subhumid zones.	16,659	42.7	1,127	52.8	208,620	181,039	86.80%	8.30%
Dwellingup, D2	Darling Plateau Uplands: Open forest of *Eucalyptus marginata* subsp. *marginata-Corymbia calophylla* on lateritic uplands in subhumid and semiarid zones.	2,190	5.6	-	-	86,183	5,918	6.90%	19.30%
Dwellingup, D4	Darling Plateau Uplands: Open forest to woodland of *Eucalyptus marginata* subsp. *thalassica-Corymbia calophylla* on lateritic uplands in semiarid and arid zones.	88	0.2	-	-	132,414	115,545	87.30%	12%
Helena 1, He1	Darling Plateau Valleys: Mosaic of open forest of *Corymbia calophylla-Eucalyptus patens-Eucalyptus marginata* subsp. marginata with some *Eucalyptus rudis* on the deeper soils ranging to closed heath and lithic complex on shallow soils associated with granite on steep slopes of valleys in humid and subhumid zones.	73	0.2	-	-	15,890	12,045	75.80%	30%
Murray 1, My1	Darling Plateau Valleys: Open forest of *Eucalyptus marginata* subsp. *marginata-Corymbia calophylla-Eucalyptus* patens on valley slopes to woodland of *Eucalyptus rudis-Melaleuca rhaphiophylla* on the valley floors in humid and subhumid zones.	6,515	16.7	143	6.7	68,737	52,296	76.10%	25.70%
Pindalup, Pn	Darling Plateau Valleys: Open forest of *Eucalyptus marginata* subsp. *thalassica-Corymbia calophylla* on slopes and open woodland of *Eucalyptus wandoo* with some *Eucalyptus patens* on the lower slopes in semiarid and arid zones.	1,472	3.8	-	-	167,270	128,685	76.90%	0%
Swamp, S	Darling Plateau Depressions and Swamps on Uplands: Mosaic of low open woodland of *Melaleuca preissiana-Banksia littoralis*, closed scrub of *Myrtaceae* spp., closed heath of *Myrtaceae* spp. and sedgelands of *Baumea* and *Leptocarpus* spp. on seasonally wet or moist sand, peat and clay soils on valley floors in all climatic zones.	752	1.9	12	0.6	53,696	40,613	75.60%	14.30%

Vegetation complex	Description	Area in Huntly Mine DE (ha)	Proportion of Huntly Mine DE (%)	Area in Willowdale Mine DE (ha)	Proportion of Willowdale Mine DE (%)	Pre-European extent (ha)	Current extent (ha)	Proportion remaining (%)	Proportion of current extent protected for conservation (%)
Yarragil 1, Yg1	Darling Plateau Valleys: Open forest of *Eucalyptus marginata* subsp. *marginata-Corymbia calophylla* on slopes with mixtures of *Eucalyptus patens* and *Eucalyptus megacarpa* on the valley floors in humid and subhumid zones.	6,080	15.6	331	15.5	80,252	64,927	80.90%	9.90%
Yarragil 2, Yg2	Darling Plateau Valleys: Open forest of *Eucalyptus marginata* subsp. *thalassica-Corymbia calophylla* on slopes, woodland of *Eucalyptus patens-Eucalyptus rudis* with *Hakea prostrata* and *Melaleuca viminea* on valley floors in subhumid and semiarid zones.	2,822	7.2	123	5.7	50,292	46,475	92.40%	10.60%



Legend

- Huntly Mine DE
- Reservoirs
- Vegetation Complexes
- Veg Complex Name
- Cooke
- Dwellingup
- Murray 1
- Swamp
- Yarragil 1
- Yarragil 2
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Mining Regions



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-5 Pre-European Vegetation Associations - Huntly Mine DE

Kilometres

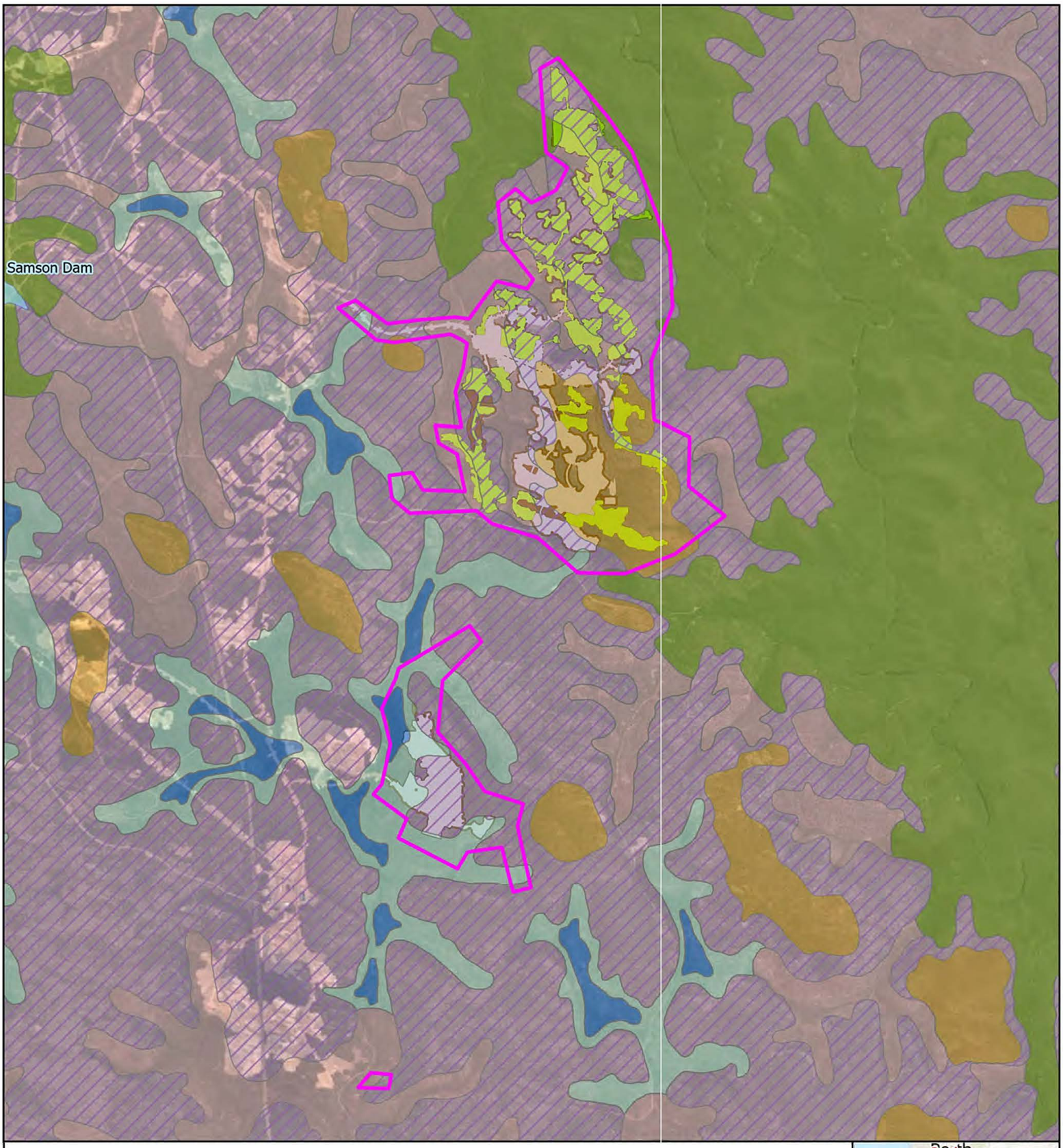
0 2 4 6 8 10 12

Scale: 1:175,000 at A4

Date Printed: 26/02/2025

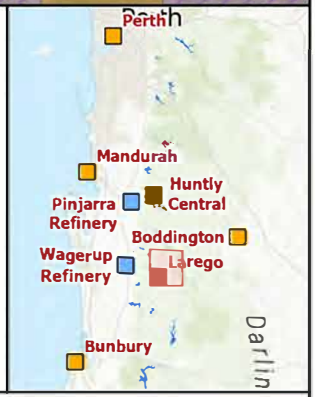
N

Alcoa



Legend

- Willowdale Mine DE
- Reservoirs
- Vegetation Complexes
- Veg Complex Name
- Cooke
- Dwellingup
- Murray 1
- Swamp
- Yarragil 1
- Yarragil 2
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-6 Pre-European Vegetation Associations - Willowdale Mine DE

Kilometres

0 0.9 1.8 2.7 3.6 4.5 5.4

Scale: 1:75,060 at A4

Date Printed: 26/02/2025

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Alcoa

5.2.4.2 Local Vegetation – Vegetation Types

Vegetation types (VTs) are delineated based on a method developed by Havel (1975a; 1975b) to differentiate vegetation across the continuum of Jarrah-Marri overstorey using key indicator species and site conditions. VTs comprise combinations of the 21 site vegetation types (SVTs) developed by Havel (1975a; 1975b), with the first letter reflecting the dominant SVT and the second letter the subdominant SVT.

VTs were recorded in baseline field surveys conducted from the 1970s, with available data covering 82.3% of the Huntly Mine DE (97.2% of the Myara-O'Neil portion and 37.5% of the Huntly-Del Park portion) and 99.3% of the Willowdale Mine SE.

The VTs are presented in Table 5-6, Figure 5-7, and Figure 5-8. They are mapped over approximately 82% of the Huntly Mine DE and 99% of the Willowdale Mine DE, with the largest gaps occurring in the Huntly-Del Park portion of the Huntly Mine DE (62.5% not covered by VT mapping). The VTs are broadly consistent with the vegetation complex mapping.

Approximately 49% of the mapped part of the Mine DEs comprises VTs with P, S and T as the dominant SVTs (i.e., VTs P, PG, PS, PT, S, SP, ST, T, TS, TP; Table 5-6). These three VTs are relatively widespread and primarily associated with the upland Dwellingup complex in the high to medium rainfall zone (>900 mm/year) (Heddle, Loneragan, & Havel, 1980). The Huntly Mine DE uplands are dominated by the P- and S-dominant VTs (11.3% and 22% of the Huntly Mine DE area, respectively), whereas the Willowdale Mine DE uplands are primarily the S- and T-dominant VTs (26.8% and 18.8% of the Willowdale Mine DE area, respectively). The three upland VTs vary substantially with respect to soil texture from coarse sandy gravels (P) to loamy gravels (S) and sandy loams (T) (Bell & Heddle, 1989).

Approximately 12% of the mapped part of the Mine DEs comprises VTs with C, D, E, Q, W and Y dominant, which are less widespread VTs found in lower slopes, valley floors and creeklines of the Murray-1, Pindalup-1, and Yarragil complexes.

Approximately 2% of the mapped part of the Mine DEs comprises VTs with G and R dominant, which are restricted in extent to granite outcrops and associated predominantly with the Cooke complex and, to a lesser degree, the Darling Scarp 2 and Helena 1 complexes. The G- and R-dominant VTs may be associated with the 'Granite communities of the northern Jarrah Forest PEC (P3) and provide habitat for conservation significant flora species.

Approximately 3% of the mapped part of the Mine DEs consists of VTs with A dominant, which is a VT restricted to swamps and associated with the Swamp, Yarragil-1 and Yarragil-2 complexes. The A-dominant VTs may be associated with the '*Empodisma* peatlands of southwestern Australia' TEC (EN), provide habitat for conservation significant flora (Section 5.2.5.2), and may be associated with GDEs (Section 5.2.4.4).

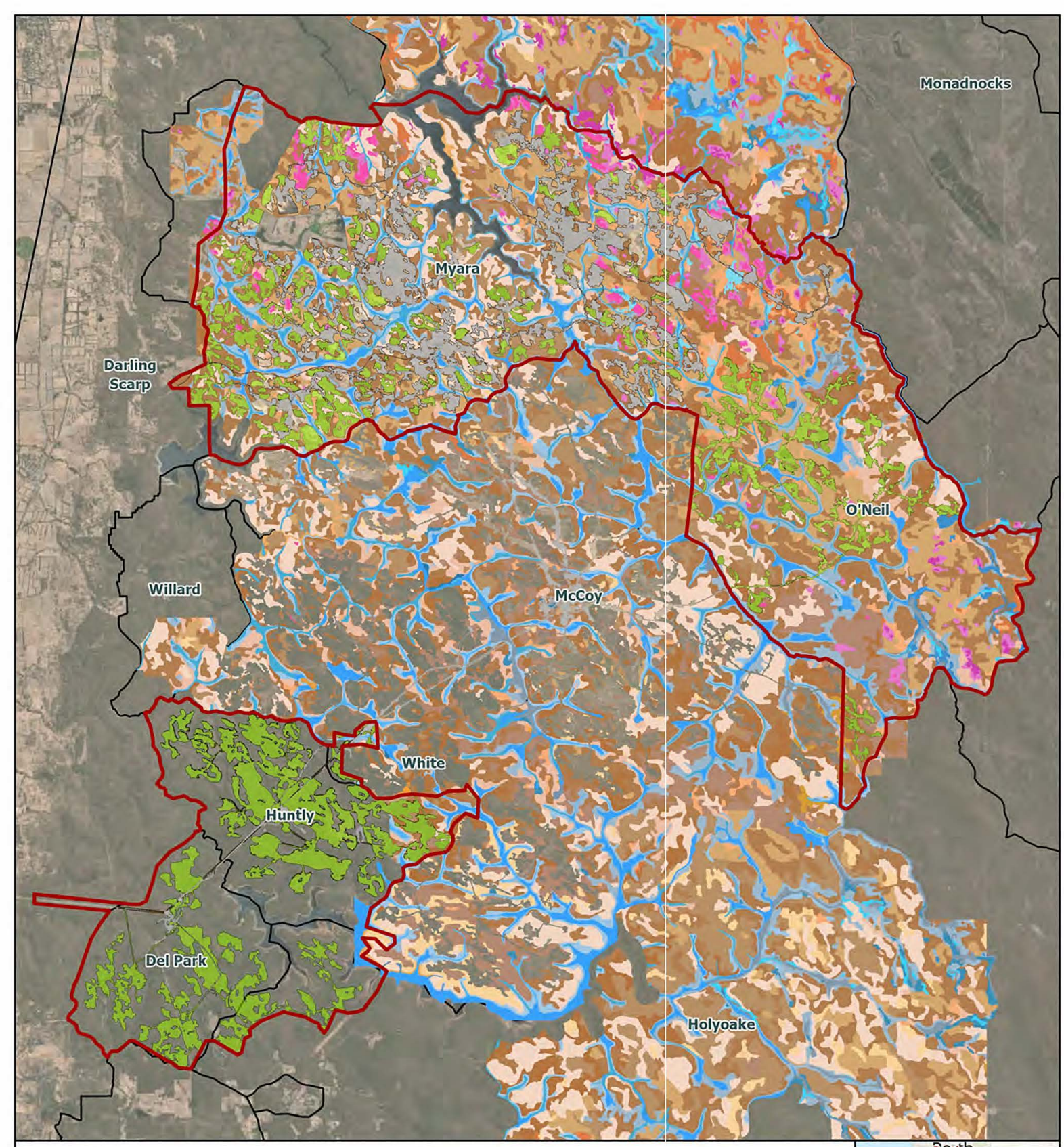
Approximately 32% of the mapped part of the Mine DEs comprises cleared land and mine rehabilitation, with another 1% being open water of the Serpentine Reservoir in the north of the Huntly Mine DE.

Table 5-6: Vegetation Types Recorded Within the Mine DEs

Code	Description	Huntly Mine DE				Willowdale Mine DE					Total area within the Mine DEs (ha)	Proportion of the Mine DEs (%)
		Huntly-Del Park (ha)	Myara-O'Neil (ha)	Total (ha)	Proportion of Huntly Mine DE (%)	Keats (ha)	Tasman (ha)	Wills(ha)	Total (ha)	Proportion of Willowdale Mine DE (%)		
Swamps and Broad Valleys												
A	Tall shrubland of *Melaleuca lateritia, Hakea varia, M. viminea* and *M. incana* subsp. *incana* on clay-loams in seasonally wet valley floors.	1	107	108	0.3	-	-	-	-	-	108	0.3
AC	Open Woodland of *Eucalyptus rudis – Melaleuca preissiana – E. patens – Banksia littoralis* with dense *Taxandria linearifolia and Astartea scoparia* in understorey on broad swamps and water-courses.	144	728	872	2.2	21	-	15	35	1.6	907	2.2
AD	Low open woodland of *Eucalyptus rudis* and *E. marginata* over *Banksia littoralis, Hakea prostrata* and *Pericalymma ellipticum* over low shrubs and herbs on leached sands over sandy-gravel on lower slopes.	-	32	32	0.1	-	-	-	-	-	32	0.1
AW	Low open woodland of *Eucalyptus patens* and *Melaleuca preissiana* over *Banksia littoralis, Hakea prostrata* and *Pericalymma ellipticum* over low shrubs and herbs on leached sands over sandy-gravel on lower slopes.	-	2	2	0.0	-	-	-	-	-	2	<0.1
AY	Open woodland of *Eucalyptus wandoo* over *Hakea varia, Hypocalymma angustifolium, Babingtonia camphorosmae* and *Gastrolobium calycinum* over herbs and sedges on clay loams in seasonally wetter valley floors.	-	28	28	0.1	-	-	-	-	-	28	0.1
D	Open Forest of *Eucalyptus marginata- Corymbia calophylla – Hakea prostrata* on lower slopes with mixed low understorey species, including *Babingtonia camphorosmae* and *Acacia extensa* on clay loams to gravelly clay-loams.	10	1,584	1,594	4.1	20	-	<1	20	0.9	1,614	3.9
DA	Open Forest of *E. marginata – C. calophylla – Hakea prostrata* on lower slopes with patches of *Melaleuca preissiana*, *Banksia littoralis* and *Hakea varia* over mixed low understorey species, including *Babingtonia camphorosmae* and Acacia extensa on clay loams to gravelly clay-loams. Local variant also includes *Xylomelum occidentale* (Woody Pear).	-	33	33	0.1	-	-	-	-	-	33	0.1
DG	Open forest of *C. calophylla* and *E. marginata* over *Hakea lissocarpha*, *Macrozamia riedlei*, *Pericalymma ellipticum*, *Grevillea bipinnatifida*, *Allocasuarina humilis*, *Acacia alata*, *Babingtonia camphorosmae*, *Hypocalymma angustifolium* and *Phyllanthus calycinus* on clay-loams on lower slopes with localised patches of outcropping.	-	204	204	0.5	-	-	-	-	-	204	0.5
E	Open woodland of *E. marginata* and *C. calophylla* over *Mesomelaena tetragona*, *Kingia australis*, *Leptospermum erubescens* and *Babingtonia camphorosmae* on sandy to sandy-loam soils on slopes.	-	106	106	0.3	6.2	-	-	6	0.3	112	0.3
Valley Floors and Lower Slopes												
C	Woodland to Open Forest of *E. patens – C. calophylla – Banksia littoralis* and *Banksia seminuda* with dense *Taxandria linearifolia* and *Astartea scoparia* in understorey on creek-lines and water-courses.	30	7	37	0.1	-	-	-	-	-	37	0.1
CQ	Open forest of *Eucalyptus marginata – Corymbia calophylla – Eucalyptus patens* on lower slopes with mixed understorey species, including T*rymalium floribundum, Agonis linearifolia* and *Astartea scoparia* along the edges of the deeper incised valleys near the creek-lines.	-	-	-	-	7	-	-	7	0.3	7	<0.1
CW	Woodland to Open Forest of E. patens – *E. megacarpa – C. calophylla – Banksia littoralis* with dense *Taxandria linearifolia* and *Astartea scoparia* in understorey on creek-lines and water-courses.	<1	825	825	2.1	43	<1	4	48	2.2	872	2.1
Q	Open Forest of *E. marginata – C. calophylla – E. patens* with mixed understorey species, including *Trymalium floribundum*, *Acacia extensa* and *Phyllanthus calycinus* on loam soils on lower slopes.	11	32	42	0.1	15	-	-	15	0.7	57	0.1

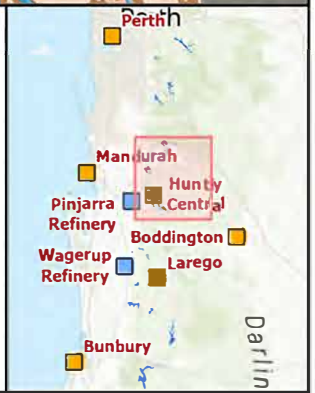
Code	Description	Huntly Mine DE				Willowdale Mine DE					Total area within the Mine DEs (ha)	Proportion of the Mine DEs (%)
		Huntly-Del Park (ha)	Myara-O'Neil (ha)	Total (ha)	Proportion of Huntly Mine DE (%)	Keats (ha)	Tasman (ha)	Wills(ha)	Total (ha)	Proportion of Willowdale Mine DE (%)		
W	Open Forest of *E. megacarpa – E. patens – C. calophylla* on lower slopes with mixed low understorey species, including *Acacia extensa* and *Hypocalymma angustifolium* on seasonally moister sandy-loam gravelly soils.	71	982	1,053	2.7	53	2	29	84	3.9	1,137	2.8
WD	Open Forest of *E. megacarpa – E. patens – C. calophylla* on lower slopes with mixed low understorey species, including *Hakea prostrata*, *Babingtonia camphorosmae* and *Hypocalymma angustifolium* on seasonally moister sandy-loam gravelly soils.	1	-	1	<0.1	-	-	-	-	-	1	<0.1
Y	Open woodland of *Eucalyptus wandoo* over *Hypocalymma angustifolium* and *Babingtonia camphorosmae* over herbs and sedges on clay-loams on seasonally moister lower slopes.	-	7	7	<0.1	-	-	-	-	-	7	<0.1
YG	Open woodland of *Eucalyptus wandoo* over *Hypocalymma angustifolium, Babingtonia camphorosmae, Grevillea bipinnatifida* and *Allocasuarina humilis* over herbs and sedges on clay-loams on seasonally moister lower slopes underlain by outcrops.	-	14	14	<0.1	-	-	-	-	-	14	<0.1
Slopes and Ridges – Sandy Loam Gravels												
P	Open Forest of *A. fraseriana – E. marginata – C. calophylla – Banksia grandis* with scattered understorey, including *Adenanthos barbiger, Styphelia nitens, Grevillea wilsonii, Leucopogon capitellatus* on sandy gravels.	-	325	325	0.8	4	-	-	4	0.2	329	0.8
PG	Open Forest of *Allocasuarina fraseriana – Eucalyptus marginata – Corymbia calophylla* with scattered understorey, including *Grevillea bipinnatifida* and *Adenanthos barbiger* and low shrubs, herbs and sedges on sandy gravels.	-	<1	<1	<0.1	-	-	-	-	-	-	<0.1
PS	Open Forest of *A. fraseriana – E. marginata – C. calophylla – Banksia grandis* with scattered understorey, including *Adenanthos barbiger*, *Leucopogon capitellatus* on gravels and sandy gravels.	-	3,251	3,251	8.3	85	-	24	109	5.1	3,360	8.2
PT	Open Forest of *A. fraseriana – E. marginata – C. calophylla – Banksia grandis* with scattered understorey, including *Adenanthos barbiger*, *Leucopogon verticillatus*, *Pteridium esculentum* and *Bossiaea aquifolium* subsp. *aquifolium* on sandy-loam gravels.	21	39	60	0.2	40	2	<1	42	2.0	102	0.2
S	Open Forest of *E. marginata – Banksia grandis – A. fraseriana* with scattered understorey, including *Adenanthos barbiger,Leucopogon capitellatus* and *Styphelia tenuiflora* on gravels and sandy- gravels.	43	5,801	5,844	15.0	317	-	72	389	18.2	6,233	15.1
SP	Open Forest of *A. fraseriana – E. marginata – C. calophylla – Banksia grandis* with scattered understorey, including *Adenanthos barbiger*, *Grevillea wilsonii* and *Leucopogon capitellatus* on sandy-gravels to gravelly soils.	20	851	871	2.2	29	-	3	31	1.5	903	2.2
SP-D	Degraded SP vegetation type	9	-	9	<0.1	-	-	-	-	-	9	<0.1
ST	Open Forest of *E. marginata – C. calophylla* with scattered understorey, including *Leucopogon capitellatus*, *Leucopogon verticillatus*, *Pteridium esculentum*, *Lasiopetalum floribundum* and *Styphelia tenuiflora* on sandy-gravelly soils.	103	769	872	2.2	59	2	29	89	4.2	962	2.3
TP	Open Forest of *Eucalyptus marginata – Corymbia calophylla – Allocasuarina fraseriana – Banksia grandis* on sandy-loams to sandy- gravels with scattered understorey, including *Clematis pubescens*, *Adenanthos barbiger*, *Leucopogon verticillatus*, *Pteridium esculentum* and *Bossiaea aquifolium* subsp. *Aquifolium* on sandy-loam gravels.	-	14	14	<0.1	4	-	-	4	0.2	17	<0.1

Code	Description	Huntly Mine DE				Willowdale Mine DE					Total area within the Mine DEs (ha)	Proportion of the Mine DEs (%)
		Huntly-Del Park (ha)	Myara-O'Neil (ha)	Total (ha)	Proportion of Huntly Mine DE (%)	Keats (ha)	Tasman (ha)	Wills(ha)	Total (ha)	Proportion of Willowdale Mine DE (%)		
Z	Open forest of *Eucalyptus marginata* and *Corymbia calophylla* over *Macrozamia riedlei, Xanthorrhoea preissii, Hakea lissocarpha* and *Lysiandra calycinus* on sandy loam to sandy-loam gravel soils on slopes.	-	13	13	<0.1	-	-	-	-	-	13	<0.1
Slopes and Ridges – Loam Gravels												
T	Open Forest of *E. marginata – C. calophylla* with scattered understorey, including *Leucopogon verticillatus*, *Pteridium esculentum*, *Clematis pubescens* and *Bossiaea aquifolium* subsp. *aquifolium* on sandy-loam gravelly soils.	35	693	727	1.9	89	-	14	102	4.8	830	2.0
TS	Open Forest of *E. marginata – C. calophylla – Banksia grandis* with scattered understorey, including *Leucopogon verticillatus, Pteridium esculentum, Clematis pubescens* and *Bossiaea aquifolium* subsp. *aquifolium* on sandy-loam gravelly to gravelly soils.	20	1,970	1,990	5.1	221	-	79	299	14.0	2,289	5.6
Slopes with Higher Seasonal Soil Moisture												
PW	Open Forest of *Allocasuarina fraseriana – E. marginata – C. calophylla* with scattered understorey, including *Grevillea wilsonii, Adenanthos barbiger, Babingtonia camphorosmae* and *Hypocalymma angustifolium* on sandy gravels.	-	762	762	2.0	5	-	-	5	0.2	767	1.9
SW	Open Forest of *E. marginata – C. calophylla – Banksia grandis* with scattered understorey, including *Adenanthos barbiger, Hypocalymma angustifolium* and *Styphelia tenuiflora* on seasonally moister sandy-gravelly soils.	37	926	963	2.5	60	-	3	63	2.9	1,025	2.5
SW-D	Degraded SW vegetation type	<1	-	<1	0.0	-	-	-	-	-	<1	<0.1
Outcrop Areas												
G	Mosaic of Open Woodland of *E. marginata – C. calophylla* on the fringes of outcrops ranging to open heath communities of Proteaceae-Myrtaceae species and lithic complexes on the outcrop areas.	-	84	84	0.2	1	-	-	1	<0.1	85	0.2
G1	Mosaic of Open Woodland of *E. marginata – C. calophylla* on the fringes of outcrops ranging to open heath communities of Proteaceae-Myrtaceae species and lithic complexes on the outcrop areas.	-	393	393	1.0	-	-	-	-	-	393	1.0
G2	Mosaic of open woodland of *Allocasuarina huegeliana* and closed heath of Proteaceae and Myrtaceae spp. to lithic complex on exposed or shallow granite outcrops.	-	1	1	<0.1	-	-	-	-	-	1	<0.1
R	Open Woodland of *E. marginata – C. calophylla* onfringes of granite outcrops or shallow soils over mixed understorey species reflecting shallow soils over granite.	-	524	524	1.3	1	-	-	1	<0.1	524	1.3
R/G	Open Woodland of *E. marginata – C. calophylla* with patches of Heath of Proteaceae – Myrtaceae species on fringes of granite outcrops or shallow soils.	-	5	5	<0.1	-	-	-	-	-	5	<0.1
Other Areas												
CL	Cleared	162	3,945	4,107	10.5	177	-	104	280	13.1	4,387	10.7
DAM	Dam	-	329	329	0.8	-	-	-	-	-	329	0.8
Rehab	Rehabilitation Areas	2,926	3,119	6,045	15.5	487	-	-	487	22.8	6,531	15.9
YS	Description not available	-	5	5	<0.1	-	-	-	0.0	0.0	5	<0.1
Total Area Mapped		**3,643**	**28,508**	**32,138**	82.3	**1,740**	**7**	**374**	**2,121**	**99.3**	**34,259**	**83.2**
N/A	Not Mapped	6,081	815	6,909	17.7	14	1	-	15	0.7	6,924	16.8



Legend

- Huntly Mine DE
- Granite Outcrops
- Species Codes
  - G
  - G1
  - G2
  - R
  - R/G
- Upland Areas
- Species Codes
  - J
  - M
  - P
  - PG
  - PL
  - PS
  - PT
  - PW
  - Q
  - S
  - S-SP
  - SP
  - SP-D
  - ST
  - SW
  - SW-D
  - T
  - TP
  - TS
  - Z
- Lower Slopes and Swamps
- Species Codes
  - A
  - AC
  - AD
  - AW
  - AX
  - C
  - CQ
  - CW
  - D
  - DA
  - DG
  - E
  - W
  - WA
  - WD
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Mining Regions



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-7 Vegetation Types - Huntly Mine DE

Kilometres

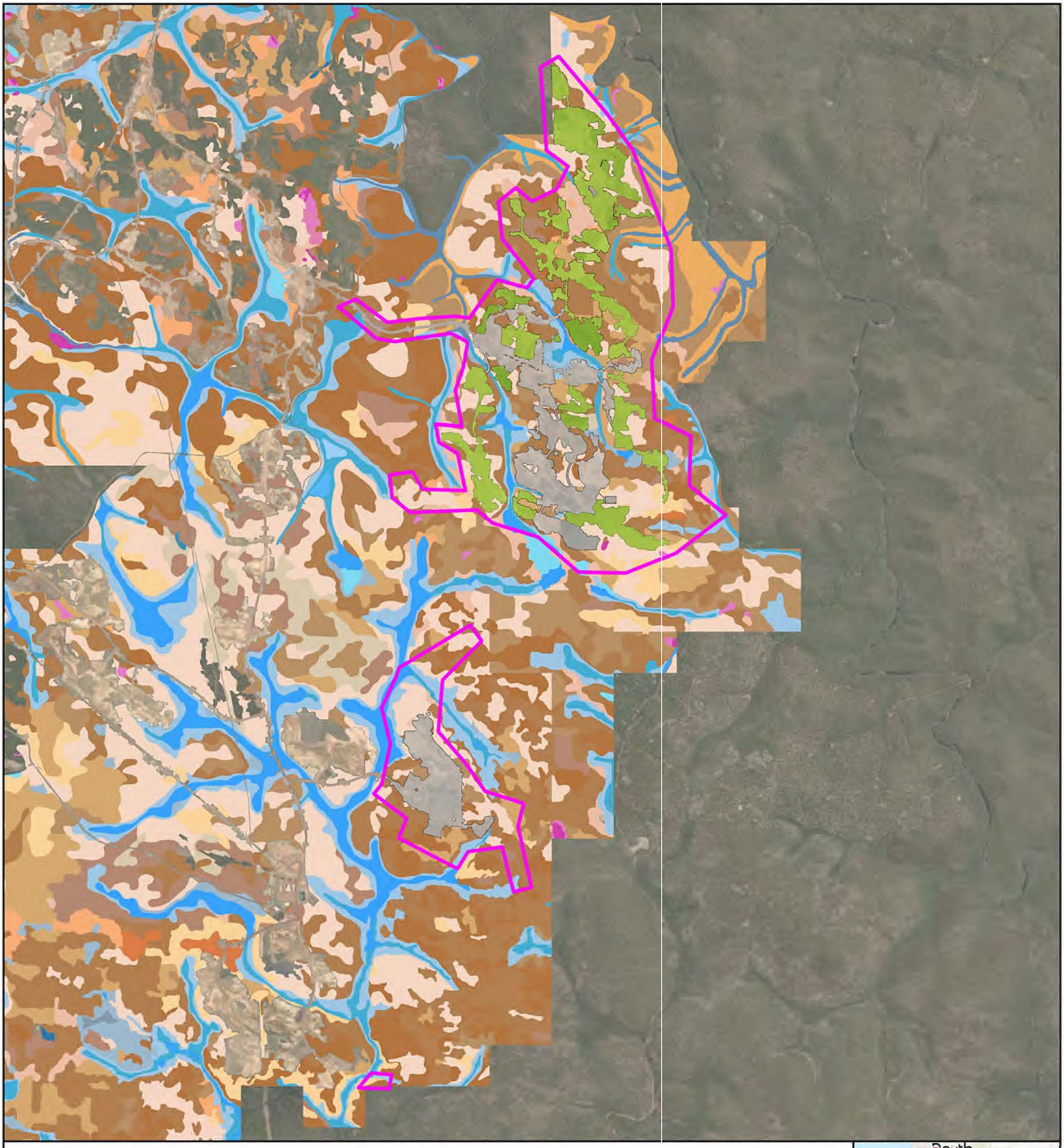
0 2 4 6 8 10 12

Scale: 1:175,000 at A4

Date Printed: 26/02/2025

N

Alcoa



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-8 Vegetation Types - Willowdale Mine DE

Kilometres

0 0.9 1.8 2.7 3.6 4.5 5.4

Scale: 1:75,000 at A4

Date Printed: 26/02/2025

N

Alcoa

5.2.4.3 Conservation Significant Ecological Communities

The potential presence of conservation significant ecological communities within the Mine DEs was assessed using search results from the DBCA's Threatened and Priority Ecological Communities database (DBCA, 2024b) and the EPBC Act PMST for Matters of National Environmental Significance (DCCEEW, 2024b) (Appendix 23) and a review of regional and local vegetation mapping. Data from the DBCA database search (ref# 30-0624EC) were provided by DBCA on 20 June 2024 with a search buffer of 10 km from 2025-2029 MMP areas. The PMST search area comprised the Huntly and Willowdale Mine DEs plus a 10 km buffer.

The scale on which the presence of conservation significant ecological communities within the Mine DEs was assessed was:

- **Recorded:** Ecological community has been recorded within the area of interest;
- **Highly Likely:** Suitable habitat is likely to be present and there are records within 500 m of the area of interest;
- **Likely:** Suitable habitat is likely to be present and there are records within 2 km of the area of interest;
- **Possible:** Suitable habitat is likely to be present and there are records within 10 km of the area of interest;
- **Unlikely:** Suitable habitat is unlikely to be present; or Suitable habitat may be present, but the species has not been found in the vicinity of the area of interest; and
- **Does Not Occur:** The species has a restricted distribution that does not coincide with the area of interest.

The results of the assessment are summarised below, with the PMST report provided in Appendix 23 and shown on Figure 5-9 and Figure 5-10.

Threatened Ecological Communities

The database searches indicated that six TECs have been recorded within 10 km of the Mine DEs:

- *Empodisma* peatlands of southwestern Australia (EN under the EPBC Act);
- Banksia Woodlands of the Swan Coastal Plain (EN under the EPBC Act and P3 by DBCA);
- Clay pans of the Swan Coastal Plain (Critically Endangered (CR) under the EPBC Act and P1 by DBCA);
- *Corymbia calophylla – Kingia australis* woodlands on heavy soils of the Swan Coastal Plain (EN under the EPBC Act and CE under the BC Act);
- *Corymbia calophylla – Xanthorrhoea preissii* woodlands and shrublands of the Swan Coastal Plain (EN under both the EPBC Act and the BC Act); and
- Tuart *(Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain Ecological Community (CR under the EPBC Act and P3 by DBCA).

Assessments for the presence of these TECs within the Mine DEs are presented in Appendix 25.

Based on key diagnostic characteristics, ecological community descriptions, and known distribution and habitat given in Conservation or Listing Advice for the TECs (Appendix 25) the '*Empodisma* peatlands' TEC is assessed as known to occur in the Willowdale Mine DE

and Potential to occur within the Huntly Mine DE. The '*Empodisma* peatlands' TEC is generally found within the Warren IBRA bioregion and Southern Jarrah Forest subregion, with scattered occurrences through the NJF. Indicative distribution mapping of the '*Empodisma* peatlands' TEC (DCCEEW, 2023) shows several areas where the TEC may occur within the vicinity of the Mine DEs (Figure 5-9 and Figure 5-10), comprising a total area of 1,080 ha within the Mine DEs. *Empodisma* peatlands TEC has been identified to occupy within the Larego mine region, within proximity of the Willowdale Mine DE.

The 'Claypans of the Swan Coastal Plain' TEC is assessed as being Unlikely to occur within the Mine DEs. It is mostly found in the Swan Coastal Plain bioregion, but occurrences are known from the NJF (none within 100 km of the Mine DEs). The known distribution and size of the 'Claypans of the Swan Coastal Plain' TEC is very restricted and cannot be mapped using existing regional soil-landscape or local vegetation mapping.

The remaining four TECs listed above are only found on the Swan Coastal Plain or its fringes and have not been recorded within the Mine DEs. These are assessed as 'Does Not Occur'.

Priority Ecological Communities

The database searches identified three PECs that occur within 10 km of the Mine DEs and have mapped occurrences not restricted to the Swan Coastal Plain (Figure 5-9, Figure 5-10).

- Mount Saddleback heath communities (P1)
- Litter Dependent Invertebrate Community of the northern Jarrah Forest (P2)
- Granite communities of the northern Jarrah Forest (P3)

A detailed assessment of the potential presence of these PECs within the Mine DEs is given in Appendix 25 with a summary provided below.

Mount Saddleback heath communities

A total of 34 occurrences (and associated buffers) of this PEC are mapped across Mt Saddleback within 5 km of the Huntly Mine DE and 20 km of the Willowdale Mine DE. The ecological community corresponds with the granite outcrop vegetation types G, G1, G3 and G4 (though the PEC as defined by DBCA does not include G4).

Vegetation types G and G1 are mapped within the Mine DEs, but do not correspond to the PEC, as the PEC is restricted to the heath communities on Mt Saddleback, within South32's Worsley Bauxite mine. This PEC is, therefore, assessed as 'Does Not Occur'.

Litter Dependent Invertebrate Community of the northern Jarrah Forest

DBCA have mapped a fauna PEC, 'Litter Dependent Invertebrate Community of the northern Jarrah Forest' (P2), as occurring approximately 10 km north of the Huntly Mine DE (Myara-O'Neil portion). Given that there is "insufficient evidence that this is a discrete community type" (DBCA, 2023b) and there are no mapped occurrences within 10 km of the Mine DEs, this PEC is assessed as 'Does Not Occur'.

Granite communities of the northern Jarrah Forest

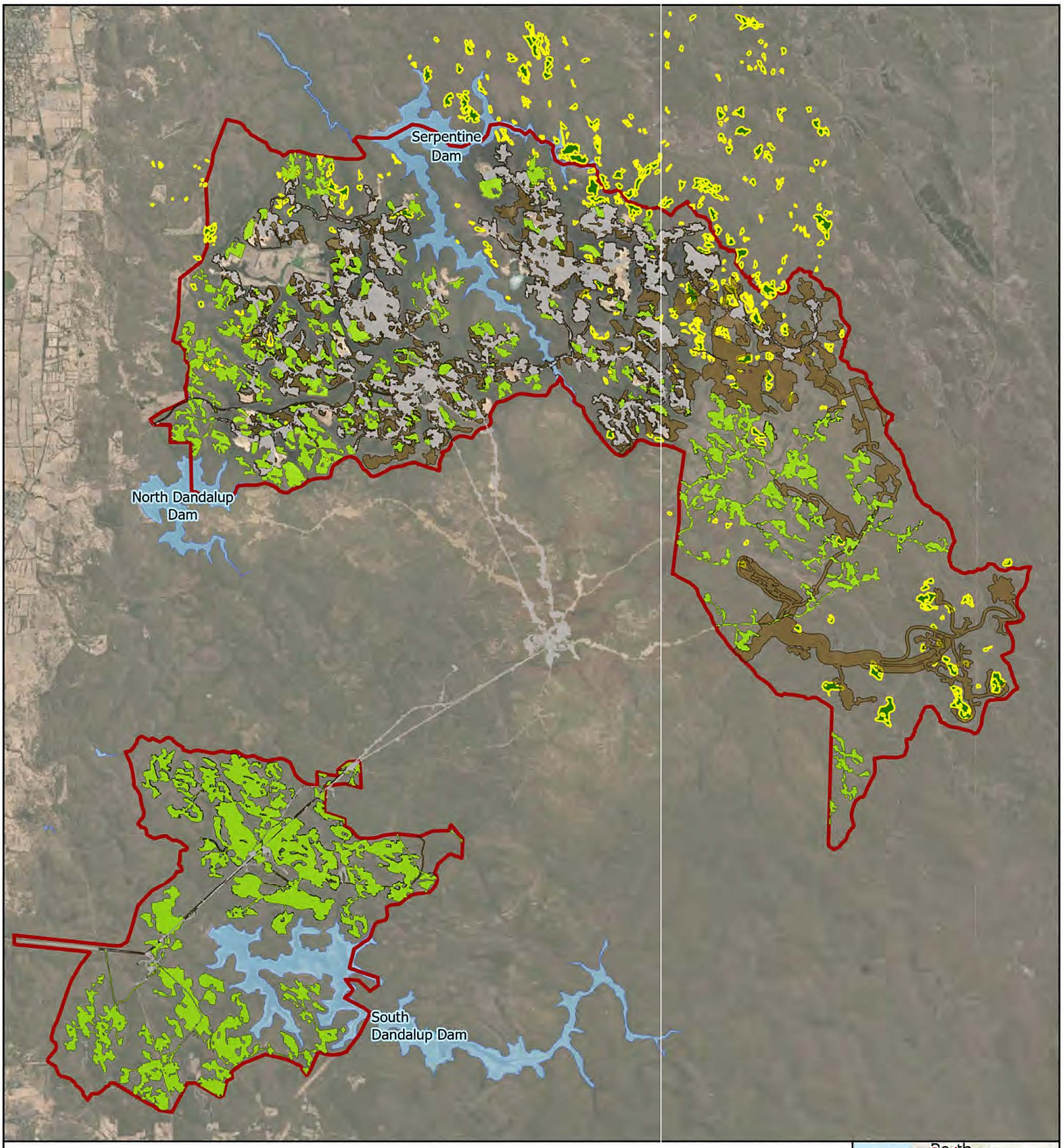
Two occurrences of the 'Granite communities' PEC (including buffers) have been mapped by DBCA approximately 7-8 km north of the Huntly Mine DE (Myara-O'Neil portion); these occurrences are associated with Blue Rock (north of Jarrahdale Road) and Sullivan Rock (east of Albany Highway). Consultation with DBCA (J. Pryde, Species & Communities Branch, pers. comm.) indicates that the potential conservation value of granite communities was identified following floristic survey of the Darling Scarp (Markey, 1997) and the PEC status is due to the restricted extent of granite communities and the poor knowledge base. However, the PEC has not been systematically mapped or assessed since then. The two PEC areas mapped over Myara North are the only areas mapped by DBCA in WA and DBCA does not hold site-specific information for either area (J. Pryde, Species & Communities Branch, pers. comm.). Both PEC areas are recreational sites readily accessible from public roads and both granite outcrops lie outside the Huntly Mine DE.

Based on DBCA advice, the lack of site information and the public access, it is expected that the two mapped PEC areas are not distinctive sites but have been nominated as examples of granite communities that are found elsewhere in the NJF, including the Monadnocks Conservation Park (i.e., the granite communities are much more widespread than the two mapped examples of the PEC).

Given that there are recorded occurrences of this PEC within 10 km of the Mine DEs and there is suitable habitat present (i.e., granite outcrops), this PEC is assessed as being 'Potential to Occur' within the Mine DEs.

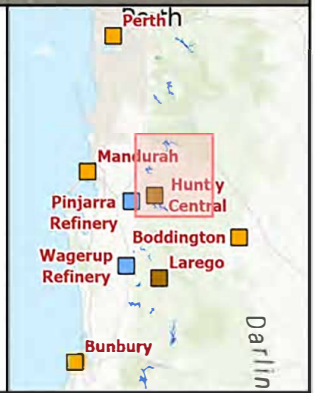
Regionally, granite outcrop communities are associated predominantly with the Cooke vegetation complex, which is mapped over approximately 30,000 ha of the NJF including large outcrops within the Monadnocks Conservation Park, Mt Solus and Mt Wells; the Cooke vegetation complex covers 6.1% of the Huntly Mine DE and 18.7% of the Willowdale Mine DE (Section 5.2.4.1, Figure 5-5, and Figure 5-6).

Locally, granite vegetation communities (outcrops and fringing vegetation) are mapped within the Mine DEs G and R dominant VT's (i.e., G, G1, G2, R, R/G; Table 5-6), which are expected to represent the potential conservation values of the PEC. A total of 1,007 ha (3.1% of the mapped part) of the Huntly Mine DE and 1.8 ha (0.1% of the mapped part) of the Willowdale Mine DE have potential to represent the 'Granite communities' PEC.



Legend

- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Potential Priority Ecological Community
- Huntly Mine DE
- Reservoirs



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-9 Conservation significant ecological communities within and in the vicinity of the- Huntly Mine region

Kilometres

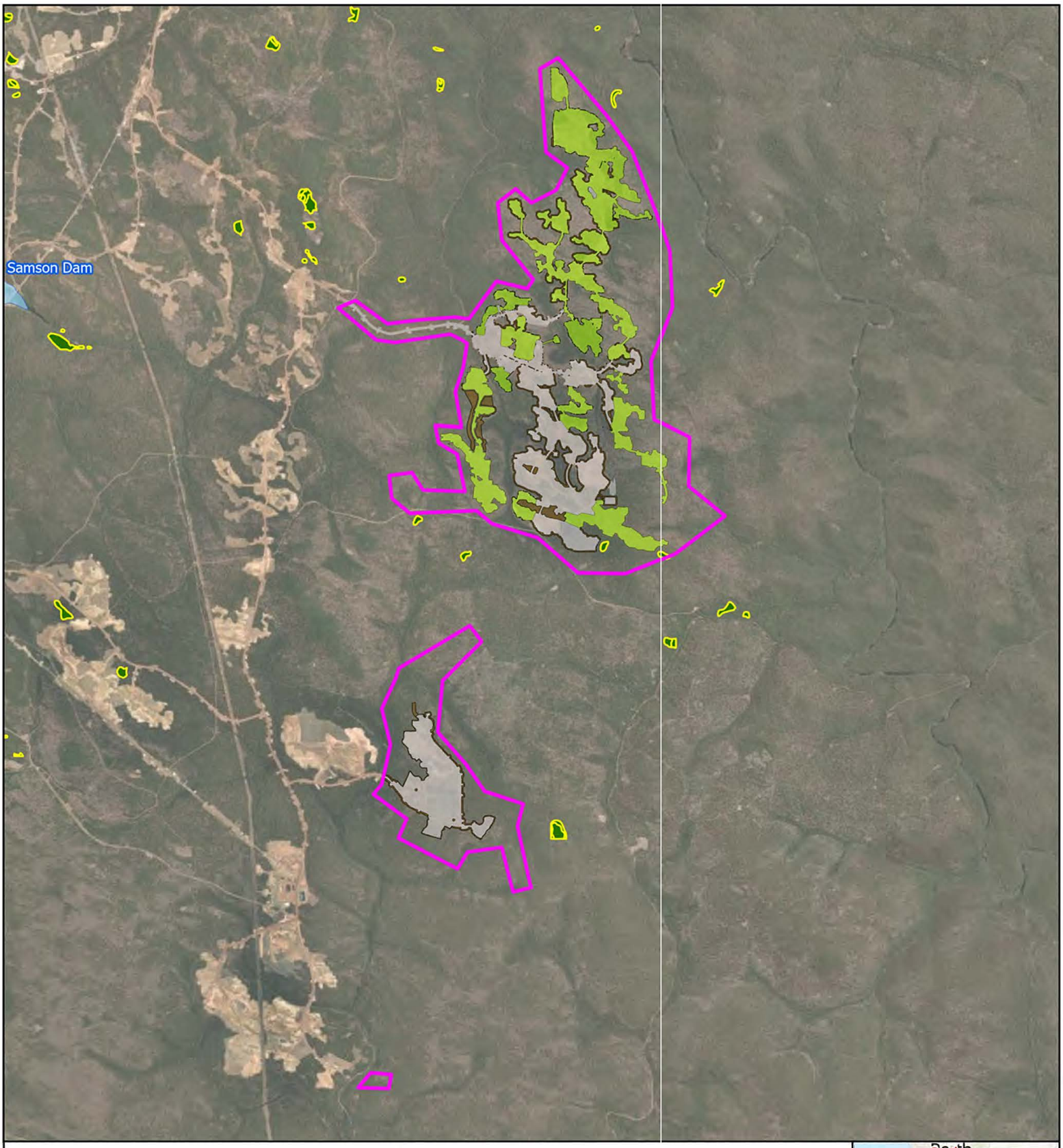
0 2 4 6 8 10 12

Scale: 1:175,000 at A4

Date Printed: 26/02/2025

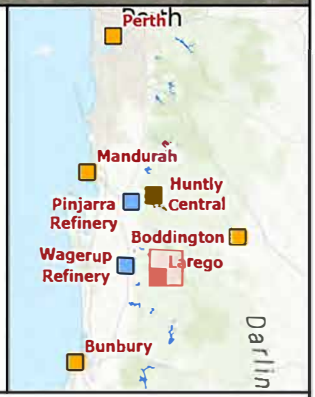
N

Alcoa



Legend

- Willowdale Mine DE
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Potential Priority
- Reservoirs



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-10 Conservation significant ecological communities within and in the vicinity of the Willowdale Mine region

Kilometres

0 0.9 1.8 2.7 3.6 4.5 5.4

Scale: 1:75,060 at A4

Date Printed: 26/02/2025

N

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5.2.4.4 Groundwater Dependent Ecosystems and Wetlands

Wetlands of International Importance

The Huntly Mine DE is located approximately 17 km east, and the Willowdale Mine DE 35 km east, of the Peel-Yalgorup System (which is also listed in the Directory of Nationally Important Wetlands as the Peel-Harvey Estuary and the Yalgorup Lakes System), being the closest Ramsar Wetland of International Importance (Figure 5-11 and Figure 5-12).

The Huntly Mine DE lies within the Serpentine and Murray River catchments (which include Serpentine, North Dandalup, and South Dandalup Reservoirs), which discharge into the Peel-Yalgorup System (Figure 5-13). The Willowdale Mine DE lies within the catchment of the Harvey River (which includes the Stirling and Harvey Reservoirs) which discharges into the Peel-Yalgorup System (Figure 5-14).

The Peel-Yalgorup System consists of shallow estuaries, freshwater marshes, and coastal saline lakes that include the Harvey Estuary, Peel Inlet, Lake McLarty, Lake Mealup, and ten Yalgorup National Park wetlands. The Peel Inlet and Harvey Estuary are fed from the Serpentine, Murray and Harvey Rivers, and are connected to the Indian Ocean through various channels. The fringing vegetation is mainly samphire, rushes, sedges, and paperbark communities (DCCEEW, 2019).

Potential impacts to the Peel-Yalgorup System are discussed as part of the consideration of cumulative impacts on Inland Waters (Section 10.6).

Directory of Nationally Important Wetlands

There are several wetlands mapped under the Directory of Nationally Important Wetlands (DCCEEW, 2021), situated approximately 17 to 35 km west of the Mine DEs including: Forrestdale Lake, Thomsons Lake, Gibbs Road Swamp System, Spectacles Swamp, Becher Point Wetlands, Barragup Swamp, Peel-Harvey Estuary, Lake McLarty System, Yalgorup Lakes System, and Benger Swamp (Figure 5-11 and Figure 5-12).

The Mine DEs lie within the catchment of Peel-Harvey Estuary and the Yalgorup Lakes System, considered Wetlands of National Importance; these wetlands are correlative to the Ramsar Peel-Yalgorup System.

Geomorphic Wetlands

The State Government has undertaken geomorphic wetland mapping over regions subject to extensive clearing, including the SCP and Avon Wheatbelt (DBCA, 2024c).

There is no geomorphic wetland mapping of the Darling Plateau; however, geomorphic wetland mapping for the SCP extends approximately 10 km east into the Darling Plateau (Figure 5-11 and Figure 5-12), and covers the western extent of the Huntly Mine DE (DBCA, 2023a). The mapping classifies wetlands present within valley floors as palusplain or floodplain flats, and headwater swamps as sump or dampland basins.

The geomorphic wetland management categories include conservation (where they are relatively intact and support a high level of ecological attributes and functions), resource enhancement (where they are partially modified but still support substantial ecological attributes and functions) and multiple use (wetlands with few remaining important attributes and functions) (DBCA, 2024c). Approximately 80% of the area of geomorphic wetlands

located within the Mine DEs are classified as conservation category, reflecting the general lack of clearing with the Mine DEs.

Potential Groundwater Dependent Ecosystems

Potential GDEs have been identified through mapping of VTs (Section 5.2.4.2) and key indicator plant species that prefer and occur on seasonally moister and wetter soils on the swamps, valley floors, and lower slopes (Mattiske, 2021a; 2021b). Mattiske (2021b) considered that the identification of potential GDEs aligns with the precautionary approach in the absence of detailed groundwater level data which would assist to confirm GDEs within the Mine DEs.

The potential GDEs identified by Mattiske (2021a; 2021b) correlate with the VTs A, AC, AD, CW, D, DA, E, PW, SW, and W (see Table 5-6 for descriptions). Key plant species identified by Mattiske (2021a; 2021b) that are indicative of potential GDEs include *Banksia littoralis, Hakea varia, Acacia divergens, Boronia molloyae, Thomasia paniculata, Astartea scoparia, Babingtonia camphorosmae, Calothamnus lateralis, Eucalyptus rudis, Hypocalymma angustifolium, Hypocalymma cordifolium, Melaleuca preissiana, Melaleuca rhaphiophylla, Melaleuca lateritia, Melaleuca viminea, Regelia ciliata and Taxandria linearifolia.*

The Mine DEs contain several VTs that were either not mapped by Mattiske (2021a; 2021b) in their studies or were not considered to represent potential GDEs, and have the potential (based on landform and soil preferences and key flora species) to be potential GDEs. These VTs are: AW, C, CQ, and SW-D (see Table 5-6 for descriptions). These four VTs have not been considered as potential GDEs in the assessment due to a lack of information (e.g., ground-truthing through mapping).

The VTs that represent potential GDEs are presented in Table 5-7, and shown on Figure 5-15, and Figure 5-16. The potential GDEs are expected to be subject to seasonal inundation and/or waterlogging due to groundwater and/or surface water flows. The hydrology of the potential GDEs within the Mine DEs is discussed further under Inland Waters (Section 5.5).

A total of 6,608 ha (16.0%) of the Mine DEs comprises potential GDEs, including 6,347 ha (16.3%) of the Huntly Mine DE and 261 ha (12.2%) of the Willowdale Mine DE. As 99.3% of the Willowdale Mine DE is covered by VT mapping, the lower proportion of potential GDEs mapped there compared with that mapped recently in Myara North (25%; (Mattiske, 2021a)(Appendix 15)) and Holyoake (19%; (Mattiske, 2021b)(Appendix 16)) is a reflection of the difference in landforms between those areas. The Myara-O'Neill portion of the Huntly Mine DE has 97.2% coverage by VTs so mapping there is very nearly complete. However, the Huntly-Del Park portion has only 37.5% VT mapping coverage. This gap in survey coverage (assuming there are potential GDEs in the unmapped part of the Huntly-Del Park portion) means that the 16.3% potential GDE coverage for the Huntly Mine DE is an underestimate.

Table 5-7: Groundwater Dependent Ecosystems Present within the Mine DEs

VT	Huntly Mine DE				Willowdale Mine DE					Total area in Mine DEs (ha)	Proportion of Mine DEs (%)
	Huntly-Del Park (ha)	Myara-O'Neil (ha)	Total Huntly Mine DE (ha)	Proportion of Huntly Mine DE (%)	Keats (ha)	Wills (ha)	Tasman (ha)	Total Willowdale Mine DE (ha)	Proportion of Willowdale Mine DE (%)		
Groundwater Dependent Ecosystems Present within the Mine DEs											
A	1	107	108	0.3	-	-	-	-	-	108	0.3
AC	144	728	872	2.2	21	-	15	35	1.6	907	2.2
AD	-	32	32	0.1	-	-	-	-	-	32	0.1
CW	<1	825	825	2.1	43	<1	4	48	2.2	872	2.1
D	10	1,584	1,594	4.1	20	-	<1	20	0.9	1,614	3.9
DA	-	33	33	0.1	-	-	-	-	-	33	0.1
E	-	106	106	0.3	6	-	-	6	0.3	112	0.3
PW	-	762	762	2.0	5	-	-	5	0.2	767	1.9
SW	37	926	963	2.5	60	-	3	63	2.9	1,025	2.5
W	71	982	1,053	2.7	53	2	29	84	3.9	1,137	2.8
Sub-Total	**263**	**6,084**	**6,347**	**16.3**	**207**	**3**	**51**	**261**	**12.2**	**6,608**	**16.0**
Other Potential Groundwater Dependent Ecosystems Present within the Mine DEs											
AW	-	2	2	<0.1	-	-	-	-	<0.1	2	<0.1
C	30	7	37	0.1	-	-	-	-	-	37	0.1
CQ	-	-	-	-	7			7	0.3	7	<0.1
SW-D	<1	-	<1	<0.1	-	-	-	-	-	<1	<0.1
Sub-Total	**30**	**9**	**39**	**0.1**	**7**	**0**	**0**	**7**	**0.3**	**46**	**0.1**
Total	**293**	**6,093**	**6,386**	**16.4**	**214**	**3**	**51**	**268**	**12.5**	**6,654**	**16.1**

Groundwater Dependence of Streamzone Vegetation

The study of GDEs within Western Australia has primarily been undertaken on the Swan Coastal Plain (Froend & Loome, 2004) (Sommer & Froend, 2010) and, to a lesser extent, the Blackwood Plateau (Froend & Loome, 2005) and Collie Basin (Sinclair Knight Merz and Wetland Research & Management, 2010). These areas are underlain by large sedimentary and often coarse-grained aquifers that host perennial superficial groundwater tables.

The hydrogeology of the Darling Plateau, in which the Mine DEs are located, substantially differs from the large sedimentary aquifers of the Swan Coastal Plain and comprises a comparatively shallow lateritic regolith over bedrock subject to high topographic relief. This creates more localised and variable groundwater aquifers, with steeper hydraulic gradients draining to an incised stream network, and a thick clayey stratum that provides greater plant available water in the unsaturated zone.

Accordingly, deep rooted streamzone vegetation of the Darling Plateau is likely to be adapted to higher variation in groundwater levels and a larger unsaturated zone and may have a more facultative groundwater dependence compared to that of the Swan Coastal Plain. However, within the Darling Plateau, seasonal waterlogging and/or shallow groundwater may remain important in allowing streamzone vegetation to outcompete terrestrial vegetation, to maintain shallow-rooted wetland species and to maintain a denser understorey than otherwise occurs in the upland Jarrah Forest.

Groundwater Dependence of Tree Species

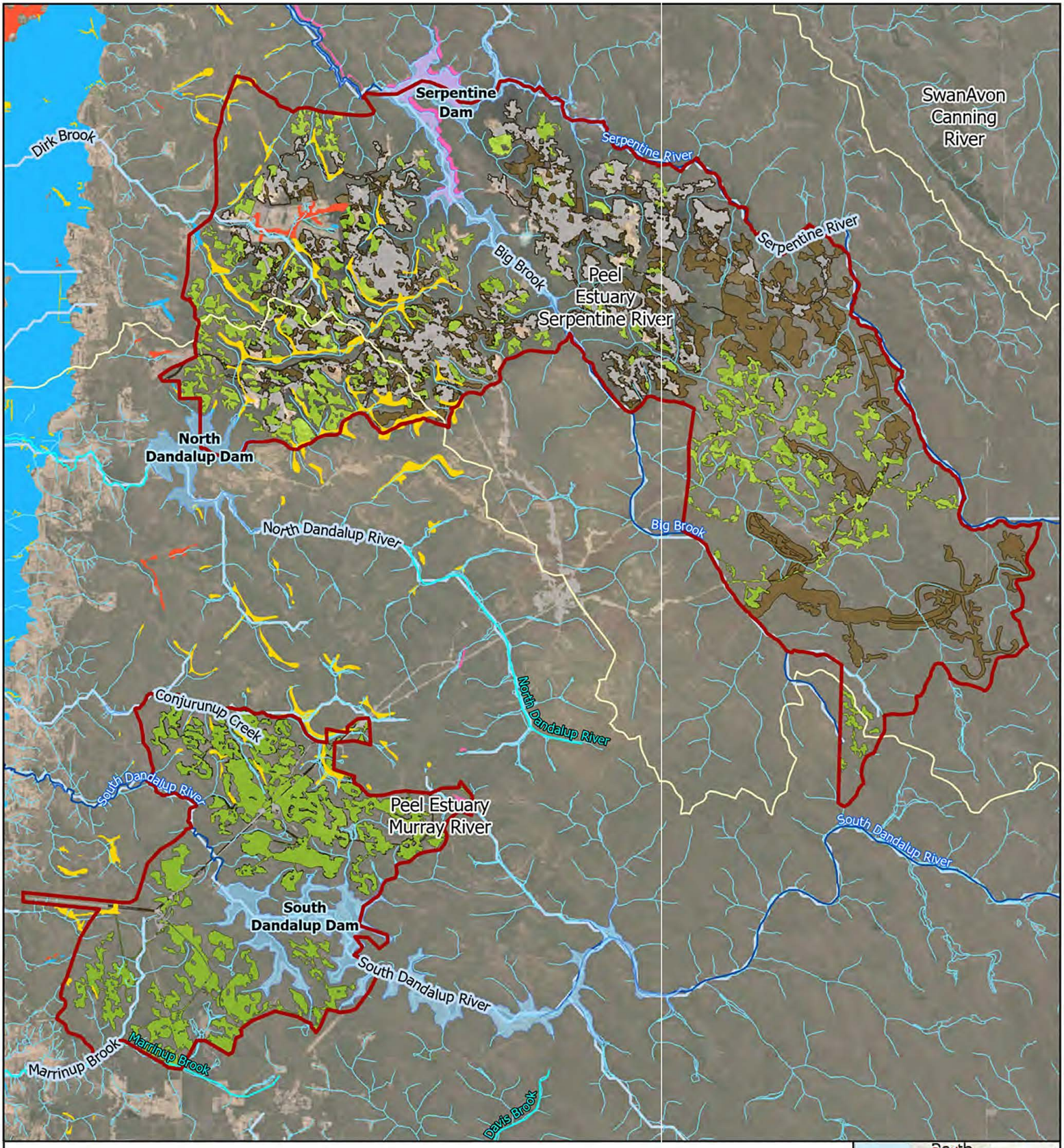
The groundwater dependence of terrestrial vegetation within the Jarrah Forest has been studied by several authors. The root system of the predominant canopy tree Jarrah (*Eucalyptus marginata*) has been described as having a dimorphic structure (Kimber, 1974; Dell, Bartle, & Tacey, 1983; Abbott, Dell, & Loneragan, 1989). This comprises dense lateral roots in the shallow soil above the lateritic duricrust / caprock and ‘sinker’ roots which extend vertically to penetrate cracks and fissures in the duricrust, up to 40 m below the surface to gain access to moisture-bearing clay through ancient root channels created by previous vegetation (Dell, Bartle, & Tacey, 1983). Carbon, Bartle Murray and Macpherson (1980) report that the bulk of *E. marginata* roots are in the shallow soil above the duricrust, which has the greatest potential to supply water in winter. While *E. marginata* trees do have deeper roots, substantial groundwater use is limited to shallower depths, being recorded in Jarrah forest at sites with depths of 6 mbgl (metres below ground level) but not at 14 mbgl or 30 mbgl (Farrington, Turner, & Gailitis, 1996).

The co-dominant canopy tree of the Jarrah Forest, Marri (*Corymbia calophylla*), favours areas with limited root development and more variable soil moisture, such as shallow soils and streamzone areas subject to waterlogging (Harris, 1956). Crombie (1992) reported that Marri suffers substantially lower water stress than Jarrah, maintaining higher water potentials during dry summer months. Marri maintains lower stomatal conductance during the summer, suggesting the species may use water more conservatively and be more resilient to drought (Szota C. , 2009). Marri was observed to be more resilient to the 2011 drought in the NJF, with lower levels of crown dieback compared to Jarrah (Matusick, Ruthrof, Brouwers, Dell, & Hardy, 2013; Ruthrof, Matusick, & Hardy, 2015). Marri is, therefore, not an indicator of groundwater dependent vegetation.

Groundwater dependence of some swamp vegetation found on the Darling Scarp has been demonstrated by studies (on the Swan Coastal Plain), including *Eucalyptus rudis*, *Melaleuca rhaphiophylla* and *Taxandria linearifolia* (Froend & Loome, 2005). Their estimated groundwater requirements are as follows (Sommer and Froend (2010) referenced in Sinclair Knight Merz (2011)):

- *E. rudis*: 0.8 to 11.7 mbgl (metres below ground level);
- *M. rhaphiophylla*: 0.8 to 9.27 mbgl; and
- *M. preissiana*: 0.18 to 13.9 mbgl.

These tree species are indicators of groundwater dependent vegetation.



Legend

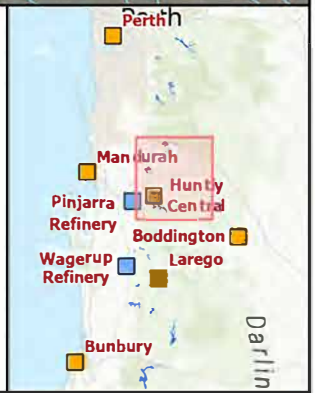
- Huntly Mine DE
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Reservoirs

Hydrography Linear (Hierarchy) (DWER-031)

- Major Rivers
- Minor Rivers
- Streams
- Rivers
- Hydrographic Catchments - Catchments (DWER-028)

Geomorphic Wetlands, Swan Coastal Plain (DBCA-019)

- Conservation
- Multiple Use
- Not Applicable
- Not Assessed
- Resource Enhancement



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-11 Wetlands - Huntly Mine DE

Kilometres

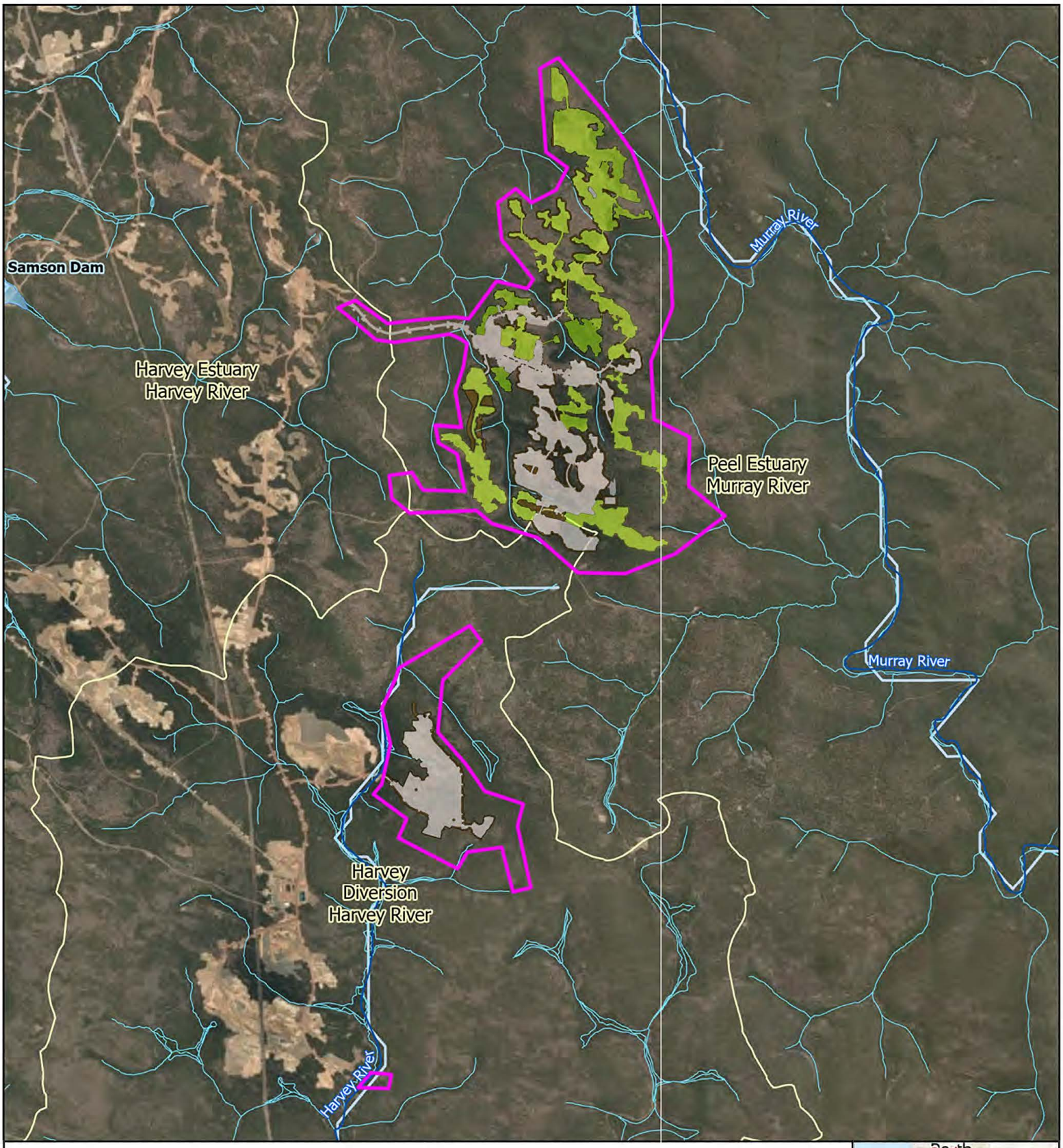
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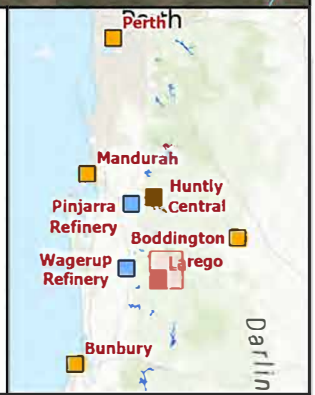
N

Alcoa



Legend

- Willowdale Mine DE
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Reservoirs
- Hydrography Linear (Hierarchy) (DWER-031)
- Major Rivers
- Streams
- Rivers
- Hydrographic Catchments - Catchments (DWER-028)



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-12 Wetlands - Willowdale Mine DE

Kilometres

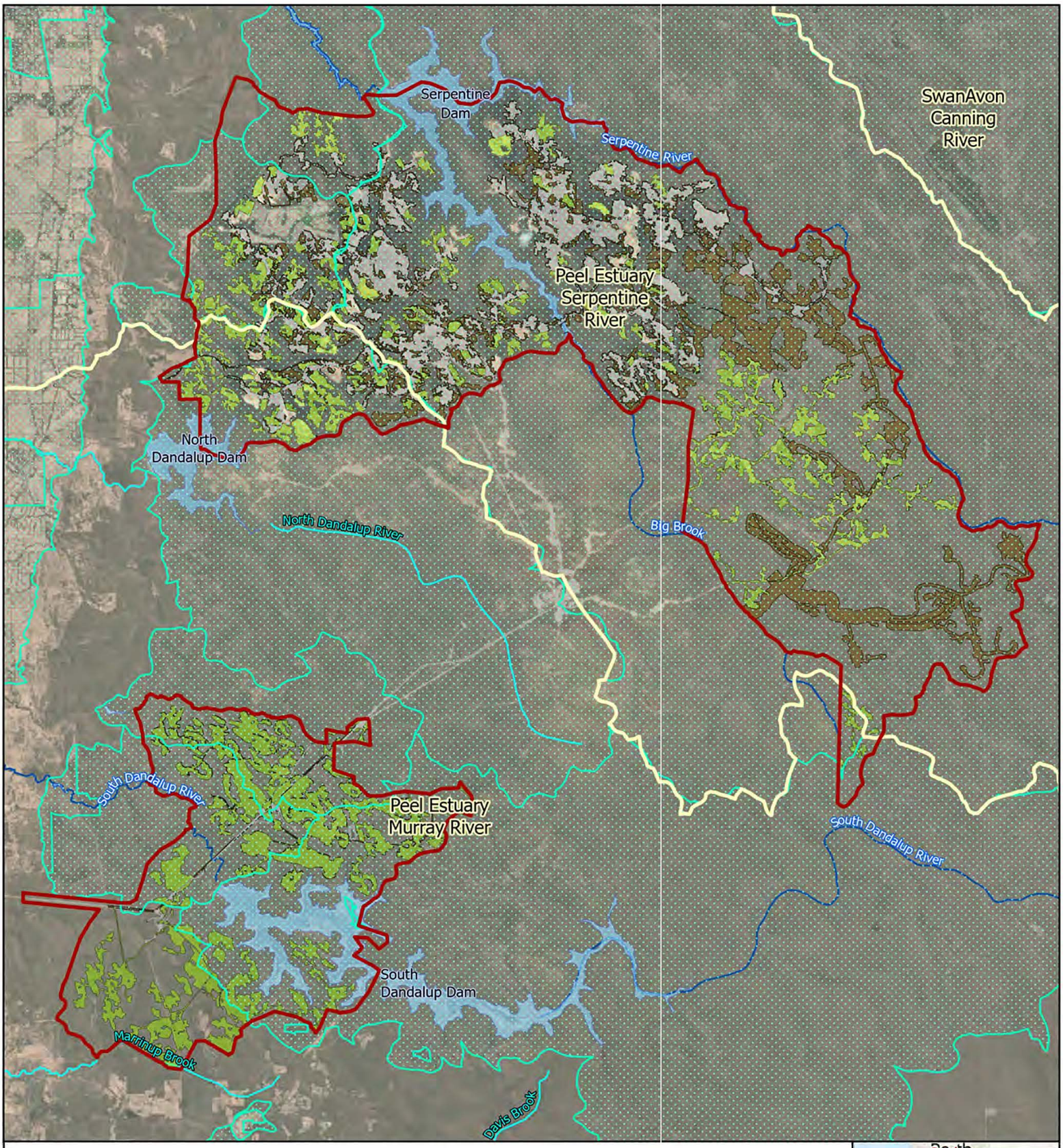
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Scale: 1:75,060 at A4

Date Printed: 26/02/2025

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Alcoa

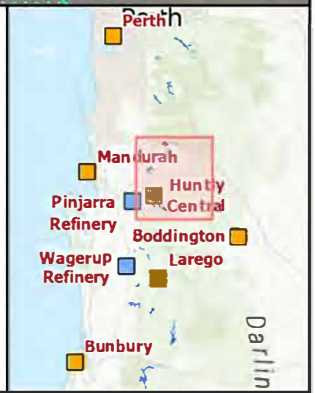


Legend

- Huntly Mine DE
- Hydrographic Catchments - Catchments (DWER-028)
- Catchments
- Proposed Disturbance Footprint
- Previously Cleared Areas
- Rehabilitation Footprint
- Reservoirs

Hydrography Linear (Hierarchy) (DWER-031)

- Major Rivers
- Minor Rivers



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-13 Catchments and Watercourses - Huntly Mine DE

Kilometres

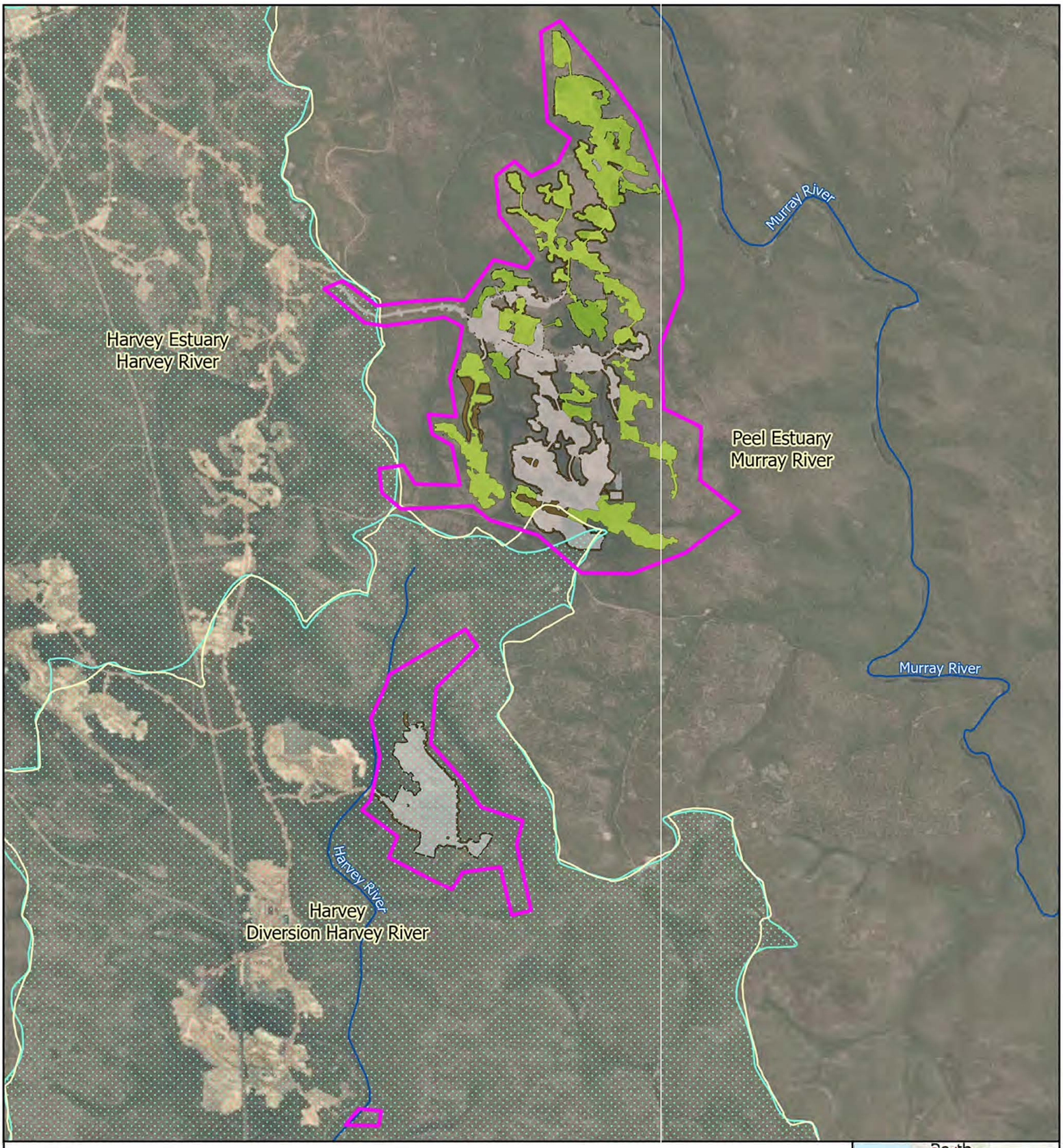
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Date Printed: 26/02/2025

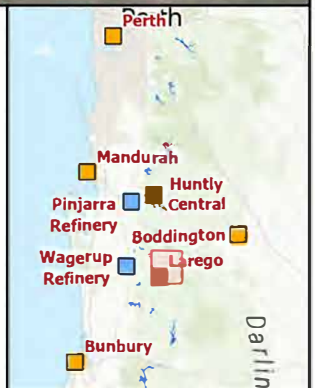
N

Alcoa



Legend

- Willowdale Mine DE
- Hydrography Linear (Hierarchy) (DWER-031)
- Major Rivers
- Hydrographic Catchments - Catchments (DWER-028)
- Catchments
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-14 Catchments and Watercourses - Willowdale Mine DE

Kilometres

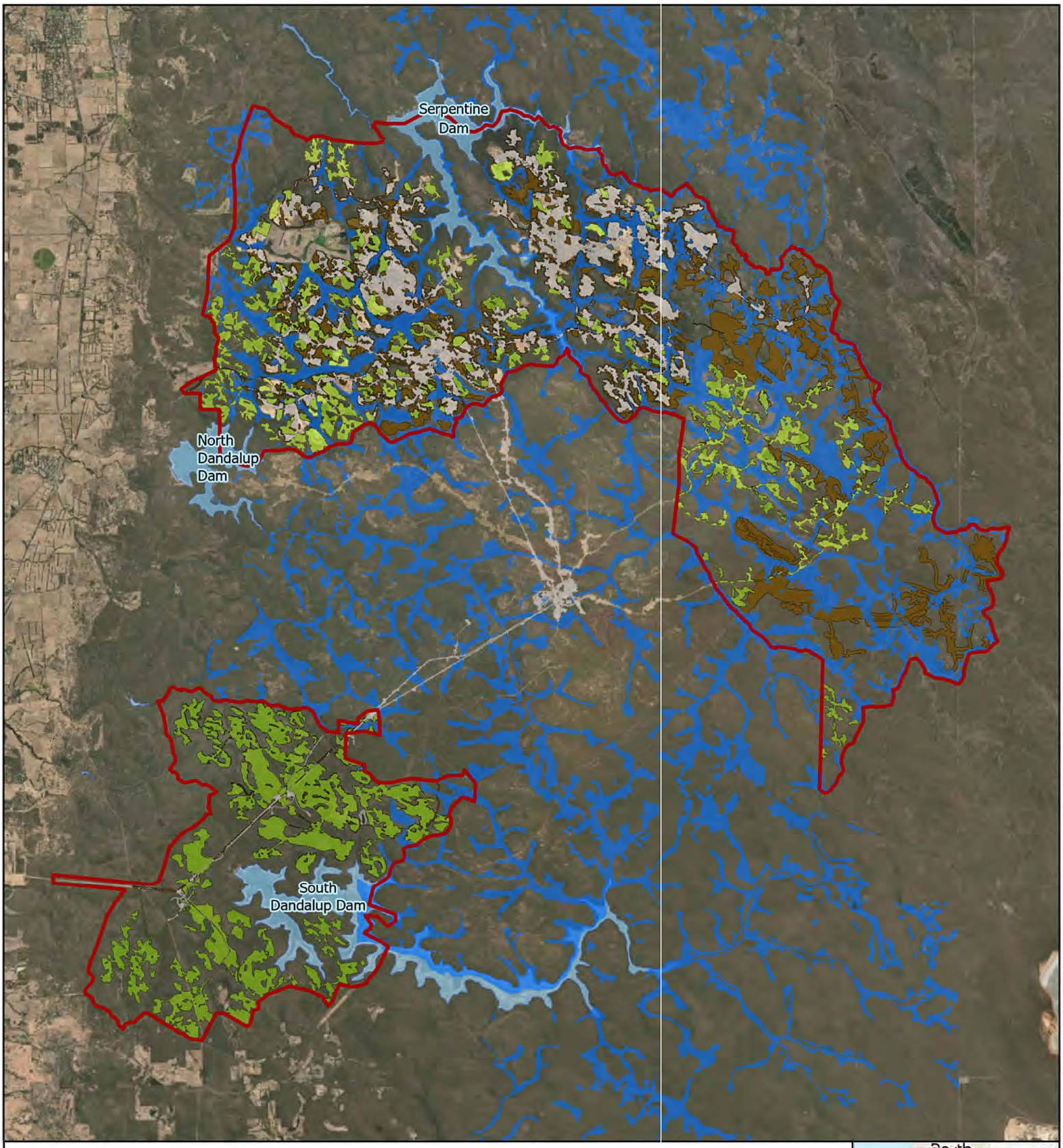
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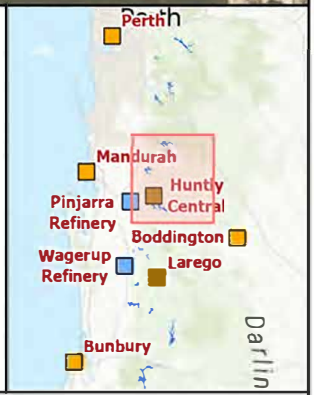
N

Alcoa



Legend

- Huntly Mine DE
- Groundwater Dependent Vegetation
- Reservoirs
- Proposed Disturbance Footprint
- Open Areas
- Proposed Rehabilitation Footprint



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-15 Potential Groundwater Dependent Ecosystems - Huntly Mine DE

Kilometres

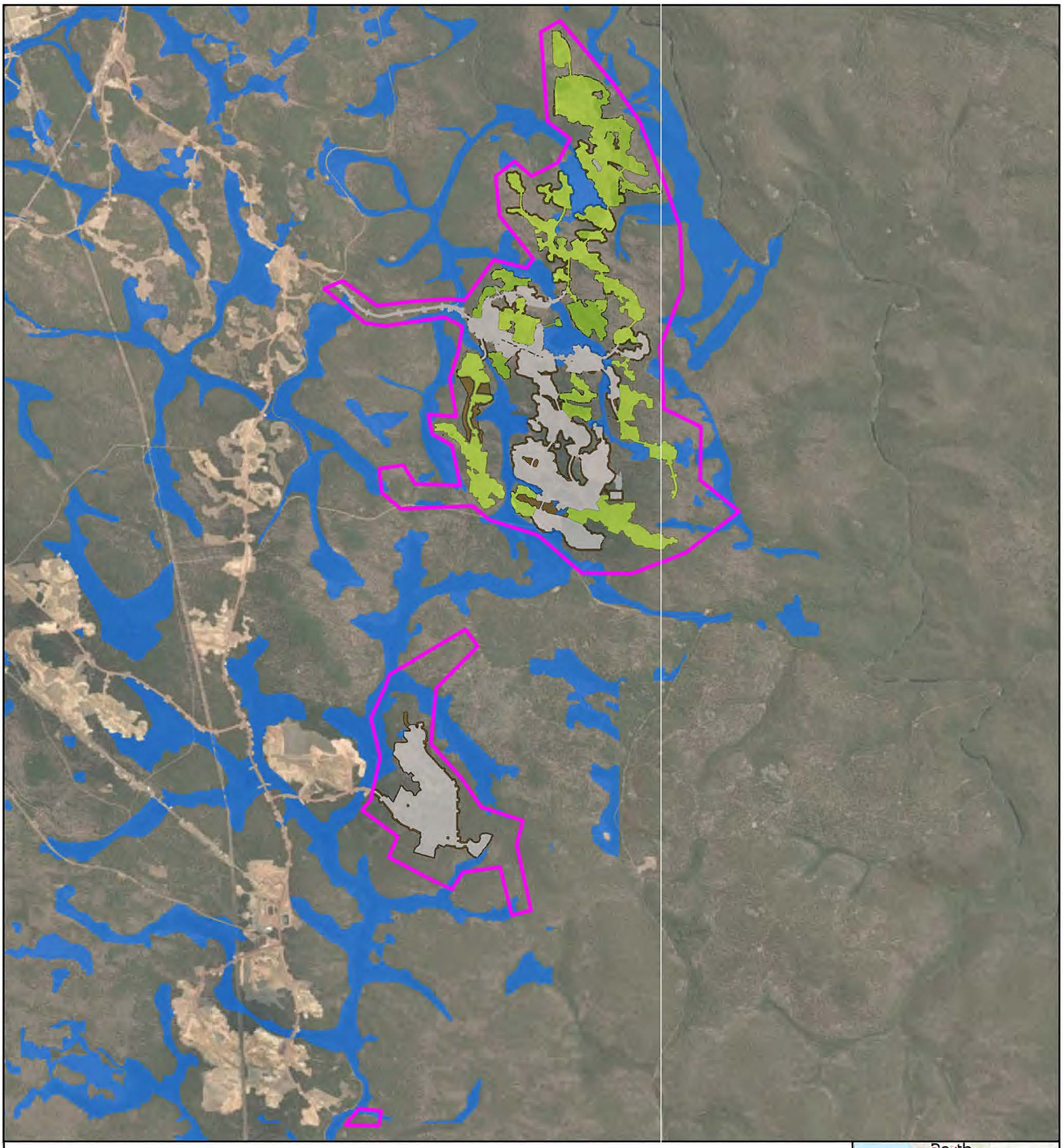
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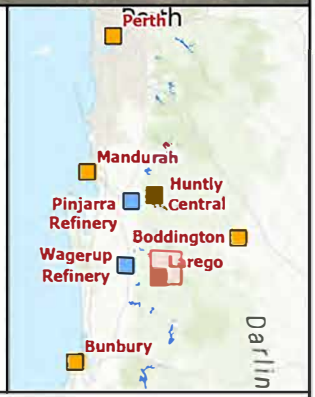
N

Alcoa



Legend

- Willowdale Mine DE
- Groundwater Dependent Vegetation
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Reservoirs



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-16 Potential Groundwater Dependent Ecosystems - Willowdale Mine DE

Kilometres

0 0.9 1.8 2.7 3.6 4.5 5.4

N

Scale: 1:70,000 at A4

Date Printed: 26/02/2025

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5.2.4.5 Old Growth Forest – Timber Harvesting and Forest Age

Extent of timber harvesting

The NJF subregion has been subject to widespread timber harvesting since the 1870s, with progressive development of silvicultural practice since the 1920s and introduction of biodiversity management in the 1980s (Stoneman, Hagan, & Rayner, 2005).

Of the 1.11 million ha of native vegetation within the NJF subregion, 0.77 million ha (69.4%) lies within DBCA managed lands, and 0.52 million ha (46.9%) is covered by ML1SA. Of the native vegetation within ML1SA, 22,793 ha (4.3%) is mapped as Old Growth Forest. The remaining 95.7% has been subject to timber harvesting of varying frequency and intensity. Approximately 0.42 million ha (80.8%) of the native vegetation within ML1SA lies within DBCA managed State Forests and Timber Reserves that have been subject to timber harvesting operations.

Forest age

Under current forest management practices, following timber harvesting, Jarrah Forest regenerates through a series of structural stages (Bradshaw F. , 2015), comprising:

- Establishment (0-20 years);
- Juvenile (15-30 years);
- Immature (30-120 years); and
- Maturity (70-250 years).

Most Jarrah and Marri trees are likely to die by 250 years (Bradshaw F. , 2015); however, some of the largest trees may live up to 450 years (Whitford K. , 2014). Old Growth Forest is defined in the *National Forest Policy Statement 1992* (Commonwealth of Australia, 1992) as:

'ecologically mature forest where the effects of unnatural disturbance are now negligible. The definition focuses on forest in which the upper stratum or overstorey is in a late mature to senescent growth stage'.

The approximate ranges of forest age across the NJF subregion and the Mine DEs are outlined in Table 5-8 and shown on Figure 5-17 and Figure 5-18. Based on DBCA timber harvesting data available over a 0.87 million ha mapped portion of the NJF as well as Old Growth Forest mapping.

The NJF subregion is predominantly (77.6% of total area mapped) established to juvenile or immature stage of forest structure (assuming maturity as early as 70 years), reflecting the widespread timber harvesting over the last century. The extent of immature forest may be greater as the mature structure may take up to 120 years to develop.

The majority of area of the Mine DEs has been subject to logging operations. The Mine DEs are predominantly (84.2%) at a juvenile or immature stage of forest structure, and 15.3% is at a mature forest stage. Willowdale Mine DE has a higher proportion of mature forest (25.2%) compared to Huntly Mine DE (18.2%).

The Huntly Mine DE was predominantly (78.3%; average 13.1% per decade) last logged from 1960-2019, whereas the Willowdale Mine DE was predominantly (72.0%) last logged from 1980-2019 (Table 5-9).

Timber Harvesting Frequency

The frequency of forest harvesting across the 0.87 million ha mapped portion of the NJF and the Mine DEs, based on DBCA timber harvesting data is shown in Table 5-10.

The mapped portion of the NJF has predominantly been logged one (42.7%) to two times (30.0%) since records commenced in 1920. Smaller areas have been logged three times (18.0%) or four to six times (5.0%).

The Mine DEs have predominantly been logged two to three times since records commenced in 1920, with 39.9% of the combined Huntly Mine DE and Willowdale Mine DEs logged twice, and 33.7% of the combined Mine DEs logged three times. Smaller areas have been logged once (12.7% of the combined DEs) or four to six times (13.2% across the Mine DEs).

The timber harvesting data indicate that the Mine DEs have, on average, a younger forest age than the NJF subregion and have a greater logging frequency.

Old Growth Forest assessment

Four of the recent baseline surveys previously conducted within or adjacent to the Mine DEs (Holyoake, Myara North, Spion, Warrington) (Section 5.2.3.3) included assessments of unmapped potential Old Growth Forest. These assessments considered DBCA timber harvesting records, vegetation structure, litter from logging activities, number of stumps, dieback infestation, proportion of overstorey tree species, and degree of local disturbance. The assessments found that some parts of the Spion and Warrington survey areas (both within the vicinity of the Willowdale Mine DE) had a higher number of potential habitat trees and fewer stumps, which may indicate lower logging rates, and hence more mature forest (but not Old Growth Forest). These areas occurred within VTs associated with creek lines, swamps and lower slopes. The surveys did not identify any additional areas within the survey area that could potentially be un-mapped Old Growth Forest, based on Department of Parks and Wildlife (2017b) criteria. Five small patches (totalling 79.5 ha within the Huntly Mine DE and none inside the Willowdale DE) of Old Growth Forest mapped by DBCA (Figure 5-17). Four of the patches are within the Myara-O'Neil portion and one patch is at the western end of the conveyor in the Del Park-Huntly portion of the Huntly Mine DE.

Table 5-8: Forest Age Across the Mapped Portion of the NJF and within the Mine DEs

Structural stage of harvesting regrowth	Time since last harvest (years)	NJF Area (ha)	Proportion of NJF mapped area (%)	Huntly Mine DE area (ha)	Proportion of Huntly Mine DE (%)	Willowdale Mine DE area (ha)	Proportion of Willowdale Mine DE (%)
Establishment to Juvenile	0-20	98,259	11.3	12,289	31.5	1,018	47.7
Immature	21-70	574,180	66.2	20,774	53.2	581	27.2
Mature	70+	157,370	18.2	5,783	14.8	537	25.2
No record of harvesting	N/A	37,171	4.3	198	0.5	0	0.0
Total mapped area		**866,981**	100.0	39,044	100.0	2,137	100.0
Old Growth Forest		33,879	3.9	79.5	0.2	0	0.0

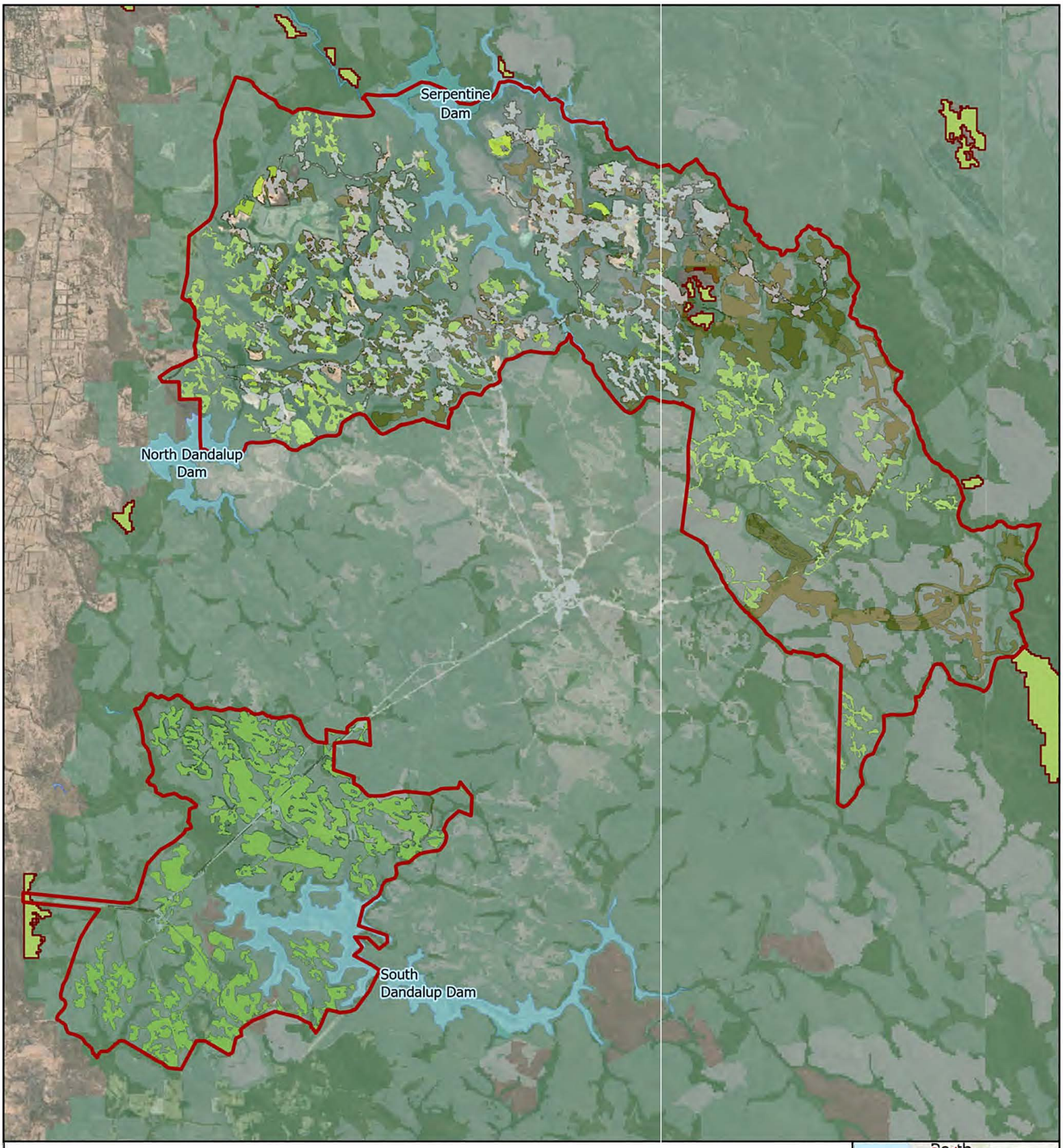
Table 5-9: Decade of Last Harvest Across the Mapped Portion NJF and within the Mine DEs

Decade of Last Harvest	NJF Area (ha)	Proportion of NJF mapped area (%)	Huntly Mine DE area (ha)	Proportion of Huntly Mine DE (%)	Willowdale Mine DE area (ha)	Proportion of Willowdale Mine DE (%)
No record of harvesting	37,171	2.0	198	0.5	0	0.0
before 1920	52,435	2.8	2,281	5.8	33	1.5
1920-29	18,801	1.0	252	0.6	13	0.6
1930-39	41,673	2.2	1,747	4.5	413	19.3
1940-49	44,462	2.3	1,502	3.8	78	3.7
1950-59	114,394	6.0	1,556	4.0	0	0.0
1960-69	166,342	8.8	3,324	8.5	0	0.0
1970-79	130,051	6.9	8,623	22.1	19	0.9
1980-89	90,438	4.8	4,215	10.8	401	18.8
1990-99	72,955	3.8	3,055	7.8	161	7.5
2000-09	59,432	3.1	5,683	14.6	351	16.4
2010-19	31,270	1.6	5,685	14.6	627	29.3

Decade of Last Harvest	NJF Area (ha)	Proportion of NJF mapped area (%)	Huntly Mine DE area (ha)	Proportion of Huntly Mine DE (%)	Willowdale Mine DE area (ha)	Proportion of Willowdale Mine DE (%)
2020-21	7,558	0.4	921	2.4	41	1.9
Total mapped area	**866,981**	**45.7**	**39,044**	**100.0**	**2,137**	**100.0**

Table 5-10: Frequency of Forest Harvesting within Mapped Portion of NJF and within the Mine DEs

Harvest Frequency	NJF Area (ha)	Proportion of NJF mapped area (%)	Huntly Mine DE area (ha)	Proportion of Huntly Mine DE (%)	Willowdale Mine DE area (ha)	Proportion of Willowdale Mine DE (%)
Once	369,994	42.7	4,749	12.2	487	22.8
Twice	260,438	30.0	15,599	40.0	845	39.5
Three times	155,800	18.0	13,196	33.8	663	31.0
Four times	39,209	4.5	4,650	11.9	137	6.4
Five times	4,115	0.5	643	1.6	5	0.2
Six times	253	**<0.1**	8	0.0	0	0.0
No occurrence	37,171	4.3	198	0.5	0	0.0
Total mapped area	**866,981**	**100.0**	**39,044**	**100.0**	**2,137**	**100.0**

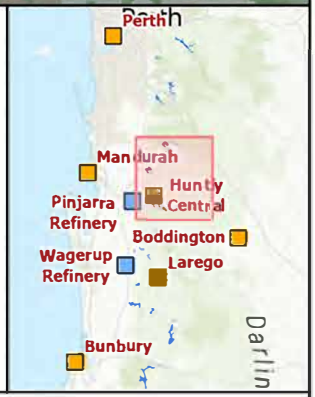


Legend

- Huntly Mine DE
- Old Growth Forest

Forest Age

- Establishment to Juvenile
- Immature
- Mature
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Reservoirs



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-17 Forest Age and Old Growth Forest - Huntly Mine DE

Kilometres

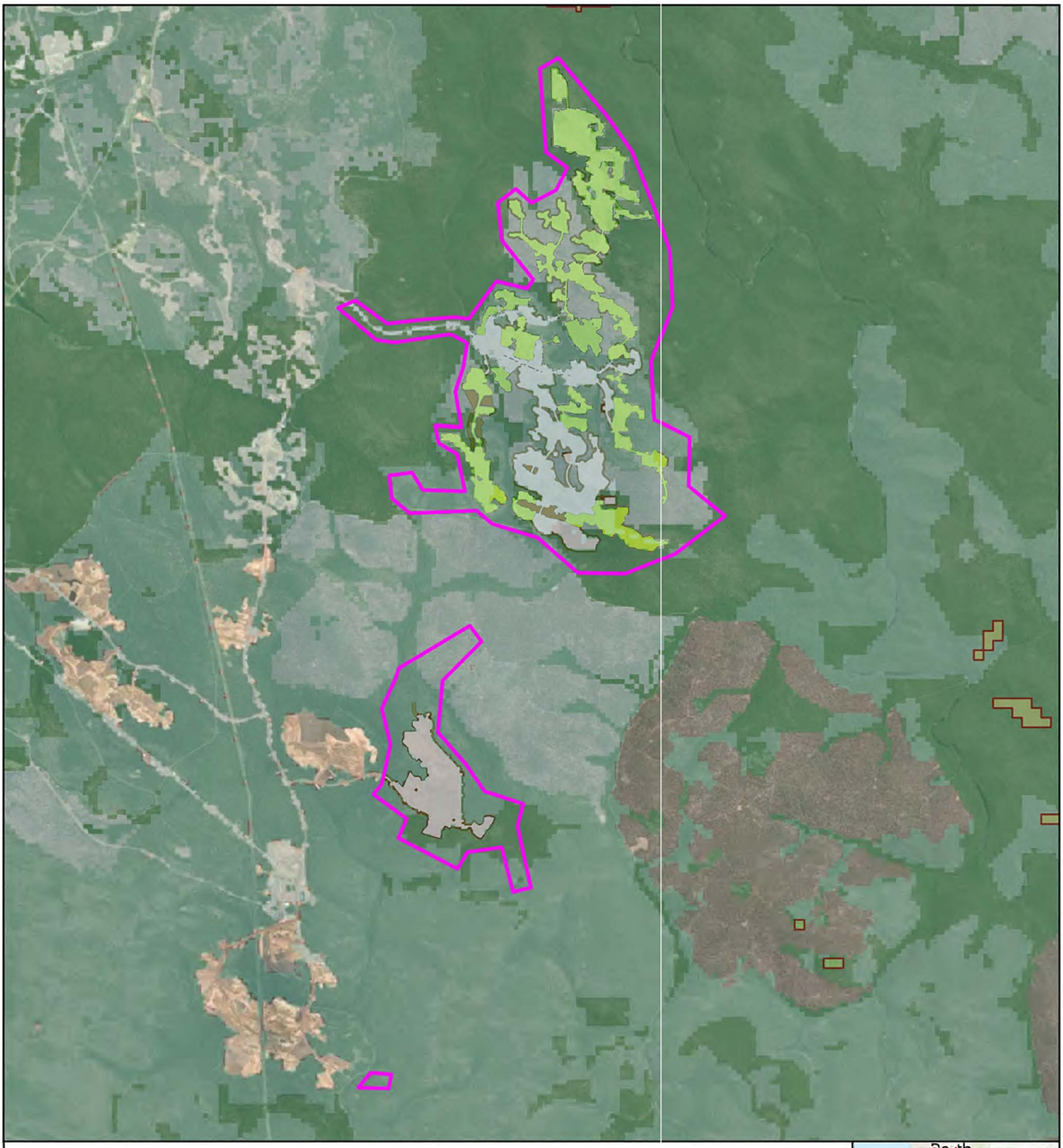
0 2 4 6 8 10 12

Scale: 1:175,000 at A4

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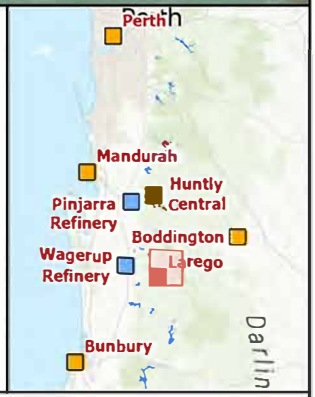


Legend

- Willowdale Mine DE
- Old Growth Forest

Forest Age

- Establishment to Juvenile
- Immature
- Mature
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-18 Forest Age and Old Growth Forest - Willowdale Mine DE

Kilometres

0 0.75 1.5 2.25 3 3.75 4.5

Scale: 1:75,060 at A4

Date Printed: 26/02/2025

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Alcoa

5.2.4.6 Ecological Linkages and Wildlife Corridors

The 2024-2033 FMP (Conservation and Parks Commission, 2023) notes that *"maintaining the total area of forest and minimising fragmentation arising from permanent clearing are key elements of biodiversity conservation strategies".* Ecological linkages and wildlife corridors in fragmented landscapes are critical for the maintenance of healthy fauna populations (Thompson, Rayfield, & Gonzalez, 2017). Alcoa recognises that fragmentation or isolation of conservation significant flora and fauna populations is a potential impact on key environmental values.

Fragmentation results in increased edge effects on vegetation, which include changes in understorey structure and composition (e.g., through weed invasion, drying effects through loss of shelter, increased exposure to dust and light). Maintaining ecological linkages and wildlife corridors reduces the physical and genetic isolation of flora and fauna populations and maintains diversity.

Stream vegetation provides connectivity between patches of remnant native vegetation and is essential for the survival and movement of some fauna populations (Conservation and Parks Commission, 2023). The 2024-2033 FMP consolidates informal reserves and Fauna Habitat Zones under Disturbance Avoidance Zones (DAZ) and suggests that corridors around rivers and streams be included as DAZ in State Forest and timber reserves. Streamzone vegetation historically has been less subject to timber harvesting than easier to access areas.

Substantial patches of native vegetation remain within the ML1SA mining lease despite historical clearing. Staged clearing and rehabilitation (Section 6.2) through the life of Alcoa's mining operations has provided corridors for fauna movement.

At a regional scale, vegetation within the Huntly Mine DE is linked to large areas of remnant Jarrah Forest/State Forest areas to the north and east, and the Willowdale Mine DE to the north, east, and south.

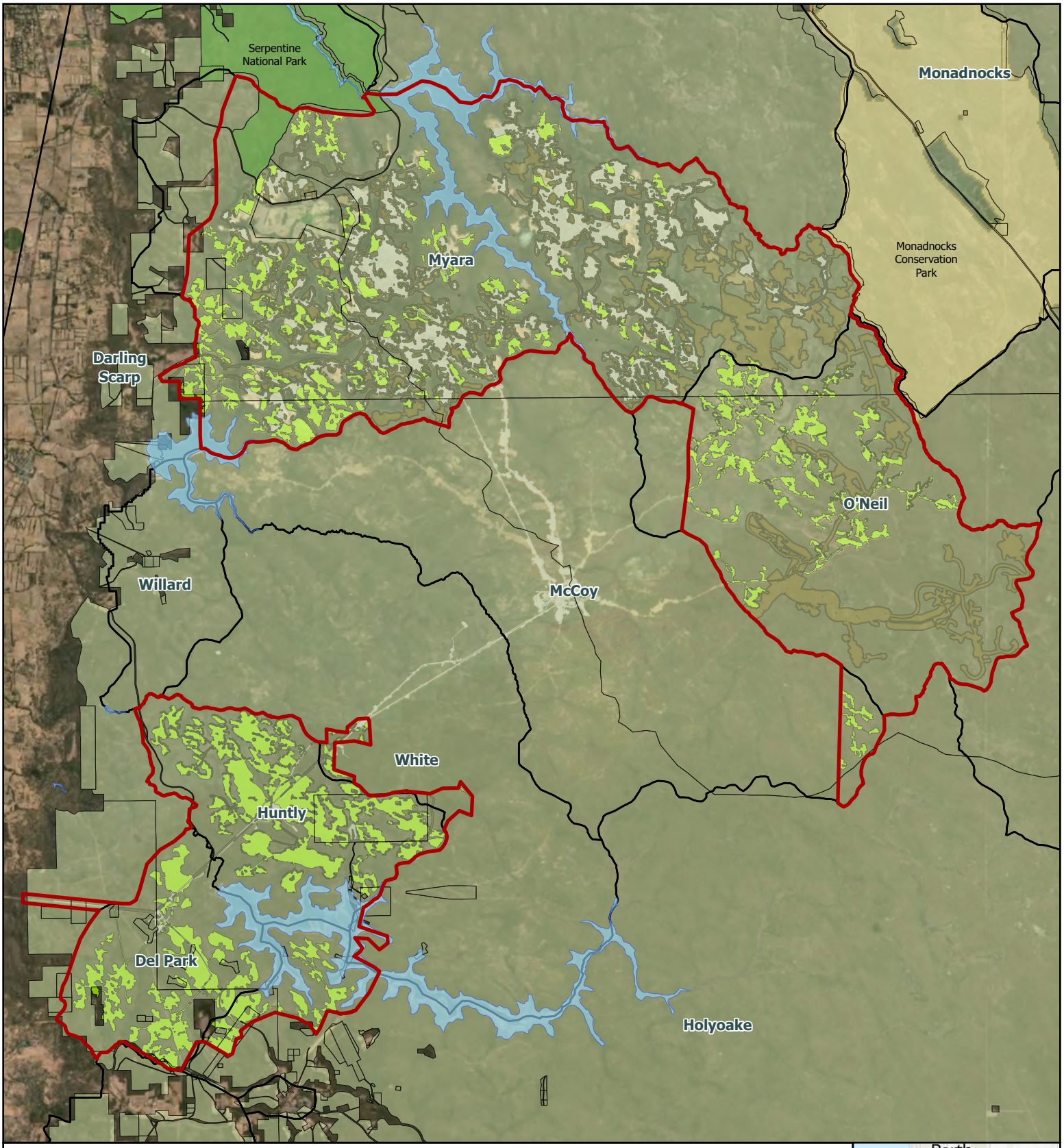
Perth Regional Ecological Linkages (WALGA, 2004) are mapped to broadly represent a link between patches of remnant vegetation judged to be of regional significance in the Perth Metropolitan Region. Ecological linkages recognised in this dataset run along the northern boundary and into the northwest portion of the Huntly Mine DE (Myara-O'Neil portion). southwest Regional Ecological Linkages (WALGA, 2009) connect with the Perth Regional Ecological Linkages and run further through the Myara-O'Neil portion and through the centre of the Huntly-Del Park portion of the Huntly Mine DE.

5.2.4.7 Protected Areas and Conservation Areas

The Mine DEs are almost entirely covered by several areas protected under the *Conservation and Land Management Act 1984*, including one National Park, one Conservation Park, two Section 5(1)(g) Reserves and three State Forests (Table 5-11; Table 5-11; Figure 5-19; and Figure 5-20). These protected areas lie within the area of the 2024-2033 FMP.

Table 5-11: Protected and Conservation Areas within the Mine DEs

Protected or Conservation Area	Total Huntly Mine DE (ha)	Proportion of Huntly Mine DE (%)	Total Willowdale Mine DE (ha)	Proportion of Willowdale Mine DE (ha)	Total Area in Mine DEs (ha)	Proportion of Mine DEs (%)
National Park						
Serpentine National Park	365	0.9	-	-	365	0.9
Conservation Park						
Lane Poole Reserve	-	-	79	3.7	79	0.2
Section 5(1)(g) Reserve						
Lane Poole Reserve	-	-	328	15.4	328	0.8
Monadnocks Conservation Park	8	<0.1	0	0	8	<0.1
State Forest						
Dwellingup State Forest	17,540	44.9	1,729	81	19,269	46.8
Jarrahdale State Forest	18,871	48.3	-	-	18,871	45.8
Marrinup State Forest	2,027	5.2	-	-	2,027	4.9
Total	***38,810***	***99.4***	***2,137***	***100.0***	***40,946***	***99.4***



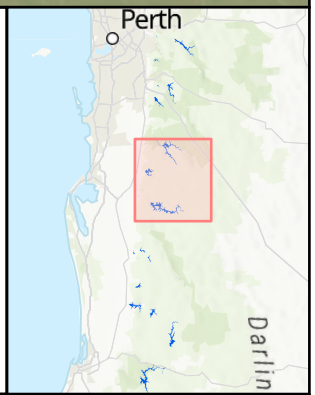
Legend

- Huntly Mine DE
- Reservoirs
- Mining Regions

DBCA - Legislated Lands and Waters (DBCA-011)

- National Park
- Conservation Reserve
- Recreation Reserve

- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-19 Protected and Conservation areas - Huntly Mine DE

Kilometres

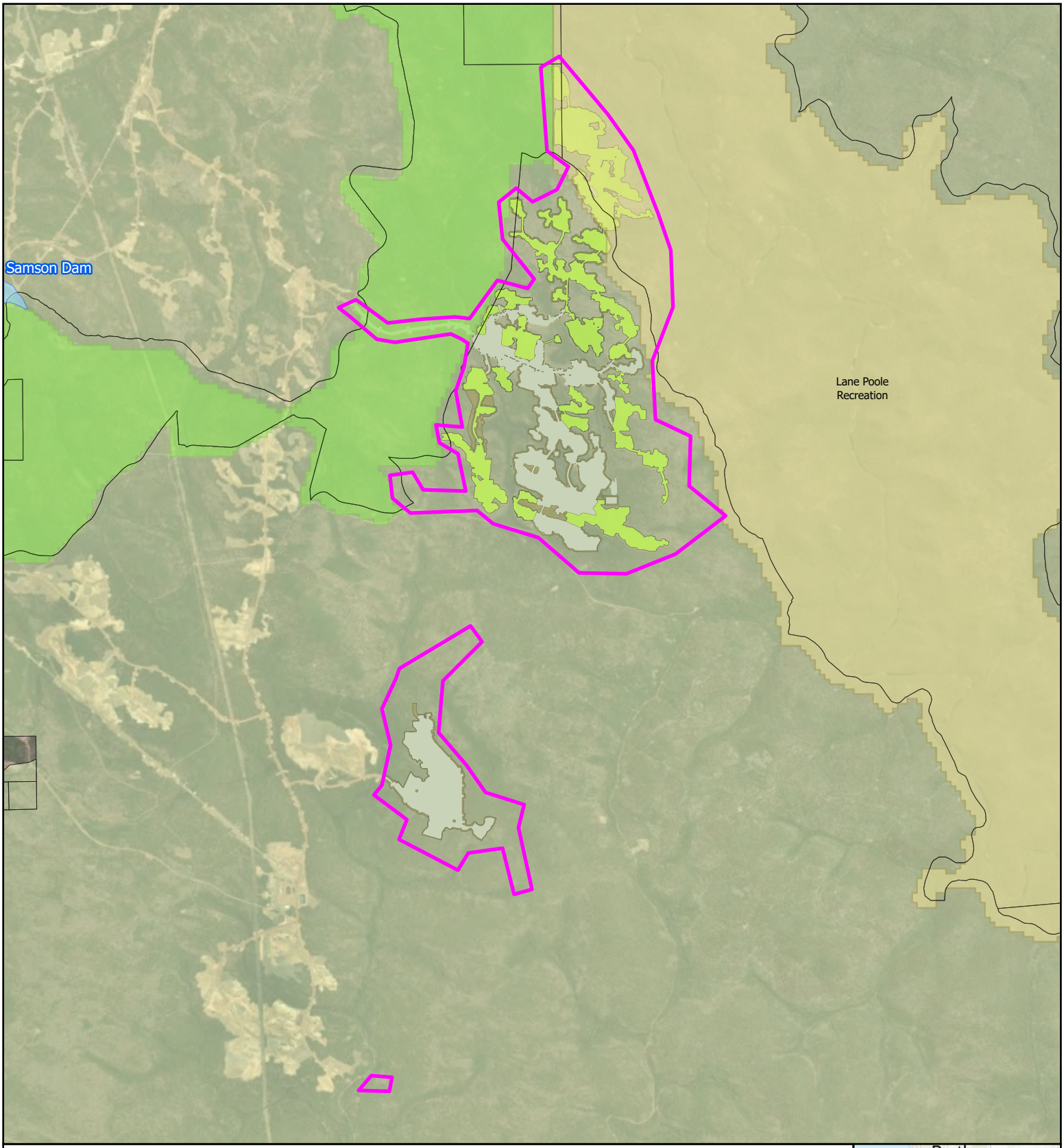
0 2 4 6 8 10 12

Scale: 1:175,000 at A4

Date Printed: 25/02/2025

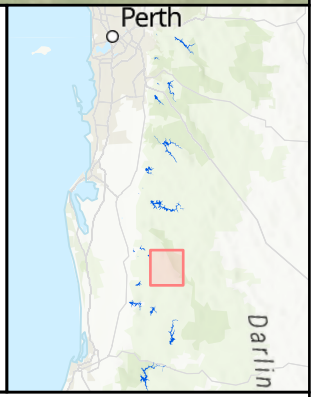
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Legend

- Willowdale Mine DE
- Reservoirs
- DBCA - Legislated Lands and Waters (DBCA-011)
- Conservation Reserve
- Recreation Reserve
- Lane Poole Conservation Reserve
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-20 Protected and Conservation areas - Willowdale Mine DE

Kilometres

0 0.9 1.8 2.7 3.6 4.5 5.4

N

Scale: 1:75,000 at A4

Date Printed: 25/02/2025

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5.2.4.8 Threats – *Phytophthora* Dieback and Other Forest Disease

Overview of *Phytophthora* Dieback

The pathogen *Phytophthora cinnamomi,* also known as Jarrah Dieback, is a destructive disease that has had a large impact on both Western Australian and Australian native plants, as described in the *Threat abatement plan for disease in natural ecosystems caused by Phytophthora cinnamomi* (DEE, 2018a). Of the many root pathogens that cause disease within Australian, *Phytophthora cinnamomi* has caused the most significant impact to date and poses the biggest threat (DoE, 2014).

Phytophthora species are considered parasitic and behave mainly as a necrotrophic pathogen causing damage to the host plant's root tissues because of infection and invasion. *Phytophthora cinnamomi* can cause permanent damage to ecosystems because once an area is infested with the pathogen, eradication is usually impossible. The disease presents a significant threat to biodiversity as it places important plant species at risk of death, local extirpation or extinction (Glevan Consulting, 2021).

Interaction between the three physical components forming the 'disease triangle' (the pathogen *Phytophthora* species, the environment and the host) is required for *Phytophthora cinnamomi* to occur and for the disease to develop over time. A population of hosts is made up of susceptible, infected and immune or resistant individuals. Also, the relationship between the presence of *Phytophthora cinnamomi* and the development of canopy dieback is variable based on the susceptibility of native plant species and the different environmental characteristics, landform types and rainfall zones across bioregions (Glevan Consulting, 2021).

Assessments classify areas with respect to *Phytophthora* dieback as:

- Uninfested – symptoms of *Phytophthora* dieback are absent in areas of natural undisturbed vegetation
- Infested – symptoms of *Phytophthora* dieback are present
- Uninterpretable – susceptible flora species are too few to determine the disease status of the vegetation reliably. Vegetation is natural and undisturbed. May be temporarily uninterpretable if indicator species presence is masked by disturbance (fire, harvesting, flooring etc.), in which case disease status may be determined after sufficient time elapsed to allow vegetation structure recovery.
- Excluded – Basic vegetation structure severely impacted by disturbance or no longer intact.

Source: DPAW (2015)

Regional *Phytophthora* dieback Presence

The NJF subregion has widespread *Phytophthora* dieback infestation, resulting from the extensive activity of the timber industry and environmental conditions favourable to the disease. *Phytophthora* dieback was first observed in the NJF in the 1920s; however, the causal agent was not isolated until 1964 (Bradshaw F. , 2015). The disease affects more than 20% of native plant species in the southwest region, the most susceptible families being Proteaceae, Ericaceae and Xanthorrhoeaceae; within these families, the genera *Banksia, Isopogon, Adenanthos, Persoonia, Petrophile, Xylomelum, Andersonia, Astroloma, Leucopogon* and *Xanthorrhoea* all demonstrate high susceptibility (Glevan Consulting,

2021). The affected species are key components of the Jarrah Forest floristic diversity (Bradshaw F. , 2015).

DBCA *Phytophthora* dieback assessment data over the NJF, is presented in Figure 5-21; the assessed area covers 349,440 ha (43.2%) of the 808,368 ha of DBCA managed lands. A total of 122,171 ha (35.0%) of the assessed area has been classified as Infested and 223,084 ha (63.8%) Uninfested, with small areas (<0.1%) either Uninterpretable or Excluded.

The Infested areas are predominantly in the western half of the NJF, due to the influence of higher rainfall. The central region of the NJF is predominantly Uninfested and is covered by 355,140 ha of Forest Disease Risk Areas (DRAs) (Figure 5-21). The DRAs are proclaimed under the *Conservation and Land Management Act 1984* and comprise areas at high risk of the introduction or spread *of Phytophthora* dieback.

Within the Huntly Mine DE, the western half of the Myara-O'Neil portion is mostly Infested and outside any DRAs and the eastern half predominantly Uninfested and in a DRA, and most of the Huntly-Del Park portion is not mapped and is outside any DRAs. Most of the Willowdale Mine DE is in the Infested zone and is entirely outside any DRA.

***Phytophthora* dieback Assessment of Mine DEs**

Phytophthora dieback assessment data cover 71.8% of the Huntly Mine DE (93.3% of the Myara-O'Neil portion and 6.9% of the Del Park-Huntly portion) and the entire Willowdale Mine DE.

A summary of the dieback assessment, which indicate that 61.3% of the assessed area was Infested and approximately 36.9% Uninfested, with a small area (1.8%) Uninterpretable is presented in Table 5-12.

Figure 5-22 and Figure 5-23 indicate that within the (predominantly Uninfested) eastern half of the Huntly Mine DE, infested areas tend to occur in valleys and swamps, with the upland areas predominantly Uninfested. This is expected as *Phytophthora* dieback is spread in surface and subsurface water and may disperse a few metres to hundreds of metres a year downslope in incised creeks and gullies, compared to less than one metre a year upslope [DEE (2018b)]. Across the western half of the Huntly Mine DE and the entire Willowdale Mine DE, this pattern is not clear, as *Phytophthora* dieback infestation has spread across most of these areas already.

Phytophthora dieback Vulnerability of Vegetation

Glevan Consulting (2021) presented the vulnerability of SVTs to *Phytophthora* dieback, based on likely impact to SVTs in DPAW's 'FEM047 *Phytophthora cinnamomi* Dieback Interpreter's manual for the lands managed by the department' (2015). The vulnerability of SVTs has been interpreted with respect to the VTs mapped over the Mine DE, through assigning impact rating to that of the dominant SVT where this is highest or assigning the average impact rating where the subdominant SVT is highest. Some SVTs have a range of vulnerability. SVTs R and G have a high impact where there are vulnerable communities on the margins of rock outcrops. SVT C has a low to high impact due to the variability of Banksia communities.

Of the 111 conservation significant flora species considered to have potential to occur in the Mine DEs (excluding the 28 species assessed as 'Do Not Occur' and the 71 considered

'Unlikely to Occur' in both Mine DEs), two species are considered to have high susceptibility to *Phytophthora* dieback (*Andersonia* sp. Saxatilis (F. & J. Hort 3324) (CR under the BC Act) and *Banksia recurvistylis* (P2)) and ten species to be vulnerable (*Grevillea flexuosa* (VU), *G. ornithopoda* (P2), *Andersonia* sp. Audax (F. Hort, B. Hort & J. Hort 3179) (P3), *Conospermum scaposum* (P3), *G. dissectifolia* (P3), *G. prominens* (P3), *Hakea oldfieldii* (P3), *Stirlingia divaricatissima* (P3), *Synaphea pandurata* (P3) and *G. pimeleoides* (P4)).

Key indicator species for *Phytophthora* dieback within the Jarrah Forest include *Adenanthos barbiger, Banksia grandis, Banksia sessilis, E. marginata, Leucopogon* spp., *Lomandra sonderi, Patersonia* spp., *Persoonia longifolia, Xanthorrhoea gracilis and Xanthorrhoea preissii* (Glevan Consulting, 2021). Disease expression within the Jarrah Forest varies from subtle expression with few indicator species deaths to obvious expression with a clear disease front.

The interpreted vulnerability of vegetation across the Mine DEs, for areas that are not assessed as Infested is presented in Table 5-13. Areas assessed as Infested (refer to Figure 5-22 and Figure 5-23) are expected to experience dieback impacts either at present or the near future, irrespective of the Proposal.

Of the 15,773 ha (40.4%) of the Huntly Mine DE that is not assessed as Infested (i.e., Uninfested, Uninterpretable or Un-assessed) and is covered by VT mapping (Section 5.2.4.2), 17.3% is classified as High vulnerability to dieback, 34.2% as Moderate to High vulnerability and 0.6% as Low to High, with 9.7% having vulnerability either Moderate or Low and the remaining 38.2% being cleared or rehabilitation areas or dams.

The Huntly-Del Park portion of the Huntly Mine DE, which comprises most of the *Phytophthora* dieback un-assessed vegetation, is not covered by baseline vegetation mapping (i.e., VTs; Section 5.2.4.2). Dwellingup vegetation complexes (uplands dominated by P-, S- and T-dominant VTs; see Table 5-6 for descriptions) comprise 48.4% of this portion; this vegetation is expected to include susceptible species, and hence has at least a Moderate vulnerability.

Within the Willowdale Mine DE, 287 ha (13.4%) is not assessed as Infested and has VT mapping (Section 5.2.4.2); this comprises 10.4% classified as High vulnerability to dieback, 23.7% as Moderate to High vulnerability and 0.2% as Low to High, with 20.1% having vulnerability either Moderate or Low and the remaining 45.7% being cleared or rehabilitation areas or dams (Table 5-13).

Armillaria luteobubalina

Armillaria luteobubalina (Australian Honey Fungus) is a widespread, endemic pathogen in the Jarrah Forest, with 75 infection centres identified in the NJF subregion over a five-year study period (1981-1985) (Shearer & Tippett, 1988). The pathogen attacks and kills the roots of susceptible trees and shrubs, causing armillaria root disease (ARD). ARD is generally not the primary cause of death in healthy forest but kills trees weakened by competition, age or environmental stress (Robinson, 2011).

ARD has been observed to cause greater impact in the intermediate to low rainfall zones of the eastern forest rather than the high rainfall zones (Shearer & Tippett, 1988), in which the Mine DEs are located. Within the high rainfall zone, ARD caused crown decline of susceptible species (e.g., *Corymbia calophylla, Eucalyptus marginata, Banksia grandis*) but there were few mortalities (Shearer & Tippett, 1988).

ARD has been identified in multiple areas within the Myara North (immediately north of the Huntly Mine DE, Myara-O'Neil portion) and Holyoake (between the Myara-O'Neil and Huntly-Del Park portions of the Huntly Mine DE) areas from 2017 to 2020, although no significant infestations were located and single or few isolated deaths attributed to the disease (Glevan Consulting, 2021).

DBCA (Bourke, DBCA, pers.comm) are not aware of situations in the Jarrah forest where Armillaria infestations are extensive enough to warrant significant management.

Marri Canker

Corymbia calophylla (Marri) can be subject to a perennial canker disease, which is caused by the fungus *Quambalaria coyrecup* (Paap T. , Burgess, McComb, Shearer, & Hardy, 2008). Since the 1970s, the canker disease has caused serious decline of Marri throughout its range in the southwest of WA (Paap, Brouwers, Burgess, & Hardy, 2017).

A thirteen-year study indicated identified cankers on 22.7% of surveyed Marri trees at study commencement, of which 6.7% died as a result of cankers at the study end (Paap T. , Burgess, Calver, & Mccomb, 2016). The majority of trees with cankers were located in disturbed areas such as roadsides or paddocks, with significantly lower incidence in forests (Paap T. , Burgess, Calver, & Mccomb, 2016).

A landscape scale study indicated that cankers were found across most of the range of *C. calophylla,* and that canker incidence was significantly related to the proportion of non-native vegetation present (a proxy for disturbance) and more prevalent in cooler and wetter areas. The study generated an indicative probability map, specifically relevant for roadside areas, which indicated a canker probability of 0.3-0.45 for the NJF subregion between Jarrahdale and Dwellingup (i.e., in the vicinity of the Huntly Mine DE), with a probability of 0.45-0.6 westwards towards the Darling Scarp (Paap, Brouwers, Burgess, & Hardy, 2017). However, no landscape sites were surveyed in the NJF subregion between Jarrahdale and Dwellingup and the canker incidence in the area is undocumented.

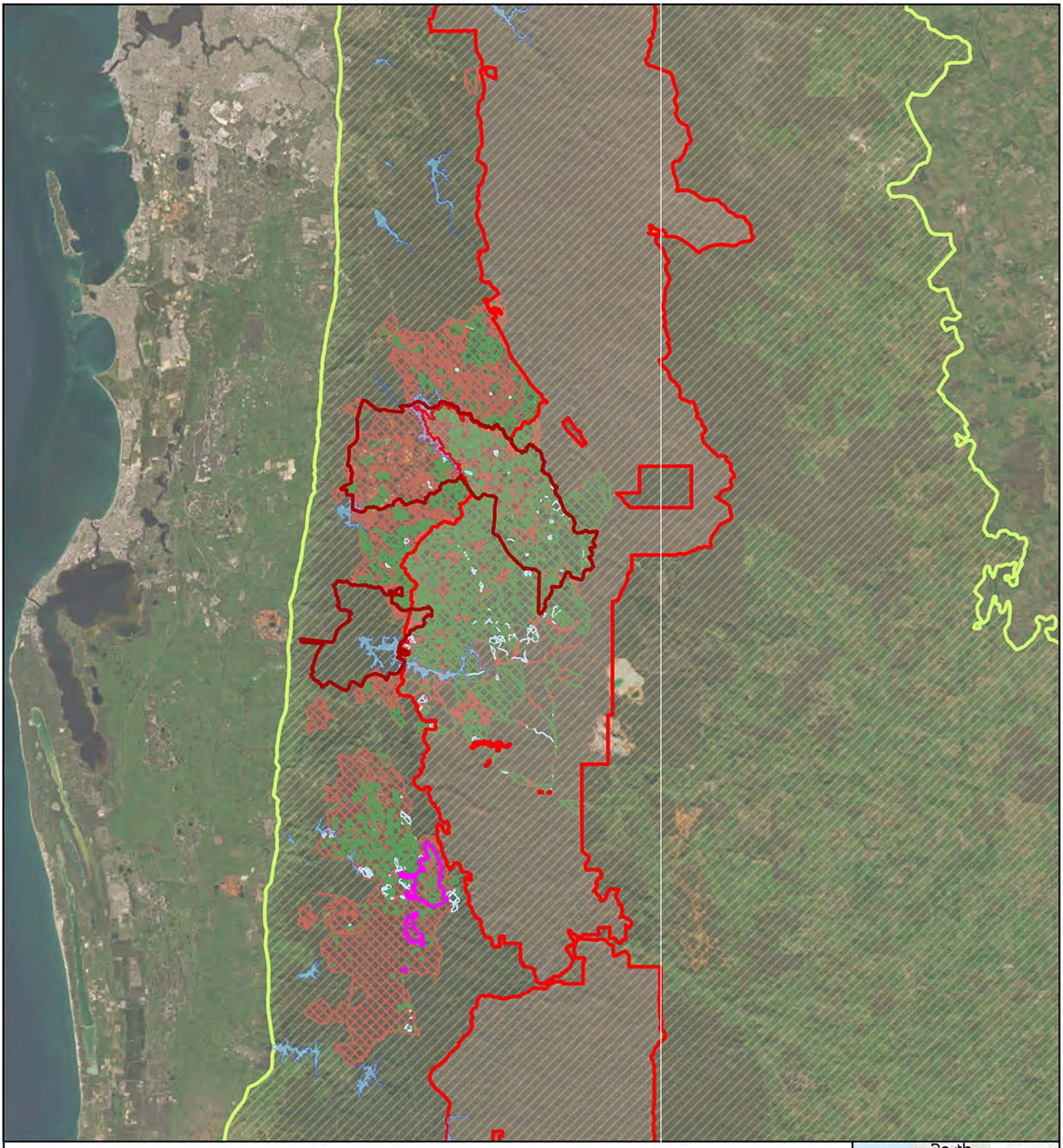
A PhD study of disturbance gradients along transects between road, forest edge and middle of intact forest indicated differences in soil nutrients and mycorrhizal composition, with a unique mycorrhizal community assemblage at the roadside (Sapsford, 2017). Sapsford (2017) suggested that the microclimate of disturbed areas may disrupt fungal communities which in turn alters nutrient update by trees, causing a predisposition of *C. calophylla* to canker disease.

Myrtle Rust

Myrtle Rust, caused by the fungal pathogen *Austropuccinia psidii,* poses a severe threat to various native plants in Australia's Myrtaceae family, which includes eucalypts, bottlebrushes, tea trees, and other key species in forest and woodland ecosystems. First detected in New South Wales in 2010, myrtle rust has since spread across multiple states and regions, including the northern part of Western Australia. The fungus thrives in moist, shaded conditions, making areas with high humidity particularly vulnerable. Plants infected by myrtle rust often display purple lesions on leaves, followed by vibrant yellow spores. As the infection advances, affected plants may exhibit stunted growth, heavy defoliation, and dieback of branches, ultimately leading to death in severely impacted trees and shrubs (DPIRD, 2022) (DBCA, 2024c) (DCCEEW, 2024).

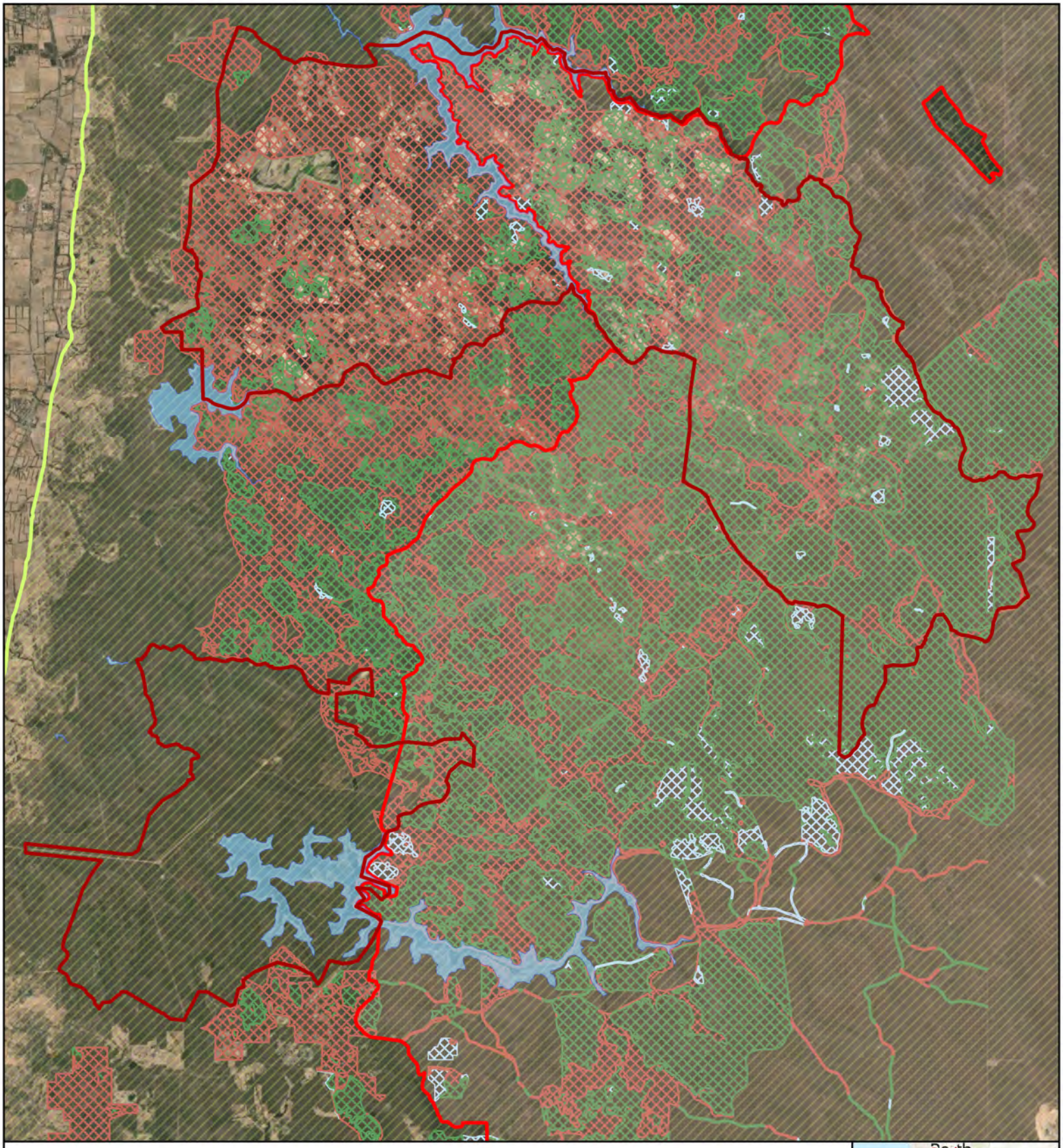
The disease primarily attacks new growth, meaning that seedlings and young foliage are especially susceptible, which can significantly reduce a plant's ability to regenerate and impact biodiversity within the ecosystem. Control of myrtle rust in natural environments is challenging due to its spore-based dispersal, which can spread via wind, animals, and even human movement. While fungicides can manage outbreaks in controlled environments like nurseries, they are impractical for large-scale natural applications. The Australian Government has established the National Myrtle Rust Working Group to coordinate responses, but biosecurity remains critical to preventing additional strains from entering Australia (DPIRD, 2022) (DBCA, 2024c) (DCCEEW, 2024).

Myrtle rust has not been recorded in the southwest of Western Australia and, therefore, not within the Mine DEs.



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-21 Phytophthora cinnamomi Dieback and Disease Risk Areas - Northern Jarrah Forest

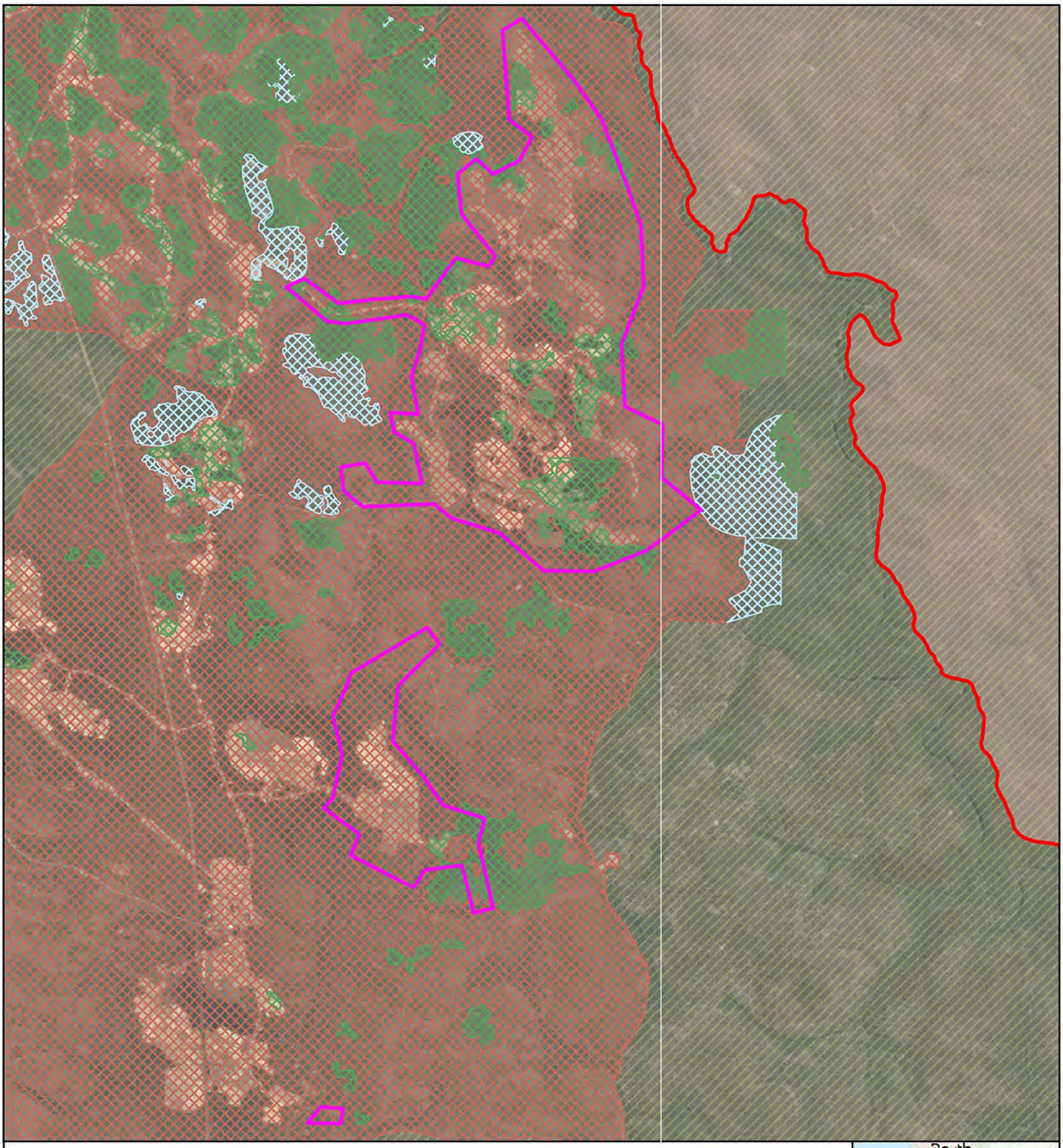


Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-22 Phytophthora cinnamomi Dieback Occurrence - Huntly Mine DE

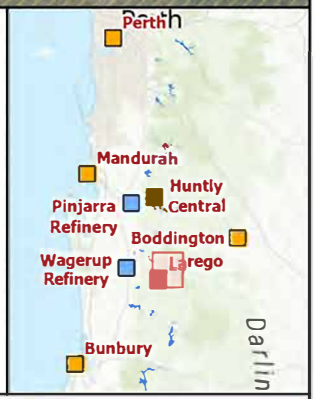
Scale: 1:175,000 at A4

Date Printed: 26/02/2025



Legend

- Willowdale Mine DE
- Phytophthora cinnamomi dieback
- Phytophthora cinnamomi dieback infested
- Phytophthora cinnamomi dieback uninfested
- Uninterpretable
- Disease Risk Areas for Phytophthora cinnamomi dieback
- IBRA sub-region (Northern Jarrah Forest)



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-23 Phytophthora cinnamomi Dieback Occurrence - Willowdale Mine DE

Kilometres

0 0.75 1.5 2.25 3 3.75 4.5

Scale: 1:70,000 at A4

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Alcoa

Table 5-12: Summary of Phytophthora dieback Occurrence Assessment in the Mine DEs

Consolidated Dieback Class	Total of Huntly Mine DE (ha)	Proportion of Huntly Mine DE (%)	Total Willowdale Mine DE (ha)	Proportion of Willowdale Mine DE (%)	Total area in Mine DEs (ha)	Proportion of Mine DEs (%)
Infested	16,645	42.6	1,847	86.5	18,492	44.9
Uninfested	10,842	27.8	289	13.5	11,131	27.0
Uninterpretable	553	1.4	0.1	0.0	553	1.3
Total assessed	28,040	71.8	2,137	100.0	30,176	73.3
Un-assessed	11,007	28.2	0	0.0	11,007	26.7
Total Mine DE	***39,047***	***100.0***	***2,137***	***100.0***	41,183	100.0
Infested proportion of assessed (%)	-	59.4	-	86.5	-	61.3
Uninfested proportion of assessed (%)	-	38.7	-	13.5	-	36.9

Table 5-13: Phytophthora dieback Vulnerability of Uninfested Vegetation within the Mine DEs

Consolidated Dieback Vulnerability rating	Dominant VTs^	Total Huntly Mine DE (ha)	Proportion of Huntly Mine DE (%)	Total Willowdale Mine DE (ha)	Proportion of Willowdale Mine DE (%)	Total area in Mine DEs (ha)	Proportion of Mine DEs (%)
High	D, DA, DG, E, P, PG, PS, PT, PW	2,732	7.0	30	1.4	2,762	6.7
Low	A, AC, AD, AW, AY, Q	224	0.6	<1	0.0	224	0.5
Low to High	C, CQ, CW	97	0.2	<1	0.0	98	0.2
Low to Moderate	T, TP, TS, Z, Y, YG, YS	1,197	3.1	57	2.7	1,254	3.0
Moderate	W, WD	101	0.3	<1	0.0	102	0.2
Moderate to High	S, SP, SP-D, ST, SW, SW-D, R, R/G, G, G1, G2	5,399	13.8	68	3.2	5,467	13.3
N/A	CL, Rehab, DAM	6,023	15.4	131	6.1	6,154	14.9
Total area	-	**15,773**	**40.4**	**287**	**13.4**	**16,060**	**39.0**
VTs not mapped	**-**	6,909	17.7	15	0.7	6,924	16.8
Existing infested area	-	16,645	42.6	1,847	86.5	18,492	44.9

^ see Table 5-5 for descriptions

5.2.4.9 Vegetation Condition

Vegetation condition has not been mapped at a regional scale or at a local scale based on the Keighery (1994) ranking within the Mine DEs.

For the purposes of this document, analysis of vegetation condition at a regional scale was made by considering factors affecting the condition of vegetation complexes across the mapped areas of the NJF subregion and within the Mine DEs. The analysis, applying the method from Mattiske (2021a), was based on Forest age (timber harvesting) and *Phytophthora* dieback datasets.

Effects of Timber Harvesting

The effects of timber harvesting on vegetation condition are primarily through the loss of Old Growth Forest structure (see Section 5.2.4.5), as well as preferential loss of Marri under past logging practices and a partial loss of understorey diversity (see Section 5.2.4.5).

As presented in Table 5-8, the Huntly Mine DE has a slightly higher proportion (84.7%) of juvenile (equivalent to Good condition) to immature age (Very Good condition) forest and Willowdale Mine DE a slightly lower proportion (74.9%) compared to the NJF (77.6%). The Huntly Mine DE has a lower proportion (14.8%) and Willowdale Mine DE a higher proportion (25.2%) of mature aged forest (equivalent to Excellent condition) compared with the NJF (18.2%).

These data suggest that, on average and on the basis of timber harvesting records, the vegetation of the Huntly Mine DE has a slightly lower condition ranking than that of the NJF, and the Willowdale Mine DE slightly higher.

Effects of Phytophthora dieback

Phytophthora dieback assessment has been limited to approximately one third of the 1.1 million ha of native vegetation of the NJF subregion and approximately 72% of the Mine DEs (Figure 5-21). The mapped area shows a trend of dieback occurrence across the NJF, with Infested areas occurring predominantly in the high rainfall zone in the western portion of the subregion and Uninfested areas in the east.

Mattiske (2021a) assessed the effect of dieback on vegetation condition, noting that vegetation condition depends on both dieback infestation and vulnerability (Section 5.2.4.8). Generally, vegetation complexes with higher levels of infestation are of variable vulnerability; vegetation condition is likely to vary at a sub-complex level (depending on the particular mix of vegetation types and presence of vulnerable flora genera such as *Banksia*), which limits a regional assessment of vegetation condition with respect to dieback. Mattiske (2021a) classified Uninfested vegetation as Excellent to Pristine and Infested vegetation as Very Good, Good or Degraded.

Within the NJF, 35.0% of the covered by *Phytophthora* dieback assessment has been classified as Infested (equivalent to Very Good, Good or Degraded condition) and 63.8% Uninfested (equivalent to Pristine to Excellent condition). The assessed portion (71.8%) of the Huntly Mine DE is classified as 59.4% Infested and 38.7% Uninfested; the Willowdale Mine DE (100% of which has been covered by *Phytophthora* dieback assessment) is classified as 86.5% Infested and 13.5% Uninfested.

This analysis suggests that, on average and on the basis of *Phytophthora* dieback assessments, the vegetation of both Mine DEs has a lower condition rating than that of the NJF.

Overall comparative vegetation condition rating

Synthesis of the above data into an overall vegetation condition rating can only be done qualitatively, given the nature of the inputs:

- Timber harvesting: vegetation of the Huntly Mine DE is ranked slightly lower condition than that of the NJF, and the Willowdale Mine DE slightly higher condition;
- *Phytophthora* dieback: the vegetation of both Mine DEs has a lower condition rating than that of the NJF; and
- Based on the above analysis, vegetation condition of the Huntly Mine DE is ranked lower than that of the NJF, and vegetation condition of the Willowdale Mine DE is ranked similar to that of the NJF.

5.2.4.10 Threats – Climate Change

The NJF subregion lies within the southwest region of Western Australia which has a Mediterranean climate with cool moist winters and warm dry summers (Beard, 1990).

The western part of the NJF subregion along the Darling Scarp receives the highest rainfall due to orographic uplift of north-westerly and westerly cold fronts during winter. Rainfall decreases in a strong west to east gradient and more gradually to the north. Open forest with a potential mature tree height greater than 10 m was, in the past, restricted to where mean annual rainfall exceeded 600 mm but has since been defined by the limits of agriculture (Maher, McCaw, & Yates, 2010).

The climate of the southwest region has been subject to warming and drying since the 1970s, with an increase in annual mean temperature at approximately +0.15°C per decade, a reduction in early winter (May to July) rainfall and an absence of the very high rainfall years that were relatively common throughout much of the 20th century (Maher, McCaw, & Yates, 2010).

Ten studies published since 1992, involving analyses of southwest regional rainfall, were reviewed by Gallant, Hennessey & Risbey (2007) and concluded:

'large decreases for both seasonal and annual rainfall [means and extremes] since the 1950s in the … southwest region … primarily due to the southward shift in rain-bearing synoptic circulations since the 1970s, which has been partly attributed to natural variability, the enhanced greenhouse effect and stratospheric ozone depletion'.

Rainfall

The contemporary annual rainfall recorded over the past three decades and shows the decline in annual rainfall over the NJF subregion, with a notable contraction in the high rainfall areas over the western parts of the subregion is shown in Figure 5-24. Within the central NJF, annual average rainfall ranges from a maximum of approximately 1,100 mm/year in the vicinity of Dwellingup, to a broad corridor of 1,000 mm/year stretching from Wungong Dam in the north to Harvey Dam in the south. Rainfall reduces to approximately 500 mm/year in the north and east of the subregion. A major effect of the

reduced rainfall has been a reduction of groundwater levels in the lateritic regolith, hydraulic disconnection of streams from groundwater, and a consequent decline in stream flow in catchments (Reed, Barrett, & Croton, 2012) (Hughes, Petrone, & Silberstein, 2012) (Kinal & Stoneman, 2012).

Winter and spring rainfall is generally predicted to decline across the Southern and South-Western Flatlands Cluster (an area which includes the South-West region of WA) over the 21st century, based on forecasts generated by Climate Change in Australia (Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Bureau of Meteorology (BOM)) projection tools. The forecast variation in rainfall in summer and autumn is less clear, with a greater range of predictions that forecast either increase or decline (depending on the plausible GHG and climate change scenario) (Hope & et al, 2015).

The duration and frequency of extreme droughts for the South-Western Flatlands Cluster area forecast to increase for all plausible GHG and climate change scenarios (Hope & et al, 2015).

For the Southern and South-Western Flatlands Cluster, '*Substantial increases in the maximum temperature on the hottest days, the frequency of hot days and the duration of warm spells are projected with very high confidence based on model results and physical understanding. Heat related extremes are projected to increase at a similar rate as projected mean temperature with a substantial increase in the number of warm spell days'* (Hope & et al, 2015).

In summary, rainfall and drought data and forecasts indicate that the southwest of Western Australia, in which the Mine DEs are located, will be subject to a drier and hotter climate in future.

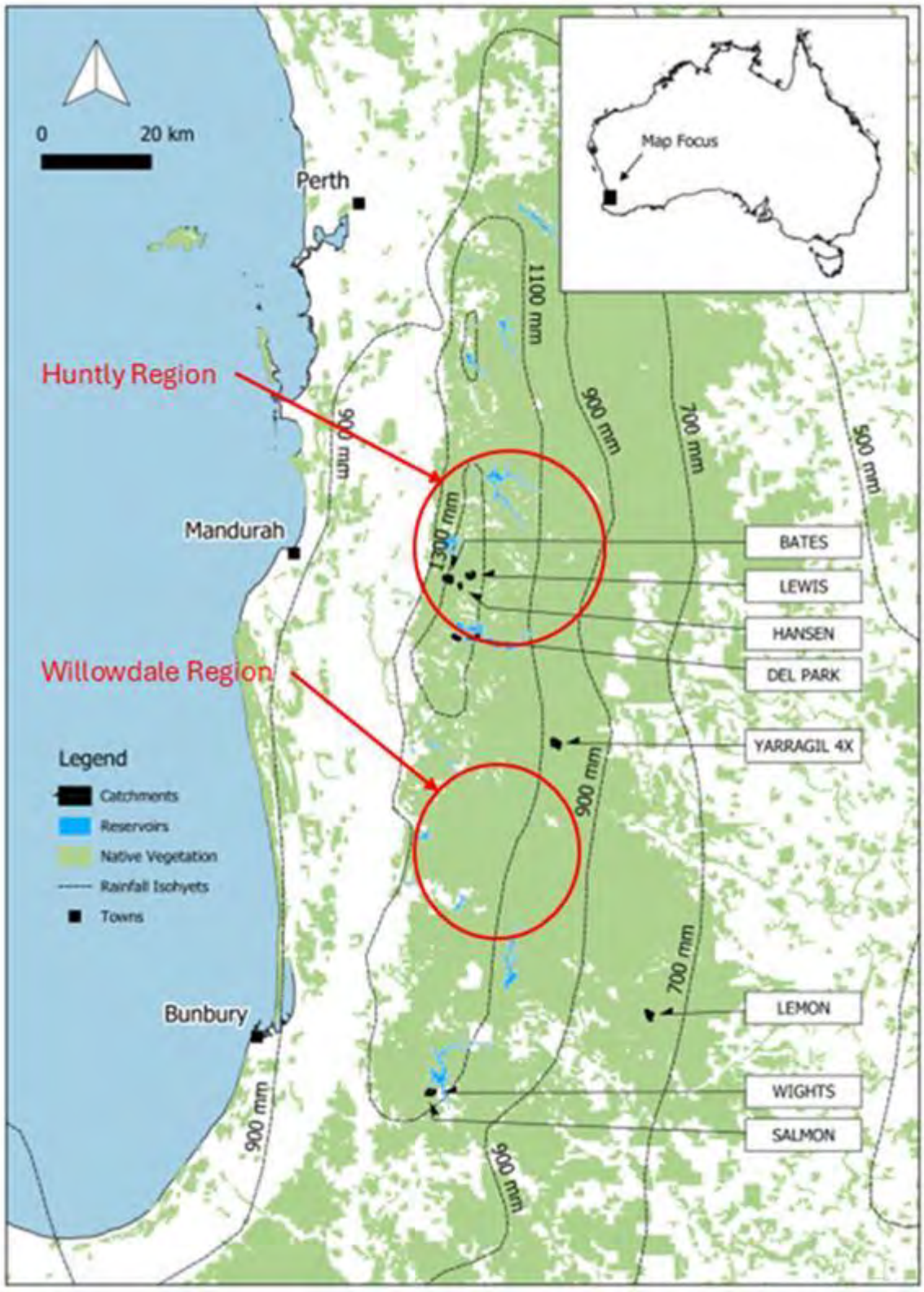


Figure 5-24: Contemporary and Historic Annual Rainfall – NJF

5.2.4.11 Threats – Fire Regime

History of Fire Management

There is evidence of frequent fires in the southwest region over the past 2.5 million years, aligning with the increasing aridity over this period and likely extinction of much of the Gondwanan rainforest flora. The southwest region forests are now predominantly sclerophyllous and devoid of mesic understorey species that may be found in other Australia forests (Burrows & Wardell-Johnson, 2003).

Substantial changes to fire patterns are expected to have occurred with the arrival of Aboriginal peoples over the last 60,000 years, with fire management evolving to meet their economic and ecological needs (Burrows & Wardell-Johnson, 2003). Aboriginal people practiced 'fire stick farming' involving a mosaic of frequent, light burning (Burrows & McCaw, 2013).

The arrival of Europeans in 1829 and resulting clearing, settlement, agriculture and introduction of pests and diseases brought further substantial changes in fire regime (Burrows & Wardell-Johnson, 2003). Un-controlled timber harvesting and the cessation of Aboriginal fire management led to damaging wildfires in the late 19th century, which resulted in a policy of fire exclusion in the early to mid-20th century (Department of Conservation and Land Management (CALM), (1994)). Prescribed burning was limited to strips between 'protected' compartments or to old growth or uncut areas, however fire was excluded from large areas to protect harvest regeneration (CALM, 1994).

The consequent fuel accumulation led to large scale wildfires from the late 1930s, with major fires in 1949-1951 and the largest in 1961. A policy of prescribed burning was introduced in 1953; however, implementation was limited due to the high fuel loads (CALM, 1994). The 1961 fires impacted an estimated 0.5 million ha of forest including approximately 0.2 million ha in the NJF subregion. The NJF was burnt at Dwellingup, Gleneagle and the Perth Hills (Rodger, 1961). The 1961 Dwellingup fire affected 150,000 ha, destroying the hamlets of Holyoake and Nanga Brook (which were thereafter abandoned) and severely damaging Dwellingup townsite.

Following the 1961 fires, the program of prescribed burning was substantially increased, with the aim of limiting fuel accumulation to 8 t/ha in the Jarrah forest, the threshold at which fire-fighting becomes problematic and damage occurs to young trees and crowns. To limit fuel accumulation to this threshold typically requires a fire interval of 5-7 years (CALM, 1994). Prescribed burning declined in the 1980s and 1990s due to several factors, including limited resources, an increasing public estate, and community criticism regarding impacts to urban and rural areas (CALM, 1994). Large wildfires became more prevalent from the 1990s, including 2003 (Mt Cooke), 2007 (Dwellingup), 2011-12 (Perth Hills), 2015 (Boddington), 2016 (Waroona), and 2012 (Wooroloo).

Impact to Flora and Vegetation

The South-West Forest vegetation is resilient to lower intensity fires, as evident by the persistence and diversity of species and dominance of Jarrah and Marri across the region. Most eucalypts can re-sprout from epicormic shoots and lignotubers, with the dominant Jarrah and Marri having thick bark to protect against moderate fires (Burrows & Wardell-Johnson, 2003). Lower intensity fires do not typically damage the crowns of mature trees,

whereas summer wildfires can damage crowns and Jarrah and Marri can take approximately four years to flower following such fires. Most forest eucalypts including Jarrah and Marri regenerate and develop prolifically following fires.

The understorey, which comprises the majority of floral diversity, is also resilient to lower intensity fires, particularly in the more fire prone upland areas. Providing that seedlings can establish after the fire, almost all understorey species can establish lignotubers or a seedbank within a timeframe of 2-4 years, which is the typical minimum fire interval in the Jarrah forest (Burrows & Wardell-Johnson, 2003). A small number of obligate seeders are fire sensitive, requiring longer fire intervals to reach flowering age and establish seeds, however these are limited to less fire prone areas (Burrows & McCaw, 2013).

In uplands, the understorey comprises approximately 75% re-sprouters and 25% obligate seeders, whereas in streamzone and granite landforms the vegetation can be 50-80% obligate seeders. Re-sprouters survive fires by below or above ground organs, such as lignotubers or epicormic buds protected under bark. These organs can withstand moderate fires but are still vulnerable to damage or death during high intensity fires (Burrows & Wardell-Johnson, 2003).

Obligate seeders rely on seed banks in soils or durable capsules to regenerate and most require fire to germinate. Accordingly, obligate seeders are vulnerable to fire frequency, requiring adequate time between fire events to replenish seed banks but also sufficient frequency to germinate seeds in above ground capsules. Drought is the main cause of seedling mortality post fire; thus, regeneration is strongest following autumn fires and the onset of winter rains (Burrows & Wardell-Johnson, 2003). Obligate seeders are also vulnerable to damage or loss of the seedbank with high intensity fires.

5.2.4.12 Vulnerability to Threats

An assessment of the vulnerability of regional vegetation complexes within the Mine DEs to reasonably foreseeable impacts, including dieback, climate change (specifically the effects of a drying climate i.e., groundwater decline and drought) and fire is presented in Table 5-14. The assessment is based on publicly available information that can be interpreted against the broadly defined vegetation complexes.

As presented in Table 5-14, all vegetation complexes within the Mine DEs have a high vulnerability to high intensity fires, which can impact a wide range of flora including both obligate seeders and re-sprouters, changing vegetation structure and floristic diversity (refer to Section 5.2.4.11). The vegetation complexes have a varying vulnerability to fire interval, with most complexes (those associated with granite outcrops, valleys and low-lying areas) having a high vulnerability to frequent fires due to a prevalence of obligate seeders, and the Dwellingup complexes on lateritic uplands having a moderate vulnerability to frequent fires due to the prevalence of re-sprouters.

The vegetation complexes within the Mine DEs have a varying vulnerability to *Phytophthora* dieback infestation, with: a moderate to high vulnerability in the Cooke, Darling Scarp, Dwellingup 2 and Dwellingup 4 and Yarragil 2 complexes; a low vulnerability in the Swamp complex; and a variable vulnerability in the Dwellingup 1, Murray 1, Pindalup and Yarragil 1 complexes. As noted above, the vulnerability of vegetation varies at a sub-complex level, depending on the mix of vegetation types and presence of vulnerable species.

Most of the vegetation complexes within the Mine DEs (other than the Dwellingup complexes) have a high vulnerability to drought due to their limited soil moisture capacity or reliance on high soil moisture and/or shallow groundwater. These complexes may be subject to species composition and structural changes, with the valley / depression complexes potentially contracting and being replaced by upland vegetation. The three Dwellingup lateritic upland complexes have a varying vulnerability to drought due to their varying depth of regolith and depth to groundwater. Areas of upland vegetation overlying shallow regolith may be more vulnerable to drought.

In summary, the vegetation complexes associated with granite outcrops and valleys, which are comparatively restricted in distribution within the NJF subregion, are expected to be more vulnerable to threats of fire and a drying climate. With a continued decline in rainfall and over successive fire events, valley vegetation may be replaced over time with upland vegetation and the extent of valley vegetation types may, therefore, contract within the NJF subregion.

Table 5-14: Vulnerability of Vegetation Complexes within the Mine DEs to Reasonably Foreseeable Threats

Landform	Vegetation Complex	Associated SVTs^	Fire	*Phytophthora* dieback	Drought / Drying Climate
Uplands (granite)	Cooke (Ce)	G, R	**High vulnerability to fire frequency and intensity** The understorey in granite landforms can be comprised of between 50-80% obligate seeders (Burrows & Wardell-Johnson, 2003). • Obligate seeders rely on seed banks in soils or durable capsules to regenerate and most require fire to germinate. • Accordingly, obligate seeders are vulnerable to fire frequency, requiring adequate time between fire events to replenish seed banks but also sufficient frequency to germinate seeds in above ground capsules. • They are also vulnerable to damage or loss of the seedbank with high intensity fires.	**Moderate to high vulnerability** R and G SVTs: moderate to high impact (vulnerable communities on the margins of rock outcrops) (Glevan Consulting, 2021). Impact defined as (DBCA, 2020): • Moderate predicted impact: expected where less than 10% of overstory species will be affected by *Phytophthora* dieback, with high numbers of understory deaths. • High predicted impact: expected in areas where 10% to 50% of overstory species will die.	**High vulnerability** Landform is characterised by exposed granite and shallow soils overlying granite, which have limited soil moisture storage capacity. Localised die-off of a range of tree species was recorded on shallow soils around granite outcrops during extended dry periods in the 1990s and 2000s (Maher, McCaw, & Yates, 2010). It is uncertain whether the heath and shrubland vegetation around granite outcrops can be maintained with a reduction in soil moisture during drought, which may be subject to species composition and structural changes in response to a drying climate.
Uplands (granite)	Darling Scarp (DS2)	N/A – No intersection between DS2 and SVT mapping	**High vulnerability to fire frequency and intensity** DS2 is associated with granite outcrops and likely has a similar vulnerability as Cooke complex.	**Moderate to high vulnerability** DS2 is associated with granite outcrops and likely has a similar vulnerability as Cooke complex.	**High vulnerability** DS2 is associated with granite outcrops and likely has a similar vulnerability as Cooke complex.
Uplands (laterite)	Dwellingup (D1)	S, T	**Moderate vulnerability to fire frequency** **High vulnerability to fire intensity** In uplands the understorey is approximately 75% re-sprouters and 25% obligate seeders (Burrows & Wardell-Johnson, 2003). See Cooke complex for obligate seeder vulnerability. • Re-sprouters survive fires by below or above ground organs such as lignotubers or epicormic buds protected under bark. • These organs can withstand moderate fires but are still vulnerable to damage or death during high intensity fires (Burrows & Wardell-Johnson, 2003).	**Variable vulnerability** • S vegetation type: moderate to high impact (wide range) • T vegetation type: low to moderate impact (Glevan Consulting, 2021). Impact defined as (DBCA 2020) (DBCA, 2020): • Low predicted impact: recognised in areas where no overstory decline is expected and minimal deaths of understory species will occur.	**Varying vulnerability** Landform is characterised by varying depth of regolith and associated soil moisture storage capacity, and varying groundwater depths. In areas of deeper regolith, deeper rooted vegetation can access extended soil moisture and/or groundwater, via ancient root channels extending though the caprock and into the clay (see Section 5.2.4.4 GDEs). The predominant canopy tree (*E. marginata*) is very likely to be facultative phreatophytes, recording substantially lower evapotranspiration rates over deeper groundwater than over shallow groundwater. The co-dominant canopy tree (*C. calophylla*) may use water more conservatively than *E. marginata* and be more reliant resilient to drought (see Section 5.2.4.4 GDEs). In areas of shallow regolith, and more limited soil moisture storage, there is potential for drought to cause more severe impacts to the vegetation. In these areas, species composition and structure changes may occur in response to a drying climate.
	Dwellingup (D2)	P, S	**Moderate vulnerability to fire frequency** **High vulnerability to fire intensity** Similar vulnerability as Dwellingup D1 complex.	**Moderate to high vulnerability** • P vegetation type: high impact • S vegetation type: moderate to high impact (wide range) (Glevan Consulting, 2021).	**Varying vulnerability** Similar vulnerability as Dwellingup D1 complex.
Uplands (laterite)	Dwellingup (D4)	P, S	**Moderate vulnerability to fire frequency** **High vulnerability to fire intensity** Similar vulnerability as Dwellingup D1 complex.	**Moderate to high vulnerability** Similar vulnerability as Dwellingup D2 complex.	**Varying vulnerability** Similar vulnerability as Dwellingup D1 complex. However, Dwellingup D4 occurs to the east of and in drier (semiarid and arid) zones than D1 or D2 and, therefore, the effects of a drying climate are likely to be more pronounced.

Landform	Vegetation Complex	Associated SVTs^	Fire	*Phytophthora* dieback	Drought / Drying Climate
Depressions and Swamps	Swamp (S)	A	**High vulnerability to fire frequency and intensity** The understorey in depression and swamps can be comprised of between 50-80% obligate seeders (Burrows & Wardell-Johnson, 2003). See under Cooke complex for obligate seeder vulnerability.	**Low vulnerability** • A vegetation type: low impact (Glevan Consulting, 2021).	**High vulnerability** Landform is characterised by soils with higher moisture, including seasonal waterlogging and shallow groundwater. Vegetation includes potential GDEs (see Section 5.2.4.4) with woodlands of *Melaleuca* and *Banksia* species. A reduction in rainfall and declining groundwater levels may reduce the area of soil with higher available moisture within the landscape. This may lead to a change in species composition and structure, with a post-fire colonisation by upland vegetation. A drying climate may lead to a contraction of this vegetation complex within the NJF subregion.
Valleys	Helena 1 (He1)	C, Q, S, T, W	**High vulnerability to fire frequency and intensity** Mostly valley slopes and floors so similar vulnerability as Murray 1 complex. Areas of shallow soils associated with granite on steep slopes colonised by heath and lithic complexes will have similar vulnerability as Cooke complex.	**Variable vulnerability** • C vegetation type: low to high due to variability of banksia communities • Q vegetation type: low • S vegetation type: moderate to high impact (wide range) • T vegetation type low • W vegetation type: moderate (Glevan Consulting, 2021)	**High vulnerability** Landform comprises incised valleys with steep slopes with shallow soil overlying granite and valley floors subject to higher soil moisture, including seasonal inundation or waterlogging, and shallow groundwater. Vegetation includes potential GDEs (see Section 5.2.4.4) with *Eucalyptus rudis* along streams. The moist valley floors of this complex have a high vulnerability similar to that of Swamp complex. Valley slopes comprise vegetation more similar to uplands and, where shallow soil overlies granite, granite outcrops. The valley slopes have a variable vulnerability similar to uplands and the areas of shallow soils have vulnerability similar to that of the Cooke complex.
	Murray 1 (My1)	C, Q, T, U	**High vulnerability to fire frequency and intensity** The understorey in valleys can be comprised of between 50-80% obligate seeders (Burrows & Wardell-Johnson, 2003). See under Cooke complex for obligate seeder vulnerability.	**Variable vulnerability** • C vegetation type: low to high due to variability of banksia communities • Q vegetation type: low • T vegetation type: low (Glevan Consulting, 2021)	**High vulnerability** Landform comprises incised valleys with areas subject to higher soil moisture, including seasonal inundation or waterlogging, and shallow groundwater. Vegetation includes potential GDEs (see Section 5.2.4.4) with *E. rudis* and *Melaleuca* species along streams. Valley slopes comprise vegetation more similar to uplands. The moist valley floors of this complex have a high vulnerability similar to that of Swamp complex. The valley slopes have a variable vulnerability similar to uplands.
	Pindalup (Pn)	A, D, P, S, T	**High vulnerability to fire frequency and intensity** Similar vulnerability as Murray 1 complex.	**Variable vulnerability** • A vegetation type: low impact • D vegetation type: high • P vegetation type: high impact • S vegetation type: moderate to high impact (wide range) • T vegetation type: low (Glevan Consulting, 2021)	**High vulnerability** This complex occurs on mid-lower valley slopes to the east of and in drier (semiarid and arid) zones than Helena 1 and Murray 1 and, therefore, the effects of a drying climate are likely to be more pronounced. Valley slopes comprise vegetation more similar to uplands. The moist valley floors of this complex have a high vulnerability similar to that of Swamp complex. The valley slopes have a variable vulnerability similar to uplands
	Yarragil 1 (Yg1)	C, D, W	**High vulnerability to fire frequency and intensity** The understorey in valleys can be comprised of between 50-80% obligate seeders (Burrows & Wardell-Johnson, 2003). See under Cooke complex for obligate seeder vulnerability.	**Variable vulnerability** • C vegetation type: low to high due to variability of banksia communities • D vegetation type: high • W vegetation type: moderate (Glevan Consulting, 2021)	**High vulnerability** Landform comprises upland valleys with areas subject to higher soil moisture, including seasonal inundation or waterlogging, and shallow groundwater. Vegetation includes potential GDEs (see Section 5.2.4.4) with admixtures of *E. megacarpa* and *E. patens* amongst *E. marginata* and *C. calophylla*. The moist valley floors of this complex have a high vulnerability similar to that of Swamp complex. The valley slopes have a variable vulnerability similar to uplands.
	Yarragil (Yg2)	D, E, W	**High vulnerability to fire frequency and intensity** The understorey in valleys can be comprised of between 50-80% obligate seeders (Burrows & Wardell-Johnson, 2003). See under Cooke complex for obligate seeder vulnerability.	**Moderate to high vulnerability** • D vegetation type: high • E vegetation type: high • W vegetation type: moderate (Glevan Consulting, 2021)	**High vulnerability** Landform comprises upland valleys with areas subject to higher soil moisture, including seasonal inundation or waterlogging, and shallow groundwater. Vegetation includes potential GDEs (see Section 5.2.4.4) with Jarrah and Marri giving way to large areas of swamps including Banksia and Melaleuca species. The moist valley floors of this complex have a high vulnerability similar to that of Swamp complex. The valley slopes have a variable vulnerability similar to uplands.

^ see Table 5-6 for descriptions

5.2.4.13 Existing Disturbances

Alcoa has operated in the Mine DEs since the 1970's in the Huntly DE.

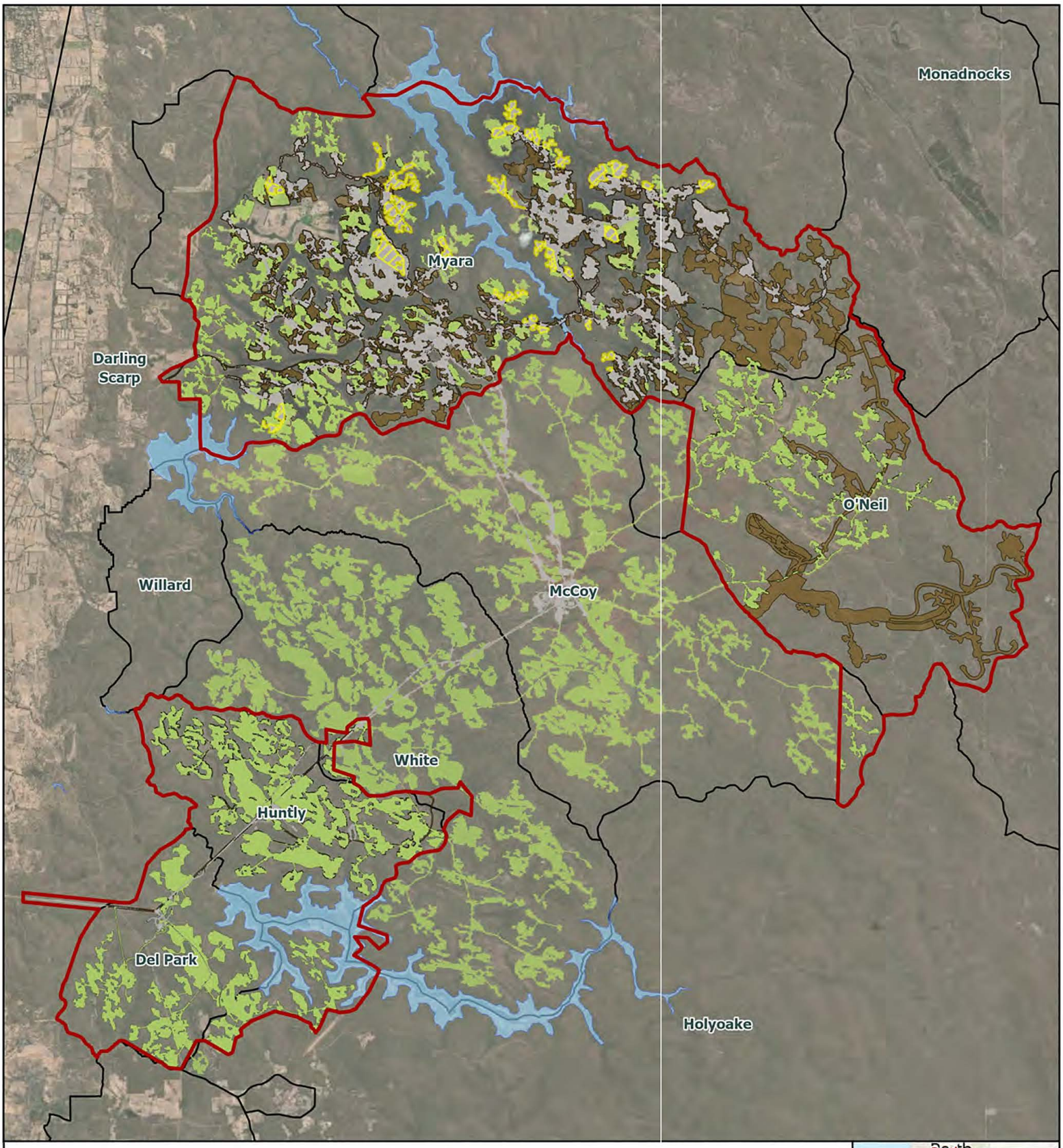
Alcoa is an acknowledged world leader in mine site rehabilitation and has evolved its rehabilitation program over more than five decades of research and development. Rehabilitation is critical to the mitigation of flora and vegetation impacts and Alcoa has a robust rehabilitation programme in place (Section 0).

The Huntly Mine DE includes 3,245 ha of previously cleared areas and 6,052 ha of rehabilitated areas, as shown in Figure 5-25. Between 2022 until 2023, 378 ha of clearing and 1,904 of rehabilitation occurred across the Huntly and Willowdale Mine DEs. Based on the current rehabilitation plan, 1,850 ha of cleared areas are expected to be rehabilitated by 2027, as shown in Figure 5-25.

The Willowdale Mine DE includes 352 ha of previously cleared areas and 650 ha of rehabilitated areas, as shown in Figure 5-26. Between 2022 until 2023, 300 ha of clearing and 1,904 of rehabilitation occurred across the Huntly and Willowdale Mine DEs. Based on the current rehabilitation plan, 233 ha of cleared areas are expected to be rehabilitated by 2027, as shown in Figure 5-26.

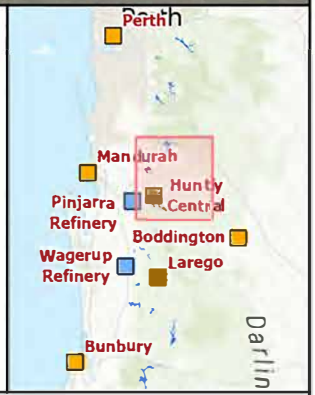
The Proposed Disturbance Footprint represents the total extent of disturbance, inclusive of conceptual clearing areas, areas which may be avoided following pre-clearance surveys (for example, Black Cockatoo known nesting and significant trees) and clearing buffers.

At Huntly, rehabilitation (up to the contour ripping stage) after topsoil clearing historically takes approximately six years for 80% of mine pits. Willowdale rehabilitation historically takes approximately four years for 80% of mine pits. Alcoa is endeavouring to minimise this timeframe, such that rehabilitation occurs within three years of clearing topsoil.



Legend

- Indicative Short Term Rehab Plan
- Huntly Mine DE
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Reservoirs
- Mining Regions



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-25 Previous and Proposed Rehabilitated Aeas - Huntly Mine DE

Kilometres

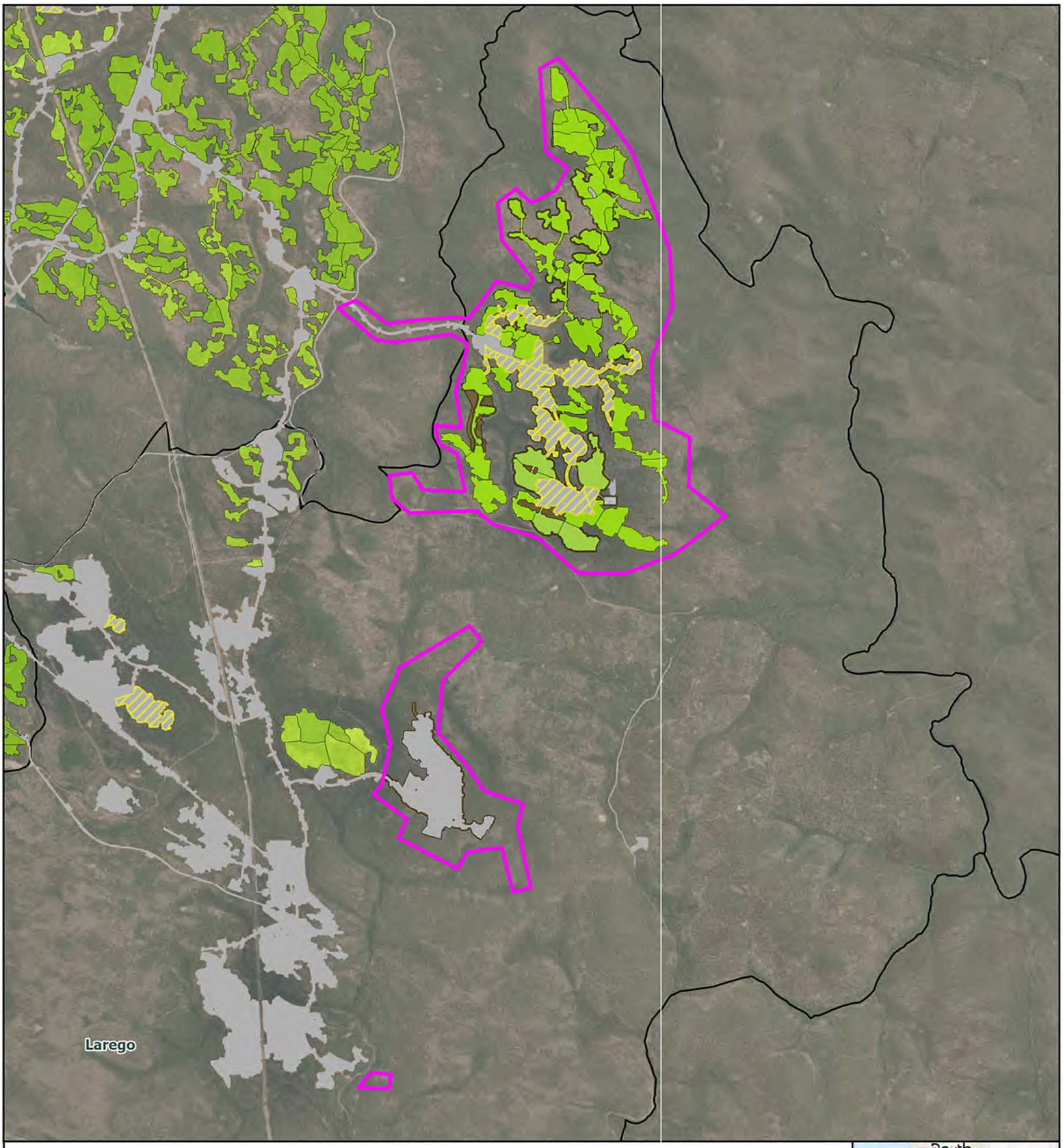
0 2 4 6 8 10 12

Scale: 1:175,000 at A4

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Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-26 Previous and Proposed Rehabilitated Areas - Willowdale Mine DE

5.2.5 Receiving Environment – Flora

5.2.5.1 Flora Diversity

The NJF subregion has moderate species richness (400–600 species per km^2), with higher species richness (500-600 species per km^2) in the high to moderate rainfall zone in the west (CALM, 1998).

The NJF subregion has previously been estimated to contain more than 784 native flora species (Bell & Heddle, 1989), the majority of which are in the understorey, with the subregion containing approximately 20 native tree species (Koch, 2007). Upland areas that are subject to mining may contain 300-400 native flora species, whereas 80 m^2 sample plots used in baseline forest monitoring typically record 50-80 native species (Koch, 2007). Floristic richness is greatest in areas which contain a combination of short-lived obligatory seeders stimulated by fire, long-lived re-sprouting species that commonly dominate the understorey, and the few species which disperse from adjacent unburnt areas (Bell & Heddle, 1989).

Results of Previous Surveys

Without comprehensive historical baseline survey data within the Mine DEs it is not possible to obtain estimates of total numbers of flora taxa inside the Mine DEs. Mattiske (2021a; 2021b) baseline surveys were conducted outside but immediately adjacent to the Huntly Mine DE and give an indication of the flora diversity within the local vicinity of the Mine DEs. A total of 681 flora taxa were recorded during field surveys within the 18,541 ha Myara North survey area (Mattiske, 2021a) (Appendix 15) and a total of 359 flora taxa in the 12,036 ha (Mattiske, 2021b) (Appendix 16). These numbers are comparable to those for the NJF subregion. The Kingsbury West, O'Neil Transport Corridor, Spion and Warrington baseline surveys (Table 5-2) are located adjacent to or within the Mine DEs, but as they only cover small areas, they are not helpful at providing an estimate of overall flora diversity.

5.2.5.2 Conservation Significant Flora

Conservation significant flora species (including Threatened, Priority, locally endemic, range-extending flora, and flora associated with restricted habitats) that could potentially occur within the Mine DEs were identified through searches of the following:

- Database search of the PMST database – using a buffer of 10 km around the Mine DEs;
- Database search of DBCA's Threatened and Priority Flora and Western Australian Herbarium databases – using a buffer of 10 km around the Mine DEs;
- A review of Alcoa's (2022a) Pinjarra Alumina Refinery Revised Proposal – Environmental Review Document Assessment No 2253; and
- Records from surveys conducted in and within the vicinity of the Mine DEs from 2020–2024 (Sections 5.2.3.3 and 5.2.3.4).

A total of 111 conservation significant flora species were identified from the searches, including: 23 species listed as Threatened under the EPBC Act or BC Act; 14 species listed as P1 by DBCA; 15 as P2; 38 as P3; and 21 as P4.

Likelihood of Occurrence

A likelihood of occurrence assessment was conducted for the 111 conservation significant flora identified as potentially occurring within the Mine DEs. Criteria for the assessment considered occurrence records (distribution and age), flora habitats and vegetation mapping over the Mine DE and the likelihood of occurrence for a particular species was ranked as follows:

- **Recorded:** Species has been recorded within the area of interest
- **Highly Likely**: Suitable habitat is likely to be present and there are records within 500 m of the area of interest;
- **Likely**: Suitable habitat is likely to be present and there are records within 2 km of the area of interest;
- **Possible:** Suitable habitat is likely to be present and there are records within 10 km of the area of interest;
- **Unlikely:** Suitable habitat is unlikely to be present; or suitable habitat may be present, but the species has not been found in the vicinity of the area of interest; and
- **Does Not Occur:** The species has a restricted distribution that does not coincide with the area of interest.

The likelihood assessment is summarised in Table 5-15. The full likelihood of occurrence assessment, including the potential habitats for these flora in the mapped VTs (Section 5.2.4.2) and potential threats to Threatened flora (summarised from the relevant species conservation advice or recovery plans) is provided in Appendix 24.

Table 5-15: Summary of likelihood of occurrence of conservation significant flora

Likelihood of Occurrence	Huntly Mine DE		Willowdale Mine DE		Comment
	Threatened species (EPBC Act / BC Act)	Priority Species (BC Act /DBCA)	Threatened species (EPBC Act /BC Act)	Priority Species (BC Act /DBCA)	
Recorded	-	16	-	-	Ten of the species were recorded in baseline and Targeted surveys from 2020–2024, and six prior to 2020. Lack of records in Willowdale Mine DE reflects absence of recent data available.
High Likely	1	1	-	2	-
Likely	1	3	-	1	-
Possible	3	27	-	9	-
Unlikely	8	23	13	58	Large number of records in Willowdale Mine DE reflects lack of survey coverage in the vicinity

Likelihood of Occurrence	Huntly Mine DE		Willowdale Mine DE		Comment
	Threatened species (EPBC Act / BC Act)	Priority Species (BC Act /DBCA)	Threatened species (EPBC Act /BC Act)	Priority Species (BC Act /DBCA)	
Does Not occur	10	18	10	18	Species with distribution limited to the Swan Coastal Plain bioregion but still fall within 10 km of the Mine DEs.

Five Threatened flora species were assessed as having a possible to high of occurrence within the Huntly Mine DE, these are discussed below.

Lasiopetalum pterocarpum (listed as EN under the EPBC Act and CR under the BC Act) is a low, open shrub that is known only from the deeply incised river valley in Serpentine National Park, where it grows in dark brown or red brown loam or clayey-sand, over granite, near creek lines and on sloping banks. It is associated with flooded gum and marri woodland over dense thickets of *Trymalium odoratissimum* subsp. *odoratissimum* and *Acacia* and *Grevillea* spp. Four natural and one translocated population comprising a total of approximately 550 individuals were recorded in 2006. The species is an obligate seeder, killed by fire and dependent on disturbance to break seed dormancy. Prolific seedling establishment occurs if a soil seed bank has had time to accumulate, as fire removes competitors for several years, allowing seedlings to become established. Subsequent survival and health depend on factors including competition. The main threats to this species include weeds (particularly blackberry), grazing by insects and kangaroos, recreational activity (trampling) and disease (Armillaria and *Phytophthora*). Too frequent or infrequent fire also threatens the survival of this species. Recommended recovery actions include: undertaking weed control, fencing plants at known sites (to protect from grazing by kangaroos), implementing a fire strategy that follows recommended fire frequency and intensity; controlling access to sites; implementing a *Phytophthora cinnamomi* plan to ensure it is not introduced to known locations of *Lasiopetalum pterocarpum* (Threatened Species Scientific Committee, 2017a).

Anthocercis gracilis (listed as VU under both the EPBC Act and BC Act) is an erect spindly shrub that grows on steep granite slopes and outcrops along the Darling Scarp in shallow, humus-rich sandy or loamy soils. In 2008, it was known from nine populations, with an estimated total of approximately 3,600 mature plants. At that time, most populations were assessed as healthy, but some had declined. The main potential threats to the species include frequent fire and weed invasion, particularly by *Watsonia* spp. Regional and local priority recovery and threat abatement actions for *Anthocercis gracilis* include: monitoring known populations and recovery progress (including effectiveness of management actions); controlling access to populations; minimise adverse impacts from land use, implement weed control programmes and prevent introduction of invasive weeds; and implement a fire management strategy to reduce frequency of fires (DAWE, 2008a).

Andersonia sp. Saxatilis (F. & J. Hort 3324) (listed as CR under the BC Act) was recorded at four locations (approximately 6,270 plants) by Mattiske (2021a) in areas adjacent to the Myara-O'Neil portion of the Huntly Mine DE. It is a single-stemmed low shrub that inhabits slopes and granite and laterite outcrops on dry, brown loam and clay over granite (Mattiske, 2021a). There have been no specific conservation advice or recovery plans published for this species.

Grevillea flexuosa (listed as VU under both the EPBC Act and BC Act) is a few-branched shrub that is known from a few locations in the Perth Hills near Stoneville and Toodyay. It grows on grows on sands of granite ridgetop plateaus and associated breakaways, and lateritic sands and gravel on hilltops, slopes and in gullies amongst heath vegetation, low-medium trees or tall shrubland. The main potential threats to the species include *P. cinnamomi,* vegetation clearing, increasing fragmentation, grazing, weeds, changed hydrology and changed fire regimes. Regional and local priority recovery and threat abatement actions for *Grevillea flexuosa* include: minimising development activities involving disturbance of vegetation or substrate in where *G. flexuosa* is known to occur; managing changes in hydrology that may cause changes in water table, run-off and salinity; developing and implementing weed management plans; ensuring that Prescribed Fire Plans do not adversely affect populations; using fencing or other barriers to reduce grazing pressure; implementing suitable hygiene controls to protect against *P. cinnamomi* (DEWHA, 2008f).

Morelotia australiensis (listed as VU under both the EPBC Act and BC Act) is a perennial, tufted sedge that is known from both the Swan Coastal Plain and Jarrah Forest south of Perth. It inhabits grey sands over clay in winter-wet, swampy depressions, drainage lines or rises surrounding swamps. Known threats to *Morelotia australiensis* include: vegetation clearing for urban development, introduction of weeds and *P. cinnamomi*, and a fire regime that is too frequent. Recommendations for regional priority recovery and threat abatement actions include: ensuring chemicals or other mechanisms used to eradicate weeds do not have a significant adverse impact; ensuring clearing activities do not adversely affect known populations; implementing a suitable fire management strategy; implementing weed control plan; implementing suitable hygiene protocols to protect against further invasion of *P. cinnamomi* (DEWHA, 2008d).

Recent Records of Occurrence

Seven baseline and four Targeted flora surveys were conducted within or in the vicinity of the Mine DEs from 2020 to 2024 (noting that none of these recent surveys were within the Willowdale Mine DE). Significant flora species results from the 2020–2024 surveys are in Table 5-16.

No flora species listed as Threatened under the EPBC Act or BC Act were recorded during baseline and targeted surveys (surveys listed in Table 5-16) within the Mine DEs. However, traverse spacing in baseline surveys is generally 120 m and, therefore, searches for Threatened species in the baseline survey areas were likely inadequate to detect the majority of the targeted flora species. The Targeted survey used a traverse spacing of 10–20 m, which is adequate for detecting the majority of the targeted species and generally aligns with EPA (2016a), which notes that an *"effective width of 10 m is acceptable for many flora in the South West"*. However, Targeted surveys cover only 2% of the Huntly Mine DE and none of the Willowdale Mine DE. Given the lack of survey intensity and coverage, there is a potential that Threatened flora species may occur within the Mine DEs.

During baseline and targeted flora surveys undertaken between 2020–2024, the following ten flora species listed as Priority by DBCA (November 2024) were recorded at 966 locations within the Huntly Mine DE and none within the Willowdale Mine DE:

- *Hibbertia ambita* (P1);
- *Hibbertia hortiorum* (P1);
- *Tetratheca phoenix* (P2);

- *Acacia horridula* (P3);
- *Grevillea dissectifolia* (P3);
- *Thysanotus anceps* (P3);
- *Calothamnus graniticus subsp. leptophyllus* (P4);
- *Cyanothamnus tenuis* (P4);
- *Senecio leucoglossus* (P4);
- *Stylidium ireneae* (P4).

Table 5-16: Conservation significant flora species recorded in or within the vicinity of the Mine DEs 2020–2024

Species	Conservation Status (State)	Surveys	VTs^	Records inside Huntly Mine DE	# recorded near Huntly Mine DE	# recorded near Willowdale Mine DE
Andersonia sp. Saxatilis (F. & J. Hort 3324)	CR	Myara North (Mattiske, 2021a).	G	-	6,270 plants at 4 locations recorded in the Myara North area in 2020.	-
Hibbertia ambita	P1	O'Neil (Mattiske Consulting, 2024b).	-	Recorded – 6 plants at 4 locations.	-	-
Hibbertia hortiorum	P1	O'Neil Transport Corridor (Mattiske Consulting, 2024a). O'Neil (Mattiske Consulting, 2024b).	-	Recorded – 312 plants at 208 locations.	3,512 plants at 160 locations recorded in 2023-24 from 0-5 km outside the Huntly Mine DE, noting further surveys are ongoing.	-
Netrostylis sp. Nannup (P.A. Jurjevich 1133)	P1	Willowdale Targeted (Eco Logical Australia, 2024).	-	-	-	1 plant at 1 location recorded in 2023 <1 km W of Willowdale Mine DE.
Paracaleana gracilicordata	P1	Myara North (Mattiske, 2021a).	G, S	-	567 plants at 6 locations recorded in the Myara North area in 2020.	-
Paracaleana granitica	P1	Myara North (Mattiske, 2021a).	G, T, D, P	-	759 plants at 7 locations recorded in the Myara North area in 2020.	-
Bossiaea modesta	P2	Holyoake (Mattiske, 2021b).	W	-	2-5 plants in 1 location recorded in the Holyoake area in 2020.	-
Grevillea ornithopoda	P2	Myara North (Mattiske, 2021a).	G	-	1 location recorded in the Myara North area in 2020.	-

Species	Conservation Status (State)	Surveys	VTs^	Records inside Huntly Mine DE	# recorded near Huntly Mine DE	# recorded near Willowdale Mine DE
Tetratheca phoenix	P2	Huntly Targeted (Ecologia, 2024b)	PW, PS, E	Total 310 plants at 136 locations	-	-
Acacia drummondii subsp. *affinis*	P3	Myara North (Mattiske, 2021a).	S, PS, D	-	4 plants at 3 locations recorded in the Myara North area in 2020, 7-14 km N of Huntly Mine DE.	-
Acacia horridula	P3	Myara North (Mattiske, 2021a) Huntly Targeted (Biologic Environmental Survey, 2024b)	AD	42 plants at 16 locations.	2 plants at 1 location recorded in Myara North area in 2020, ~8km N of Huntly Mine DE.	-
Andersonia sp. Audax (F. Hort, B. Hort & J. Hort 3179)	P3	Myara North (Mattiske, 2021a).	G, E, P	-	17,646 plants at 4 locations recorded in the Myara North area in 2020.	-
Conospermum scaposum	P3	Myara North (Mattiske, 2021a).	DA	-	2-5 plants recorded in 1 location in the Myara North area in 2020.	-
Grevillea dissectifolia	P3	O'Neil (Mattiske Consulting, 2024b).		238 plants at 128 locations.	18 plants at 12 locations recorded in 2024 <500 m outside Huntly Mine DE.	-
Grevillea prominens	P3	Spion (Mattiske Consulting, 2023b). Warrington (Mattiske Consulting, 2023c). Willowdale Targeted (Eco Logical Australia, 2024).		-	-	41 plants at 29 locations recorded in 2023 from 1-8km outside the Willowdale Mine DE (Eco Logical Australia, 2024).
Hakea oldfieldii	P3	Holyoake (Mattiske, 2021b).	T	-	2-5 plants in 1 location recorded in the Holyoake area in 2020.	-

Species	Conservation Status (State)	Surveys	VTs^	Records inside Huntly Mine DE	# recorded near Huntly Mine DE	# recorded near Willowdale Mine DE
Hemigenia microphylla	P3	Holyoake (Mattiske, 2021b).	D	-	2-5 plants in 1 location recorded in 2020 7-8 km outside the Huntly Mine DE.	-
Stackhousia sp. Redblotched corolla (A. Markey 911)	P3	Myara North (Mattiske, 2021a).	PS	-	1 location recorded in the Myara North area in 2020.	-
Thysanotus anceps	P3	Holyoake (Mattiske, 2021b). Huntly Targeted (Biologic Environmental Survey, 2024b).	SP	18 plants at 18 locations	2-5 plants in 1 location recorded in the Holyoake area in 2020.	-
Calothamnus graniticus subsp. *leptophyllus*	P4	Pinjarra Conveyor (Mattiske Consulting, 2024c).	-	154 plants at 12 locations	80 plants at 2 locations recorded in 2023 <500 m outside Huntly Mine DE.	-
Cyanothamnus tenuis	P4	Myara North (Mattiske, 2021a) Pinjarra Conveyor (Mattiske Consulting, 2024c)	-	62 plants at 14 locations	1 plant in 1 location recorded in Myara North area in 2020	-
Hemigenia platyphylla	P4	Myara North (Mattiske, 2021a).	PW	-	100 plants in 1 location recorded in Myara North area in 2020.	-
Pimelea rara	P4	Myara North (Mattiske, 2021a).	D, ST, S	-	132 plants in 3 locations recorded in Myara North area in 2020.	-
Senecio leucoglossus	P4	Holyoake (Mattiske, 2021b). Warrington (Mattiske Consulting, 2023c). Huntly Targeted (Ecologia, 2024b).	T, TS, S, PS, PT, D	1802 plants at 46 locations	104 plants at 28 locations recorded in the Holyoake area in 2020.	2118 plants at 383 locations recorded in 2020–2024 between the Mine DES, from 4-12km outside Huntly Mine DE and 0-15 km outside Willowdale Mine DE.

Species	Conservation Status (State)	Surveys	VTs^	Records inside Huntly Mine DE	# recorded near Huntly Mine DE	# recorded near Willowdale Mine DE
		O'Neil Transport Corridor (Mattiske Consulting, 2024a). O'Neil (Mattiske Consulting, 2024b). Willowdale Targeted (Eco Logical Australia, 2024). Huntly Targeted (Biologic Environmental Survey, 2024b).				
Stylidium ireneae	P4	Myara North (Mattiske, 2021a). Holyoake (Mattiske, 2021b). Huntly Targeted (Ecologia, 2024b). Huntly Targeted (Biologic Environmental Survey, 2024b).	CW, AC	44 plants at 2 locations.	24 plants in 2 locations recorded in 2020 7-8km outside the Huntly Mine DE. 2-5 plants in 1 location recorded in the Holyoake area in 2020.	-
Stylidium scabridum	P4	Myara North (Mattiske, 2021a).	D, S, PS, P, CW	-	107 plants in 6 locations recorded in Myara North area in 2020.	-

^ see Table 5-6 for descriptions

Range Extensions

The following nine flora taxa recorded within the vicinity of the Mine DEs represent extensions to the previously known range of their populations as listed on Florabase (Western Australian Herbarium, 1998):

- *Acacia browniana* var. *endlicheri* (Mattiske, 2021a): occurs to the east of the Myara North survey area;
- *Acacia browniana* var. *intermedia* (Mattiske, 2021a): occurs to the east of the Myara North survey area;
- *Boronia stricta* (Eco Logical Australia, 2024): 30 individuals were recorded across five point locations approximately 3 km west of the Tasman portion of the Willowdale Mine DE. This represents a northeast range extension of approximately 125 km;
- *Chorizema ilicifolium* (Mattiske, 2021a);
- *Conospermum scaposum* (P3) (Mattiske, 2021a): occurs mainly to the north-east of the Myara North area;
- *Cyrtostylis robusta* (Mattiske, 2021a): recorded in monitoring plots in Jarrahdale and Huntly/Myara area;
- *Empodisma gracillimum* (Mattiske, 2021a): recorded in the wider Huntly/Myara plots near the Myara North survey area;
- *Stachystemon virgatus* (Mattiske, 2021a): occurs to the north-east of the Myara North survey area; and
- *Xanthosia tasmanica* (Mattiske, 2021a): occurs mainly south of the Myara North survey area.

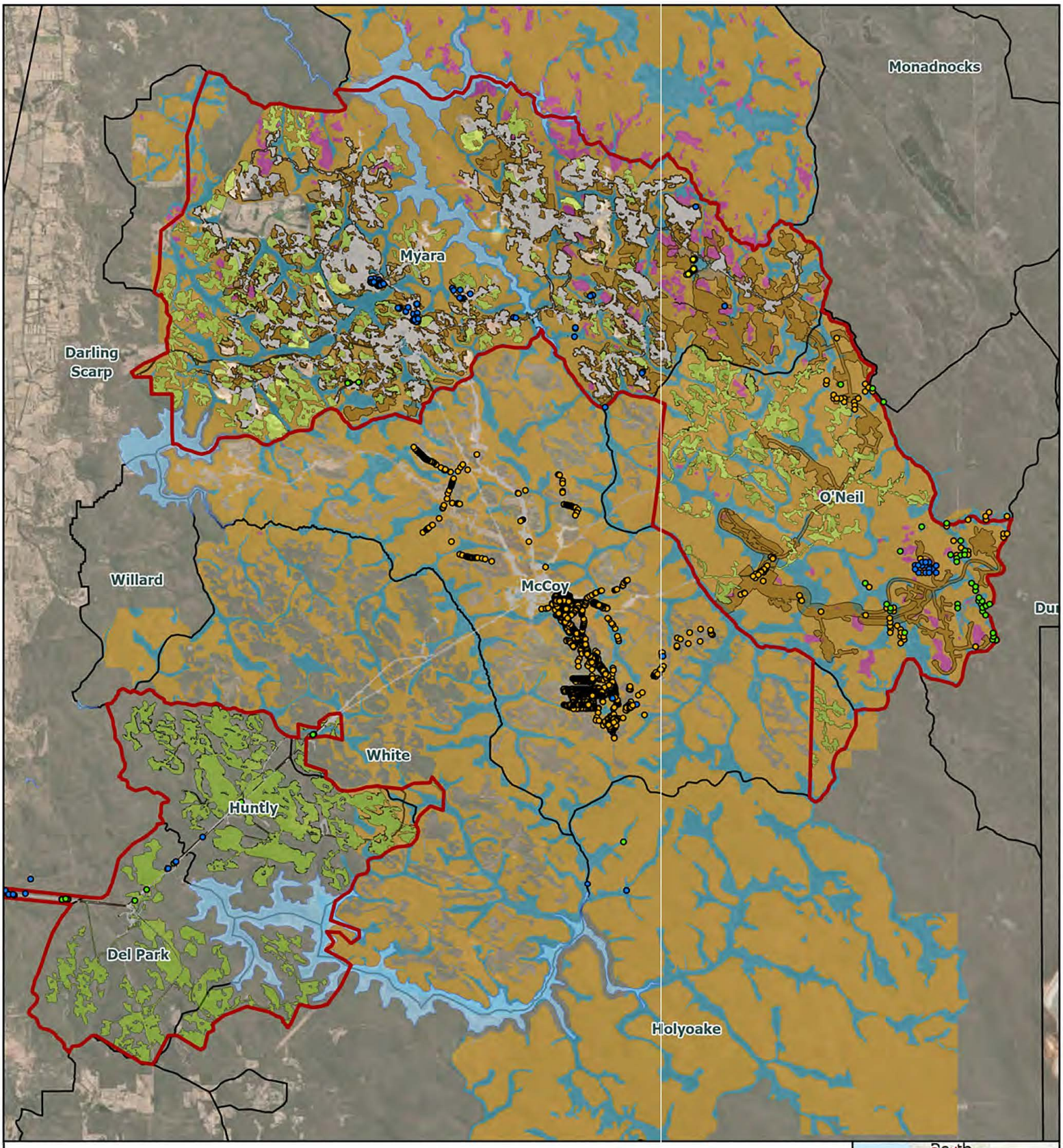
Habitats for Conservation Significant Flora

The preferred habitat (e.g., swamps, valleys, granite outcrops etc.) for conservation significant flora species recorded or possibly occurring within or in the vicinity of the Mine DEs can be interpreted through the species' associations with VTs (Section 5.2.4.2 and Appendix 25.

The five Threatened flora species with a Highly Likely, Likely, or Possible likelihood of occurrence (all within the Huntly Mine DE) prefer either granite outcrop related habitats (e.g., VTs dominated by G and R; i.e., G, G1, G2, R, R/G; see Table 5-6 for descriptions) (4 species) or potential GDE habitats (VTs dominated by A, C, D, E and W; i.e., A, AC, AD, CW, D, DA, E, PW, SW, and W).

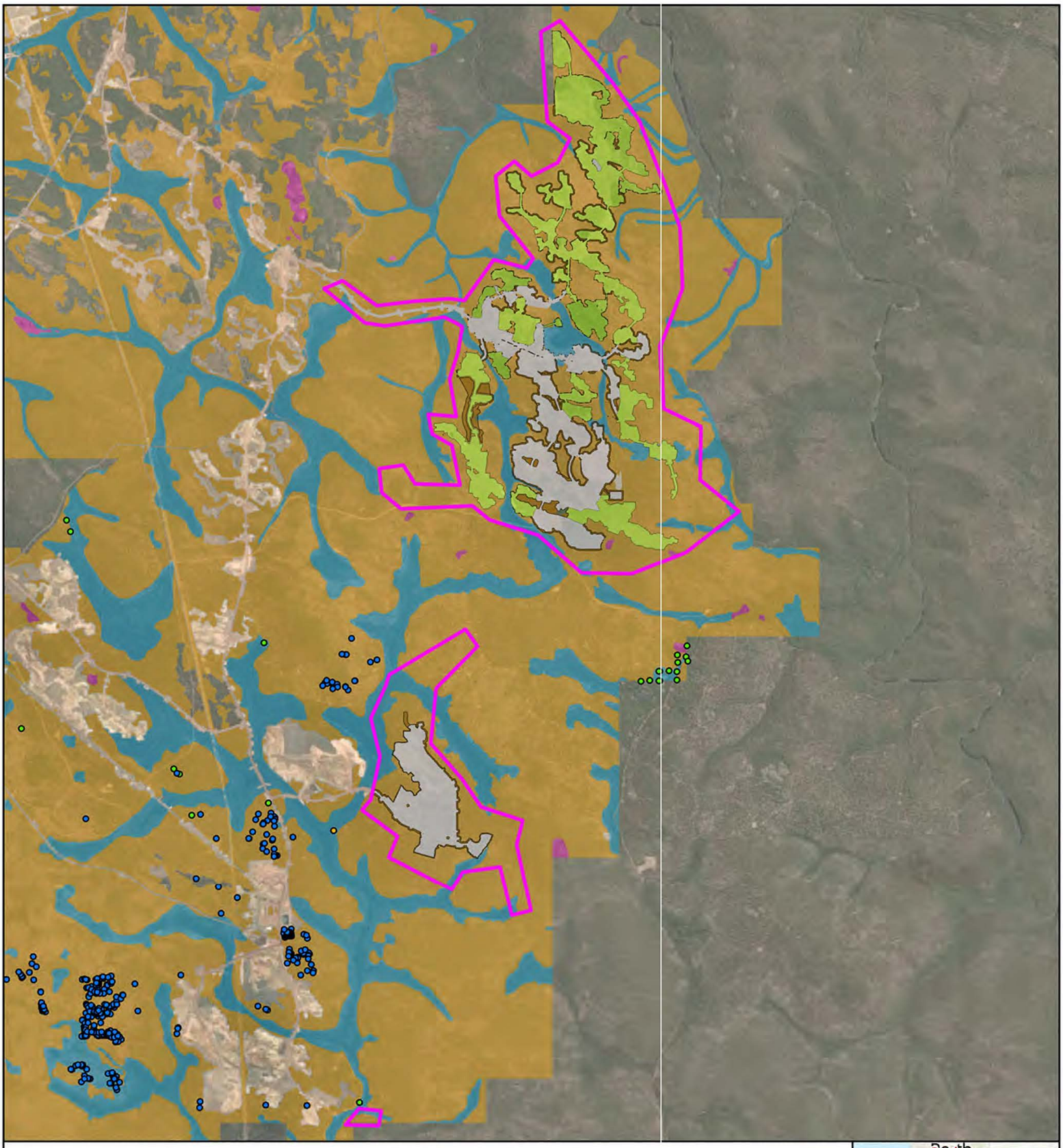
The Priority flora species either Recorded in the Mine DEs or with a Highly Likely, Likely or Possible likelihood of occurrence (47 species in the Huntly Mine DE and 12 in the Willowdale Mine DE) have a broader distribution of habitats. In the Huntly Mine DE, 21 of these species prefer habitats associated with potential GDEs, 16 prefer granite outcrops and ten are associated with the widespread lateritic uplands. Within the Willowdale Mine DE, nine of the species are associated with potential GDE habitat, two with lateritic uplands and one species with granite outcrops.

Conservation significant flora and flora habitats for the Huntly and Willowdale Mine DEs are shown on Figure 5-27 and Figure 5-28 respectively.



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-27 Conservation Significant Flora and Flora habitat - Huntly Mine DE



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-28 Conservation Significant Flora and Flora habitat - Willowdale Mine DE

Kilometres

0 0.9 1.8 2.7 3.6 4.5 5.4

Scale: 1:70,000 at A4

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5.2.5.3 Introduced Flora

Seven baseline (Table 5-2) and four targeted flora surveys (Table 5-3) were conducted within or in the vicinity of the Mine DEs from 2020 to 2024 (noting that none of these recent surveys were conducted within the Willowdale Mine DE) and their results with respect to key weed species (listed as WoNS or Declared Pest flora species) are outlined in Table 5-17 and shown on Figure 5-29. Ecological Impact and Invasiveness ratings for the Swan Region have been determined using a prioritisation process by DBCA (2016).

No introduced species listed as WoNS or Declared Pests were recorded within the Mine DEs during recent surveys. During the recent surveys, three species listed as Declared Pests under the BAM Act (one of which is also a WoNS) were recorded outside but in the vicinity of the Mine DEs:

- Narrowleaf cottonbush (**Gomphocarpus fruticosus*);
- Blackberry (**Rubus* sp.) – also listed as a WoNS; and
- Arum lily (*Zantedeschia aethiopica).

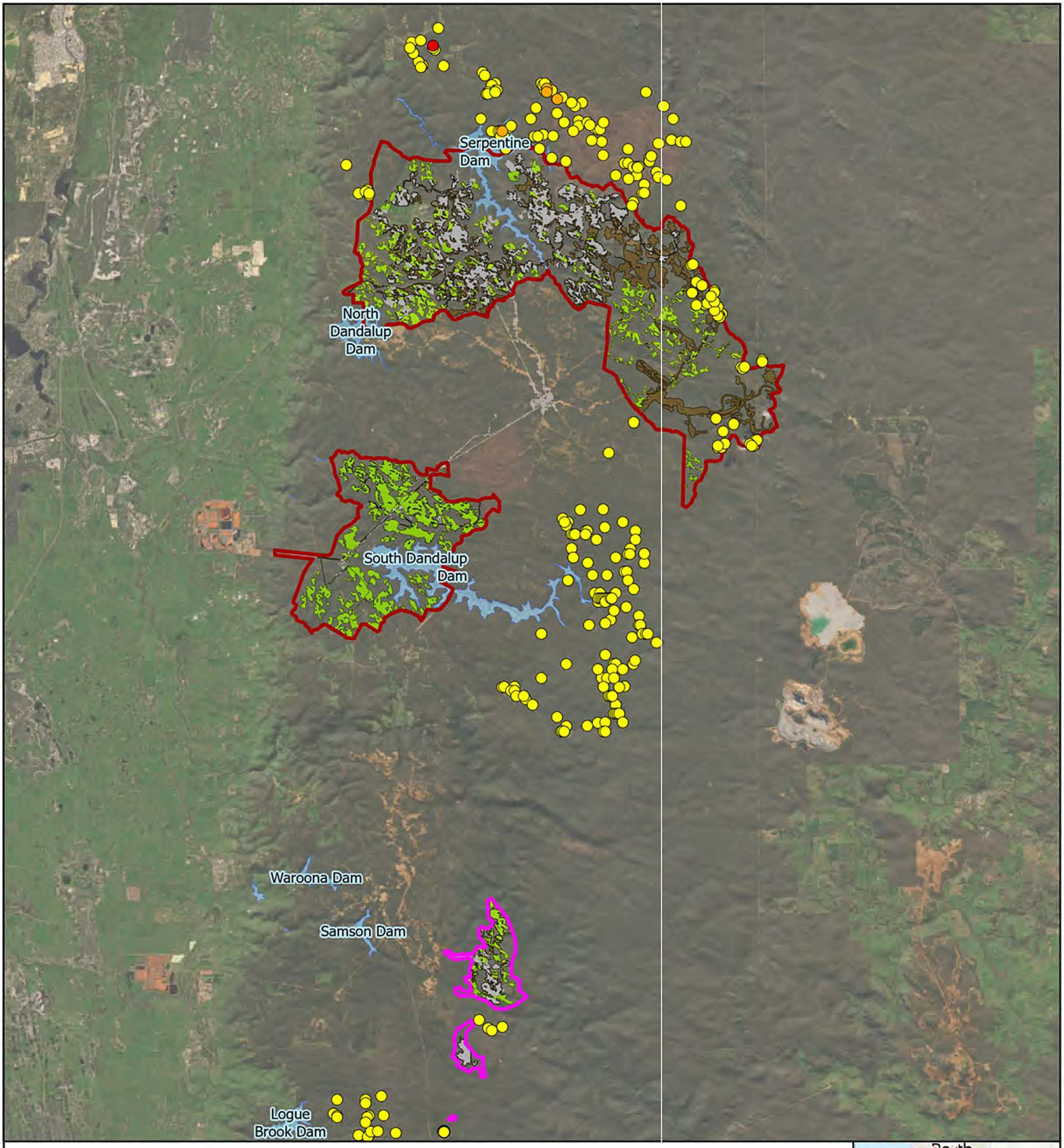
Narrowleaf cottonbush is an erect perennial herb or shrub that colonises disturbed sites and is common weed across southwestern WA. It invades run down or low fertility pastures where it displaces useful species such as clover and it is toxic to humans and livestock. Narrowleaf cottonbush also invades streamzone areas where it competes with native plants (Agriculture and Food, 2017). This species was recorded in 2020 at one location approximately 8 km north of the Huntly Mine DE.

Blackberry is a semi-deciduous scrambler to two metres high that invades pastures, riverbanks and creeklines, forming dense thickets that harbour pests such as foxes and rabbits (Agriculture and Food, 2020a). Approximately 310 plants in total spread across 31-point locations were recorded in 2023 approximately 1 km southwest of the Tasman portion of the Willowdale Mine DE (i.e., outside the Mine DE).

Arum lily is a robust, dark green, succulent perennial herb that grows to 1 m high. It is found in creeks, irrigation ditches and areas of summer-moist land in the higher rainfall southwest of WA, often forming large dense clumps. Arum lily competes with valuable perennial pasture plants on summer land. It has been claimed to cause eczema in humans. Stock deaths have occurred from grazing arum lily (Agriculture and Food, 2020b). One individual from one point location was recorded in 2023 approximately 1 km southwest of the Tasman portion of the Willowdale Mine DE (i.e., outside the Mine DE).

Table 5-17: Weeds of National Significace and Declared Pest Plants recorded in the vicinity of the Mine DEs 2020–2024

Species	Common Name	WoNS	Status BAM Act	Ecological Impact Rating	Invasiveness Rating	Surveys	# recorded near Huntly Mine DE	# recorded near Willowdale Mine DE
**Gomphocarpus fruticosus*	Narrowleaf cottonbush	No	Declared Pest – s22(2) (C3)	High	Rapid	Mattiske (2021a)	One location ~8 km north	0
**Rubus* sp.	Blackberry	Yes – as Rubus fruticosus aggregate	Declared Pest (various categories dependent on species)	High	Moderate	Eco Logical Australia (2024)	0	~310 plants across 31 locations approx. 1 km SW
**Zantedeschia aethiopica*	Arum lily	No	Declared Pest – s22(2) (Exempt)	High	Rapid	Eco Logical Australia (2024)	0	One plant in one location approx. 1 km SW

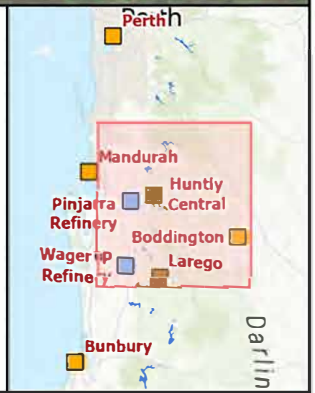


Legend

Weeds

- Declared Pest (DPIRD 2020) *Gomphocarpus fruticosus*
- High Ecological Impact (DPAW 2014)
- Other Weeds

- Huntly Mine DE
- Willowdale Mine DE
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Reservoirs



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-29 Weeds in the vicinity of the Mine DEs

Kilometres

0 4 8 12 16 20 24

Scale: 1:350,000 at A4

Date Printed: 27/02/2025

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5.2.6 Potential Environmental Impacts

The following Proposal activities have the potential to impact flora and vegetation:

- Construction of mine access and haul roads, conveyors and facilities;
- Extension of mining activities; and
- Operation of mining and haulage equipment.

The Proposed Disturbance Footprint for the Huntly and Willowdale Mine DEs are shown on Figure 1-2 and Figure 1-3 respectively.

The Proposal may result in the following potential direct and indirect impacts to flora and vegetation:

- Direct impacts as a result of clearing including:
  - Habitat loss through construction and operation of infrastructure, mine access and haul roads, conveyors and facilities (including mine pits);
  - Potential loss of and/or decline in health of significant flora and vegetation communities
  - Potential loss of significant flora while operating mine access and haul roads, conveyors and facilities.
  - Habitat fragmentation due to the loss of habitat connectivity and genetic flow through construction and operation of infrastructure, mine access and haul roads, conveyors, and facilities (including mine pits).
- Indirect impacts (include those to flora, vegetation and communities outside the proposed clearing areas) as a result of:
  - Introduction and/or spread of *Phytophthora* dieback (and other disease such as Armillaria), and introduction of and / or spread of weeds);
  - Introduction and/or spread of emerging biosecurity risks such as Myrtle Rust (*Austropuccinia psidii*) and Polyphagous Shot-hole Borer (PSHB, *Euwallacea fornicates*);
  - Indirect impacts from dust and ground vibration during construction activities.

5.2.6.1 Direct Impacts

5.2.6.1.1 Assessment Framework

The Proposal will result in the clearing of up to 4,042 ha in the Huntly Mine DE and up to 76 ha in the Willowdale Mine DE, associated with extension of mining areas, conveyors, haul roads, stockpiles, water supply and turbidity monitors. Given the indicative nature of estimates, clearing areas are presented to the nearest hectare.

The actual locations of the mine pits, facilities and infrastructure may be subject to change within the Mine DEs in response to detailed mine planning. This planning will occur on a progressive basis over inter-annual and intra-annual timeframes, and the detailed design of mine infrastructure. This flexibility ensures efficient mining and optimal resource recovery for a given disturbance area, and enables adjustment to mine infrastructure in response to pre-clearing surveys and impact avoidance measures. The retained flexibility in the areas cleared within the Mine DEs allows for adaptive management of environmental factors and is, therefore, consistent with the principles of conservation of biodiversity and ecological integrity, and waste minimisation.

5.2.6.1.2 Direct Loss of Native Vegetation at a Local and Regional Scale

For the purposes of this EIA, the impact of clearing is assessed with respect to vegetation mapped at a regional scale (vegetation associations and complexes within the NJF subregion) and at a local scale (VTs within the Huntly and Willowdale Mine DEs; Section 5.2.4.2).

Loss of Vegetation Mapped at Regional Scale

Regionally, vegetation proposed to be cleared for the Proposal (4,117 ha) represents approximately 0.37% of the 1.1 million ha of native vegetation remaining in the NJF subregion (Table 5-18).

Impacts to the four vegetation associations within the Mine DEs (refer to Section 5.2.4.1) are all less than a 1% decrease in current extent within the NJF. Following the proposed clearing, three of the vegetation associations within the Mine DEs (East Darling-3, West Darling-3 and West Darling-128) will have greater than 75% of their pre-European extent remaining; West Darling-4, which is not within Proposed Disturbance Footprint, will stay at 51.7% of the pre-European extent remaining.

Vegetation association West Darling-3, which has the highest proportion of all proposed clearing (4,012.8 ha; 97.5% of the Proposed Disturbance Footprint) is the most widespread vegetation association across the NJF subregion, with its current extent comprising approximately 38% of the subregion.

Impacts to vegetation complexes are less than a 1% decrease in current extent within the NJF for all complexes except Cooke (Ce), which will have a 1.9% reduction in current extent following proposed clearing. Following the proposed clearing, all vegetation complexes within the Mine DEs will have greater than 75% of pre-European extent remaining, except Darling Scarp (DS2), which is not within the Proposed Disturbance Footprint and will stay at 41.9% of the pre-European extent remaining.

The Dwellingup vegetation complexes D1, D2 and D4 have the highest proportion of all proposed clearing (2,498.7 ha; 60.7% of the Proposed Disturbance Footprint) and are situated on the uplands and slopes. The Dwellingup complexes comprise the greatest proportion of any vegetation complexes within the NJF, covering 24.4% of the mapped area.

Loss of Vegetation Mapped at Local Scale

The areas of VTs (Section 5.2.4.2) within the Proposed Disturbance Footprint are presented in Table 5-19 below.

The greatest proportion of clearing (81.8% Proposed Disturbance Footprint; 8.2% of the total area of the Mine DEs) is proposed to occur on slopes and ridges with sandy loam gravels and loam gravels and slopes with higher seasonal moisture (P-, S- and T-dominant VTs, i.e., P, PG, PS, PT, S, SP, SP-D, ST, T, TP, TS; see Table 5-6 for descriptions). These VTs are relatively widespread and are primarily associated with the upland areas in the high to medium rainfall zone (>900 mm/year) (Heddle, Loneragan, & Havel, 1980). In comparison, the smallest proportion of clearing (1.3% of the Proposed Disturbance Footprint; 0.1% of the total area of the Mine DEs) is proposed to occur within the G- and R-dominant VTs (i.e., G, G1, G2, R, R/G; see Table 5-6 for descriptions), which are associated with granite outcrops.

Summary

In summary, clearing for the Proposal will predominantly (over 80%) occur within widespread vegetation on lateritic soils. Proposed clearing over restricted and potentially conservation significant vegetation in swamps and broad valleys (5.1% of the Proposed Disturbance Footprint), valley floors and lower slopes (1.4%) and fringing granite outcrops (1.3%) will be restricted in area.

Vegetation Type mapping from baseline vegetation surveys is available over 4,101.8 ha (99.6%) of the Proposed Disturbance Footprint; where gaps in survey data exist, baseline vegetation surveys will be undertaken prior to the inclusion of an area proposed for clearing in an FCA, with a revised impact assessment.

Table 5-18: Estimates of Direct Impacts to Regional Vegetation – Pre-European Vegetation Associations and Vegetation Complexes

Vegetation Scale	Pre-European Extent – NJF (ha)	Current Extent – NJF (ha)	Proportion of Pre-European Extent Remaining – NJF (%)	Extent within the Mine DEs (ha)	Indicative Clearing of Proposal (ha)	Extent Remaining (NJF) after Clearing		Reduction of Current Extent due to Proposal (%)
						ha	%	
Vegetation Associations								
East Darling-3	303,496	241,876	79.7	399	103.9	241,772	79.7	0.04
West Darling-3	485,010	416,422	85.9	40,592	4,012.8	412,409	85.0	0.87
West Darling-4	49,604	25,643	51.7	164	0	25,643	51.7	-
West Darling-128	1,450	1,402	96.7	28	0.4	1,402	96.7	0.04
Vegetation Complexes								
Cooke, Ce	36,779	30,304	82.4	2,781	681.2	29,623	80.5	1.86
Darling Scarp, DS2	32,448	13,586	41.9	13	0	13,586	41.9	-
Dwellingup, D1	208,491	181,039	86.8	17,786	1,982.0	179,057	85.9	0.92
Dwellingup, D2	86,128	71,056	82.5	2,190	470.7	70,585	82.0	0.55
Dwellingup, D4	132,416	115,662	87.3	88	46.0	115,616	87.3	0.00
Helena 1, He1	15,890	12,010	75.6	73	0	12,010	75.6	-
Murray 1, My1	68,695	52,296	76.1	6,659	104.2	52,192	76.0	0.12
Pindalup, Pn	167,151	128,358	76.8	1,472	143.6	128,214	76.7	0.09
Swamp, S	53,658	40,613	75.7	765	46.2	40,567	75.6	0.10

Vegetation Scale	Pre-European Extent – NJF (ha)	Current Extent – NJF (ha)	Proportion of Pre-European Extent Remaining – NJF (%)	Extent within the Mine DEs (ha)	Indicative Clearing of Proposal (ha)	Extent Remaining (NJF) after Clearing		Reduction of Current Extent due to Proposal (%)
						ha	%	
Yarragil 1, Yg1	80,203	64,927	81.0	6,410	366.0	64,561	80.5	0.50
Yarragil 2, Yg2	50,259	46,475	92.5	2,945	277.2	46,198	91.9	0.58

Table 5-19: Estimates of Direct Impacts to Local Vegetation – Vegetation Types, Potential PECs and potential GDEs

VT	Existing area in Mine DEs (ha)	Existing Proportion of Mine DEs (%)	Indicative clearing total (ha)	Clearing as proportion of total clearing (%)	Proposal proportion of total Mine DEs (%)	Potential TEC/PEC	Potential GDE	Potential Conservation Significant flora habitat
Swamps and Broad valleys								
A	108	0.3	12	0.3	0.03	*Empodisma* peatlands	Yes	Potential Threatened (1 species – Huntly) Recorded or Potential Priority (21 species – Huntly, 9 species – Willowdale)
AC	907	2.2	16	0.4	0.04	*Empodisma* peatlands	Yes	
AD	32	0.1	4	0.1	0.01	*Empodisma* peatlands	Yes	
AW	2	0.0	-	-	-	*Empodisma* peatlands	-	
AY	28	0.1	-	-	-	*Empodisma* peatlands	-	
D	1,614	3.9	123	3.0	0.30	*Empodisma* peatlands	Yes	
DA	33	0.1	6	0.1	0.01	*Empodisma* peatlands	Yes	
DG	204	0.5	19	0.5	0.05	*Empodisma* peatlands	-	
E	112	0.3	30	0.7	0.07	*Empodisma* peatlands	Yes	
Subtotal Swamps and Broad valleys	*3,040*	*7.4*	*210*	*5.1*	*0.51*			
Valley Floors and Lower slopes								
C	37	0.1	<1	0.0	0.00	-	-	Potential Threatened (1 species – Huntly) Recorded or Potential Priority (21 species – Huntly, 9 species – Willowdale)
CQ	7	0.0	-	-	-	-	-	
CW	872	2.1	17	0.4	0.04	-	Yes	
Q	57	0.1	<1	0.0	0.00	-	-	
W	1,137	2.8	40	1.0	0.10	-	Yes	
WD	1	0.0	-	-	-	-	-	
Y	7	0.0	-	-	-	-	-	
YG	14	0.0	-	-	-	-	-	
Subtotal Valley floors and Lower slopes	*2,132*	*5.1*	*57*	*1.4*	*0.14*			
Slopes and Ridges – Sandy loam Gravels								
P	329	0.8	168	4.1	0.41	-	-	Recorded or Potential Priority (10 species – Huntly, 2 species – Willowdale)
PG	<1	0.0	<1	0.0	0.00	-	-	
PS	3,360	8.2	1,109	26.9	2.69	-	-	
PT	102	0.2	20	0.5	0.05	-	-	
S	6,233	15.1	1,330	32.3	3.23	-	-	
SP	903	2.2	254	6.2	0.62	-	-	
SP-D	9	0.0	<1	0.0	0.00	-	-	
ST	962	2.3	94	2.3	0.23	-	-	
TP	17	0.0	4	0.1	0.01	-	-	
Z	13	0.0	-	-	-	-	-	
Slopes and Ridges – Loam Gravels								
T	830	2.0	102	2.5	0.25	-	-	Recorded or Potential Priority (10 species – Huntly, 2 species – Willowdale)
TS	2,289	5.6	330	8.0	0.80	-	-	
Slopes with Higher seasonal moisture								
PW	767	1.9	235	5.7	0.57		Yes	
SW	1025	2.5	96	2.3	0.23		Yes	

VT	Existing area in Mine DEs (ha)	Existing Proportion of Mine DEs (%)	Indicative clearing total (ha)	Clearing as proportion of total clearing (%)	Proposal proportion of total Mine DEs (%)	Potential TEC/PEC	Potential GDE	Potential Conservation Significant flora habitat
SW-D	<1	0.0	-	-	-			
Subtotal – Slopes and Ridges	*15,853*	*38.4*	*3,367*	*81.8*	*8.2*			
Outcrop Areas								
G	85	0.2	<1	0.0	0.00	Granite communities		Potential Threatened (4 species – Huntly) Recorded or Potential Priority (16 species – Huntly, 1 species – Willowdale)
G1	393	1.0	9	0.2	0.02	Granite communities		
G2	1	0.0	-	-	-	Granite communities		
R	524	1.3	46	1.1	0.11	Granite communities		
R/G	5	0.0	-	-	-	Granite communities		
Subtotal Outcrop areas	*1,008*	*2.4*	*55*	*1.3*	*0.13*			
Other areas								
CL	4,387	10.7	37	0.9	0.09			
DAM	329	0.8	-	-	-			
Rehab	6,531	15.9	<1	0.0	0.00			
YS (*description unavailable)*	5	0.0	-	-	-			
Total area mapped								
-	***34,273***	***83.1***	***4,102***	***99.6***	***10.0***			

Note: VTs G, G1, G2, R & R/G may form part of the PEC 'Granite communities of the northern Jarrah Forest' (P3). VTs dominated by A, D and E may form part of the '*Empodisma* peatlands of southwestern Australia' TEC. VTs A, AC, AD, CW, D, DA, E, J, PW, SW, W and WA are correlated with GDEs. See Table 5-6 for VT descriptions.

5.2.6.1.3 Direct Loss of Threatened and Priority Ecological Communities

The '*Empodisma* peatlands' TEC and the 'Granite communities' PEC are assessed as being 'Potential to Occur' within the Mine DEs (Section 5.2.4.3) and the '*Empodisma* peatlands' TEC considered 'known to occur' within the Willowdale Mine DE.

Indicative distribution mapping of the '*Empodisma* peatlands' TEC (DCCEEW, 2023a) shows that 1,080 ha of the TEC may occur within the Huntly Mine DE (Table 5-20).

A total of 1,007 ha (3.1% of the mapped area) of the Huntly Mine DE and 1.8 ha (0.1% of the mapped area) of the Willowdale Mine DE has potential to represent the 'Granite communities' PEC.

Table 5-20: Potential Direct Impacts to potential Threatened and Priority Ecological Communities

Conservation Significant Ecological Community	Associated VT^	Mapped Extent in Mine DEs (ha)	Proposed Clearing	
			Area (ha)	Proportion of Mapped Extent (%)
Empodisma peatlands TEC	Dominated by A and D, E, J and WA	1,080	5	0.5
Granite communities PEC	G, G1, G2, R, R/G	1,009	55	5.5

^ see Table 5-6 for descriptions

5.2.6.1.4 Direct Loss of Groundwater Dependent Ecosystems

A total of 6,608 ha (16.0%) of the Mine DEs comprises potential GDEs, including 6,347 ha (16.3%) of the Huntly Mine DE and 261 ha (12.2%) of the Willowdale Mine DE (refer to Section 5.2.4.4).

The Proposed Disturbance Footprint will directly impact 8.7% (579 ha) of the mapped, uncleared extent of potential GDEs (as defined in Section 5.2.4.4) within the Mine DEs.

5.2.6.1.5 Direct Loss of Old Growth Forest

Most of the clearing in the Huntly and Willowdale Mine DEs will impact forest at establishment to immature stage (0–70 years since last harvest). No Old Growth Forest will be cleared and the total potential impact to Mature forest (70+ years since last harvest) is 596 ha in the Huntly Mine DE (10.3% of the extent within the Mine DEs) and 11 ha (2.0% of the extent in the Mine DEs) in the Willowdale Mine DE.

Areas with no record of harvesting will be mapped to confirm the regrowth stage. If Old Growth Forest is identified, it will be avoided through implementation of a MAZ.

5.2.6.1.6 Direct Loss of Ecological Linkages and Wildlife Corridors

Clearing of vegetation can result in loss of ecological linkages and wildlife corridors, which may increase the physical and genetic isolation of flora populations and decrease flora genetic and species diversity.

5.2.6.1.7 Direct Loss to Protected Areas and Conservation Areas

The Proposed Disturbance Footprint does not include any areas designated as National Park or Conservation Park. Most of the proposed clearing (99.9% of the Proposed Disturbance Footprint) will occur within State Forests (Dwellingup, Jarrahdale and Marrinup State Forests), with the remainder (0.1%) proposed to occur for rehabilitation purposes within the portion of Lane Poole Reserve designated as a Section 5(1)(g) reserve.

5.2.6.1.8 Direct Loss of Conservation Significant Flora

The impact of potential clearing of conservation significant flora habitats and populations is presented in Table 5-21.

Threatened Flora Populations and Potential Habitats

Pre-clearance Targeted flora surveys (Appendix 19, Appendix 20, and Appendix 21) have been conducted over 792 ha (2.0%) of the Huntly Mine DE and no pre-clearance Targeted flora surveys have been conducted within the Willowdale Mine DE (refer to Section 5.2.3.4). Whilst there have been no recorded Threatened flora populations within the Proposed Disturbance Footprint to date, the potential for Threatened flora to occur with the Proposed Disturbance Footprint cannot be ruled out.

The likelihood of occurrence assessment (Appendix 24) identified five Threatened flora species that have a Highly Likely, Likely, or Possible likelihood of occurrence within the Huntly Mine DE. Four Threatened flora species have potential to occur in areas associated with granite outcrops*: Lasiopetalum pterocarpum, Anthocercis gracilis, Grevillea flexuosa* and *Andersonia* sp. Saxatilis (F. & J. Hort 3324). Clearing of the Proposed Disturbance Footprint will result in direct impact to 55 ha (5.5% of that within the Mine DEs) of the granite outcrop associated vegetation. A total of 5.8 ha of those 55 ha has been covered by Targeted flora surveys (all within the Huntly Mine DE and none in the Willowdale Mine DE).

One Threatened flora species, *Morelotia australiensis*, has potential to occur in habitats associated with potential GDEs, i.e., winter-wet, swampy depressions, drainage lines or rises surrounding swamps. Clearing of the Proposed Disturbance Footprint will result in direct impact to 238 ha (3.6% of that within the Mine DEs) of the potential GDE vegetation in the Huntly Mine DE. A total of 141.1 ha of those 238 ha has been covered by Targeted flora surveys (all within the Huntly Mine DE and none in the Willowdale Mine DE).

Clearing of the Proposed Disturbance Footprint will result in direct impact to 55 ha (5.5%) of the granite outcrop associated vegetation and 238 ha (3.6%) of the potential GDE vegetation in the Huntly Mine DE.

No Threatened flora species were identified in the likelihood of occurrence assessment (Appendix 24) as having a Highly Likely, Likely or Possible likelihood of occurrence within the Willowdale Mine DE.

Priority Flora Populations and Potential Habitats

A total of ten Priority flora species have been recorded within the Mine DEs in the period 2020–2024. Six of these species are known to occur within the Proposed Disturbance Footprint:

- *Hibbertia hortiorum* (P1);
- *Tetratheca phoenix* (P2);

- *Acacia horridula* (P3);
- *Grevillea dissectifolia* (P3);
- *Thysanotus anceps* (P3); and
- *Senecio leucoglossus* (P4).

The direct impact to these significant flora species is shown in Table 5-21. Three species will have direct impacts to over 50% of their populations known within the Mine DEs: *Tetratheca phoenix* (97.4% reduction in number of individuals within the Mine DEs); *Thysanotus anceps* (66.7% reduction); and *Senecio leucoglossus* (86.0% reduction). Further surveys are underway to confirm *Hibbertia hortiorum* individuals and potential impacts.

One of the six species with existing records within the Proposed Disturbance Footprint, *Tetratheca phoenix*, is known to occur only within 10 km of the Mine DEs (Western Australian Herbarium, 1998), (Atlas of Living Australia, 2024a). Records from the DBCA TPFL and WAH database searches indicate that populations at 10 locations (unspecified number of individuals) are known inside and within 10 km of the Mine DEs. Data from baseline and Targeted flora surveys shows that 310 individuals from 136 locations are located inside the Mine DEs; of these, 302 individuals from 134 locations are within the Proposed Disturbance Footprint.

The other five species recorded in 2020–2024 within the Proposed Disturbance Footprint have distributions that extend further than 10 km outside the Mine DEs and/or are widespread within the NJF.

A further six Priority flora species were recorded (Section 5.2.5.2) within the Huntly Mine DE prior to 2020 (DBCA TPFL and WAH database search) (Appendix 25). Five of these species are widespread either within the NJF or the Swan Coastal Plain. The sixth species, *Drosera silvicola* (P1) is only known from four other locations in the NJF outside the Mine DEs. There is one record of *D. silvicola* within the Mine DEs (from 2012); this record is located within the Proposed Disturbance Footprint.

Impacts associated with other conservation significant flora will be addressed in FCAs, with consideration of the results of pre-clearance Targeted flora surveys.

As described above, the likelihood of occurrence assessment (Appendix 24) noted 16 Priority flora species that have been recorded within the Huntly Mine DE. A further 36 Priority flora species were assessed as being Highly Likely, Likely or Possible to occur in the Mine DEs. Of these 52 Priority flora species, 20 have potential to occur in areas associated with granite outcrops, 25 species have potential to occur in habitats associated with potential GDEs (i.e., winter-wet, swampy depressions, drainage lines or rises surrounding swamps), and 22 species are associated with lateritic soils on uplands (some species are associated with more than one habitat). Further detail on preferred habits for Priority flora species is provided in Section 5.2.5.2.

Clearing of the Proposed Disturbance Footprint will result in direct impact to 55 ha (5.5%) of the granite outcrop associated vegetation, 580 ha (8.8%) of the potential GDE vegetation and 3,411 ha (22.7%) of the vegetation associated with lateritic soils within the Mine DEs.

Whilst the proportion of clearing of vegetation associated with lateritic soils on uplands is large, this vegetation is widespread across the Mine DEs and NJF (Section 5.2.4.1). Accordingly, it is expected that there will be substantial areas of similar potential habitat for the species remaining in the subregion.

Table 5-21: Estimates of Direct Impacts to Conservation Significant Flora Recorded in the Mine DEs 2020–2024 and their Habitats

Species	Conservation Status (DBCA)	Preferred habitat	# individuals recorded within Mine DEs	Area of potential habitat within Mine DEs (ha)	# individuals remaining after clearing	Area of potential habitat remaining after clearing (ha)	Reduction in # individuals due to Proposal (%)	Reduction in potential habitat area due to Proposal (%)	Distribution outside Mine DEs^
Hibbertia ambita	P1	Laterite	4	15,033	4	11,622	0	22.7	All records outside the Mine DEs are clustered 30-40km E of the Mine DEs.
Hibbertia hortiorum	P1	Laterite	208	15,033	172	11,622	17.3	22.7	Over 100 populations have been recorded within 10 km of the Mine DEs, with only a few populations known from outside this area. Further surveys are underway to identify further records.
Tetratheca phoenix	P2	Granite	136	1,009	2	953	98.5	5.5	Known to occur only within 10 km of the Mine DEs.
Acacia horridula	P3	GDE Laterite	16	6,608 15,033	14	6,028 11,622	12.5	8.8 22.7	There are at least 27 records within 10 km of the Mine DEs and this species also has a known distribution reaching approximately 100 km along the western margin of the NJF.
Grevillea dissectifolia	P3	GDE Laterite	126	6,608 15,033	122	6,028 11,622	3.2	8.8 22.7	There are approximately 30 records within 10 km of the Mine DEs and this species is also widely distributed within the NJF, with known locations across an area 100 km from north to south and 50 km from west to east.
Thysanotus anceps	P3	GDE Laterite	18	6,608 15,033	6	6,028 11,622	66.6	8.8 22.7	There are only 3 records within10 km of the Mine DEs but several more records stretching approximately 80 km north to south within the western half of the NJF.
Calothamnus graniticus subsp. leptophyllus	P4	Granite Laterite	12	1,009 15,033	12	953 11,622	0	5.5 22.7	Over 100 known locations within 10km of the Mine DEs. Multiple other records distributed along 100km of the western half of the NJF.
Cyanothamnus tenuis	P4	Granite Laterite	14	1,009 15,033	14	953 11,622	0	5.5 22.7	Approximately 20 known locations within 10km of the Mine DEs. Widespread throughout the entire NJF.
Senecio leucoglossus	P4	GDE	426	6,608	86	6,028	79.8	8.8	This species has hundreds of records within 10 km of the Mine DEs and is widespread in the western half of the NJF with a north to south range of 60 km.
Stylidium ireneae	P4	Granite Laterite	4	1,009 15,033	4	953 11,622	0	5.5 22.7	A total of 24 known locations within 10km of the Mine DEs. Multiple other records distributed along 30km of the western half of the NJF.

^See Appendix 24 for further detail; note the number of individuals recorded within the Mine DE may differ to the number provided in the Appendices. The number of individuals referenced in the Appendices is derived from individual studies and as such does not take into account the recording of the same individual.

5.2.6.2 Indirect Impacts

5.2.6.2.1 Fragmentation of Vegetation

The Proposal has the potential to indirectly impact flora and vegetation within the Mine DEs through fragmentation of vegetation and hence increased edge effects. Margins of vegetation patches are exposed to greater dust (reducing a plant's ability to photosynthesise and increasing leaf temperature), light and wind (and therefore increased drying), which then result in changes in understorey structure and composition.

5.2.6.2.2 Introduction and/or Spread of Weed Species

The Proposal has the potential to introduce and/or spread weeds within the Mine DEs through the following activities:

- Movement of earthmoving machinery, heavy and light vehicles;
- Topsoil movement from cleared to rehabilitated areas; and
- Stormwater runoff from stockpiles.

Potential Introduction of Weed Species

The highest potential for introduction of weeds occurs through movement of vehicles and equipment entering the Mine DEs.

Potential spread of Existing Weed Species

No WoNS or Declared Pest plant species have been recorded within the Mine DEs. However, WoNS and Declared Pest plant species have been recorded within the last five years outside, but within the vicinity of the Mine DEs (refer to Section 5.2.5.3). The lack of data on key weed species is likely due to both lack of survey coverage of large parts of the Mine DEs and the type of surveys conducted (e.g., baseline vegetation surveys are focussed on mapping vegetation types without systematic searching for key weed species).

There is potential for key weed species to be present within the Mine DEs, particularly in cleared and disturbed areas, along tracks, or in creek lines or valley floors which act as vectors for weed invasion. Accordingly, construction and operations have the potential to spread existing weed infestations within the Mine DEs where they interface with these areas. Construction of haul road and conveyor crossings over creeks and swamps, or forest access tracks, are the activities most likely to encounter and spread weeds. Haul road development, topsoil stripping and rehabilitation over creeks and swamps, or forest access tracks, are the activities most likely to encounter and spread weeds during operations.

Impact of Introduction and/or Spread of Weeds

Weeds can impact biodiversity of an area by competing with native understory species, thereby changing the structure and composition of the understorey, altering the fire regime and changing the nature of habitat available for native fauna. Weed invasion is listed as a threatening process for four of the five Threatened flora identified as potentially occurring within the Mine DEs (Appendix 24).

The Mine DEs contain vegetation communities vulnerable to weed invasion, particularly valley and swamp communities (VTs dominated by A, C, D, E and W; i.e., A, AC, AD, CW, D, DA, E, PW, SW, and W; see Table 5-6 for descriptions) that are restricted in distribution, retain soil moisture and provide habitat for Threatened and Priority flora.

Granite outcrops (VTs dominated by G and R; i.e., G, G1, G2, R, R/G; see Table 5-6 for descriptions) are also restricted in distribution and provide habitat for Threatened and Priority flora. Granite outcrops are typically located at higher elevations in the landscape but may still be located adjacent, downhill or downstream of weed invasion that may then spread into the outcrops. Granite outcrops can also retain moisture through seepage faces at the base of outcrops.

The dominant lateritic vegetation (VTs dominated by P, S and T; i.e., P, PG, PS, PT, S, SP, SP-D, ST, T, TP, TS; see Table 5-6 for descriptions) within the Mine DEs typically occurs higher in the landscape and retains less moisture; however, it can also be subject to weed invasion.

As presented in Section 5.2.6.2, the Proposed Disturbance Footprint is predominantly located (over 90%) within the dominant lateritic vegetation types (P, S and T), with limited (5.1%) proposed clearing in swamps and broad valleys (5.1%), Valley floors and lower slopes (1.4%) and granite outcrops (1.3%). This indicates that the Proposal will have limited direct interface with swamps, valleys and granite outcrops and that the greatest potential for weeds to spread into these restricted distribution communities will be via stormwater runoff and creek flow.

The impact of weeds to swamps, creeks and granite outcrops is likely to depend on whether there are existing weed invasions in these areas due to past public access, timber harvesting, forest management and exploration activities. Swamps, creeks and outcrops in isolated catchments that have remained free of weeds are expected to be in comparatively better condition and more vulnerable to impacts from weed invasion.

5.2.6.2.3 Introduction and/or Spread of *Phytophthora* dieback and other Forest Diseases

The Proposal has the potential to spread *Phytophthora* dieback within the Mine DEs through the following activities:

- Movement of earthmoving machinery, heavy, and light vehicles
- Topsoil movement from cleared to rehabilitated areas or stockpiles
- Stormwater runoff

The Proposal does not involve any importation of soil or earth materials from outside the Mine DEs.

In contrast to the limited presence of key weed species, the Mine DEs (where mapped) have widespread infestation by *Phytophthora* dieback (Section 5.2.4.8). Within the Huntly Mine DE, the western half of the Myara-O'Neil portion is mostly Infested and the eastern half predominantly Uninfested, and most of the Huntly-Del Park portion is not mapped. Most of the Willowdale Mine DE is in the Infested zone. Accordingly, the potential impacts of the Proposal primarily relate to the spread of *Phytophthora* dieback from Infested to Uninfested areas.

Alcoa has investigated the residual spread of *Phytophthora* dieback from bauxite mining after the application of *Phytophthora* dieback hygiene management. An initial monitoring program covering 141 km of boundary between Uninfested forest and mining operations indicated new infestation to 6.55 ha over an initial 1,950 ha mining area, or 0.003 ha per hectare cleared for mining (Colquhoun & Hardy, 2000). Subsequent monitoring programs

determined that mining related *Phytophthora* dieback spread at 0.006-0.007 ha per hectare cleared for mining (Grant & Koch, 2007). Adopting a conservative estimate of 0.007 ha per hectare, the Proposal may result in the spread of *Phytophthora* dieback to approximately 29 ha of Uninfested forest.

Potential Spread of Existing Phytophthora dieback

Construction within creeks and swamps will encounter existing *Phytophthora* dieback infestations, which could be spread to other areas through movements of construction equipment and vehicles. Operations have the potential to spread *Phytophthora* dieback throughout the mine pits and haul road network, through the movement of earthmoving machinery and infested topsoil between clearing areas and other areas such as topsoil stockpiles and rehabilitation. Spread of *Phytophthora* dieback with stormwater runoff to Uninfested sites downstream is unlikely as the majority of creek and swamp areas are already mapped as Infested.

Mine pits will be situated over uplands that have a higher proportion of Uninfested areas and *Phytophthora* dieback vulnerable vegetation. Accordingly, progressive development of haul roads and movement of vehicles and equipment may result in the spread of *Phytophthora* dieback from Infested areas in valleys and swamps, to Uninfested areas in the mine pits.

All overburden and the majority of topsoil that is stripped within a mine pit is stockpiled and reused in areas with corresponding dieback status, thereby substantially preventing the export of any *Phytophthora* dieback present to other areas. However, topsoil may be exported to other mine pits or to haul roads in the event of a local shortfall at those locations to meet minimum topsoil depths (as per completion criteria).

Similarly, mine facilities and infrastructure corridors will not be rehabilitated until the end of mining activities within each mine region and so overburden or topsoil stripped from these areas may be stored as long-term stockpiles until closure. The export of overburden or topsoil material from infested areas within the Mine DE may cause infestation if reused in uninfested areas.

Impact of Introduction and/or Spread of Phytophthora dieback

Phytophthora dieback spread into Uninfested areas is expected to have a range of impacts depending on the flora species composition. The Mine DEs predominantly have vegetation types with Moderate to High vulnerability to impact (refer to Section 5.2.4.8).

Dieback spread is characterised by an infection front of dead and dying susceptible understorey species of Proteaceae, Myrtaceae, Fabaceae, and Ericaceae families. *Banksia grandis* is a notable indicator of infestations due to is size, widespread occurrence and rapid mortality. Jarrah (E. *marginata*) dies after the understorey, most commonly on poorly drained and infertile soils, and may persist in some areas. Other eucalypt canopy species (*C. calophylla*, *E. patens, E. rudis, E. megacarpa*) are resistant to *Phytophthora* dieback.

The effects of *Phytophthora* dieback on Jarrah forest vegetation have been described by Shearer and Tippett (1989) and Shearer (1994). Dieback impact in the Jarrah Forest results in a loss of floristic diversity and change in community structure and function (Shearer B. , 1994). Jarrah dominant forest with a diverse understorey is characteristically replaced by open woodlands with Marri dominant canopy and sedge dominant understorey. The loss of floristic diversity can include loss of conservation significant flora, either through direct vulnerability or loss community structure / habitat. Two Threatened species with potential to

occur in the Mine DEs are considered vulnerable to *Phytophthora* dieback: *Andersonia* sp. Saxatilis (F. & J. Hort 3324)(CR under the BC Act) and *Grevillea flexuosa* (VU under both the EPBC Act and BC Act), both associated with granite outcrop habitats. Ten Priority flora species are also considered vulnerable.

Spread of other Forest Diseases

There is potential for the Proposal to result in the spread of ARD and Marri canker; however, there is limited information to predict the magnitude of impact.

Based on the limited impact of ARD within the NJF, it is unlikely that the Proposal would spread ARD such that significant impacts occur to flora and vegetation.

There is no published data on Marri canker occurrence within the Mine DEs; however, the disease has been demonstrated to occur along roadsides in high rainfall areas of the southwest region. The Mine DEs lie in a high rainfall zone of the NJF and accordingly there is potential for the Proposal to introduce and/or spread Marri canker along the boundaries of disturbed areas such as haul roads or infrastructure corridors or the mine facilities. The potential for Marri canker to occur along the boundaries of mine pits is unknown.

5.2.6.2.4 Spills and/or Leaks from Storage and Handling of Hazardous Materials and Waste

The Proposal has the potential to cause impacts to flora and vegetation due to spills and/or leaks of hazardous materials or wastes. The potential for spills and/or leaks of hazardous materials or wastes to contaminate soils and water is detailed under Terrestrial Environmental Quality in Section 5.4.5 and Inland Waters in Section 5.5.6.

As presented, all storage and the majority of handling of hazardous materials and wastes will occur at the mine facilities, within bunded and sealed areas; however, refuelling and maintenance of earthmoving equipment will occur in the field and may result in spills or leaks outside of bunded areas. There is also potential for vehicle accidents to result in spills in the field. The highest likelihood of spills or leaks occurring will be in cleared mine pits or haul roads.

If they occur, spills and/or leaks of hazardous materials or wastes have potential to cause localised impact to vegetation condition and potentially death in the vicinity of the soil or water contamination.

5.2.6.2.5 Dust Emissions

The Proposal will generate dust emissions from mine development, bauxite mining, and rehabilitation operations as well as from open mine pits in the period between clearing and completion of rehabilitation. The assessment of dust emissions from mining is detailed i the Social Surroundings – Amenity factor in Section 5.7.4.2.1.

There is little published research available on the quantified effects of dust deposition on native vegetation within the NJF; some information is given below.

The deposition of dust has the potential to adversely affect native vegetation, primarily by reducing photosynthesis and increasing leaf temperature (Doley, 2006) (Doley & Rosato, 2010). Farmer (1993) demonstrated that inert mineral dusts can impair plant growth when surface loads exceed 7 g/m^2.

Dust accumulation is expected to peak during the summer and autumn seasons when high rainfall events are infrequent, though it can be increased by high wind events. Climatic data for the Dwellingup BOM station (site 009538) indicates that summer and autumn winds exceed 20 kmph (5.6 m/s) approximately 20% of the time, suggesting potential for dust removal during this period.

Understorey vegetation is potentially more susceptible to dust accumulation and impact, as predicted by Doley (2013). However, the Jarrah Forest understorey is likely to exhibit lower photosynthetic activity during summer and autumn due to shallower roots and limited access to soil moisture compared to deeper-rooted overstorey species. As a result, dust accumulation that occurs during summer and autumn between wind events may have limited impacts on understorey vegetation. Following winter and spring rains and the recharge of shallow soil moisture, the understorey vegetation will become more active. However, this will coincide with rainfall events that cause dust wash-off and reduce dust accumulation. Alcoa has developed mitigation measures associated with dust emissions, which are outlined in Social Surroundings – Amenity (see Section 5.7.5).

5.2.6.2.6 Water Use for Dust Suppression

Alcoa will apply dust suppression water on haul roads and mine pits, using a combination of harvested stormwater and treated oily wastewater from mine facilities, supplemented by water sources from public drinking water sources. The use of water for dust suppression has the potential to impact flora and vegetation in the areas adjacent to the application areas. These impacts can be as a result of excess water runoff and mobilisation of contaminants from the surface of the application areas, and spray drift from the application areas.

Dust suppression is limited to when conditions require, which is during periods of dry ground conditions that may result in dust lift off from prevailing winds or vehicle activity. Dust suppression is not required during wet ground conditions or when rainfall is forecast. Alcoa use sumps along the margins of haul roads to capture any run-off that may occur.

Due to the dry ground conditions and lack of incidental rainfall, applied dust suppression water will be absorbed by the dry surface of the application area and lost to evaporation over the following day, and is not expected to cause widespread or substantial runoff from application areas. Any localised runoff (e.g., if caused by over-application or impervious areas) will be limited in volume and captured by Alcoa's mine drainage system, which is designed to capture much larger volumes of surface runoff from major storm events overhaul road and mine pit catchments. Accordingly, dust suppression is unlikely to cause runoff that causes significant impacts to adjacent flora and vegetation.

Impacts from spray drift can occur during windy conditions, when fine droplet water used during dust suppression is mobilised away from the application area. Unlike surface water runoff, spray drift is not captured by Alcoa's mine drainage system and so can be transported to adjacent vegetation. This excess water can then potentially increase the risk of pathogen growth on foliage, increasing the risk of impacts from disease related foliage decline. However, dry conditions that lead to a requirement for dust suppression are likely to result in increased evaporation both within the mining area, but also within areas of vegetation. Therefore, the increase in spray drift potential is likely to be mitigated by an increase in evaporation, limiting the time excess moisture is present on adjacent vegetation.

5.2.6.2.7 Altered Hydrology/Groundwater Regimes

Mining activities can result in altered hydrology, including alteration of surface water flow and groundwater level. Surface water dependent ecosystems (e.g., streamzone vegetation), GDEs and other sensitive ecosystems can be impacted through changes in water regimes, including changes in plant available water and surface water mechanical effects (runoff causing erosion of substrate and increased turbidity). It is anticipated that groundwater mounding will occur beneath and around mine pits because of the removal of native vegetation and the subsequent increase in rainfall recharge. The most significant rise in groundwater levels is expected to happen near the mining areas, while a more moderate rise is predicted in valleys where potential GDEs are situated. This will possibly benefit groundwater dependent vegetation in the valleys but have less effect on vegetation on slopes and uplands that is not dependent on groundwater.

5.2.6.2.8 Change in Fire Regimes

The southwest forests have been subject to fire for cultural reasons by indigenous people for up to 60,000 years prior to European settlement. The plants of the southwest forest region, including both canopy and understorey species have adapted to this fire regime and are resilient to lower intensity fire. However, higher intensity and/or more frequent fires can result in damage or death to plants and damage to or loss of the soil seedbank.

Controlled burning activities in the southwest forests of WA are undertaken by DBCA, and as such the role of burning in Alcoa operations is undertaken in consultation with district and regional DBCA offices. Fire activities are undertaken in pre-clearing areas in consultation with DBCA. The plants of the southwest forest region have mechanisms to be resilient to fire and recent efforts have been undertaken to manage the forests to minimise risks associated with uncontrolled intense wildfires which is unfavourable to some plant species.

Fire is generally excluded in the initial rehabilitation phases, partly as the fuel load is not sufficient to carry the fires but mainly to protect the establishment and growth of forest trees in the overstorey and to develop biodiversity values in the rehabilitation areas. Older rehabilitation areas are subject to fire when the initial risk to biodiversity values is reduced.

5.2.7 Mitigation

Environmental management of the Huntly and Willowdale Mine DEs incorporates the mitigation hierarchy consistent with Western Australian guidance, which is in order of priority: avoidance, minimisation and rehabilitation.

The FVMP (Appendix 11) specifically addresses management of the risks and impact of bauxite mining on key environmental values associated with flora and vegetation, including environmental objectives and management targets. Mitigation measures, as outlined in the FVMP, are summarised in Table 5-23, below. The FVMP is currently being implemented as part of existing operational practises and is expected to be revised to reflect the information, mitigations and outcomes provided in this ERD. Therefore, the ERD is considered to take precedence over the FVMP.

5.2.7.1 Environmental Management System

Alcoa operates the Huntly and Willowdale Mines through a mature environmental management system that meets international standards and undergoes continual improvement. Alcoa has undertaken flora and vegetation surveys within the Huntly Mine since the late 1980s, using the same vegetation mapping methodology conducted for this Proposal. The surveys have guided mine planning and informed the clearing approval process under Alcoa's existing State Agreements Administrative Framework.

Alcoa's *Phytophthora* dieback management system has been developed over five decades, in accordance with arrangements agreed with DBCA, and has been demonstrated to effectively mitigate dieback spread during mining.

Alcoa manages dust emissions and contaminant discharges through established strategies and procedures and through continual improvement, which minimise the potential impacts to adjacent vegetation. Alcoa commits to implementing a dust management plan for Mine operations to minimise dust impacts to sensitive receptors such as rural properties (see dust emissions section within 5.2.6.2.5), which will also reduce the potential for dust impacts to vegetation. Alcoa's Dust Management Plan is currently under development with mitigation measures included in Section 5.7.5.

Alcoa's preventative risk management framework for drinking water quality incorporates multiple barriers to prevent contaminant discharges, such as hydrocarbons or sediment (see spills and/or leaks section within 5.2.6.2). Though designed to protect water quality, these multiple barriers will also reduce the risk of discharges occurring that could impact vegetation at the discharge site as well as along streamzones downstream.

5.2.7.2 Avoidance Measures

Mining Avoidance Zones

As part of the Proposal, Alcoa has committed to the protection of key flora and vegetation values and areas identified by environmental studies and stakeholder consultation, which include:

- TECs;
- Old Growth Forest;
- Known Threatened flora populations and their immediate surrounding habitat; and
- National Parks and formal conservation reserves.

MAZs, incorporating the above values and areas, have been developed through collaboration between Alcoa's mine planning, engineering and environmental teams. MAZs within the Huntly and Willowdale Mine DEs are shown on Figure 5-30 and Figure 5-31 respectively. MAZs currently comprise a total of 2,910.96 ha (7.5%) of the Huntly Mine DE and 484.77 ha (22.7%) of the Willowdale Mine DE.

Mining activities prohibited within the MAZs include all disturbance (with the exception of monitoring and management activities which have minimal impacts), such as clearing for pits, construction of haul roads, mine infrastructure and facilities, stockpiles and ROM pads etc.

Given the paucity of information available on presence and distribution of potential TECs within the Mine DEs (and hence Proposed Disturbance Footprint), it is recommended that

future pre-clearance Targeted flora surveys also include a Targeted vegetation component to identify TEC and PEC occurrences for appropriate avoidance measures.

Targeted flora surveys should be conducted at optimal times in native vegetation prior to clearing and any Priority or other conservation significant flora species identified through these surveys may be avoided through implementation of LDAs.

As mine planning progresses, the area to be considered within MAZs may be further expanded to protect additional areas.

Limited Disturbance Areas

Limited Disturbance Areas (LDAs), in which mine pits are prohibited but infrastructure and haul roads are allowed are implemented for:

- Granite outcrops greater than 1 ha with a 50 m buffer;
- Confirmed PECs;
- Mapped streamzone vegetation and a 100 m buffer; and
- Priority and other significant flora (as far as practicable).

Given the paucity of information available on presence and distribution of potential PECs within the Mine DEs (and hence Proposed Disturbance Footprint), it is recommended that future pre-clearance Targeted flora surveys also include a Targeted vegetation component to confirm PEC occurrence.

Targeted flora surveys will be conducted at optimal times in native vegetation prior to clearing and any Priority or other conservation significant flora species identified through these surveys may be avoided through implementation of LDAs, as detailed in the FVMP (Appendix 11). The Proposal activities will be managed (through avoidance and indirect impact management) to ensure that no disturbance or adverse impacts to more than 2% of the known population of Priority listed flora species occurs, until it can be demonstrated that more than 100 individuals have been recorded, in which case up to 10% of the known population can be impacted. This impact limit has been established through bench-marking against other recent proposals approved with Ministerial Statement conditions.

The key flora and vegetation areas protected through the MAZs and LDAs are shown in Table 5-22 below. MAZ and LDA areas will be revised as a result of further survey information.

Table 5-22: Key Values Currently Protected through Mining Avoidance Zones and Limited Disturbance Areas

Key value	Area within Huntly Mine DE (ha)	Portion within MAZ / LDA (ha / %)	Area within Willowdale Mine DE (ha)	Proportion of total value (% within specified area)
Potential TECs (*Empodisma* peatlands TEC)	1,079 (potential)	17.8 (1.6%) ha within MAZ 113.3 (10.5%) ha within LDA	2.3 (known)	2.3 ha (100%) within MAZ
Potential PECs (Granite communities PEC)	1,007 (potential)	183.9 ha (18.3%) within MAZ	1.8 (potential)	1.8 ha (100%) within MAZ

Key value	Area within Huntly Mine DE (ha)	Portion within MAZ / LDA (ha / %)	Area within Willowdale Mine DE (ha)	Proportion of total value (% within specified area)
		823.1 ha (81.7%) within LDA		
Potential GDEs	6,347	741.5 ha (11.7%) within MAZ 5,605.5 ha (88.3%) within LDA	261	30.6 ha (11.7%) within MAZ 230.4 ha (88.3%) within LDA
Old Growth	79	79 ha (100%) within MAZ	0	-
Threatened flora populations & habitat	-	Not able to be estimated	-	Not able to be estimated
Priority flora populations & habitat	Five Priority species totalling 224 individual plants	Not able to be estimated	-	Not able to be estimated
National Parks and formal conservation reserves	372 (Serpentine National Park)	372 ha (100%) within MAZ	81 (Lane Poole Reserve – Conservation Park)	81 ha (100%) within MAZ

Other avoidance measures

Alcoa will implement further avoidance measures to protect flora and vegetation key values and areas:

- Avoid or minimise clearing of restricted range vegetation types as far as practicable, including:
  - Granite outcrop vegetation (VTs dominated by G and R; see Table 5-6 for descriptions), which is a potential PEC and habitat for conservation significant flora;
  - Minimise clearing of streamzone vegetation (VTs A, AC, AD, AW, AW/AX, AX, C, CW, D, DA, DG, E, PW, Q, SW, SW-D, W, WD and WA; see Table 5-6 for descriptions), which are potential GDEs and habitat for conservation significant flora;
- Minimise clearing Priority flora populations as far as practicable.

The avoidance of particular vegetation types is expected to be highly effective at protecting key environmental values within the Mine DEs. Based on the Proposed Disturbance Footprint for the Mine DEs, the Proposal is predicted to avoid the following direct impacts on flora and vegetation values within the Huntly and Willowdale Mine DEs:

- approximately 99% of granite outcrop vegetation;
- approximately 95% of swamps and broad valley vegetation; and
- approximately 99% of valley floor and lower slope vegetation.

The predicted high level of avoidance within the Mine DEs is consistent with, and empirically validated by, the protection of these vegetation types in the Huntly and Willowdale Mine to date. The substantial avoidance of restricted range vegetation types will protect the

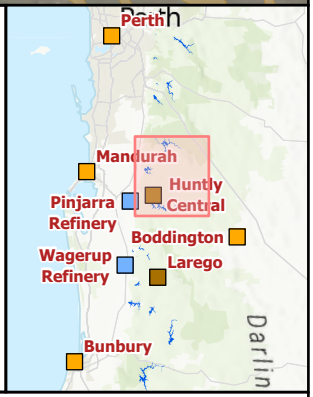
associated conservation significant flora populations, contributing to the maintenance of the ecological integrity of the NJF.

For all flora and vegetation values to be protected as far as practicable, where direct or indirect impacts are proposed to occur, Alcoa will investigate alternatives to avoid the disturbance such as alternative infrastructure routes or locations. Where avoidance of the key environmental values is not practicable, Alcoa will document the findings and present to relevant stakeholders (e.g., DBCA) to determine appropriate mitigation of impacts (i.e., minimisation, rehabilitation).



Legend

- Mining Avoidance Zones
- National Parks
- Conservation Parks
- Limited Disturbance Areas
- Mapped & Derived Stream Vegetation 100m Buffer
- Rock Outcrops >1ha 50m Buffer
- Huntly Mine DE
- Reservoirs
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-30 Mining Avoidance Zones - Huntly DE

Kilometres

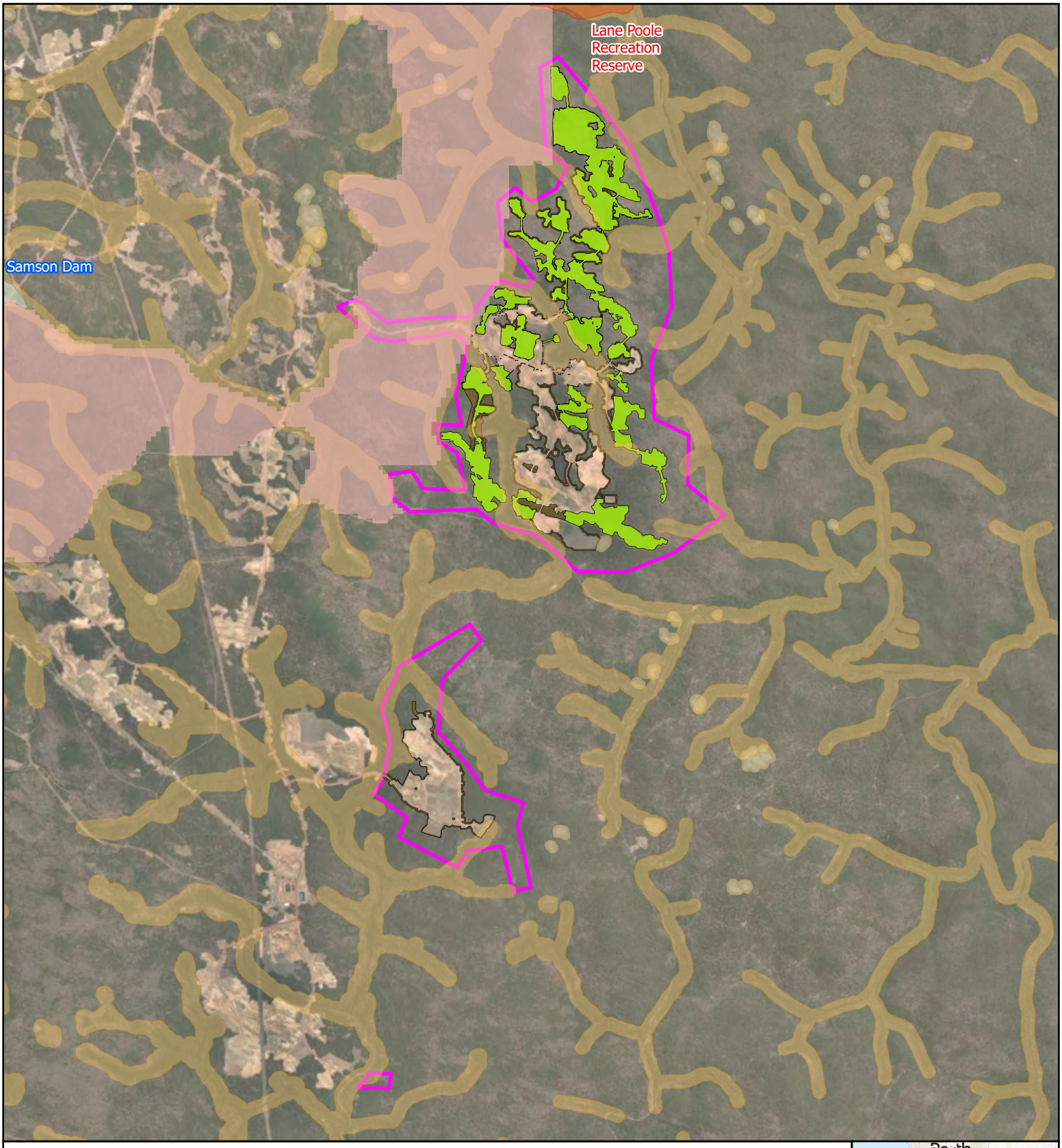
0 2 4 6 8 10 12

N

Scale: 1:169,573 at A4

Date Printed: 27/02/2025

Alcoa



Legend

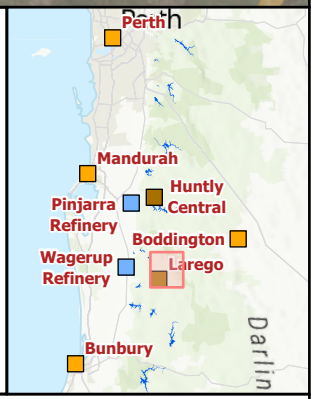
Mining Avoidance Zones

- Mining Avoidance Zones
- Conservation Parks

Limited Disturbance Areas

- Mapped & Derived Stream Vegetation 100m Buffer
- Rock Outcrops >1ha 50m Buffer
- Proposed Disturbance Footprint

- Rehabilitation Footprint
- Willowdale Mine DE
- Reservoirs



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-31 Mining Avoidance Zones - Willowdale DE

Kilometres

0 0.9 1.8 2.7 3.6 4.5 5.4

Scale: 1:75,060 at A4

Date Printed: 27/02/2025

N

Alcoa

Table 5-23: Avoidance, minimisation, and rehabilitation of potential impacts to flora and vegetation

Potential Impacts and mitigations	Industry standard, best practice and certainty of effectiveness
Direct loss of flora and vegetation due to clearing	
Avoid	
Provision of Mining Avoidance Zones (MAZs), whereby no clearing activities for mining or infrastructure will occur. MAZs, as shown in Figure 5-30 and Figure 5-31, will be implemented for the following: • Old Growth Forest; • National Parks; • Formal conservation reserves; • Threatened flora populations and habitat; and • Any TECs. No construction or operational activities undertaken within any identified MAZ for known threatened flora populations[4], [5] (unless prior regulatory approval obtained).	Established practice at Huntly & Willowdale Mine, high certainty
Pre-clearance Targeted flora and vegetation surveys (within conceptual clearing areas) will be conducted in potential habitat to identify conservation significant flora and TECs. Provision of MAZs, as shown in Figure 5-30 and Figure 5-31, whereby no clearing activities for mining or infrastructure will occur. Prior to undertaking any clearing under the State Agreement Administrative Framework, pre-clearance surveys are completed, where required, and outcomes, mitigation measures & monitoring proposed and impacts provided to Minister for State Development for endorsement.	Targeted flora surveys are established practice at Huntly & Willowdale Mine, high certainty. Targeted vegetation surveys are proposed practice at Huntly & Willowdale Mine, moderate certainty.
Haul roads, conveyors, mine pits and other infrastructure within the Mine DEs will be re-aligned to avoid mapped conservation significant flora species recorded in pre-clearance surveys, as far as practicable.	Proposed practice at Huntly & Willowdale Mine, moderate certainty
Avoid or minimise fragmentation by retaining ecological corridors and linkages, such as streamzone vegetation, and by prioritising and sequencing rehabilitation areas to enhance habitat connectivity as far as practicable.	Established practice at Huntly & Willowdale Mine, high certainty

[4] At the time of publication, there were no known threatened flora species occurring within the Huntly and Willowdale mines.

[5] Appropriate MAZ will be established for any newly identified threatened flora aligning with State guidelines and principles.

Potential Impacts and mitigations	Industry standard, best practice and certainty of effectiveness
Minimise	
Minimise clearing of: • mature growth forest • potential PECs and GDEs • Priority flora, with disturbance or adverse impacts limited to 2% if the known population is less than 100 individuals, otherwise impacts limited to 10% of the known population	Established practice at Huntly & Willowdale Mine, high certainty
Provision of LDAs, as shown in Figure 5-30 and Figure 5-31, whereby no clearing activities for mining will occur, however clearing for haul roads and infrastructure may occur. LDAs will be implemented for the following: • Confirmed PECs[6]; • mapped streamzone vegetation and 100 m buffer; and • Granite outcrops (>1 ha + 50 m buffer).	Proposed practice at Huntly & Willowdale Mine, moderate certainty
Implement the Ground Disturbance Permit process to ensure clearing markup and demarcation processes in the field and within work packs to clearly identify avoidance areas.	Established practice at Huntly & Willowdale Mine, high certainty
Clearing or construction activities required within mapped and derived (i.e., in the absence of mapping) streamzones will occur during summer or autumn months, as far as practicable.	Established practice at Huntly & Willowdale Mine, high certainty
Implementation of clearing markup and demarcation processes in the field and within work packs to identify LDA and MAZ.	Established practice at Huntly & Willowdale Mine, high certainty
Construction and operational vehicle and equipment movements limited to designated roads, access tracks and cleared areas.	Established practice at Huntly & Willowdale Mine, high certainty
Mapped conservation significant flora records to be retained in appropriate data information system and reviewed as part of Ground Disturbance Permit process, to ensure clearing impacts are not significant.	Established practice at Huntly & Willowdale Mine, high certainty
Minimise clearing of mature growth forest where practicable through review of available forest age mapping in clearing design.	Established practice at Huntly & Willowdale Mine, high certainty
Minimise infrastructure clearing in streamzone vegetation and major rock outcrops, with haul road creek crossings constructed perpendicular to creek flow to reduce habitat impact.	Established practice at Huntly & Willowdale Mine, high certainty
Minimise disturbance to significant flora and vegetation through provision of appropriate training for all personnel around the protection of these.	Established practice at Huntly & Willowdale Mine, high certainty

[6] The extent and / or radius of appropriate buffer zones will take into account individual species' physiological and biological attributes and landscape profiles

Potential Impacts and mitigations	Industry standard, best practice and certainty of effectiveness
Minimise the creation of vegetation peninsulas with only one connection to larger remnants.	Established practice at Huntly & Willowdale Mine, high certainty
Rehabilitate	
Rehabilitation within the Mine DEs will be undertaken as presented in Section 5.5.2.	Established practice at Huntly & Willowdale Mine, high certainty
Fragmentation of vegetation	
Avoid	
Provision of Mining Avoidance Zones (MAZs), whereby no clearing activities for mining or infrastructure will occur. MAZs, as shown in Figure 5-30 and Figure 5-31, will be implemented for the following: • Old Growth Forest; • National Parks; • Formal conservation reserves; • Threatened flora populations and habitat[7] [8]; and • TECs.	Established practice at Huntly & Willowdale Mine, high certainty
Minimisation	
Minimise clearing of: • mature growth forest • potential PECs and GDEs	Established practice at Huntly & Willowdale Mine, high certainty
Provision of LDAs, as shown in Figure 5-30 and Figure 5-31, whereby no clearing activities for mining will occur, however clearing for haul roads and infrastructure may occur. LDAs will be implemented for the following: • Confirmed PECs • mapped streamzone vegetation and 100 m buffer; and • Granite outcrops (>1 ha + 50 m buffer).	Established practice at Huntly & Willowdale Mine, high certainty
Reduce as far as practicable the creation of vegetation with single connection to larger remnants (peninsulas)	Established practice at Huntly & Willowdale Mine, moderate certainty

[7] At the time of publication, there were no known threatened flora species occurring within the Huntly and Willowdale mines.

[8] Appropriate MAZ will be established for any newly identified threatened flora aligning with State guidelines and principles.

Potential Impacts and mitigations	Industry standard, best practice and certainty of effectiveness
Introduction and/or spread of weeds (Including emerging biosecurity risks such as Myrtle Rust *(Austropuccinia psidii*) Polyphagous Shot-hole Borer (PSHB*, Euwallacea fornicatus*).	
Avoid	
Avoid and or otherwise minimise the introduction of biosecurity risks by following appropriate vehicle hygiene procedures.	Established practice at Huntly & Willowdale Mine, high certainty
Avoid the introduction of the PSHB into exploration areas by following recommendations, to the extent practicable, for Zone B within DPIRD's guidance notes (DPIRD, 2024)	Established practice at Huntly & Willowdale Mine, high certainty
Avoid the introduction of Myrtle Rust into exploration areas by following recommendations, to the extent practicable, within DPIRD's guidance notes (DPIRD, 2022)	Established practice at Huntly & Willowdale Mine, high certainty
Minimise	
Pre-clearance weed surveys to be conducted in clearing areas within the Mine DEs	Established practice at Huntly & Willowdale Mine, moderate certainty
All identified Declared Pests treated in accordance with their Control Codes, with the aim of eradication where possible but as a minimum prevent offsite movement.	Established practice at Huntly & Willowdale Mine, moderate certainty
All identified Weeds of National Significance and environmental weeds treated according to the weed control management outlined by Weeds Australia with the aim of controlling off-site movement.	Established practice at Huntly & Willowdale Mine, moderate certainty
Construction and operational vehicle and equipment movements limited to designated roads, access tracks, and cleared areas.	Established practice at Huntly & Willowdale Mine, moderate certainty
All construction vehicles and equipment cleaned of soil and vegetative material prior to entry to the Mine DEs.	Established practice at Huntly & Willowdale Mine, moderate certainty
Inspections of construction vehicles and equipment for soil and vegetative material prior to entry to the Mine DEs.	Established practice at Huntly & Willowdale Mine, moderate certainty
Periodic weed monitoring of recorded weed infestations and treatment areas and repeat treatments within the Mine DEs.	Proposed practice at Huntly & Willowdale Mine, moderate certainty
Conceptual Clearing Area will be surveyed for key weed species prior to clearing as part of targeted and / or detailed surveys.	Established practice at Huntly & Willowdale Mine, high certainty

Potential Impacts and mitigations	Industry standard, best practice and certainty of effectiveness
During operational activities, if key weed species[9] are observed, appropriate weed treatment will be undertaken according to the weed control management outlined by Weeds Australia ((Invasive Plants and Animals Committee, 2017).	Established practice at Huntly & Willowdale Mine, high certainty
Rehabilitation	
Topsoil will typically be reused within each mine pit but may be imported from other mine pits within the mine region where there is a local shortfall. All non-topsoil overburden is typically stockpiled and reused locally within each mine pit. The local reuse of soil materials within each mine pit and mine region prevents importation of weeds.	Established practice at Huntly & Willowdale Mine, moderate certainty
Seeds for rehabilitation are collected from within defined provenance zones in the NJF (see Section 0) which may lie within the Huntly Mine or other forest blocks within State Forest. Tubestock are sourced from a range of plant nursery providers using cuttings and seeds from defined provenance zones in the NJF. Rehabilitation plants sourced from nursery suppliers with appropriate weed control management.	Established practice at Huntly & Willowdale Mine, moderate certainty
Monitoring and verification that rehabilitation and planting are free from Weeds of National Significance, Declared Pests and environmental weeds, which is observed to reduce over time as native vegetation re-establishes (see Section 0).	Established practice at Huntly & Willowdale Mine, moderate certainty
Introduction and/or spread of dieback and forest diseases	
Minimise	
Prior to ground-breaking activity within the Mine DEs, conduct a *Phytophthora* dieback assessment by a registered *Phytophthora* dieback interpreter in accordance with DBCA guidelines. Assessment to include other high risk forest diseases identified in consultation with DBCA.	Established practice at Huntly & Willowdale Mine, high certainty
Demarcation of *Phytophthora* dieback infested, uninfested and uninterpretable areas in construction and operational drawings.	Established practice at Huntly & Willowdale Mine, high certainty
Establishment and maintenance of cleaning facilities for all *Phytophthora* dieback uninfested areas. All vehicles and equipment to be cleaned prior to entry into *Phytophthora* dieback uninfested areas.	Established practice at Huntly & Willowdale Mine, high certainty
Topsoil, overburden and vegetative material (e.g., coarse woody debris) from uninterpretable or infested areas not to be moved to uninfested areas.	Established practice at Huntly & Willowdale Mine, high certainty

[9] Weed species listed as either Declared Pest, Weed of National Significance (WoNS) or weed species ranked as having high invasiveness and low feasibility of control by DBCA (2024b)

Potential Impacts and mitigations	Industry standard, best practice and certainty of effectiveness
Construction and operational vehicle and equipment movements limited to designated roads, access tracks and cleared areas.	Established practice at Huntly & Willowdale Mine, high certainty
All construction vehicles and equipment cleaned of soil and vegetative material prior to entry to Mine DEs.	Established practice at Huntly & Willowdale Mine, high certainty
Containment of stormwater runoff from identified *Phytophthora* dieback infested areas to prevent discharge into uninfested areas.	Established practice at Huntly & Willowdale Mine, high certainty
Construction and operations contractors and personnel who enter the Mine DEsare inducted on the Dieback Free Mining System and specific mapping and hygiene relevant to their activities.	Established practice at Huntly & Willowdale Mine, high certainty
Monitor *Phytophthora* dieback management, including equipment / vehicle cleaning and stormwater retention from cleaning facilities.	Established practice at Huntly & Willowdale Mine, high certainty
Phytophthora dieback and other forest diseases signage.	Established practice at Huntly & Willowdale Mine, high certainty
Planted seedlings will only be sourced from nursery suppliers with appropriate weed and dieback control management.	Established practice at Huntly & Willowdale Mine, high certainty
Restrict access to areas of the mine site with native vegetation susceptible to biosecurity risks, such as locations with large populations of Myrtaceae species, to limit the movement of potential vectors	Established practice at Huntly & Willowdale Mine, high certainty
Apply appropriate fungicides and insecticides in targeted high-risk areas (such as revegetation zones) where the establishment of myrtle rust or shot-hole borers (is likely, particularly during known peak periods of vulnerability.	Established practice at Huntly & Willowdale Mine, high certainty
Create physical barriers (e.g., fencing, cleared MAZs) around susceptible areas to minimise the spread of pests or diseases across the landscape.	Established practice at Huntly & Willowdale Mine, high certainty
Abide by vehicle hygiene procedures, *Phytophthora* dieback management procedure and weed control.	Established practice at Huntly & Willowdale Mine, high certainty
Phytophthora dieback and other forest diseases controls including wash down bays, clean down points, abide by dieback hygiene procedures.	Established practice at Huntly & Willowdale Mine, high certainty
Demarcation of *Phytophthora* dieback-infested, uninfested, and uninterpretable areas in construction and operational drawings and in the field using signage and flagging tape.	Established practice at Huntly & Willowdale Mine, high certainty
Completion of *Phytophthora* dieback assessment as part of GDP prior to clearing activities.	Established practice at Huntly & Willowdale Mine, high certainty

Potential Impacts and mitigations	Industry standard, best practice and certainty of effectiveness
Contamination from Spills and/or leaks from storage and handling of hazardous materials and waste	
Hazardous material and waste management as presented in Sections 5.4.5 Terrestrial Environmental Quality and 5.5.8 Inland Waters.	See Sections 5.4 and 5.5.
Rehabilitation	
All mine pits and haul roads will be rehabilitated post mining, and any un-identified minor soil contamination arising from small spills and leaks will be overlaid with overburden, topsoil and establishing native species. Pockets of soil contamination remaining in the rehabilitation are expected to biodegrade over time.	Established practice at Huntly & Willowdale Mine, high certainty
Dust emissions	
Minimise	
Minimise the generation of dust through the use of low impact exploration drill rigs.	Established practice at Huntly & Willowdale Mine, high certainty
Appropriate speed limits along access tracks are established to minimise the generation of excessive dust.	Established practice at Huntly & Willowdale Mine, high certainty
Regular inspection of machinery and equipment to ensure operating as expected and are not causing additional / excess ground vibration.	Established practice at Huntly & Willowdale Mine, high certainty
Dust suppression for conveyor belts (through utilisation of covers), haul roads and other key operational areas.	Established practice at Huntly & Willowdale Mine, high certainty
Dust suppression activities carried out (e.g., via water carts) during high-level usage of haul roads.	Established practice at Huntly & Willowdale Mine, high certainty
Routine housekeeping practices around central facilities and workshops will be implemented to reduce dust generation.	Established practice at Huntly & Willowdale Mine, high certainty
Maximise efficiency of loads when transporting ore (including haul trucks and conveyers), where possible.	Established practice at Huntly & Willowdale Mine, high certainty
Minimise open area footprint and rehabilitate as soon as practicable	Established practice at Huntly & Willowdale Mine, high certainty
Optimising blast charge sizing and spaces to avoid unnecessary energy releases which has the potential to generate dust	Established practice at Huntly & Willowdale Mine, high certainty
Dust mitigation measures as presented in Section 5.7.	Established practice at Huntly & Willowdale Mine, high certainty

Potential Impacts and mitigations	Industry standard, best practice and certainty of effectiveness
Dust suppression is limited to when conditions require, which is during periods of dry ground conditions that may result in dust lift off from prevailing winds. Dust suppression is not required during wet ground conditions or when rainfall is forecast.	Established practice at Huntly & Willowdale Mine, high certainty
Due to the dry ground conditions and lack of incidental rainfall, applied dust suppression water will be absorbed by the dry surface of the application area and lost to evaporation over the following day, and is not expected to cause widespread or substantial runoff from application areas.	Established practice at Huntly & Willowdale Mine, high certainty
Any localised runoff (e.g., if caused by over-application or impervious areas) will be limited in volume and captured by Alcoa's mine drainage system, which is designed to capture much larger volumes of surface runoff from major storm events over mine pit and haul road catchments.	Established practice at Huntly & Willowdale Mine, high certainty
Altered hydrology/groundwater regimes	
Surface and groundwater management as presented as presented in Section 5.5.8.	See Section 5.5.8.
Change in fire regimes	
Implementation of fire ban and management procedures to minimise potential for fires	Established practice at Huntly & Willowdale Mine, high certainty
Emergency response process – Fire crews trained and equipment at hand (fire trucks etc.)	Established practice at Huntly & Willowdale Mine, high certainty

5.2.8 Assessment and Significance of Residual Impacts

5.2.8.1 Residual Impacts

Alcoa has proposed substantial avoidance, mitigation and rehabilitation to reduce the residual impacts to be as low as reasonably practicable. The effectiveness of rehabilitation, disease hygiene and weed hygiene has been demonstrated through long-term research and is at a high level of confidence.

Significant impacts to flora and vegetation after application of the avoidance and minimisation elements of the mitigation hierarchy are shown in Table 5-24 and Table 8-1.

5.2.8.2 Significance of Residual Impacts

The Proposal may cause significant residual impacts to flora and vegetation from the following:

- Clearing and rehabilitation of 4,117 ha within the Mine DEs that results in a partial loss of floristic diversity, ecosystem diversity and structural complexity of predominantly widespread vegetation complexes that are well retained within the NJF. The impact will occur in the context of other mining and more widespread cumulative impacts from historic timber harvesting, climate change, fire and *Phytophthora* dieback.
- For further impacts on cumulative impacts, refer to Section 10.3 and the Pinjarra Alumina Refinery Revised Proposal (Assessment 2253) ERD.

5.2.8.2.1 Significance of Impacts on Conservation Significant Vegetation

Potential TECs and PECS

The Proposal may cause a significant direct impact to TECs and PECs in the NJF subregion as there are one TEC and one PEC assessed as Known or as Potential to Occur within the Mine DEs:

- *Empodisma* peatlands of southwestern Australia (listed as EN under the EPBC Act); and
- Granite communities of the northern Jarrah Forest (listed as P3 under the BC Act).

Empodisma peatlands have been recorded within proximity to the Willowdale Mine DE. Whilst no TECs and PECs have been recorded within the Huntly Mine DE, there have not been sufficient Targeted surveys to define their precise distribution and extent. Targeted vegetation surveys will occur in conjunction with future pre-clearance Targeted flora surveys in order to identify any occurrences of the TEC, and to implement MAZs to protect this value. If PECs are identified and confirmed, avoidance measures will be implemented and LDAs will be implemented.

Through selective placement of the Proposed Disturbance Footprint and application of MAZs and LDAs, there will be limited clearing to habitats (i.e., swamps, broad valley floors, granite outcrops) for the potential TECs and PEC, and hence significant impacts are not expected to occur.

Potential GDEs

The Proposal is unlikely to cause a significant direct impact to Potential GDEs as their extent has been clearly delineated through association with VTs and the use of VT mapping

(Section 5.2.4.2). Through selective placement of the Proposed Disturbance Footprint and application of LDAs, there will be limited clearing to habitats (i.e., swamps, broad valley floors, lower slope vegetation) for the potential GDEs.

Mining activities will result in groundwater mounding (see Section 5.2.6.2), with the most significant rise in groundwater levels expected to happen near the mining areas, and a more moderate rise is predicted in valleys where potential GDEs are situated. This indirect impact is likely to be positive for potential GDEs, as it may counteract changes in groundwater levels related to climate change.

Old Growth Forest

The Proposal will not cause a significant direct impact to Old Growth Forest, as their existing extent has been clearly mapped and MAZs have been implemented.

Summary

The Proposal is unlikely to cause significant direct impacts to the '*Empodisma* peatlands' TEC and the 'Granite communities' PEC that may potentially occur within the Mine DEs, as Targeted vegetation surveys will be conducted prior to clearing and MAZs implemented if the TEC is identified and LDAs (whereby clearing will be minimised) implemented if the PEC is identified.

The Proposal is unlikely to cause significant indirect impacts to potential TECs, PECs, potential GDEs or Old Growth Forest relating to fragmentation of vegetation, the spread of weeds, the spread of *Phytophthora* dieback or other forest diseases, contaminant discharges, dust emissions, hydrological changes, or changes in fire regimes.

Pre-clearance Targeted vegetation surveys will be conducted to identify actual occurrences of TECs and PECs within the Proposed Disturbance Footprint. MAZs and LDAs will be implemented where TECs and PECs are identified. The Proposal is, therefore, unlikely to cause significant impacts to conservation significant vegetation that result in a loss of biodiversity or ecological integrity in the NJF subregions.

5.2.8.2.2 Significance of Impacts on Conservation Significant Flora

The Proposal is unlikely to cause a significant impact to Threatened flora populations either locally (within the Mine DEs) or regionally (within the NJF subregion), as:

- No occurrences of Threatened flora were recorded within the Mine DEs (noting that large areas of the Mine DEs have not been surveyed);
- All areas will be covered by Targeted flora surveys prior to clearing in order to identify any Threatened flora populations present (if present they will be excluded from clearing through the implementation of MAZs); and
- The Proposal will substantially avoid potential habitat (granite outcrops or potential GDEs) for the five Threatened species assessed as having a Highly Likely, Likely or Possible likelihood of occurrence within the Mine DEs.

The Proposal may cause a significant impact to Priority flora populations either locally (within the Mine DEs) and regionally (within the NJF subregion), as:

- Ten Priority flora species were recorded during baseline and Targeted surveys (Section 5.2.5.2) at 966 locations within the Huntly Mine DE and none within the Willowdale Mine DE during surveys from 2020–2024;
- Six of the ten Priority flora species recorded from 2020–2024 within the Mine DEs have known locations within the Proposed Disturbance Footprint;
    - One of the species, *Tetratheca phoenix* (P2) was recorded inside the Proposed Disturbance Footprint during the 2020–2024 surveys. The species is known to only occur within 10 km of the Mine DEs and within the Mine DEs, 97.4% of the known individuals are located within the Proposed Disturbance Footprint;
- A further six Priority flora species were recorded (Section 5.2.5.2) within the Huntly Mine DE prior to 2020. Two of these species have known locations within the Proposed Disturbance Footprint;
    - One of the species *Drosera silvicola* (P1), has only four records outside the Mine DEs, and within the Mine DEs, the one known population is located within the Proposed Disturbance Footprint;
- A total of 31 Priority flora species were assessed as Highly Likely, Likely or Possible to occur within Huntly Mine DE and 12 within Willowdale Mine DE (Appendix 24);
- Whilst all areas will be covered by Targeted flora surveys prior to clearing in order to identify any conservation significant flora populations present, if Priority flora species are identified they will only be avoided as far as practicable (Section 5.2.7.2);
- Any potential impacts (direct and indirect) to Priority flora species will be included in FCA approval submissions for approval by MOG and no more than 2% of a known population will be directly impacted, unless more than 100 individuals are identified whereby up to 10% of the known population may be impacted;
- The Proposal will substantially avoid some of the preferred habitat for the Priority flora recorded or assessed as potentially occurring within the Mine DEs, i.e., granite outcrops, and potential GDEs (winter-wet, swampy depressions, drainage lines or rises surrounding swamps) (Section 5.2.6.1); and
- Lateritic soils on uplands are also a preferred habitat for many of the recorded and potentially occurring Priority flora species, and the proportion of clearing of vegetation associated with this habitat is large. However, this vegetation is widespread across the Mine DEs and NJF (Section 5.2.4.1). Accordingly, it is expected that there will be substantial areas of similar potential habitat for the species remaining in the subregion and therefore significant impact to this habitat is unlikely.

An assessment of significance of impacts to conservation significant flora species with potential to occur within the Mine DEs is given in Table 5-24.

Table 5-24: Significance of Impacts to Conservation Significant Flora Species

Habitat (associated VTs)^	Conservation Significant flora species with Recorded, Highly Likely, Likely or Possible likelihood of occurrence (conservation status under EPBC Act/BC Act)	Total area of potential habitat within Mine DEs (ha)	Total area of potential habitat within Proposed Disturbance Footprint (ha)	Significance	Likelihood of significant impact
Potential GDEs – valleys and swamps (VTs A, AC, AD, CW, D, DA, E, PW, SW, and W)	• *Morelotia australiensis* (VU/VU) • *Hibbertia ambita* (P1) • *Netrostylis* sp. Nannup (P.A. Jurjevich 1133) (P1) • *Bossiaea modesta* (P2) • *Grevillea ornithopoda* (P2) • Lepyrodia curvescens (P2) – Recorded • *Schizaea rupestris* (P2) • *Acacia horridula* (P3) – Recorded • *Actinotus repens* (P3) • *Andersonia* sp. *Audax* (F. Hort, B. Hort & J. Hort 3179) (P3) • *Boronia capitata* subsp. *gracilis* (P3) – Recorded • *Conospermum scaposum* (P3) • *Cyathochaeta teretifolia* (P3) – Recorded • *Grevillea dissectifolia* (P3) – Recorded • *Grevillea prominens* (P3) • *Hakea oldfieldii* (P3) • *Hemigenia microphylla* (P3) • *Lepyrodia heleocharoides* (P3) • *Meionectes tenuifolia* (P3) • *Netrostylis* sp. Blackwood River (A.R. Annels 3043) (P3) • Stirlingia divaricatissima (P3) • *Thysanotus anceps* (P3) – Recorded • *Drosera occidentalis* (P4) • *Parsonsia diaphanophleba* (P4) • *Pimelea rara* (P4) – Recorded • *Senecio leucoglossus* (P4) – Recorded	6,608	238	Proposed clearing within the Proposed Disturbance Footprint comprises 3.6% of the potential GDEs (represented by VTs) present in the Mine DEs. At a regional scale (vegetation complexes), the Swamp complex and, to a lesser degree, the Murray-1, Pindalup, Yarragil-1 and Yarragil-2 complexes are associated with GDEs. Proposed clearing within the Proposed Disturbance Footprint comprises 5.1% of the GDE associated vegetation complexes present in the Mine DEs and 0.3% of those mapped across the Darling Plateau subregion of the Southwest Forest region.	Conservation Significant Flora habitat: Unlikely Conservation Significant Flora: Unlikely
Granite outcrops (VTs G, G1, G2, R, R/G)	• *Lasiopetalum pterocarpum* (EN/CR) • *Anthocercis gracilis* (VU/VU) • *Grevillea flexuosa* (VU/VU) • *Andersonia* sp. *Saxatilis* (F. & J. Hort 3324) (-/CR) • *Darwinia hortiorum* (P1) • *Hibbertia acrotoma* (P1) • *Hibbertia micrantha* (P1) • *Paracaleana gracilicordata* (P1) • *Paracalaena granitica* (P1) • *Banksia recurvistylis* (P2) • *Tetratheca phoenix* (P2) – Recorded • *Acacia horridula* (P3) • *Acacia oncinophylla* subsp. *oncinophylla* (P3) • *Andersonia* sp. *Audax* (F. Hort, B. Hort & J. Hort 3179) (P3) • *Dicrastylis reticulata* (P3) • *Lasiopetalum glutinosum* subsp. *glutinosum* (P3) • *Stackhousia* sp. Red-blotched *corolla* (A. Markey 911) (P3) • *Acacia oncinophylla* subsp. *patulifolia* (P4) • *Calothamnus graniticus* subsp. *leptophyllus* (P4) – Recorded • *Cyanothamnus tenuis* (P4) – Recorded • *Eucalyptus* x *graniticola* (P4) • *Grevillea pimeleoides* (P4) • *Hemigenia platyphylla* (P4)	1,009	55	Proposed clearing within the Proposed Disturbance Footprint comprises 5.5% of the granite outcrop associated vegetation (represented by VTs) present in the Mine DEs. At a regional scale (vegetation complexes), the Cooke complex and, to a lesser degree, the Darling Scarp-2 and Helena-1 complexes are associated with granite outcrops. Proposed clearing within the Proposed Disturbance Footprint comprises 23.8% of the granite outcrop associated vegetation complexes present in the Mine DEs and 1.2% of those mapped across the Darling Plateau subregion of the Southwest Forest region.	Conservation Significant Flora habitat: Unlikely Conservation Significant Flora: Likely for *Tetratheca phoenix* (P2), Unlikely for all other species.

Habitat (associated VTs)^	Conservation Significant flora species with Recorded, Highly Likely, Likely or Possible likelihood of occurrence (conservation status under EPBC Act/BC Act)	Total area of potential habitat within Mine DEs (ha)	Total area of potential habitat within Proposed Disturbance Footprint (ha)	Significance	Likelihood of significant impact
	• *Stylidium ireneae* (P4) – Recorded				
Lateritic soils on uplands (VTs P, PG, PS, PT, S, SP, SP-D, ST, T, TP, TS)	• *Deyeuxia inaequalis* (P1) • *Drosera silvicola* (P1) – Recorded • *Hibbertia ambita* (P1) – Recorded • *Hibbertia hortiorum* (P1) – Recorded • *Grevillea ornithopoda* (P2) • *Acacia drummondii* subsp. *affinis* (P3) – Recorded • *Acacia horridula* (P3) – Recorded • *Andersonia* sp. *Audax* (F. Hort, B. Hort & J. Hort 3179) (P3) • *Gastrolobium* sp. *Asperum* (F. Hort 2864) (P3) • *Grevillea dissectifolia* (P3) – Recorded • *Hakea oldfieldii* (P3) • *Lasiopetalum glutinosum* subsp. *glutinosum* (P3) • *Stackhousia* sp. Red-blotched *corolla* (A. Markey 911) (P3) • *Synaphea pandurate* (P3) • *Tetratheca pilifera* (P3) • Tetratheca *similis* (P3) • *Thysanotus anceps* (P3) – Recorded • Calothamnus graniticus subsp. leptophyllus (P4) – Recorded • *Cyanothamnus tenuis* (P4) – Recorded • Grevillea *pimeleoides* (P4) • *Pimelea rara* (P4) – Recorded • *Stylidium ireneae* (P4) – Recorded	15,033	3,411	Proposed clearing within the Proposed Disturbance Footprint comprises 22.7% of the laterite associated vegetation (represented by VTs) present in the Mine DEs. At a regional scale (vegetation complexes), the Dwellingup-1, -2 and -4 complexes are associated with lateritic uplands. Proposed clearing within the Proposed Disturbance Footprint comprises 12.5% of the laterite associated vegetation complexes present in the Mine DEs and 0.7% of those mapped across the Darling Plateau subregion of the Southwest Forest region.	Conservation Significant Flora habitat: Unlikely Conservation Significant Flora: Possible for *Drosera silvicola* (P1), Unlikely for all other species.

^ see Table 5-6 for descriptions

5.2.8.2.3 Summary of Residual Impacts on Flora and Vegetation

The potential residual impacts to flora and vegetation from the Proposal is summarised in Table 5-25. Clearing of native vegetation within the Proposed Disturbance Footprint is Unlikely to result in significant residual impacts to:

- One TEC (assessed as Potential to occur within Huntly Mine DE and known to occur within Willowdale DE) and one PEC (assessed as being Potential to Occur within the Mine DEs.
- Five Threatened flora species assessed as being Possible to Occur within the Mine DEs.
- Up to 47 Priority flora species either recorded or assessed as being Highly Likely, Likely or Possible to occur within the Mine DEs.
- Habitat for conservation significant flora.

Whilst the '*Empodisma* peatlands' TEC and 'Granite communities' PEC have not been recorded within the Mine DEs, there have not been sufficient Targeted surveys to date to define their precise distribution and extent. However, Targeted vegetation surveys will be conducted in conjunction with future pre-clearance Targeted flora surveys in order to identify any occurrences of the TEC, and to implement MAZs to protect this value. If the PEC is identified and confirmed, avoidance measures will be implemented and LDAs will be implemented. In this case there will be no significant residual impact on the TEC, but there may be significant impact on the PEC given that LDAs allow clearing for infrastructure and haul roads.

Whilst no occurrences of Threatened flora have been recorded within the Mine DEs, large areas of the Mine DEs have not been covered by Targeted flora surveys. Five Targeted flora species recorded within the vicinity of the Mine DEs and assessed as having a Highly Likely, Likely or Possible likelihood of occurrence within the Mine DEs cannot be ruled out as occurring within the Proposed Disturbance Footprint. Alcoa has committed to conducting pre-clearance Targeted flora surveys; the methodology for these surveys is sufficient to identify any occurrences of Threatened flora. Alcoa has committed to no clearing of Threatened flora populations or their habitat and will implement this through MAZs (Table 5-23). There is, therefore, no significant residual impact on Threatened flora species.

One Priority flora species recorded within the Proposed Disturbance Footprint, *Tetratheca phoenix* (P2), is known from only 10 locations (unspecified number of individuals) inside and within 10 km of the Mine DEs. Data from baseline and Targeted flora surveys in the period 2020–2024 shows that 310 individuals from 136 locations are located inside the Mine DEs; of these, 302 individuals from 134 locations are within the Proposed Disturbance Footprint.

One of the Priority flora species recorded within the Huntly Mine DE prior to 2020, *Drosera silvicola* (P1), is only known from four other locations in the NJF outside the Mine DEs. There is one record of *D. silvicola* within the Mine DEs (from 2012); this record is located within the Proposed Disturbance Footprint.

Up to 47 Priority flora species have been assessed as being Highly Likely, Likely or Possible to occur within the Mine DEs. Alcoa has committed to conducting pre-clearance Targeted flora surveys; the methodology for these surveys is sufficient to identify any occurrences of Priority flora.

Alcoa has committed to protecting Priority flora populations by minimising impacts to the known population and the implementation of LDAs as far as practicable; however, two

Priority flora species with restricted known distributions will have their populations reduced through clearing of vegetation. However, direct and indirect impacts to these species will be limited to 2% of the known population, until 100 individuals are identified whereby impacts may occur up to 10% of the known population. The outcomes of pre-clearances surveys will be included in the State Agreement Administrative Framework. Therefore, endorsement by the Minister for State Development is expected prior to clearing. This will not result in significant residual impact on Priority Flora species.

Table 5-25: Preliminary Offset Triggers – Residual Impact Significance Model

Part IV Environmental Factor	Flora and Vegetation							
	Threatened flora	Threatened Ecological Communities	Remnant vegetation	Wetlands & waterways	Conservation areas	High biological diversity	Habitat for fauna	Other
Residual impact that is environmentally unacceptable or cannot be offset	-	-	-	-	-	-	-	-
Significant residual impacts that will require an offset – All significant residual impacts to species and ecosystems protected by statute or where the cumulative impact is already at a critical level	-	-	-	-	-	-	-	-
Significant residual impacts that may require an offset – Any significant residual impact to potentially Threatened species and ecosystems, areas of high environmental value or where the cumulative impact may reach critical levels if not managed	-		-	-	-	-	-	**Direct clearing of the 'Granite communities' PEC.** The distribution and extent of this PEC within the Mine DEs has been predicted based on association of the PEC with VTs (Section 5.2.4.2) and vegetation complexes. Only 5.5% of the potential area of the PEC inside the Mine DEs is proposed to be cleared. Clearing of identified granite outcrop areas is minimised through application of LDAs; however, significant impacts may occur as LDAs allow clearing for infrastructure and haul roads. **Direct clearing of Priority flora populations.** Populations of *Tetratheca phoenix* (P2) and *Drosera silvicola* (P1) have been recorded within the Proposed Disturbance Footprint, Both these species have restricted distributions outside the Mine DEs and clearing within the Proposed Disturbance Footprint will result in loss of a large proportion of the known populations of these species.
Residual impacts that are not significant		**Direct clearing of the '*Empodisma* peatlands' TEC.** The distribution and extent of this TEC within the Mine DEs is not fully understood, however a known occurrence has been identified within proximity to the Willowdale Mine DE. This TEC is Potential to Occur within the Huntly Mine DE (and hence, the Proposed Disturbance Footprint). If identified, avoidance of the TEC will occur through implementation of MAZs.		**Direct clearing of potential GDEs.** The Proposal is unlikely to cause a significant direct impact to potential GDEs as their extent has been clearly delineated through association with VTs and the use of VT mapping (Section 5.2.4.2)	-	-	-	**Direct clearing of Priority flora populations (other than *Tetratheca phoenix* and *Drosera silvicola*).** Priority flora populations have been recorded within the Mine DEs and many more species have been identified as potentially occurring within the Mine DEs. Whilst all areas will be covered by Targeted flora surveys prior to clearing in order to identify any conservation significant flora populations present, if Priority flora species are identified they will be protected by LDAs as far as practicable. However, future FCAs will include outcomes of Targeted flora surveys and regulatory consultation will occur to ensure no significant impacts occur, with Alcoa proposing a limit on known population impacts.

5.2.9 Environmental Outcomes

The proposed environmental outcomes with respect to flora and vegetation as a result of implementation of the Proposal is outlined in Table 5-26 below. These environmental outcomes have been developed in accordance with *Environmental outcomes and outcomes-based conditions – Interim guidance* (EPA, 2021c) and they:

- Reflect specific and measurable environmental states;
- Have a clear boundary, size, extent, or limit; and
- Are consistent with the EPA's objective to protect flora and vegetation so that biological diversity and ecological integrity are maintained.

Table 5-26: Proposed Environmental Outcomes – Flora and Vegetation

Potential environmental impact	Environmental outcome	Other statutory approval that will assure outcome	Monitoring of outcomes
Direct loss of vegetation at a regional and local scale	Clearing of no more than 4,042 ha and 77 ha of native vegetation within the Huntly and Willowdale Mine DEs respectively.	Assessment and approval of the MMP and subsequent FCAs include consultation with key regulatory agencies.	Annual reporting of clearing extent
	No disturbance or adverse impacts to Old Growth Forest within the Mine DEs		
	No disturbance or adverse impacts to National Parks or formal conservation reserves		
	No direct impacts (excluding monitoring and management activities) in defined Mining Avoidance Zones		
	Pre-clearance surveys for Threatened and Priority flora, TECs and PECs considered likely to occur will be undertaken. Prior to undertaking any clearing, pre-clearance surveys are completed, where required, and outcomes, mitigation measures & monitoring proposed and impacts provided to Minister for State Development for endorsement through the State Agreement Administrative Framework	Assessment and approval of the MMP and subsequent FCAs include consultation with key regulatory agencies.	

Potential environmental impact	Environmental outcome	Other statutory approval that will assure outcome	Monitoring of outcomes
	No disturbance or adverse impacts to TECs within the Mine DEs		
	No disturbance or adverse impacts to confirmed PECs, except for only for the purposes of construction and operation of haul roads, services roads, transport corridors, mine water supply and other infrastructure		
	No disturbance or adverse impacts to more than 55 ha of granite vegetation.		
	No disturbance or adverse impacts to more than 579 ha of potential GDE vegetation.		
	All cleared areas rehabilitated to Jarrah Forest ecosystem in accordance with approved completion criteria.	Rehabilitation Management Plan and Schedule developed in accordance with MMP approval conditions and aligns with the Rehabilitation Completion Criteria reviewed by DBCA and approved by the Department of State Development.	Annual monitoring and reporting of rehabilitation extent and performance against completion criteria
Direct loss of conservation significant flora at a regional and local scale.	No disturbance or adverse impacts to Threatened Flora species	Assessment and approval of the MMP and subsequent FCAs include consultation with key regulatory agencies.	Annual reporting of clearing extent
	No uplift to the listing status of threatened or priority flora species.		
	No uplift to the listing status of threatened or priority ecological communities.		
	No disturbance or adverse impacts to more than 2% of the known population of Priority listed flora species, until it can be demonstrated that more than 100		

Potential environmental impact	Environmental outcome	Other statutory approval that will assure outcome	Monitoring of outcomes
	individuals have been recorded, in which case 10% of the known population.		

5.3 Key Environmental Factor – Terrestrial Fauna

Alcoa applied the Environmental Factor Guideline for Terrestrial Fauna to the activities described within the Proposal. Alcoa have taken steps to identify fauna species of conservation significance and apply protection measures to these species, such as those identified in Section 5.3.8 to avoid or minimise impacts. The protection measures discussed throughout this section demonstrate Alcoa's commitment to protecting the values of terrestrial fauna and their high-value habitat.

A Fauna MP (Appendix 5) has been developed and implemented to meet State Agreement requirements. The Fauna MP, which discusses the outcome and objective-based management provisions, with additional information on monitoring methods. Where the residual impact to conservation significant fauna species has been identified as significant, further protection measures have been considered and will be applied, as outlined in Section 8, and in accordance with the EPA's guidance for offsets.

The baseline and targeted surveys for terrestrial fauna and short-range endemics undertaken to support the Proposal has been carried out in accordance with the relevant EPA's Technical Guidance documents. These surveys were completed to support the EIA process and provide confidence in the current knowledge within the Mine DEs and surrounding area. A discussion of these surveys is presented in Section 5.3.3.1.

Whilst this chapter focusses predominantly on the factor of Terrestrial Fauna in isolation, it is understood that this factor interacts with other Key Environmental Factors such as Flora and Vegetation and Inland Waters. A holistic impact assessment has been provided within Section 9.

This section aims to address Tasks 1–13 as outlined in the ESD, focusing on fauna within the Huntly and Willowdale Mine DEs, with an emphasis on:

- State-listed Threatened, Priority, and conservation significant fauna (and key habitat);
- Fauna species with restricted range or with degree of historical impact from threatening process;
- Fauna species listed under the EPBC Act as threatened or migratory.
- Short-range endemic (SRE) invertebrates; and
- Ecological linkages and wildlife corridors.

5.3.1 EPA Objective

The EPA's environmental objective of the factor 'Terrestrial Fauna' is:

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

For the purposes of EIA, the EPA defines terrestrial fauna as animals living on land or using land (including aquatic systems) for all or part of their lives. Terrestrial fauna includes vertebrate and invertebrate groups (EPA, 2016c).

Ecological integrity is defined as "the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements" (EPA, 2016c).

5.3.2 Relevant Policy and Guidance

5.3.2.1 EPA Policy and Guidance

- Environmental Factor Guideline – Terrestrial Fauna (EPA, 2016c);
- Technical Guidance – Terrestrial fauna surveys (EPA, 2016d);
- Technical Guidance – Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA, 2020a);
- Technical Guidance – Sampling of short range endemic invertebrate fauna (EPA, 2016f)
- Instructions on how to prepare an Environmental Review Document (EPA, 2024c); and
- Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans (EPA, 2024b).

5.3.2.2 Commonwealth Policy and Guidance

- Approved Conservation Advice for *Calyptorhynchus banksii naso* (Forest Red-tailed Black Cockatoo) (DAWE, 2009);
- Carnaby's Cockatoo (*Zanda latirostris*) Recovery Plan: Western Australian Wildlife Management Program No. 52, (DPaW, 2013);
- Chuditch (*Dasyurus geoffroii*) National Recovery Plan: Wildlife Management Program No. 54 (DEC, 2012a);
- Conservation Advice *Bettongia penicillata* Woylie (DAWE, 2018a);
- Conservation Advice *Zanda baudinii* Baudin's cockatoo (DAWE, 2018b);
- Conservation Advice *Pseudocheirus occidentalis* Western ringtail possum (Threatened Species Scientific Committee, 2017b);
- Conservation Advice *Westralunio carteri* Carter's freshwater mussel (DAWE, 2017);
- Conservation Advice *Myrmecobius fasciatus* numbat (DAWE, 2018c);
- Draft referral guideline for 14 birds listed as migratory species under the EPBC Act (DoE, 2015);
- *Environment Protection and Biodiversity Conservation Act 1999* Environmental Offsets Policy (DSEWPC, 2012a);
- EPBC Act Policy Statement 3.10: Significant impact guidelines for the vulnerable western ringtail possum (*Pseudocheirus occidentalis*) in the southern Swan Coastal Plain, Western Australia [DEWHA (DEWHA, 2009e);
- EPBC Act Policy Statement 3.21 – Industry Guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species [DEE (DEE, 2017c)];
- EPBC Act Referral guidelines for three threatened Black Cockatoo species: Carnaby's cockatoo, Baudin's cockatoo and Forest red-tailed Black Cockatoo (DAWE, 2022);
- Forest Black Cockatoo (Baudin's Cockatoo *Zanda baudinii* and Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso*) Recovery Plan [DEC (DEC, 2008);
- National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds (DEE, 2020);
- National Recovery Plan for the Malleefowl (*Leipoa ocellata*) (DCCEEW, 2024a);
- National Recovery Plan for the Woylie (*Bettongia penicillata ogilbyi*): Wildlife Management Program No. 51 (DEC, 2012b);
- Numbat (*Myrmecobius fasciatus*) Recovery Plan. Wildlife Management Program No. 60 (DPAW, 2017e);

- Quokka *Setonix brachyurus* Recovery Plan. Wildlife Management Program No. 56 (DEC, 2013);
- Significant Impact Guidelines 1.1 – Matters of National Environmental Significance (DoE, 2013a);
- Survey guidelines for Australia's threatened birds (DEWHA, 2010);
- Survey guidelines for Australia's threatened mammals (DSEWPC, 2011);
- Survey guidelines for Australia's threatened reptiles (DSEWPC, 2011a);
- Threat abatement plan for competition and land degradation by rabbits (DEE, 2016);
- Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* (DEE, 2018a);
- Threat abatement plan for predation by feral cats (DoE, 2015);
- Threat abatement plan for predation by the European red fox (DEWHA, 2008a);
- Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*) (DEE, 2017);
- Western Ringtail Possum (*Pseudocheirus occidentalis*) Recovery Plan. Wildlife Management Program No. 58. (DPAW, 2017c);
- Threat abatement plan for competition and land degradation by unmanaged goats (DEWHA, 2008g); and
- Wildlife Conservation Plan for Migratory Shorebirds (DEH, 2006).

5.3.2.3 Other Policy and Guidance

- WA Environmental Offsets Policy (GoWA, 2011);
- WA Environmental Offsets Guidelines (GoWA, 2014);
- Statutory Guidelines for Mine Closure Plans (DMIRS, 2023);
- EPBC Act Environmental Offsets Policy (DSEWPC, 2012a);
- EPBC Act Offsets Assessment Guide (DCCEEW, 2012);
- *Conservation and Land Management Act 1984* (DBCA, 2024a); and
- Forest Management Plan 2024-2033 (Conservation and Parks Commission, 2023).

5.3.3 Receiving Environment

5.3.3.1 Baseline Studies

A summary of the terrestrial, aquatic, and SRE invertebrate fauna studies that have been undertaken within a 10 km buffer of the Proposal isa are presented in Table 5-27. The studies included in this table have been completed within the Huntly and Willowdale Mine sites. The recent survey extents for the Huntly and Willowdale mine regions are shown in Figure 5-32 and Figure 5-33 respectively, with survey reports and desktop assessments provided in Appendix 27 to Appendix 35 inclusive).

Baseline surveys have been conducted in the O'Neil mine region at Huntly, with preliminary fauna desktop habitat mapping undertaken where baseline data was not available. The extrapolation of habitats was achieved using the available historical site Havel vegetation type mapping, which was undertaken by Mattiske Consulting (Section 5.2.3).

Targeted pre-clearance fauna surveys are undertaken in suitable habitat for Threatened fauna species prior to clearing to ensure fauna are identified and then appropriate avoidance measures can be implemented. Targeted pre-clearance Black Cockatoo surveys are

undertaken by suitably qualified/experience personnel through visual inspection for the presence of Black Cockatoo nesting trees. If the suitability of a hollow cannot be determined from the ground, a pole camera or drone is used to obtain a better visual. The associated targeted assessments are provided in Appendix 36 to Appendix 40 inclusive.

Targeted studies were undertaken for Woylie, Quokka, Chuditch, and Western Ringtail Possum, and for threatened aquatic species such as the Carter's Freshwater Mussel. All other incidental observations were recorded as part of the assessment. The survey information has been used to determined avoidance (for example streamzone vegetation that will need to be avoided during mining construction and operations) and where additional mitigation measures would need to be implemented.

In addition, the Long-Term Fauna Monitoring Program (LTFMP) is implemented to gauge how closely the vertebrate fauna assemblage in rehabilitated areas of 5, 10, and 15 years old is approaching that in the unmined forest (Terrestrial Ecosystems, 2023a). Surveys are conducted every 5 years across the summer and winter seasons at both mines. Since 2021, active searches and dry pitfall trapping for each LTFMP site has been undertaken for representative specimens of invertebrates.

A detailed Short-Range Endemic (SRE) invertebrate survey was also completed for the O'Neil mine region.

5.3.3.1.1 Knowledge and survey gaps

As outlined in Table 5-27 and shown on Figure 5-32 and Figure 5-33, many studies have been conducted over the life of the mines. As required by the Fauna MP/FVMP ongoing pre-clearance surveys are required prior to clearing, to allow avoidance and mitigation measures to be implemented where required. These surveys provide a large amount of fauna information within the Alcoa mine area; however, the entire Mine DE has not been fully surveyed.

The assessment areas within the Huntly and Willowdale Mine DE have not been extensively studied, specifically the Huntly and Del Park region of Huntly Mine, and the Keates region of the Willowdale Mine. Due to these areas lacking detailed information, studies conducted in nearby areas will be used to provide a regional indication of the fauna species and their associated habitats.

Limited Targeted fauna surveys (Figure 5-32 and Figure 5-33) have occurred throughout the Mine DEs, with limited information on fauna populations and variable likelihood of occurrence information is included in various reports. Therefore, a summary of ecological reports and consolidated LOO (Appendix 27) has been prepared for the Proposal Mine DE. It is noted the pre-clearance Targeted surveys are proposed for Threatened fauna, with the survey outcomes currently included within the State Agreement Administrative Framework. Avoidances will occur as per relevant Management Plans, mitigations and outcomes.

There are likely to be information gaps associated with the lack of surveys conducted in the Mine DEs, particularly in relation to surveys in Myara, SRE invertebrate studies, and aquatic habitat assessments. However, these will be addressed through pre-clearance surveys to ensure conservation significant fauna values are avoided as required. Oversight is currently provided through the State Agreement Administrative Framework, with outcomes of pre-clearance surveys included in the MMP and FCAs.

The current surveys are considered adequate to determine potential impacts to fauna, due to:

- A high level of existing regional knowledge of the NJF and associated conservation significant fauna species and their habitats;
- The existing fauna surveys confirm species considered likely to occur;
- Targeted pre-clearance surveys for any threatened or conservation significant fauna species will be undertaken;
- Ongoing clearing being contained within mine regions, limiting the level of fragmentation; and
- Conservation significant fauna species habitat extent and distribution occurring beyond the Huntly and Willowdale mine regions.

Limited information on indirect impacts to fauna values is available, in particular impacts from dust emissions and altered hydrological/hydrogeological regimes. In addition, limited information on the effectiveness of Black Cockatoo avoidance measures is available.

Table 5-27: Summary of Terrestrial Fauna Studies

Study	Location and key finding	Location in relation to the Mine DE	Appendix
(Spectrum Ecology and Spatial, 2024a) O'Neil Region – Targeted Fauna Survey	Location: O'Neil region, Huntly Mine. This report highlighted findings from the targeted species survey for state and Commonwealth listed Quokka, and Chuditch (listed as Vulnerable) and the Woylie (listed as Critically Endangered under BC Act and Endangered under the EPBC Act) across the O'Neil area of 650 ha from November to December 2024. The camera trapping recorded Chuditch four times and Woylie three times over the survey period. The survey was compliant with EPA guidance and requirements.	Within Huntly Mine DE	Appendix 26
(SLR, 2024a) Myara – Carter's Freshwater Mussel Targeted Survey.	Location: Myara region, Huntly Mine. This report highlighted findings from the targeted species search for the state (BC Act) and Commonwealth (EPBC Act) listed Vulnerable Carter's Freshwater Mussel within the Myara survey region. Six sites were surveyed across a period of several weeks in October and November of 2023 approximately 12 km upstream from known locations within Serpentine Dam. No confirmed sightings or evidence were found of Carter's Freshwater Mussel in any of the six surveyed areas, and water parameters (pH and dissolved oxygen levels) were determined to be outside of the suitable range to provide long-term habitat for the species. The survey was completed as per the EPA guidance and requirements.	Within Huntly Mine DE	Appendix 35
(SLR Consulting Australia, 2024b) Myara Region – Targeted Fauna Survey for Chuditch, Quokka and Woylie.	Location: Myara region, Huntly Mine. This report highlighted findings from the targeted species survey for state and Commonwealth listed Quokka, and Chuditch (listed as Vulnerable) and the Woylie (listed as Critically Endangered under BC Act and Endangered under the EPBC Act) across the Myara area of 928.6 ha from August to September 2023. Two main habitat types were identified throughout the survey area, that being Jarrah-Marri Forest, and drainage lines, both of which provide core habitat for the three targeted species. The targeted surveys recorded 52 instances of Chuditch with 14 specific individuals reliably recorded, along with 18 recordings of Quokkas. In addition to the two targeted fauna species, six significant species were recorded during the fauna survey in Jarrah-Marri Forest and drainage line habitats: • Baudin's Cockatoo (*Zanda baudinii).*	Within Huntly Mine DE	Appendix 30

Study	Location and key finding	Location in relation to the Mine DE	Appendix
	• Carnaby's Cockatoo (*Zanda latirostris).* • Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*). • Wambenger Brush-tailed Phascogale (*Phascogale tapoatafa wambenger).* • Quenda (Southern Brown Bandicoot) (*Isoodon fusciventer).* • Western Brush Wallaby (*Notamacropus irma).* The survey was completed as per the EPA guidance and requirements.		
(SLR Consulting Australia, 2024c) Myara Region – Black Cockatoo Habitat Assessment.	Location: Myara region, Huntly Mine. This report highlighted findings from a targeted species assessment for all three EPBC Act listed Black Cockatoo species in terms of direct observation and recorded feeding, foraging behaviour, as well as identification of suitable roosting, feeding and breeding hollow habitat within the Myara survey area covering 501.7 ha from July to December 2023. Ground-based, drone and camera searches were conducted, using specific government referral guidelines for all three Black Cockatoos species. The surveys recorded all three EPBC Act listed Black Cockatoos species as well as foraging, roosting and breeding habitat. Numerous suitable breeding hollows for all three species were identified, with five confirmed nesting hollows and 11 confirmed mass roosting sites within the survey area. The survey was completed as per the EPA guidance and requirements.	Within Huntly Mine DE	Appendix 38
(SLR Consulting Australia, 2024d) Larego Region – Chuditch, Quokka and Woylie Targeted Survey.	This report highlighted findings from the targeted species survey for Quokka, Chuditch and Woylie across the Larego mine area of 451.8 ha in October and November 2023. Two main habitat types were identified throughout the survey area, that being Jarrah-Marri Forest, which provides core habitat for Chuditch and Woylie, and supporting habitat for Quokka, and drainage lines which provide core habitat for the three targeted species. One target species, Chuditch, was recorded through secondary evidence (scat). No direct evidence for either Woylie or Quokka were recorded within the survey area, however historical records from previous studies and databases revealed recordings of both such species within 200 m of the survey area. In addition to the targeted fauna, a further four conservation significant fauna were identified within the survey area; • Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) • Baudin's Cockatoo (*Zanda baudinii)* • Rakali (Water Rat) (Hydromys chrysogaster)	Within Larego region, Willowdale Mine	Appendix 30

Study	Location and key finding	Location in relation to the Mine DE	Appendix
	• Western Brush Wallaby (Notamacropus irma). The survey was completed as per the EPA guidance and requirements.		
(Biologic Environmental Survey, 2024a) Alcoa Willowdale (Larego Region) Targeted Carter's Freshwater Mussel Survey.	A targeted survey for Carter's Freshwater Mussel (*Westralunio carteri*) in the Larego region was undertaken in October 2023. Carter's Freshwater Mussel conservation status is under review due to range reductions, so existing populations like those found are increasingly important. Seven sites were successfully surveyed via mussel rakes, hand searches, quadrat searches, and sediment sieving to locate juveniles. A total of nine Carter's Freshwater Mussel individuals were recorded – eight deceased mussels (37-47 mm) and one live mussel (55 mm). Water quality and habitat were considered to be suitable for Carter's Freshwater Mussel at the time, not explaining the cause of deaths. The survey was completed as per the EPA guidance and requirements.	Within Larego region, Willowdale Mine	Appendix 34
(Western Environmental, 2024a) Willowdale Mine Black Cockatoo Targeted Assessment.	Location: Larego region, Willowdale Mine. This report highlighted findings from a targeted species assessment for all three EPBC Act listed Black Cockatoo species in terms of direct observation and recorded feeding, foraging behaviour, as well as identification of suitable roosting, feeding and breeding hollow habitat within the Willowdale Mine and Larego survey area covering 477.7 ha from July to December 2023. Ground-based, drone and camera searches were conducted, using specific government referral guidelines for all three Black Cockatoos species. A combined total of 13,267 potential, suitable or known nesting trees were recorded. The vast majority (97%) of these trees were Bamford Class 4 or 5 trees, defined by DAWE (2022) as potential nest trees, however these do not currently contain suitable nesting hollows. Analysis of regional habitat extent indicates there is 63,554.9 ha of remnant native vegetation mapped within a 12 km buffer of the surveyed area. It is expected that the majority of this vegetation would contain suitable foraging species at the same or greater rate than that present within the surveyed area. Therefore, approximately 470 ha of foraging habitat represents 0.74% of the estimated regional habitat extent. Six locations were recorded that displayed evidence of having been used as a roost site and based on additional mapping and direct evidence of cockatoo species presence, it is considered highly likely that more roosting sites exist within the survey area than the six confirmed locations.	Within Larego region, some areas within Willowdale Mine DE	Appendix 40

Study	Location and key finding	Location in relation to the Mine DE	Appendix
(GHD, 2024b) McCoy Haul Road Fauna Pre-clearance Survey.	Location: McCoy and O'Neil regions, Huntly Mine. This technical memorandum outlines the results of a targeted preclearance assessment for the McCoy Haul road accessing the O'Neil region covering approximately 563.4 ha in 2024. In total nine significant fauna species were recorded including; Carnaby's Black Cockatoo, Baudin's Black Cockatoo, Forest Red-tailed Black Cockatoo, Chuditch, Quokka, Wambenger Brush-tailed Phascogale, Peregrine Falcon, Western Brush Wallaby and Quenda. Foraging for all three Black Cockatoo species was recorded within the area along with roosting sites and three known nesting trees were recorded. The survey was completed as per the EPA guidance and requirements.	Partly within Huntly Study Area.	Appendix 43
(GHD, 2024c) O'Neil East Targeted Woylie Assessment.	Location: O'Neil East region, Huntly Mine. This memo outlines the results of a targeted Woylie assessment within the O'Neil East survey area and study area. Covering an area approximately 1,402 ha. In total approximately 3 – 6 Woylies were observed within the Area. Five other conservation significant species were also recorded within the area, Chuditch, Quokka, Southwestern Brush-tailed Phascogale, Western Brush Wallaby and Quenda. The survey was completed as per the EPA guidance and requirements.	Approximately 5 km southeast of the Huntly Study Area.	Appendix 44
(GHD, 2024d) Terrestrial Fauna Assessment O'Neil.	Location: O'Neil region, Huntly Mine. This baseline and targeted report outlines the results of a terrestrial vertebrate fauna survey of the Alcoa O'Neil DE. The O'Neil survey area is approximately 30 km east of the town of Dwellingup in the Southwest of Western Australia. The survey area covered an approximate of 12,687.5 ha. In total nine significant fauna species was recorded in the survey area including: Chuditch, Baudin's Black Cockatoo, Forest Red-tailed Black Cockatoo, Quokka, Rakali, Western Brush Wallaby, Dell's Skink, Quenda and Carter's Fresh Water Mussel. Extensive foraging habitat for two of the Black Cockatoos (Baudin's and Forest Red-tailed Black Cockatoo) was recorded. The survey was completed as per the EPA guidance and requirements.	Within Huntly Study Area.	Appendix 28

Study	Location and key finding	Location in relation to the Mine DE	Appendix
(Terrestrial Ecosystems, 2023a) Baseline Rehabilitation Monitoring (Jan 2023)	Location: McCoy, Myara and White, Huntly Mine. Alcoa has established 12 long-term monitoring sites for vertebrate fauna. Terrestrial Ecosystems has undertaken the baseline survey, which will be the first of the long-term monitoring surveys. These survey data indicated that the three unmined sites selected as analogue climax communities for the rehabilitation areas are not similar, and there are appreciable differences among the fauna assemblages within aged classes of rehabilitation. The preliminary data collected in this survey would suggest that conservation significant species are in the unmined areas, but not the rehabilitated areas.	Partially within Huntly Mine DE	Appendix 41
(Terrestrial Ecosystems, 2023b) Baseline Rehabilitation Monitoring (Jun 2023)	Location: McCoy, Myara and White, Huntly Mine. The second rehabilitation baseline survey undertaken in winter 2023. Outcome was similar to that observed in summer 2023, that being, the current monitoring program requires adjustment, as the analogue sites for the rehabilitated areas appear not to be appropriate given the spatial variability in the vertebrate fauna assemblages in the unmined, and possibly older rehabilitated sites of the northern Jarrah forest. Many of the vertebrate fauna caught and recorded in the monitoring program are common, widespread and abundant, and given the mosaic disturbance pattern undertaken by Alcoa to mine bauxite in the northern Jarrah forest, the mining program is unlikely to threaten any of these common species.	Partially within Huntly Mine DE	Appendix 42
(Phoenix Environmental Sciences, 2021a) Short-range Endemic invertebrate survey for the Alcoa Huntly Mine – Myara North and Holyoake.	Desktop assessment and two season short-range endemic (SRE) invertebrate fauna survey of Myara North, Holyoake and Huntly Mine rehabilitation sites. SRE habitat mapping was undertaken based on vegetation mapping prepared for the Proposal and considering habitat attributes relevant to SRE invertebrates (Mattiske, 2021a). Each habitat was rated for its potential to support SREs (potential habitat rating; PHR) as High, Low or None. The survey was completed as per the EPA guidance and requirements.	Within Huntly Mine DE	Appendix 31

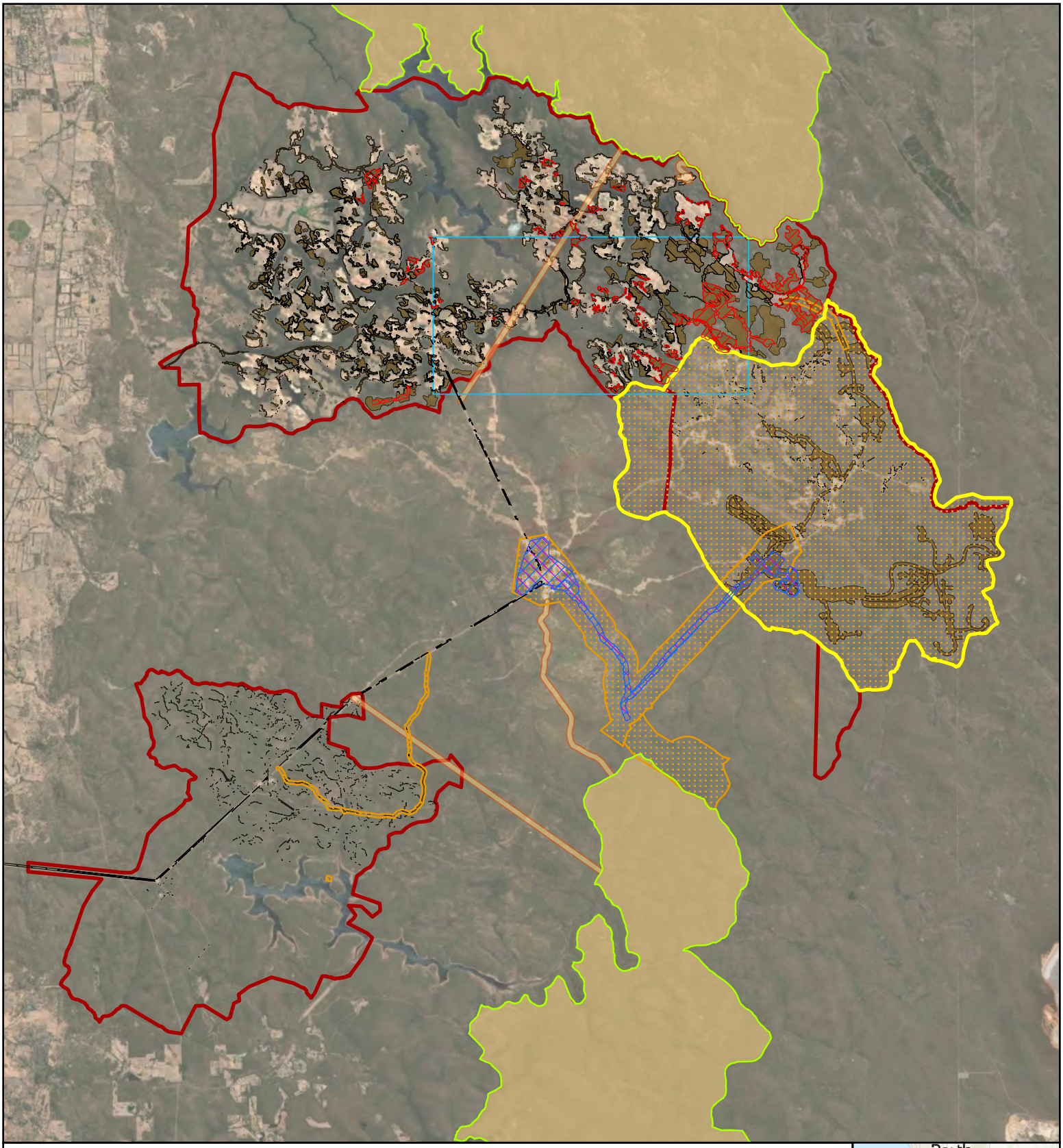
Study	Location and key finding	Location in relation to the Mine DE	Appendix
(GHD, 2021a) Terrestrial Fauna Survey and Black Cockatoo Habitat Assessment for Huntly Mine – Holyoake.	Location: Holyoake region, Huntly Mine. This Terrestrial Fauna Survey and Black Cockatoo Habitat Assessment report details the results of a terrestrial vertebrate fauna survey of the Holyoake DE and adjacent conveyor and haul road corridors. The region is located approximately five kilometres east of the Dwellingup town site in the southwest of WA. The region covers approximately 10,541 ha. In total ten significant species were recorded in the region including the Quokka, Chuditch, Brush-tailed Phascogale, Western Brush Wallaby, Forest Red-tailed Black Cockatoo, Baudin's Black Cockatoo, Carnaby's Black Cockatoo, Western False Pipistrelle, Quenda and Peregrine Falcon. All significant species identified are likely to have resident populations and habitat present within the region. Although recorded nearby and outside of the region, the presence of Carter's Freshwater Mussel is unlikely due to the lack of permanent surface waterbodies present. The region has extensive foraging habitat for the three Black Cockatoo species, and potential breeding habitat (limited in extent) for Carnaby's and Forest Red-tailed Black Cockatoo. Regarding migratory shorebirds, the region lacks open water such as shallow shorelines or tidal zones for foraging habitat. The creek lines and vegetated dampland areas within the region are not suitable for migratory shorebirds. The survey was completed as per the EPA guidance and requirements.	Abuts the western boundary of the Huntly Mine DE (extending up to 10 km west).	Appendix 36
(Stokes, 2011) Orion Long Term Fauna Monitoring Program.	Location: Orion region, Willowdale Mine. Six monitoring sites within Alcoa's Orion mine region comprising two typical upland forest areas, two associated with streamzones and two within rehabilitated forest (8 years old). Mammals, birds, reptiles and frogs were surveyed during both autumn (March) and winter (July), and ground dwelling invertebrates were sampled in summer only. Survey methods were similar to those used in (EMRC, 2007) with the addition of a single large trapping transect designed to specifically target Chuditch and Varanids (Goannas/Monitor Lizard). This transect covered approximately 880 ha and comprised 40 wire cage traps spaced 300 m apart and was trapped over four successive nights at the same time as the generic mammal survey. A total of 10 mammals (three introduced), 38 birds, nine reptiles, two frogs, 22 ground invertebrates, 49 ant species was recorded.	Within 10 km of the far western boundary of the Huntly Mine DE	n/a

Study	Location and key finding	Location in relation to the Mine DE	Appendix
	Recorded significant species comprise: • Chuditch – five males trapped in summer; • Quenda – one trapped; • Western Brush Wallaby – multiple sightings; • Baudin's Black Cockatoo – sightings; and • Forest Red-tailed Black Cockatoo – sightings.		
(McGregor R.A., 2014) – Does forest restoration in fragmented landscapes provide habitat for a wide-ranging carnivore.	Location: Huntly and Willowdale mines. Fourteen Chuditch trapping sessions (13 at Huntly, one at Willowdale) across nine trapping transects (eight at Huntly, one at Willowdale) were undertaken between June 2009 and Dec 2010. Radio collars with a two-stage transmitter and mortality mode were attached to 14 adult Chuditch (nine female, five males – all trapped at Huntly). Chuditch were tracked to their dens during the day. Spool and line tracking was also used. In total 29 individual Chuditch were captured on 60 occasions. Of the 14 individuals fitted with radio collars, three were found dead on the Huntly mine access road with evidence of road trauma. Another three Chuditch were also found dead from vehicle strikes along this road. The study identified 138 den sites from 11 tracked animals: 75 in unmined forest and 63 in restored forest ranging from 2-32 years old. In unmined forest, dens were mostly in hollow logs and ground burrows beneath tree stumps, but these substrates were never used in restored forest where dens were mostly ground burrows, usually associated with rock piles at the surface.	Huntly Mine approximately 20 km north of the region. Willowdale (within 30 km south of the far southern boundary of the region).	-
(EMRC, 2015) Long Term Fauna Monitoring Program Summary of Results at Orion Mining region.	Location: Numerous plots over the Willowdale Mine area. Results of the third survey of the LTFMP. Same methodology and plot locations as the 2010 survey of the area. Additionally, a large trapping transect targeting Chuditch and remote sensing cameras were also deployed. Trapping was conducted over four nights in both winter and summer seasons. The study results: • Twelve mammal species were trapped; • Thirty-five bird species recorded; • Thirteen reptile species recorded; and • Three frog species recorded.	Willowdale Mine	n/a

Study	Location and key finding	Location in relation to the Mine DE	Appendix
	Results were indicative of some species being affected (not present afterwards or in lower numbers) by the January 2016 wildfire that burnt through the Willowdale Mine and surrounding areas including four of the six Orion sites.		
(Mastrantonis et al., 2019) Climate change indirectly reduces breeding frequency of a mobile species through changes in food availability.	Location: The Northern Jarrah Forest of South- Western Australia over both the Swan and Murray River Catchments. Using a dataset of annual breeding frequency spanning 19 years, in combination with hydrological, climatological, and remotely sensed data, the effects of environmental variation on the annual breeding frequency of Forest Red-tailed Black Cockatoo's (FRTBC) were modelled. In total, 143 unique trees were surveyed over the 19-year period. A total of 173 breeding events were observed during this time with 104 and 71 events observed in the Swan and Murray River catchments respectively. On average there were 5.83 breeding events recorded per year with events ranging from 0 to 21 annually. Results found several significant relationships between annual breeding frequency of FRTBCs and environmental variation. While the model, which included a proxy for the availability of the cockatoo's primary food source and the previous season's rain, explained 49% of annual breeding frequency, there were also direct and indirect effects of heatwaves and forest productivity. FRTBC breeding was found to appear be linked to the spatiotemporal availability of its primary food sources, the fruit from the tree species, Marri *Corymbia calophylla* and Jarrah *Eucalyptus marginata*. However, due to climate change experienced and predicted to be experienced in the future in WA it is expected that the food resources during the breeding season for Black Cockatoos will become increasingly limited in time and space, thus threatening their persistence.	Approximately 10 km north of the northern boundary of the Huntly Mine DE	-
(Burn , 2000) A survey of the impact of burning on mammals and birds in Alcoa's rehabilitated Bauxite mines at Jarrahdale.	Location: Jarrahdale forest (two unmined and four rehabilitated bauxite mine pits). To ascertain the impact of burning on birds and mammals at the above location pre burning monitoring took place in 1997, and post burn monitoring commenced in 1998 in both burnt and unburnt, rehabilitated and unmined forest sites. Low numbers of mammals were caught making it difficult to conclude with certainty whether burning influenced most species. New epicormic growth may have attracted possums into one rehabilitated area, while mice invaded the dense rehabilitated site after the burn. There was a large decline in the numbers of birds and bird species following the burn in the dense rehabilitation. Burning sparse rehabilitation only resulted in a small decline while fire had little effect on bird populations of unmined forest.	Approximately 10 km north of the northern boundary of the Huntly Mine DE	n/a

Study	Location and key finding	Location in relation to the Mine DE	Appendix
	It was concluded that more time was needed to define the longer-term effects of burning on mammals and birds. The survey was therefore undertaken in 2000 to assess the situation three years after burning.		
(EMRC, 2004)Orion LTFMP report 2004 Final.	Location: Willowdale northeast portion of Orion region (two healthy forest and two dieback forest plots, two steam zone plots and two plots in rehabilitation). The LTMFP was reviewed in 2003 which included a recommendation for a similar program to be established at Orion so that any differences in faunal successional processes taking place at Willowdale could be detected (Majer, 2007). Similar techniques to those used at Jarrahdale, Huntly and McCoy. Mammals recorded during the survey included the Chuditch, Quokka, Mardo, Dunnart, Common Brushtail Possum, Western Brush Wallaby. Only one mammal species was recorded in the young rehabilitation (Feral Mouse). Forty-one bird species were recorded including the Baudin's Black Cockatoo. Bird numbers were highest at steam sites and lowest at rehabilitated sites. Six reptile species were recorded compared with 15 species recorded in the 1999 pre-mining survey. Three frog species were recorded. Fifty ant species were recorded. Further monitoring was recommended to determine successional patterns.	Willowdale Mine (within 20 km south of the northern boundary of the Willowdale Mine DE).	n/a
(EMRC, 1999) A fauna survey of planned mining areas at Alcoa's Orion Mining region.	Location: Orion region, Willowdale Mine. This report provides the results of the fauna survey conducted between February and November 1999. The habitats monitored were poorly surveyed in current mining areas, extensive dieback affected areas, small dieback free areas and on sites where mining operations are planned. A total of 46 bird species, nine mammals (six native, three introduced), 13 reptiles and five frogs were recorded. These included the Chuditch, Baudin's Cockatoo and possibly the Quokka, and the South-Western Carpet Python (Specially Protected species). As well as these, the report noted that the Noisy Scrub-bird has been reintroduced into the surrounding and the uncommon Brush-tailed Phascogale is present albeit in low densities. The fauna of the Orion area was largely comparable to that of existing Willowdale mining areas. Eleven recommendations were given for managing the area's faunal diversity including: protection of adjacent fauna habitat, construction of fauna habitats and corridors, control of feral species, construction of suitable habitat specific to mammals and reptiles. In particular, the report noted the need for ongoing fox control, and rehabilitation using Jarrah and other indigenous species offers the best prospects of successfully recreating suitable habitat for the species.	Willowdale (within 20 km north of the far northern boundary of the Huntly Mine DE).	-

Study	Location and key finding	Location in relation to the Mine DE	Appendix
(EMRC, 2007) A Vertebrate Fauna Survey of Rehabilitated Areas at Alcoa's Huntly Minesite.	Location: Huntly (rehabilitated bauxite mine sites). This report details the 2007 results of the long-term fauna monitoring. Previous monitoring events occurred in 1994, 2000 (following fox control) and again in 2007. In the 2007 survey a total of 25 bird species, 10 mammals (seven native, three introduced) and five reptiles was recorded in rehabilitation. They included the Chuditch, Brush-tailed Phascogale and Forest Red-tailed Black Cockatoo. Numbers of native mammals trapped in rehabilitation were higher than in previous years, with Mardo (Yellow-footed Antechinus) increasing from none in 1994 to six in 2007; Brush-tailed Phascogales increased from none to one and Chuditch increased from none to three. Bird species had declined since the 2000 survey. Total numbers of both insectivores and honeyeaters both showed large declines between 1994 and 2000. There was a gradual decline in numbers of the skink *Acritoscincus trilineatus* as the rehabilitated sites become more like upland forest habitat and less suitable for this species. Fifteen recommendations were given for managing the area's faunal diversity including; protection of adjacent fauna habitat, construction of fauna habitats and corridors, control of feral species, construction of suitable habitat specific to mammals and reptiles	Huntly Mine DE	-
(EMRC, 2001) A Vertebrate Fauna Survey of rehabilitated areas at Alcoa's Willowdale Mine site.	Location: Willowdale (rehabilitated bauxite mine sites). This report details the 2000 fauna monitoring event results after the introduction of fox control following the 1994 monitoring event. A total of 31 bird species, nine mammals (five introduced, four indigenous) and five reptiles was recorded. Although not trapped or recorded in the present survey, both the rare Chuditch and the specially protected Carpet Python have been recently recorded in rehabilitation at Willowdale. Numbers of native mammals trapped in rehabilitation were low, as in 1994. Some evidence suggests that fox predation may still be a problem near farmland. The 31 bird species recorded in the 2000 survey is less than the 45 recorded in 1994. The five reptile species recorded indicate that the rehabilitation has not yet become more suitable for this fauna group. Fifteen recommendations were given for managing the area's faunal diversity including; protection of adjacent fauna habitat, construction of fauna habitats and corridors, control of feral species, construction of suitable habitat specific to mammals and reptiles.	Willowdale (within 20 km north of the far northern boundary of the Willowdale Mine DE).	-



Legend

Targeted Black Cockatoo Survey
- 2024, Western Environmental
- 2024, Western Environmental
- 2024 GHD

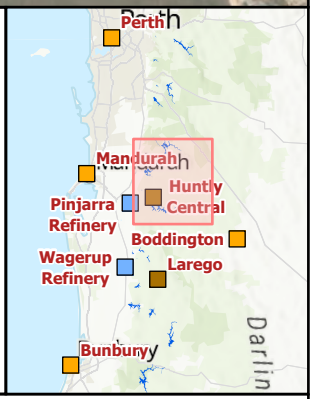
SRE Invertebrate Fauna Survey
- 2024, Phoenix
- 2021, Phoenix

Pre-clearance Targeted Fauna Survey
- 2024, SLR
- 2024 GHD

Detailed Fauna Survey
- 2024, GHD

Targeted Carter's Freshwater Mussel Survey
- 2024, SLR
- 2024, Biologic

Basic and Targeted Fauna Survey
- 2021, GHD
- Proposed Disturbance Footprint
- Huntly Mine DE



Bauxite mining on the Darling Range 2023 to 2027 (Assessment No. 2385) Environmental Review Document

Figure 5-32 Terrestrial Fauna Surveys - Huntly Mine DE

Kilometres

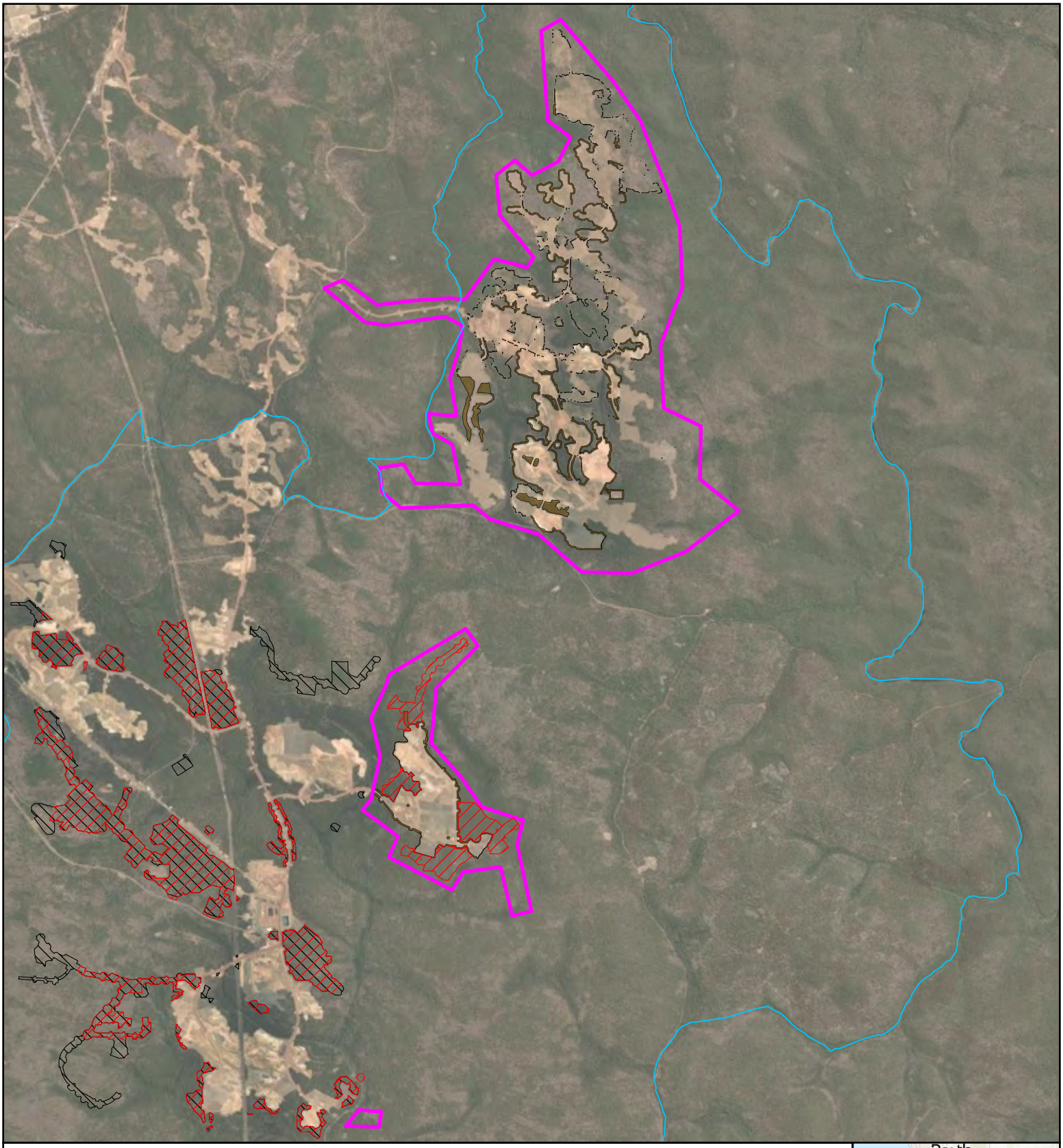
0 2 4 6 8 10 12

Scale: 1:181,197 at A4

Date Printed: 5/05/2025

N

Alcoa



Legend

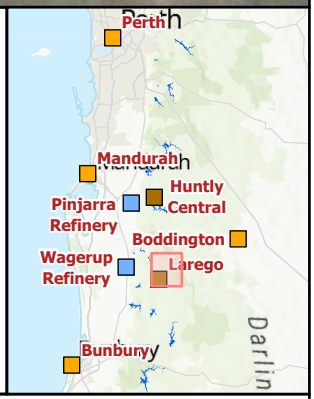
Targeted Black Cockatoo Survey
- 2024, Western Environmental

Pre-clearance Targeted Fauna Survey
- 2024, SLR

Targeted Carter's Freshwater Mussel Survey
- 2024, Biologic

Willowdale Mine DE

Proposed Disturbance Footprint



Bauxite Mining on the Darling Range 2023 to 2027 (Assessment No. 2385) Environmental Review Document

Figure 5-33 Terrestrial Fauna Surveys - Willowdale Mine DE1

Kilometres

0 0.9 1.8 2.7 3.6 4.5 5.4

Scale: 1:70,000 at A4

Date Printed: 5/05/2025

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Alcoa

5.3.3.2 Summary of Receiving Environment

A summary of the receiving environment with respect to terrestrial fauna is as follows:

- Alcoa has conducted various targeted and baseline fauna surveys over the Mine DE. The field surveys used various techniques such as traps, cameras, acoustic recorders, spotlighting, opportunistic observations and searches consistent with the EPA guidance and requirements.
- Alcoa has significant scientific knowledge of the fauna habitats within the Jarrah Forest, attained through research and having operated in the in the Huntly since 1972 and Willowdale since 1984. This provides contextual baseline and background data that can be applied to fauna habitats that will be present in the new mining areas.
- Jarrah-Marri Forest and Drainage Line habitats provide core habitat for many significant species including the Chuditch, Quokka, Brush-tailed Phascogale, Quenda, Western Brush Wallaby, Woylie, and Western False Pipistrelle.
- The fauna habitats present in the Mine DE contain tree hollows and hollow logs which are important microhabitats for hollow-dependent species including the Chuditch and Black Cockatoos.
- Baudin's Cockatoo, Carnaby's Cockatoo, and Forest Red-Tailed Black Cockatoos have been recorded within the Mine DEs. Known nesting trees have also been recorded along with habitat used for breeding and foraging.

5.3.4 Terrestrial Vertebrate Fauna

5.3.4.1 Fauna Communities

Recent terrestrial fauna surveys conducted over the Huntly and Willowdale Mine DE did not explicitly mention distinct fauna communities within each study area (SLR, 2024a) (SLR Consulting Australia, 2024d) (GHD, 2024d). For the purpose of the assessment the three distinct communities mentioned in the (GHD, 2021b) and (GHD, 2021a) will be discussed below. These fauna communities include:

- Granite fauna community;
- Woodlands/forests fauna community; and
- Damplands/riparian fauna community.

The granite fauna community is present within the granite outcrop habitat type. This habitat type provides shelter and foraging for a range of reptile and frog fauna, such as the Ornate Crevice Dragon, Barking Gecko, Speckled Stone Gecko, Gould's Hooded Snake, Southern Carpet Python, and Black-headed Monitor. Associated watercourses provide seasonal breeding for locally common frog species such as Quacking Froglet and Moaning Frog.

The woodlands/forests fauna community occurs in Jarrah-Marri Forest, Bullich forest, Blackbutt forest, and Flooded Gum woodland habitat types. The woodland and forest habitat provides habitat for a range of species including birds (including Black Cockatoos) and mammals (including Chuditch, Brush-tailed Phascogale, and Western Brush Wallaby).

The damplands/riparian fauna community occur in the low dense understory and near creek lines present in the majority of fauna habitat types (Bullich forest, Blackbutt Forest, Flooded Gum woodland, Melaleuca dampland). Quokka, Quenda, Rakali, and several frog and reptile species are potentially present in this community.

A proportion of the Huntly and Willowdale Mine DE comprises cleared land which has limited habitat values due to lack, paucity, or low quality of intact native vegetation, however, much of this cleared land will be subjected to rehabilitation. Although rehabilitation will not provide an immediate benefit to the species, as habitat features (e.g., hollows, fallen timber/logs, sufficient supply of fruit/flower) will develop over the following 10 years to create usable fauna habitat.

In addition to the mapped terrestrial fauna habitats, the Huntly and Willowdale Mine DE contains aquatic habitat associated with seasonally flowing streams, seasonally waterlogged swamps and downstream artificial perennial water bodies (drinking water reservoirs). To date, limited aquatic studies have been conducted in the area. Primarily targeted studies for the Carter's Freshwater Mussel have been the only aquatics studies recently completed.

5.3.4.2 Fauna Habitats

The Northern Jarrah Forest bioregion is an area of high biodiversity values within WA and provides some key habitat types for fauna. This is related to the diversity of geological, altitudinal and climatic elements in the region as well as being a function of its location.

The vegetation within the Huntly and Willowdale Mine DE is predominately juvenile to immature forest with fire history occurring in the last 10 years (refer to Section 5.2.4.11). Despite this, the Huntly and Willowdale Mine DEs contain areas that have a contiguous intact forest with seasonal creeks and wetlands, providing multiple habitat types suitable for wide ranging species such as Black Cockatoos, Chuditch, Brush-tailed Phascogale, and Western Brush Wallaby.

The forested habitats provide a diversity of micro-habitats such as logs, hollows, leaf litter, soft sand, and dense foliage with a broad range of flora species providing a range of foraging, roosting, denning, and sheltering habitat.

Streamzone areas throughout the Huntly and Willowdale Mine DE provide access to drinking water to terrestrial vertebrate fauna on a seasonal basis. This includes the Serpentine and North and South Dandalup Reservoirs, which lie within the Huntly Mine DE, and provide a water resource year-round for more mobile fauna, such as birds. Seasonally waterlogged or inundated swamps were associated with some of the streams and may provide suitable Quokka and amphibian habitat. Low dense vegetation associated with riparian areas was also identified as suitable habitat for Quokka, and frogs were also recorded calling during both survey phases around these areas.

5.3.4.2.1 Fauna Habitat Types

Fauna habitat types were defined during the targeted fauna surveys conducted by SLR Consulting Australia (SLR) in 2023 and 2024 at the Huntly Mine – Myara and Willowdale Mine – Larego, and by GHD in 2024 at the O'Neil Mine region (GHD, 2024d). Fauna habitat mapping is based on historical site vegetation mapping, undertaken by Mattiske consulting, which is then verified in the field using fauna habitat assessments.

Previous surveys completed by GHD (GHD, 2021b); (GHD, 2021a) determined Blackbutt Forest, Bullich, and Flooded Gum fauna habitats were separate however the SLR survey determined that there was no discernible difference between the Blackbutt, Bullich, and Flooded Gum Woodland fauna habitats and therefore they were collectively referred to as

“Drainage Lines”. Terrestrial fauna habitats present in the Huntly and Willowdale Mine DEs are summarised in Table 5-28 below.

The surveys conducted by SLR only included the Myara portion of the Huntly Mine DE and did not include any portion of the Willowdale Mine DE (Figure 5-34 and Figure 5-35). Due to the incompleteness of the fauna habitat mapping of the Proposal areas, the data solely provides an informed extrapolation of the likely fauna habitats that will be within these areas.

During the Huntly Myara fauna survey, 928.6 ha of area was surveyed, and three fauna habitats were identified and mapped (SLR Consulting Australia, 2024b). These habitats included:

- Jarrah – Marri Forest which encompassed 91.5% (849.8 ha) of the surveyed area;
- Drainage Line (Blackbutt, Bullich, and Flooded Gum) encompassed 1.7% (15.6 ha) of the surveyed area;
- Rehabilitated area encompassed 0.03% (0.3 ha) of the surveyed area.

Approximately 62.9 ha was unable to be surveyed and <0.01 ha has been previously cleared.

During the Willowdale – Larego fauna survey 451.8 ha of area was surveyed, and two fauna habitats were identified and mapped (SLR Consulting Australia, 2024d). These habitats included:

- Jarrah-Marri Forest which encompassed 97.2% (439.2 ha) of the surveyed area; and
- Drainage Line (Blackbutt, Bullich, and Flooded Gum) encompassed 2.8% (12.7 ha) of the surveyed area.

Although the most recent assessment only included the three habitat types listed above (Jarrah-Marri Forest, Drainage Line, Rehabilitated area), the habitat types listed in Table 5-28 better represent the fauna habitat types within the region. As a result, Alcoa has standardised the habitat types within the Mine DEs into seven types:

- Drainage Lines;
- Drainage Line (Blackbutt Forest);
- Drainage Line (Bullich Forest);
- Jarrah – Marri Forest;
- Granite Outcrop;
- Melaleuca Dampland; and
- Other (cleared, Rehabilitated and/or Plantation).

The proportions of each habitat type present in the Mine DEs are outlined in Table 5-28.

The value of each habitat type for each conservation significant species known or with a high likelihood to occur in the Huntly and Willowdale Mine DE are presented in Table 5-29 below. It is noted that the persistence of populations of critical weight range (CWR) mammals (e.g., Chuditch, Quokka) in the habitat types is expected to be dependent on the ongoing suppression of feral predators (such as foxes and cats) that could lead to a reduction in the number of individuals or a loss of local populations. Further information on conservation significant fauna and their likelihood of occurrence is presented in Section 5.3.4.4.

Vegetation Types

Vegetation types (VTs) are delineated based on a method developed by Havel (1975a; 1975b) to differentiate vegetation across the continuum of Jarrah-Marri overstorey using key indicator species and site conditions. VTs comprise combinations of the 21 site vegetation types (SVTs) developed by Havel (1975a; 1975b), with the first letter reflecting the dominant SVT and the second letter the subdominant SVT as described in Table 5-5 within Section 5.2.4.1.2.

The habitat mapping results were broadly consistent with the VTs and vegetation complex mapping (refer to Section 5.2.4.2). Approximately 50% of the mapped part of the Huntly and Willowdale Mine DE comprises Jarrah-Marri Forest, which is associated with the P, S, and T dominant SVTs in uplands and slopes, and is widespread across the NJF. Portions of the Jarrah-Marri Forest habitat type associated with the Q, E and D dominant SVTs on the lower slopes are associated with potential GDEs and high-value SRE habitat.

Approximately 7.3% of the Huntly and Willowdale Mine DE comprises Blackbutt and Bullich Forest, associated with the C and W dominant SVTs in lower slopes and creek lines, and less widespread across the NJF subregion. These habitat types are also associated with potential GDEs, seasonal aquatic fauna habitat along creek lines and high value SRE habitat.

Approximately 3.4% of the Huntly and Willowdale Mine DE comprises of the drainage line and Melaleuca Dampland, associated with the A dominant SVT in swamps and drainage floors, which has a relatively restricted distribution in the NJF subregion. These habitat types are also associated with potential GDEs, seasonal aquatic fauna habitat and high value SRE habitat.

Approximately 2.5% of the Huntly and Willowdale Mine DE comprises Granite Outcrops, associated with the G and R dominant SVTs, comprised VTs with G and R dominant, which is relatively restricted in distribution in the NJF subregion. This habitat is also associated with high value SRE habitat.

Approximately 39.9% of the Huntly and Willowdale Mine DE comprises cleared land, rehabilitated, and/or unsurveyed area.

Table 5-28: Terrestrial fauna habitats present in the Huntly and Willowdale Mine DEs

Habitat Types	Huntly Mine DE		Willowdale Mine DE	
	Total (ha)	Proportion (%)	Total (ha)	Proportion (%)
Drainage Line Closed mosaic upper storey of Bullich (*E. megacarpa*), Blackbutt (*E. patens),* and Flooded Gum (*E. rudis*), forest over a closed mixed shrubland of *Melaleuca sp., B. aquifolium*, and other *Myrtaceae sp*. and *Acacia sp.,* over tall sedgeland. This habitat has areas of drainage with thin channels of surface water present. Substrate consists of clay loam soils. The habitat has low levels of disturbance. Habitat for conservation significant species: Core habitat for Chuditch, Quokka, Rakali, Brush-tailed Phascogale, all three Black Cockatoo species (for breeding, roosting, and foraging), Quenda, Western Brush Wallaby and Western False Pipistrelle and potential foraging habitat for Western Ringtail Possum, Numbat and Woylies.	14.0	0.0	0.0	0.0
Drainage Line (Blackbutt Forest) Blackbutt open forest with occasional Bullich, and Marri over sparse *Banksia littoralis* over *Trymalium, Macrozamia, Xanthorrhoea preissii*, over *Lepidospermum tetraquetrum, Astartea scoparia* and areas of dense Swamp peppermint (*Taxandria linearifolia*). This habitat is limited to localised patches often associated with creeks and drainage lines. Disturbance factors include frequent fire, feral pigs, *Phytophthora* dieback, trail bike and 4WD. Habitat for conservation significant species: Core habitat for Western Brush Wallaby, Quenda, Quokka, Chuditch and Western False Pipistrelle and potential foraging habitat for Western Ringtail Possum and Woylies. Breeding and roosting habitat for all three Black Cockatoo species with moderate foraging quality for Forest Red-tailed Black Cockatoo.	860.1	2.2	57.8	2.7
Drainage Line (Bullich Forest) Valleys and drainage areas dominated by Bullich (*Eucalyptus megacarpa*) and with some Blackbutt (*E. patens*), occasional Marri (*Corymbia calophylla*), over Sheoak (*Allocasuarina fraseriana*), *Banksia littoralis* over Grass trees (*Xanthorrhoea preissii*), Bracken fern, patches of dense *Gahnia trifida* shrubland over *Lasiopetalum floribundum*, flooded gum (*E. rudis*) woodland, sedges and herbs. Substrate is dark clayloam soil, and sandy clays that vary from dark grey to grey brown. These areas are associated with seasonal creeks and drainage areas. The flooded gum woodland is associated with poorly drained broad valleys forming seasonal swamps and occasionally tall open forest along drainage lines. Disturbance factors include frequent fire, feral pigs, *Phytophthora* dieback. Habitat for conservation significant species:	1,954.7	5.0	126.3	5.9

Habitat Types	Huntly Mine DE		Willowdale Mine DE	
	Total (ha)	Proportion (%)	Total (ha)	Proportion (%)
Core habitat for Black Cockatoos (all three, breeding and roosting with low foraging), Chuditch, Quokka, Quenda, Western Brush Wallaby, Masked Owl, Brush-tailed Phascogale and Western False Pipistrelle.				
Jarrah – Marri Forest *E. marginata* and *C. calophylla* open forest over Grass trees (*Xanthorrhoea preissi*), *Lasiopetalum floribundum*, Macrozamia mid shrubland. Patches have dominance of understory *Allocasuarina fraseriana* and *Banksia grandis*. Often with complex mosaic of low shrubs such as Fabaceae, *Hibbertia*, *Leucopogon*, *Adenanthos*, and *Pteridium*. This is the most extensive habitat identified and comprises a number of vegetation types dominated by Jarrah on upper, mid and low slopes and broad valleys. Soils range from well drained gravely sand to sandy clay loam. Historical logging is a significant disturbance factor: extensive areas of forest are at varying ages of regeneration. Other disturbances include frequent fire (significant), feral pigs, *Phytophthora* dieback, trail bike, 4WD and dumped rubbish including weed plants. Habitat for conservation significant species: Core habitat for Chuditch, Brush-tailed Phascogale, Western Brush Wallaby, Peregrine Falcon, Masked Owl, Western False Pipistrelle, Dell's Skink, and Southern Death Adder. Breeding, foraging and potential roosting habitat for Black Cockatoos. Potential foraging habitat for Western Ringtail Possum, Woylie and Numbat. Quokka may use dense areas of Jarrah-Marri Forest for foraging and dispersal.	18,633.3	47.7	1,936.5	90.6

Habitat Types	Huntly Mine DE		Willowdale Mine DE	
	Total (ha)	Proportion (%)	Total (ha)	Proportion (%)
Granite outcrop Granite outcrops with associated lithic vegetation complexes and adjacent associated fringing open Jarrah and Marri areas with scattered Sheoak, Melaleuca, *Banksia ilicifolia* over occasional Grass trees over mixed open heath communities of myrtaceous and proteaceous low shrubs. Soils are pale grey to yellowish fine sand or sandy clay. Granite outcrops often associated with seasonal watercourse and seasonally damp areas. This habitat found as localised patches throughout the Survey Area. Disturbance factors include frequent fire, feral pigs, *Phytophthora* dieback, damage caused by rock removal, trail bike and 4WD on granite. Habitat for conservation significant species: Foraging and denning habitat for Chuditch and Woylie. Habitat for Western Brush Wallaby, Southern Death Adder, Woylie and Dell's Ctenotus.	1,010.2	2.6	1.8	0.1
Melaleuca dampland Paperbark (*Melaleuca pressiana*) over sparse isolated *Banksia littoralis* over open *Hakea*, occasional Woody Pear (*Xylomelum*), Grass trees and over mixed shrublayer of Cyperaceae, Restionaceae, *Babingtonia*, *Jacksonia* and *Acacia*, over low shrubs, sedges and herbs. There are areas of sparse to occasional stunted Jarrah and Marri however these are limited to lowland transitional zones adjacent to slightly higher elevation and drainage open forest areas. Generally limited to areas of poor drainage and subject to winter inundation such as broad valleys and swamps. Substrate is grey gravely clay and clay loam. Disturbance factors include frequent fire and feral pigs. Habitat for conservation significant species: Western Brush Wallaby, Woylie, Western False Pipistrelle. Foraging habitat for Black Cockatoos although Jarrah and Marri are generally stunted and sub-optimal for potential breeding habitat. Where creek lines or dense vegetation is present Quokka and Quenda reside.	140.1	0.4	0.00	0.00
Unsurveyed	7,238.8	18.5	15.0	0.7
Open Areas	4,085.0	10.5	-	0.0
Areas Under Rehabilitation	5,127.4	13.1	-	0.0
Total Area	**39,071.7**	**100**	**2,137.4**	**100**

Table 5-29: Habitat values for conservation significant fauna species known or likely to occur in the Fauna Habitat Types.

Fauna habitat type	Extent within the Huntly and Willowdale Mine DE (ha)	Conservation significant species																
		Baudin' s Cockatoo	Carnaby' s Cockatoo	Forest Red-tailed Black Cockatoo	Masked Owl	Peregrine Falcon	Western Ringtail Possum	Numbat	Chuditch	Quokka	Western False Pipistrelle	Quenda	Western Brush Wallaby	Wambenger Brush tailed Phascogale	Rakali	Woylie	Southern Death Adder	Dell' s Skink
Conservation Status	EPBC Act	EN	EN	VU	-	-	CR	EN	VU	VU	-	-	-	-	-	CR	-	-
	BC Act/DBCA	EN	EN	VU	P3	SP	CR	EN	VU	VU	P4	P4	P4	CD	P4	EN	P3	P4
Likelihood of occurrence		Known	Known	Known	Known	Known	Known	Likely	Known	Known	Known	Known	Known	Known	Known	Likely	Likely	Known
Drainage line	14.0	Medium	Medium	Low	High	Medium	High	Low	High	High	High	High	High	High	High	High	Medium	High
Drainage Line (Blackbutt Forest)	917.8	Medium	Medium	High	High	High	Medium	Medium	High	High	High	High	High	High	Medium	High	Medium	High
Drainage Line (Bullich Forest)	2,080.9	Medium	Medium	Medium	High	High	Medium	Medium	High	High	High	High	High	High	Medium	High	Medium	High
Granite Outcrop	1,012.0	Low	Low	Low	High	Medium	Low	Low	High	Medium	Medium	Medium	High	High	Medium	Medium	High	High
Jarrah-Marri Forest	20,568.6	High	High	High	High	High	High	High	High	Medium	High	Medium	High	High	Low	High	High	High
Melaleuca Dampland	1,401.0	Low	Low	None	Medium	Medium	High	Medium	High	High	Medium	High	High	Medium	High	High	Medium	High
Other	16,450.6	Medium	Medium	Medium	Medium	Medium	Low	Low	High	Low	Medium	Medium	Medium	Medium	Low	Medium	Medium	High

Conservation Status

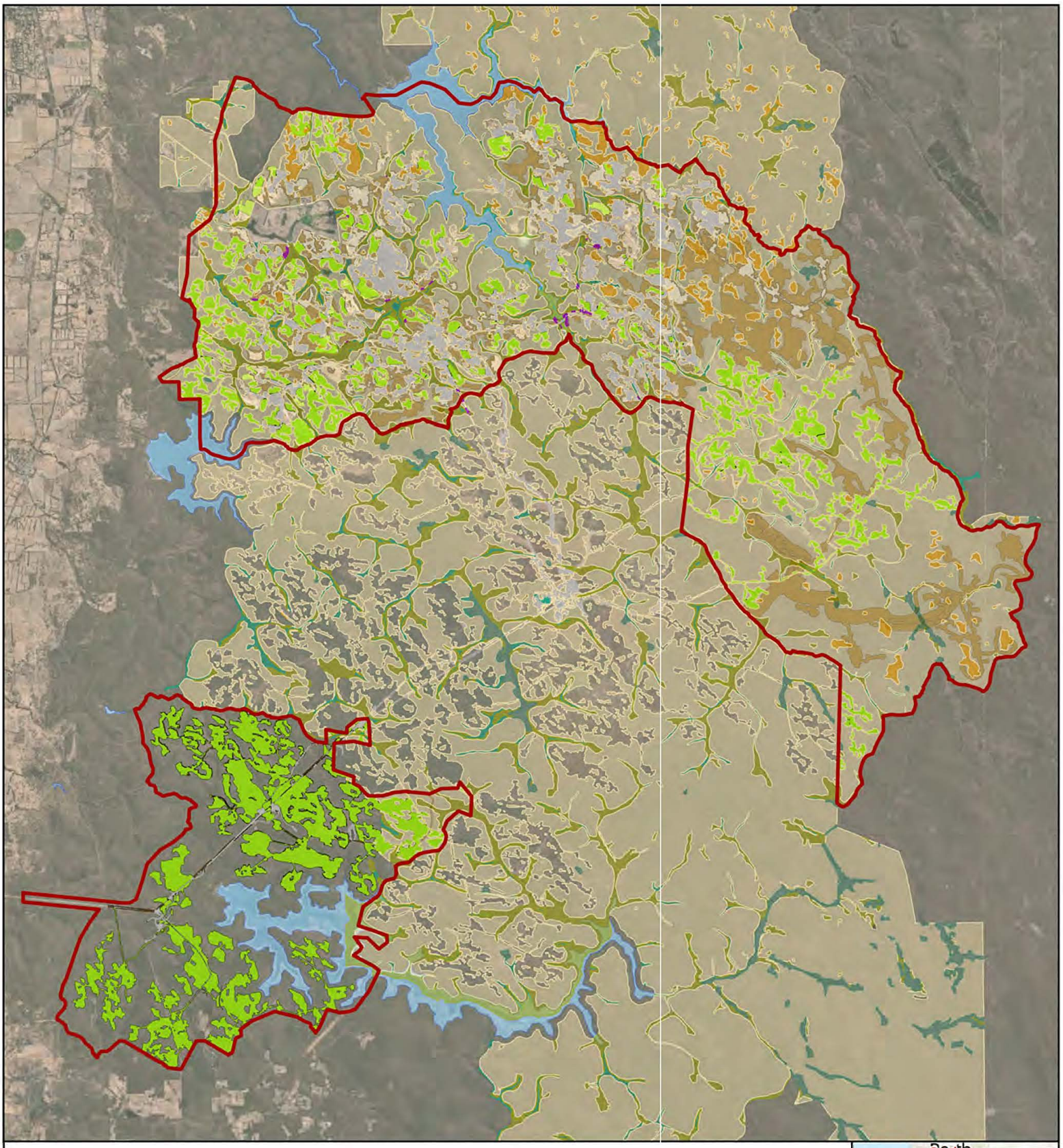
CD= Conservation dependent fauna
CR = Critically endangered under the EPBC Act or BC Act
EN = Endangered under the EPBC Act or BC Act
VU = Vulnerable under the EPBC Act or BC Act
SP (S7) = Schedule 7, Special Protection under BC Act
P3 = Priority 3 under DBCA, poorly known species.
P4 = Priority 4 under DBCA, rare, near threatened and species in need of monitoring.

Likelihood Occurrence

High – Species has been recorded more than once in the last 15 years and suitable habitat is present within the Survey Area.

Medium – There are existing records of the species within the Desktop Study Area, however the taxon has not been recorded within the Desktop Study Area in the last 15 years or suitable habitat within the Survey Area is marginal or limited in extent.

Low Suitable habitat is not present within the Survey Area, or the species is very infrequently recorded in the locality despite reasonable previous search effort, or the species is believed to be extinct or locally extinct.



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-34 Terrestrial Fauna Habitats - Huntly Mine DE

Kilometres

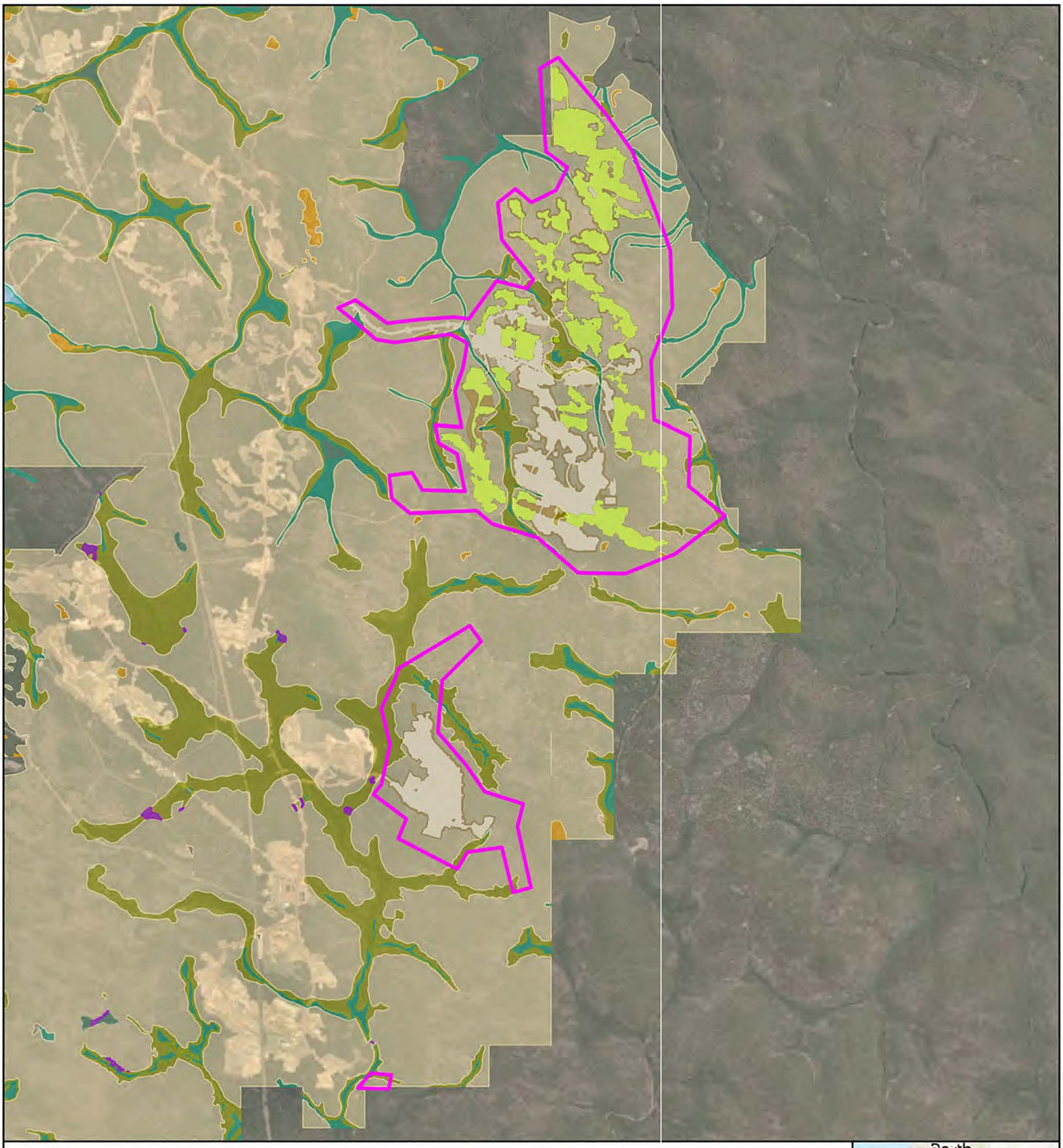
0 2 4 6 8 10 12

Scale: 1:175,000 at A4

Date Printed: 27/02/2025

N

Alcoa

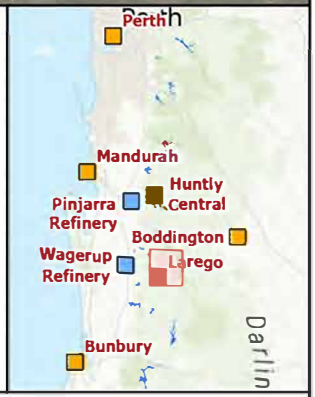


Legend

- Willowdale Mine DE

Fauna Habitat

- Blackbutt Forest
- Bullich Forest
- Granite Outcrop Association
- Jarrah – Marri Forest
- Melaleuca Dampland
- Drainage Line
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Reservoirs



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-35 Terrestrial Fauna Habitats - Willowdale Mine DE

Kilometres

0 0.9 1.8 2.7 3.6 4.5 5.4

Scale: 1:75,000 at A4

Date Printed: 27/02/2025

N

Alcoa

5.3.4.2.2 Fauna Habitat Zones

Fauna Habitat Zones (FHZ) are patches of forest that has been systematically distributed across the landscape which are temporarily excluded from disturbance as set out by the state government. FHZ are selected according to the following principles (Department of Parks and Wildlife, 2017a):

- Even and systematic spacing to best sample the full range of habitats;
- Vulnerable populations;
- Mature forest and habitat diversity;
- Long-term habitat quality and linkage with reserves;
- Low perimeter/area ratio;
- Indigenous vegetation, non-fauna values; and
- Practicable and least cost management.

The establishment of FHZ to ensure that biodiversity recovers between timber harvest rotations as per the requirements set out in the 2024 – 2033 Forest Management Plan (FMP) as a result FHZ are not static and shift across the NJF subregion. In a broader context FHZ are defined as being part of a Comprehensive, Adequate and Representative (CAR) reserve, which includes other exclusion zones i.e., river and streamzones, old-growth forest, diverse ecotype travel routes (Department of Environment and Conservation, 2010a).

Prior to the release of the 2024-2033 FMP, FHZ were treated separately from all other CAR reserves, but upon the release of the most recent Fauna MP (Appendix 5) all these reserves were collectively renamed as DAZ. Zones considered to be DAZ in State Forest and timber reserves include:

- Old Growth Forest;
- River and streamzones;
- Diverse ecotype zones;
- Travel route zones;
- Less well reserved vegetation complexes;
- Poorly reserved forest ecosystem;
- RFA-accredited linkage zones; and
- FHZ.

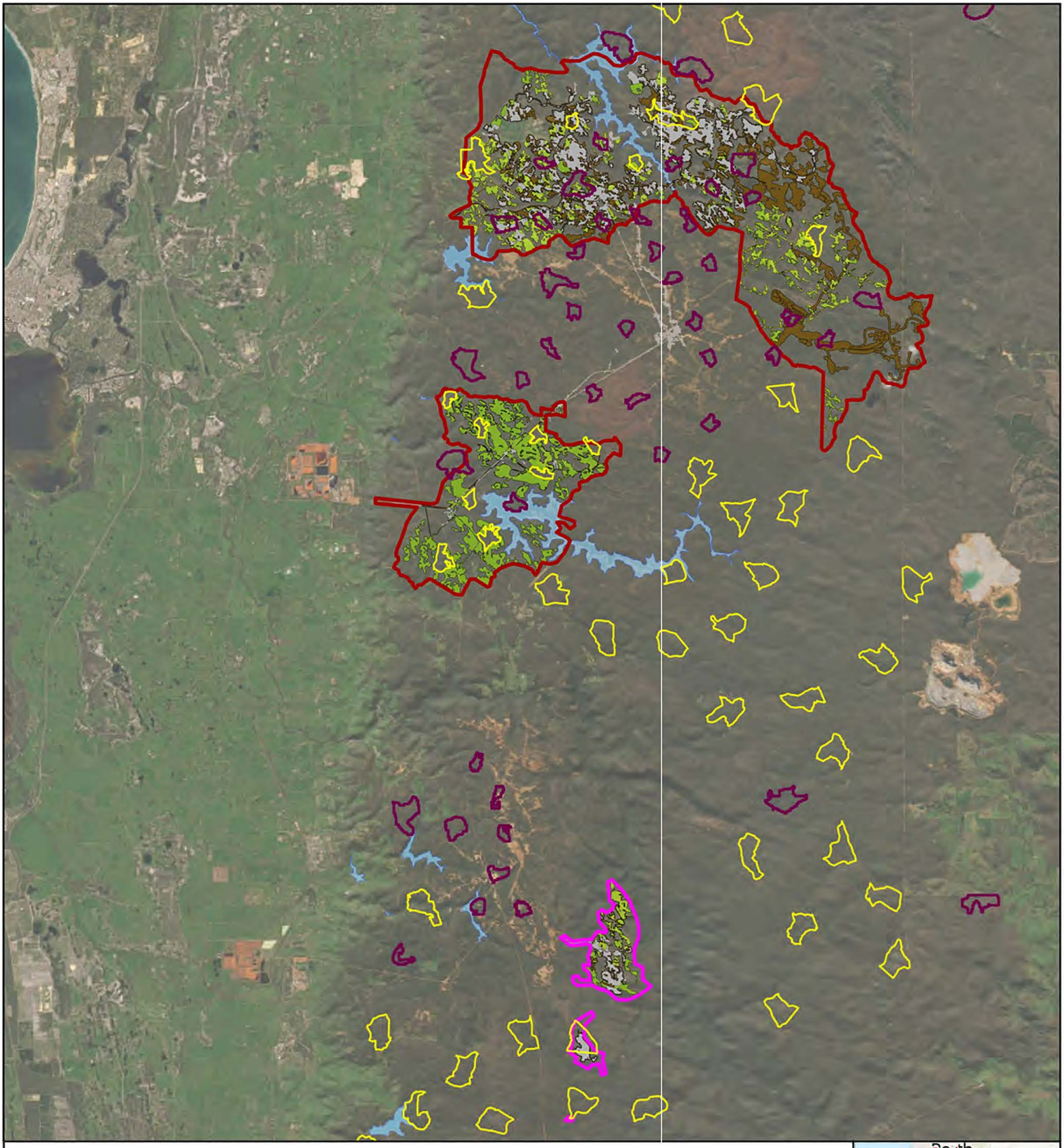
For the purpose of the assessment, the FHZ will be discussed in further detail as the DAZ spatial data was not available.

Approximately 2,366.9 ha (6.0%) of the Huntly Mine DE is covered by a total of 1,045.1 ha of interim and 1,321.8 ha of indicative FHZ, as seen in Figure 5-36. Approximately 171.0 ha of the Willowdale Mine DE (8%) is covered by interim FHZ, as seen in Figure 5-36. An interim and indicative FHZ can be defined as:

- **Interim FHZ:** where the boundary and location of the FHZ has been approved by the Director of Sustainable Forest Management (SFM) (Department of Environment and Conservation, 2010a); and
- **Indicative FHZ:** is one of the 283 FHZ designed and located during the development of the Fauna MP and whose location was published at the commencement of the Fauna MP (Department of Environment and Conservation, 2010a).

Figure 5-36 shows the coverage of fauna habitats across the FHZ within the Huntly and Willowdale Mine DE. The zones provide: proportionally higher protection of Granite Outcrop habitat; a representative protection of Bullich, Blackbutt, and Jarrah; and limited protection of Melaleuca Dampland and rehabilitation.

In addition to the government prescribed FHZ, Alcoa has created two protection zones that were established to protect significant fauna which included Limited Disturbance Areas (LDA) and Mining Avoidance Zones (MAZ). LDZs prohibit mine pits but allows for infrastructure and haul roads. MAZ and LDZ can be added based on the results from flora and fauna assessments.



Legend

Fauna Habitat Zones

- Indicative
- Interim

- Huntly Mine DE
- Willowdale Mine DE
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Reservoirs



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-36 Mine Region Fauna Zones

Kilometres

0 4 8 12 16 20 24

Scale: 1:320,000 at A4

Date Printed: 27/02/2025

N

Alcoa

5.3.4.2.3 Fauna Habitat Linkages

The Huntly and Willowdale Mine DE represents a large continuous tract of fauna habitat that retains high connectivity to the habitats directly adjacent. The Lane Poole Recreation Reserve, Monadnocks Conservation Reserve, and Serpentine National Park are on the periphery of the Mine DEs and provide protected fauna habitat. Streamzone areas and swamps in the Huntly and Willowdale Mine DE support areas of relatively low-density vegetation which has a linkage value as preferred habitat for medium sized mammals, such as Quenda and Quokka.

5.3.4.3 Fauna Diversity

A desktop assessment of the Huntly and Willowdale Mine DE, which included a 20 km buffer of the Proposal areas, completed by SLR (2024b) and (2024d) noted that:

- 189 terrestrial vertebrate fauna species have potential to occur within the Willowdale Mine DE including:
    - 126 birds, of which 19 are significant;
    - 28 mammals, of which 10 are significant;
    - 25 reptiles, of which four are significant; and
    - 10 amphibians, of which none are significant.
- 218 terrestrial vertebrate fauna species have potential to occur within the Huntly Mine DE including:
    - 156 birds, of which 31 are significant;
    - 30 mammals, of which 12 are significant;
    - 22 reptiles, of which two are significant; and
    - 10 amphibians, of which none are significant.

An additional desktop assessment was conducted by GHD (2024d) for the O'Neil mine region, which included a 10 km buffer of the survey area. The results of this desktop study identified 166 terrestrial vertebrate fauna species including:

- 31 mammals, of which nine are significant;
- 83 birds, of which 13 are significant;
- 41 reptiles, of which two are significant; and
- 11 frogs, of which none are significant.

Basic and targeted fauna surveys conducted by SLR (2024b; 2024d) recorded 61 vertebrate fauna species, including 13 mammals, 35 birds, 10 reptiles and three amphibians in the Huntly Mine DE and 30 vertebrate fauna species, including 10 mammals, 12 birds, five reptiles, and three amphibians in the within the Willowdale Mine DE.

A basic and targeted survey of the O'Neil mine region recorded 121 vertebrate fauna species, including 19 mammals, 68 birds, 27 reptiles, and seven amphibians.

A summary of the species and their conservation status recorded in the Proposal isa from the three studies is presented in Table 5-30 below. Fauna species considered to be conservation significant are discussed further in Section 5.3.4.4.

Table 5-30: Species recorded within the Study Area during recent surveys (2023 – present)

Family	Scientific Name	Common Name	Conservation Status		Survey Area	
			State	Commonwealth	Huntly (including O'Neil)	Willowdale
Amphibians						
Limnodynastidae	*Heleioporus inornatus*	Whooping Frog	-	-		X
Myobatrachidae	*Crinia georgiana*	Quacking Frog	-	-	X	X
Myobatrachidae	*Crinia glauerti*	Clicking Frog	-	-	X	X
Pelodryadidae	*Litoria adelaidensis*	Slender Tree Frog	-	-	X	
Birds						
Acanthizidae	*Acanthiza apicalis*	Inland Thornbill	-	-	X	
Acanthizidae	*Acanthiza inornata*	Western Thornbill	-	-	X	
Acanthizidae	*Gerygone fusca*	Western Gerygone	-	-	X	X
Acanthizidae	*Sericornis maculatus*	Spotted Scrubwren	-	-	X	X
Acanthizidae	*Smicrornis brevirostris*	Weebill	-	-	X	
Accipitridae	*Lophoictinia isura*	Square-tailed Kite	-		X	
Alcedinidae	*Dacelo novaeguineae*	Laughing Kookaburra	**Introduced**	-	X	
Anatidae	*Anas superciliosa*	Pacific Black Duck	-	-	X	
Artamidae	*Artamus cyanopterus*	Dusky Woodswallow	-	-	X	
Artamidae	*Strepera versicolor*	Grey Currawong	-	-	X	
Cacatuidae	*Calyptorhynchus banksii naso*	Forest Red-tailed Black Cockatoo	**VU**	**VU**	X	X
Cacatuidae	*Cacatuidae Zanda baudinii*	Baudin's Cockatoo	**EN**	**EN**	X	X
Cacatuidae	*Zanda latirostris*	Carnaby's Cockatoo	**EN**	**EN**	X	
Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckooshrike	-	**MA**	X	

Family	Scientific Name	Common Name	Conservation Status		Survey Area	
			State	Commonwealth	Huntly (including O'Neil)	Willowdale
Casuariidae	*Casuariidae Dromaius novaehollandiae*	Emu	-	-	X	
Climacteridae	*Climacteris rufus*	Rufous Treecreeper	-	-	X	
Columbidae	*Phaps elegans*	Brush Bronzewing	-	-	X	X
Corvidae	*Corvus coronoides*	Australian Raven	-	-	X	
Cuculidae	*Cacomantis flabelliformis*	Fan-tailed Cuckoo	-	**MA**	X	
Maluridae	*Malurus elegans*	Red-winged Fairywren	-	-	X	X
Maluridae	*Malurus splendens*	Splendid Fairywren	-	-		X
Meliphagidae	*Acanthorhynchus superciliosus*	Western Spinebill	-	-	X	
Meliphagidae	*Anthochaera lunulata*	Western Wattlebird	-	-	X	
Meliphagidae	*Phylidonyris novaehollandiae*	New Holland Honeyeater	-	-	X	
Pachycephalidae	*Pachycephala fuliginosa*	Western Whistler	-	-	X	
Pachycephalidae	*Colluricincla harmonica*	Grey Shrikethrush	-	-		X
Pachycephalidae	*Pachycephala rufiventris*	Rufous Whistler	-	-	X	
Pardalotidae	*Pardalotus punctatus*	Spotted Pardalote	-	-	X	
Pardalotidae	*Pardalotus striatus*	Striated Pardalote	-	-	X	
Petroicidae	*Eopsaltria griseogularis*	Western Yellow Robin	-	-	X	X
Petroicidae	*Petroica boodang*	Scarlet Robin	-	-	X	
Petroicidae	*Quoyornis georgianus*	White-breasted Robin	-	-	X	X
Podargidae	*Podargus strigoides*	Tawny Frogmouth	-	-	X	
Psittaculidae	*Barnardius zonarius*	Australian Ringneck	-	-	X	
Psittaculidae	*Platycercus icterotis*	Western Rosella	-	-	X	
Rhipiduridae	*Rhipidura albiscapa*	Grey Fantail	-	-	X	X
Turnicidae	*Turnix varius*	Painted Buttonquail	-	-	X	
Strigidae	*Ninox boobook*	Boobook Owl	-	-		X

Family	Scientific Name	Common Name	Conservation Status		Survey Area	
			State	Commonwealth	Huntly (including O'Neil)	Willowdale
Mammal						
Canidae	*Vulpes vulpes*	Red Fox	**Introduced**	**Introduced**	**X**	
Dasyuridae	*Antechinus flavipes leucogaster*	Yellow-footed Antechinus, Mardo	**-**	**-**	**X**	**X**
Dasyuridae	*Dasyurus geoffroii*	Chuditch	**VU**	**VU**	**X**	**X**
Dasyuridae	*Phascogale tapoatafa wambenger*	Wambenger Brush-tailed Phascogale	**CD**	**-**	**X**	
Felidae	*Felis catus*	Cat	**Introduced**	**Introduced**		**X**
Leporidae	*Oryctolagus cuniculus*	Rabbit	**Introduced**	**Introduced**	**X**	
Macropodidae	*Macropus fuliginosus melanops*	Western Grey Kangaroo	**-**	**-**	**X**	**X**
Macropodidae	*Notamacropus irma*	Western Brush Wallaby	**P4**	**-**	**X**	**X**
Macropodidae	*Setonix brachyurus*	Quokka	**VU**	**VU**	**X**	
Muridae	*Hydromys chrysogaster*	Rakali	**P4**	**-**		**X**
Muridae	*Rattus rattus*	Black Rat	**Introduced**	**Introduced**	**X**	**X**
Peramelidae	*Isoodon fusciventer*	Quenda	**P4**	**-**	**X**	
Phalangeridae	*Trichosurus vulpecula hypoleucus*	Common Brushtail Possum	**-**	**-**	**X**	**X**
Suidae	*Sus scrofa*	Pig	**Introduced**	**Introduced**	**X**	**X**
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked Echidna	**-**	**-**	**X**	**X**
Reptiles						
Carphodactylidae	*Underwoodisaurus milii*	Southern Barking Gecko	**-**	**-**	**X**	
Elapidae	*Pseudonaja affinis*	Dugite	**-**	**-**	**X**	
Gekkonidae	*Christinus marmoratus*	Marbled Gecko	**-**	**-**	**X**	
Pygopodidae	*Aprasia pulchella*	Pretty Worm-lizard	**-**	**-**	**X**	

Family	Scientific Name	Common Name	Conservation Status		Survey Area	
			State	Commonwealth	Huntly (including O'Neil)	Willowdale
Scincidae	*Cryptoblepharus buchananii*	Buchanan's Snake-eyed Skink	-	-	X	
Scincidae	*Ctenotus labillardieri*	Red-legged Ctenotus	-	-	X	
Scincidae	*Egernia kingii*	King's Skink	-	-	X	
Scincidae	*Egernia napoleonis*	South-western Crevice-skink	-	-	X	X
Scincidae	*Lissolepis luctuosa*	Western Swamp Skink	-	-		X
Scincidae	*Morethia obscura*	Shrubland Morethia Skink	-	-		X
Scincidae	*Tiliqua rugosa*	Bobtail	-	-	X	X
Varanidae	*Varanus gouldii*	Sand Goanna	-	-	X	X

Conservation Status

CD= Conservation dependent fauna

CR = Critically endangered under the EPBC Act or BC Act

EN = Endangered under the EPBC Act or BC Act

VU = Vulnerable under the EPBC Act or BC Act

SP (S7) = Schedule 7, Special Protection under BC Act

P3 = Priority 3 under DBCA, poorly known species.

P4 = Priority 4 under DBCA, rare, near threatened and other species in need of monitoring.

5.3.4.4 Conservation Significant Fauna

Conservation significant fauna is subjected to protection under the *Commonwealth EPBC Act* and the *BC Act (WA)*. These protected species are listed in Section 178 of the *EPBC Act*, for Commonwealth listed species, and on the DBCA Database for State (WA) listed species.

Desktop searches and fauna surveys within 10 km of the Proposal areas within the Huntly or Willowdale survey areas were completed by SLR Consulting (2024b; 2024d), GHD (2024d), Western Environmental (2024a; 2024b), Biologic Environmental Survey (2024a), and Phoenix Environmental Services (2024a).

As outlined in Table 5-27 a large number of studies have been conducted over the years; however, for the purpose of this ERD only recent surveys (1–2 years old) are detailed below.

In a targeted fauna survey conducted in the Huntly – Myara mine region, eight conservation significant fauna within the survey area were identified (SLR Consulting Australia, 2024b). The eight significant taxa recorded during the survey are included in Table 5-31 below. The survey was conducted between 22–26 August 2023 and 9–11 September 2023 and covered an area of 928.6 ha. Additionally, identified conservation significant fauna species can be seen in Figure 5-37, Figure 5-40, Figure 5-38, and Figure 5-39.

Table 5-31: Conservation Significant Fauna found within the the Huntly – Myara mine region Survey

Species	Conservation Status		Number Recorded	Habitat Type
	State	Common wealth		
Baudin's Cockatoo	EN	EN	2	Jarrah-Marri Forest; Drainage Line
Carnaby's Cockatoo	EN	EN	50	Jarrah-Marri Forest; Drainage Line
Forest Red-tailed Black Cockatoo	VU	VU	110	Jarrah-Marri Forest; Drainage Line
Chuditch	VU	VU	52 (minimum 14 individuals)	Jarrah-Marri Forest
Quenda	P4	-	56	Jarrah-Marri Forest; Drainage Line
Western Brush Wallaby	P4	-	35	Jarrah-Marri Forest; Drainage Line
Quokka	VU	VU	18	Jarrah-Marri Forest; Drainage Line
Wambenger Brush-tailed Phascogale	CD	-	24	Jarrah-Marri Forest

In the basic and targeted fauna survey conducted in the Huntly – O'Neil mine region, 12 terrestrial conservation significant fauna within the survey area were identified (GHD, 2024d; Spectrum, 2024). The survey included seven survey events between June 2023 and January 2024. The 12 significant taxa recorded during the survey are listed in Table 5-32 below.

Table 5-32: Conservation Significant Fauna found within the Huntly – O'Neil mine region Survey

Species	Conservation Status		Number Recorded	Habitat Type
	State	Common wealth		
Woylie	CR	EN	Minimum 1 individual	Jarrah – Marri Forest
Baudin's Cockatoo	EN	EN	35	Jarrah – Marri Forest
Forest Red-tailed Black Cockatoo	VU	VU	82	Jarrah – Marri Forest
Carnaby's Cockatoo	EN	EN	3	Jarrah – Marri Forest
Chuditch	VU	VU	16 (minimum 4 individuals)	Jarrah – Marri Forest
Rakali	P4	-	1	Jarrah – Marri Forest
Quenda	P4	-	2	Jarrah – Marri Forest
Dells Skink	P4		3	Jarrah – Marri Forest
Quokka	VU	VU	25	Jarrah – Marri Forest
Western Brush Wallaby	P4	-	161	Jarrah – Marri Forest
Masked Owl	P3	-	5	Jarrah – Marri Forest
Western False Pipistrelle	P4	-	1	Jarrah – Marri Forest

In a targeted fauna survey conducted in the Huntly- O'Neil mine region, six conservation significant fauna within the survey area were identified (Spectrum Ecology and Spatial, 2024a). Forty baited camera traps were deployed from 10–12 September 2024 to 11–13 November 2024 and covered an area of 650.5 ha. In addition, targeted field surveys to identify scats, tracks, dens/nests, tunnels, and remains were undertaken at 20 locations within the survey area on 13 October 2024, and 13–15 November 2024. The six significant taxa recorded during the survey are included in Table 5-34 below.

Table 5-33: Conservation Significant Fauna found within the Willowdale Mine Survey

Species	Conservation Status		Number Recorded	Habitat Type
	State	Common wealth		
Chuditch	VU	VU	4	Jarrah – Marri Forest
Woylie	CR	EN	3	Jarrah – Marri Forest
Wambenger Brush-tailed Phascogale	CD	-	Not disclosed in study	Jarrah – Marri Forest
Western Brush Wallaby	P4	-	Not disclosed in study	Jarrah – Marri Forest

Species	Conservation Status		Number Recorded	Habitat Type
	State	Common wealth		
Forest Red-tailed Black Cockatoo	VU	VU	Not disclosed in study	Jarrah – Marri Forest
Carnaby's Black Cockatoo	EN	EN	Not disclosed in study	Jarrah – Marri Forest

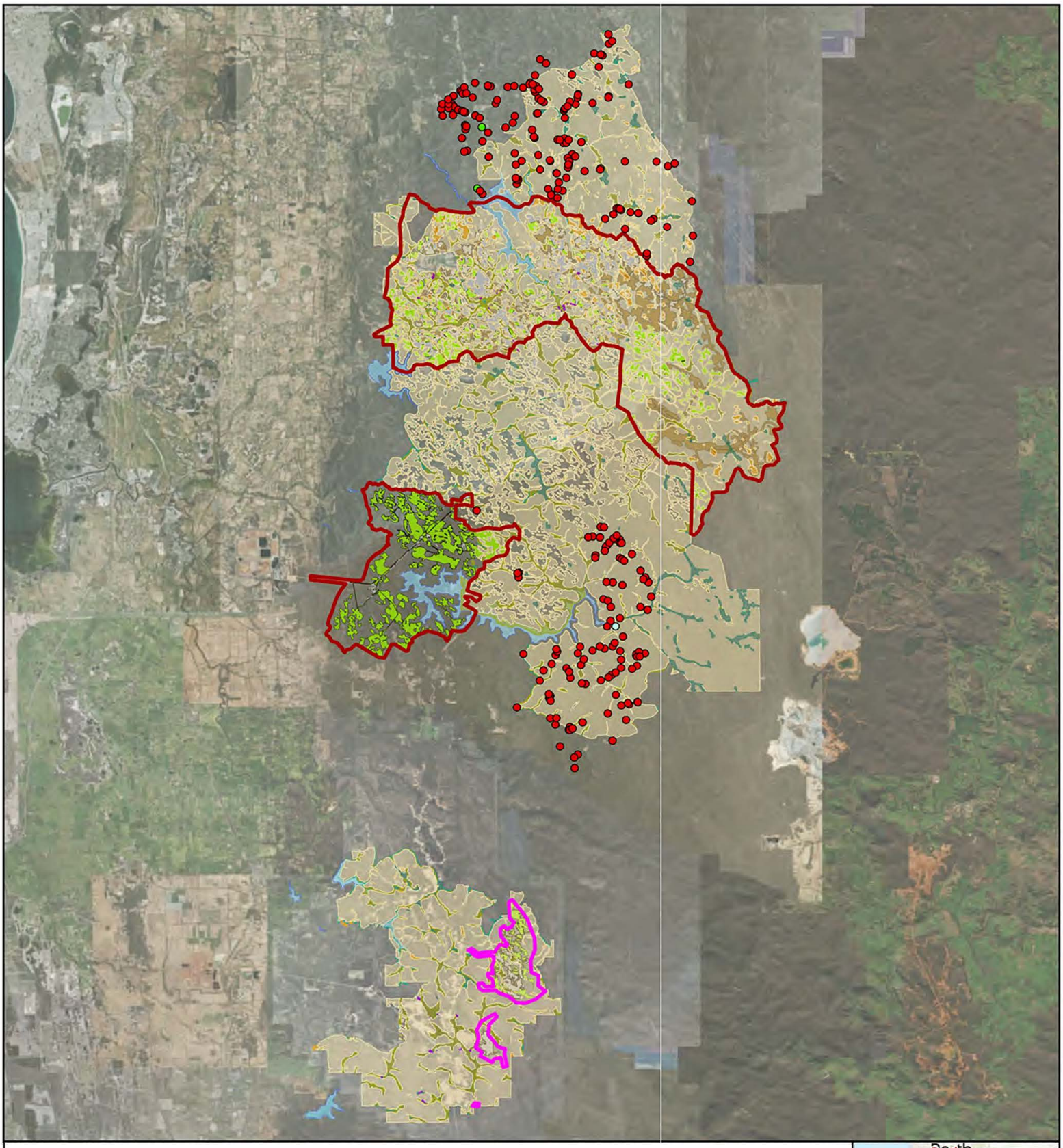
In a targeted fauna survey conducted in the Willowdale – Larego mine region, five conservation significant fauna within the survey area were identified (SLR Consulting Australia, 2024d). The survey was conducted between 13–16 October 2023 and 7–8 November 2023 and covered an area of 451.8 ha. The five significant taxa recorded during the survey are included in Table 5-34 below.

Table 5-34: Conservation Significant Fauna found within the Willowdale Mine Survey

Species	Conservation Status		Number Recorded	Habitat Type
	State	Common wealth		
Baudin's Cockatoo	EN	EN	1	Jarrah-Marri Forest; Drainage Line
Forest Red-tailed Black Cockatoo	VU	VU	20	Jarrah-Marri Forest
Chuditch	VU	VU	1	Jarrah-Marri Forest
Rakali	P4	-	1	Drainage Line
Western Brush Wallaby	P4	-	29	Jarrah-Marri Forest; Drainage Line

During a pre-clearance targeted survey on the evening of 30 July 2024 a mature male Western Ringtail Possum (*Pseudocheirus occidentalis*) was recorded via spotlighting within the Arundel region of Willowdale Mine (SLR Consulting Australia, 2024g). The Western Ringtail Possum was spotted in a blackbutt sapling during a spot lighting survey approximately 5 m from the edge of the vegetation in a drainage line habitat.

Based on the surveys, 12 conservation significant species have been recorded within the Mines DEs with a further six identified as having a likely or highly likely likelihood of occurrence at either Huntly Mine DE or Willowdale Mine DE. A list of conservation significant species, that have either been previously recorded or are likely to occur within the Proposal areas are outlined in Table 5-35. Further details are provided in the Desktop Assessment Report (GHD, 2024m) included in Appendix 27. The likelihood of occurrence below has been based on the previous ecological assessments. For the purpose of this assessment, where the ecological assessments differ a conservative approach has been undertaken.



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-37 Conservation significant fauna Records (Birds) and Fauna Habitat within the Mine DEs

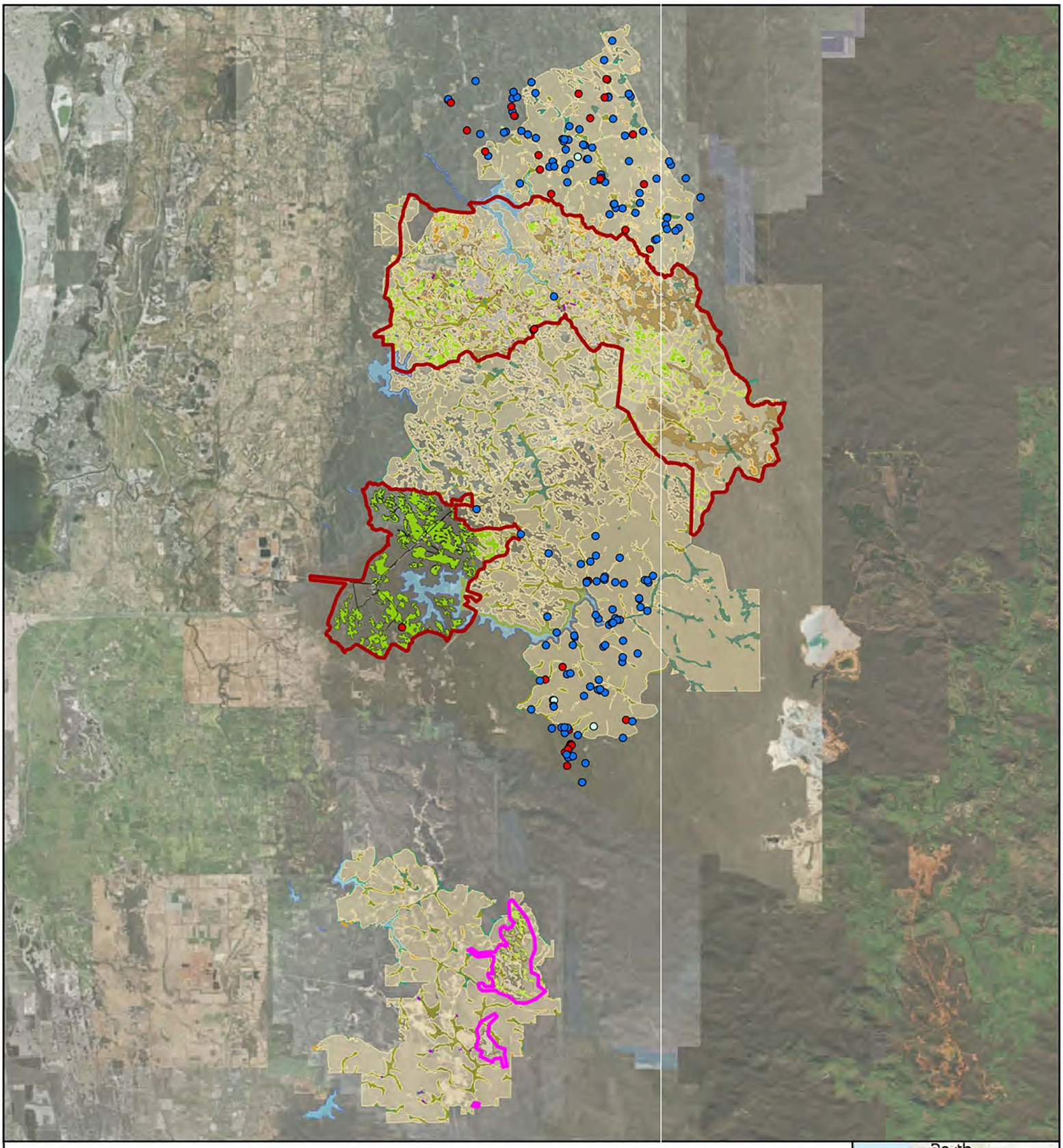
Kilometres
0 5 10 15 20 25 30

Scale: 1:375,000 at A4

Date Printed: 27/02/2025

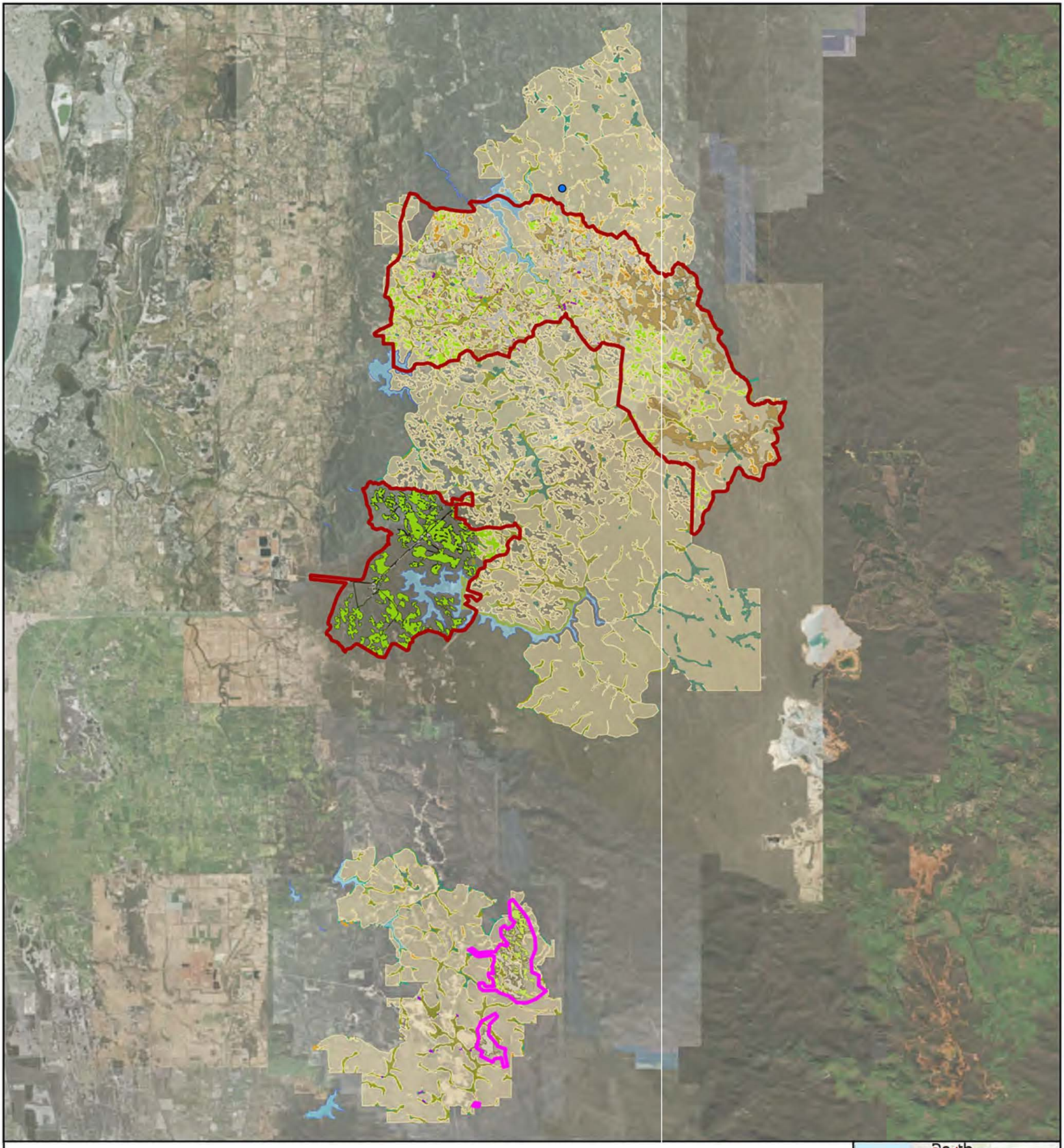
N

Alcoa



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-38 Conservation significant fauna Records (Mammals) and Fauna Habitat within the Mine DEs

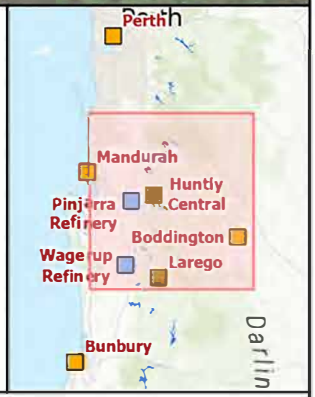


Legend

Fauna (Reptiles) Survey Results
- Priority 4
- Huntly Mine DE
- Willowdale Mine DE
- Proposed Disturbance Footprint
- Rehabilitation Footprint

- Open Areas
- Reservoirs

Fauna Habitats
- Blackbutt Forest
- Bullich Forest
- Granite Outcrop Association
- Jarrah – Marri Forest
- Melaleuca Dampland
- Drainage Line



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Kilometres
0 5 10 15 20 25 30

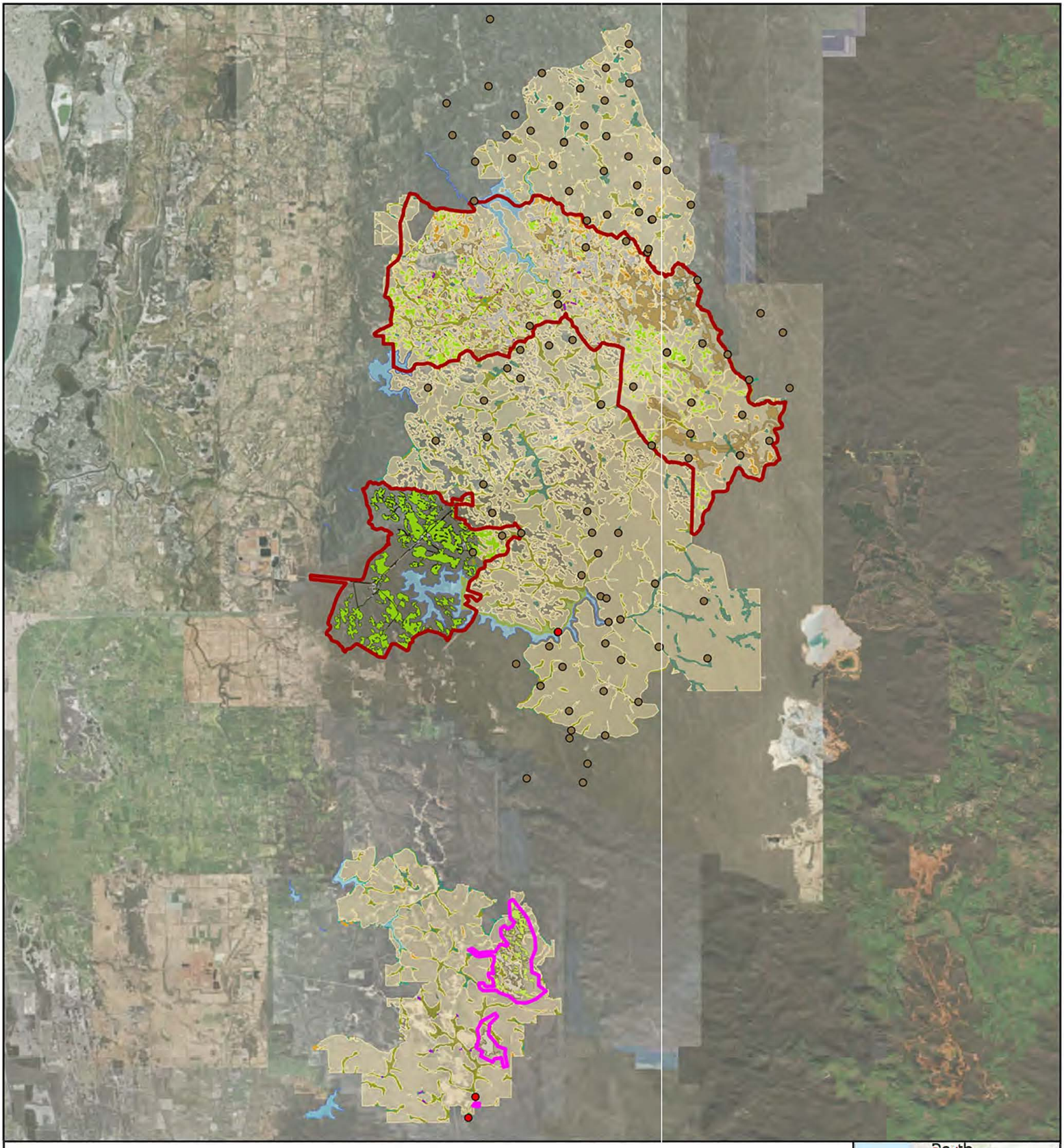
N

Alcoa

Figure 5-39 Conservation significant fauna Records (Reptiles) and Fauna Habitat within the Mine DEs

Scale: 1:375,000 at A4

Date Printed: 27/02/2025



Legend

Fauna (Invertebrates) Survey Results

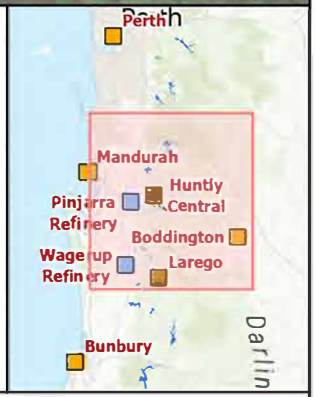
- Threatened
- Feral/Other

- Huntly Mine DE
- Willowdale Mine DE
- Proposed Disturbance Footprint

- Rehabilitation Footprint
- Open Areas
- Reservoirs

Fauna Habitats

- Blackbutt Forest
- Bullich Forest
- Granite Outcrop Association
- Jarrah – Marri Forest
- Melaleuca Dampland
- Drainage Line



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-40 Conservation significant fauna Records (Invertebrates) and Fauna Habitat within the Mine DEs

Kilometres

0 5 10 15 20 25 30

N

Scale: 1:375,000 at A4

Date Printed: 27/02/2025

Alcoa

Table 5-35: Conservation Significant Terrestrial Fauna within the Study Area

Scientific Name	Common Name	Conservation Status		Habitat Preference	Likelihood of Occurrence		Key threatening processes (for threatened species)
		State	Commonwealth		Huntly	Willowdale	
Birds							
Calyptorhynchus banksii naso	Forest Red-tailed Black Cockatoo	VU	VU	Endemic to the southwest of WA and occurs in one population of approximately 15,000 birds (Department of the Environment, Water, Heritage and the Arts, 2009a) Species distribution ranges from NJF at Muchea north-east of Perth, south to Albany and Margaret River. The distribution has contracted from a former range as far north as Moora and east to Toodyay (Johnstone, Kirkby, & Sarti, 2017). In recent years that has been a dynamic expansion of foraging from the NJF west into the Swan Coastal Plain and to a lesser extent east into the Wheatbelt (Johnstone, Kirkby, & Sarti, 2017). FRTBC display erratic breeding activity in the summer and winter seasons, peaking from April to June and August to October. The species primarily nests in hollows of large, mature Marri trees and to a lesser extent Jarrah, Blackbutt, Bullich and Wandoo. Key breeding areas are within the Jarrah-Marri Forest of the Darling Scarp / Plateau (Johnstone, Kirkby, & Sarti, 2017). Breeding has been recorded from adjacent areas including Serpentine National Park, Wungong Catchment, 39 Mile Brook area and Monadnocks Nature Reserve. The FRTBC is a canopy feeder, with a diet primarily consisting of seeds of Marri and Jarrah and, in recent times, the seeds of *Melia azedarach* (Cape Lilac) over the Swan Coastal Plain (Johnstone, Kirkby, & Sarti, 2017). Other, less important foods include Blackbutt, Karri, Sheoak, Snotty Gobble, *Hakea* spp. and Tuart (Johnstone, Kirkby, & Sarti, 2017). The habitat critical to survival and important populations of FRTBCs comprises all Marri, Karri and Jarrah forests, woodlands and remnants in the south-west of Western Australia receiving more than 600 mm of annual average rainfall (DEC, 2008).	Recorded	Recorded	Recovery Plan (DEC, 2008): • Illegal shooting; • Nest competition with native and introduced birds and European honey bees; • Habitat loss including selective removal of Marri; and • Nest site shortage.
Zanda baudinii	Baudin's Cockatoo	EN	EN	Endemic to the south-west of WA. Generally found in woodland or forest habitat but can be found in fragmented forests. Species distribution confined to the south-west humid and subhumid zones with average rainfall greater than 600 mm/year, ranging from NJF east of Perth, south to Albany and Margaret River. Known foraging areas lie in the vicinity of Jarrahdale and Dwellingup with wintering habitat throughout the NJF to the east (Department of Sustainability, Environment, Water, Population and Communities, 2012b); (DAWE, 2022). The species migrates during the autumn-winter from the SJF and south coast up to the NJF (Johnstone, Kirkby, & Sarti, 2017). The total population was previously estimated at 12,500 individuals, and the species occurs mainly in flocks (up to 300 individuals) and occasionally larger aggregations (up to 1,200 individuals) at roosts. There has been a recent decline in numbers returning to traditional roost sites in the NJF during autumn-winter, with the population estimated at 5,000-8,000 (Johnstone, Kirkby, & Sarti, 2017). Baudin's Cockatoo primarily nest in hollows of live or dead Karri, Marri, Wandoo and Tuart trees. The species breeds from August to March in the eucalypt forests of the south west of WA (Department of Sustainability, Environment, Water, Population and Communities, 2012b); (DAWE, 2022). From March, the species flies north to the central and northern parts of the Darling Scarp for the non-breeding season. The species roosts in or near riparian environments or other permanent water sources.	Recorded	Recorded	Recovery Plan (DEC, 2008): • Illegal shooting; • Nest competition with native and introduced birds and European honey bees; • Habitat loss including selective removal of Marri; and • Nest site shortage.

Scientific Name	Common Name	Conservation Status		Habitat Preference	Likelihood of Occurrence		Key threatening processes (for threatened species)
		State	Commonwealth		Huntly	Willowdale	
				The species forages in eucalypt species of mainly Jarrah, Marri and Karri, and proteaceous woodland and heath. They also feed on nectar, buds and flowers and strip bark from dead trees to search for beetle larvae. The habitat critical to survival and important populations of Baudin's comprises all Marri, Karri and Jarrah forests, woodlands and remnants in the south-west of Western Australia receiving more than 600 mm of annual average rainfall (DEC, 2008).			
Zanda latirostris	Carnaby's Cockatoo	EN	EN	Endemic to the south-west of WA. Its range and abundance has significantly reduced due to land clearing for agriculture, forestry and urban development. It faces continuing threats on the Swan Coastal Plain as important feeding habitat is cleared. The total population has been estimated at a maximum of 60,000 (Saunders, Ingram, & Mawson, 1985) and more recently at around 40,000 (DPaW, 2013). Breeding range of the species comprises Eucalypt woodlands between the Stirling Range and Three Springs (Department of Sustainability, Environment, Water, Population and Communities, 2012b); (DAWE, 2022). The species nests in hollows in live or dead trees of Salmon Gum, Wandoo, Tuart, Jarrah, Flooded Gum, York Gum, Powderbark, Karri and Marri. Breeding occurs mainly from July to mid-December. The breeding range of this species has undergone a shift since the middle of the last century to the west and south, with a more rapid shift in the past 10 to 30 years, moving into the Tuart forests of the Swan Coastal Plain and Jarrah-Marri forests of the Darling Scarp (Johnstone & Kirkby, 2009). Breeding has been recorded in Marri at the Wungong Catchment and 39 Mile Brook Catchment approximately 5 km to the north (Johnstone & Kirkby, 2009). The species is a post-nuptial nomad with many individuals spending the non-breeding season on the Swan Coastal Plain from December to July. The species feeds in the canopy and understorey. Important foraging species consist of Banksia, Hakea, Marri, Jarrah and non-native Pinus species (Valentine & Stock, 2008)and (Higgins, 1999). Vegetation that provides food resources in the non-breeding season, as well as nearby roosting and watering habitat (DEC, 2008).	Recorded	Recorded	Recovery Plan (DPaW, 2013) • Loss of breeding habitat; • Nest competition with native and introduced birds and European honeybees; • Loss of non-breeding foraging and night roosting habitat in the vicinity of water availability; • Decline in tree health (e.g., *Phytophthora* Dieback, Canker); • Mining and extraction; • Illegal shooting and taking; • Climate change, including impact to vegetation and heat stress; • Collisions with motor vehicles; and • Disease.
Falco peregrinus	Peregrine Falcon	OS	-	The Peregrine Falcon is found on and near cliffs, gorges, timbered watercourses, riverine environments, wetlands, plains, open woodlands, and pylons and spires of buildings, though less frequently in desert regions of Australia (Morcombe, 2004). They are not common but can be found almost anywhere throughout WA and in the southwest, including particularly at Fitzgerald River, Stirling Range, Porongurup National Parks, Kondinin, and Peak Charles, with many more locations north of Perth. In woodlands the species is known to breed in shallow tree hollows in suitable large trees (Morcombe, 2004).	Recorded	Likely	Historic – bioaccumulation of DDT, now banned globally. Loss of tree hollows may affect local individuals
Tyto novaehollandiae novaehollandiae	The Masked Owl	P3	-	The Masked Owl is found in wet and dry sclerophyll, non-eucalypt dominated forests and open woodlands, farmlands or scrub with large trees (12-20 m). These woodlands will often be adjacent to cleared country, timbered watercourses, paperbark woodlands, and caves (Pizzey & Knight, 2012). This species requires large hollows in old growth eucalypts, including large Karri (*Eucalyptus diversicolor*), Marri (*Corymbia calophylla*) and Jarrah (*E. marginata*), or bare sand or the earth of a cave for nesting, with a preference for habitat containing a dense understorey or ecotones comprising dense and sparse ground cover. Masked Owls are typically recorded foraging within 100-300 m of the boundary of two vegetation types (Bell & Mooney, 2002)The	Likely	Likely	Loss, disturbance and modification of habitat are the main threats. Other threats include loss of nesting habitat through tree dieback, secondary poisoning, loss of individuals by collision and competition for tree hollows (Department of Agriculture

Scientific Name	Common Name	Conservation Status		Habitat Preference	Likelihood of Occurrence		Key threatening processes (for threatened species)
		State	Commonwealth		Huntly	Willowdale	
				bird is restricted to the thicker humid forests of the southwest region, particularly in the Pemberton and Manjimup area and along the Murray River in the Lane Poole area (Nevill, 2013).			Water and the Environment, 2010a).
Mammals							
Dasyurus geoffroii	Chuditch	VU	VU	Chuditch formerly ranged across nearly 70% of Australia, occurring in every mainland State and Territory. Free-ranging populations of Chuditch are now restricted to WA, within an estimated 5% of their former range (DEC, 2012a). Chuditch require habitats that are of a suitable size and not excessively fragmented, as they have large home ranges and are generally present in low numbers (DEC, 2012a). The species inhabits eucalypt forest (especially Jarrah), dry woodland, mallee shrublands, heaths, and desert, particularly in the south coast of WA. The densest populations have been found in riparian jarrah forest, with lower densities in drier woodland and mallee shrubland in the Goldfields and Wheatbelt, as well as in Kalbarri National Park (translocated). Chuditch are opportunistic feeders and mostly nocturnal, with a diet primarily of insects and large invertebrates but also some mammals, birds and lizards. The species are solitary for most of their life and, in the absence of foxes, occupy relatively large home ranges. Males range over 15 km² with a core area of 4 km^2 and females may range over 3-4 km² with a core area of 0.9 km^2 (DEC, 2012a). Chuditch require adequate numbers of suitable den and refuge sites (horizontal hollow logs or earth burrows) and sufficient prey biomass to survive (DEC, 2012a). In Jarrah Forest, populations occur in both moist, densely vegetated, steeply sloping forest and drier, open, gently sloping forest. Chuditch use a range of habitats including forest, mallee shrublands, woodland and desert.	Recorded	Likely	Recovery Plan (DEC, 2012a)): • Land clearing, particularly of riparian vegetation, and the removal of suitable den logs and den sites from Chuditch habitat; and • Predation by, and competition from, foxes and feral cats. • Deliberate and accidental loss of individuals from poisoning, trapping, illegal shooting, and road kills.
Phascogale tapoatafa wambenger	Wambenger Brush-tailed Phascogale	CD	-	The species is presently sparsely distributed around the coastal zone of Australia in dry sclerophyll forest and monsoonal forest and woodland (Burbidge & Woinarski, 2020). The Western Australian sub species once was more widespread throughout the southwest into semi-arid areas but has now declined in distribution to persist in the Jarrah and Karri Forests. Generally rare and threatened by habitat fragmentation. Occurs at low densities in the Northern Jarrah Forest with highest densities occurring in the Perup/Kingston area, Collie River valley and near Margaret River and Busselton (Department of Energy and Conservation, 2012b). For populations to persist the species generally requires large intact areas of habitat due to the large home ranges required for the species, females 20 -70 ha (Dec 2012) and males 100 ha (Burbidge & Woinarski, 2020). The species requires habitat with hollow bearing trees to persist.	Recorded	Likely	Historical and current reduction in area of occupancy for this species has been predominantly caused by continued habitat clearing and fragmentation. Habitat alteration as a result of logging and mining has also been detrimental to the species. The greatest current threat is predation by feral cats and lesser extent foxes; the increasing decline in the availability of hollow-bearing trees is also a threat. Male die-off immediately after breeding makes this taxon particularly vulnerable to stochastic events. Reproductively viable populations require large areas of suitable habitat in order to persist because male home ranges are often greater than 100 hectares.

Scientific Name	Common Name	Conservation Status		Habitat Preference	Likelihood of Occurrence		Key threatening processes (for threatened species)
		State	Commonwealth		Huntly	Willowdale	
Notamacropus irma	Western Brush Wallaby	P4	-	There is little information on the biology of this species with limited data on feeding/foraging behaviour, reproduction and information on declines (Maxwell, Burbidge, & Morris, 1996). Locally common in dry sclerophyll forest and woodlands in the southwest of Western Australia particularly where fox control is undertaken (Morris & Christensen, 2008). The species has been found primarily in open forest or woodland, particularly favouring open, seasonally wet flats with low grasses and open scrubby thickets (Morris & Christensen, 2008). Also recorded in some areas of mallee and heathland and is uncommon in karri forest. Populations appear to persist within larger remnant areas of vegetation in reserves and forest from Kalbarri to Cape Arid National Park.	Recorded	Recorded	Predation by foxes appears to be the main threatening process for this species.
Setonix brachyurus	Quokka	VU	VU	The Quokka is endemic to WA and was once widespread and abundant within the south-west of WA, ranging from Jurien Bay in the north, to east of Albany (DEC, 2013). Current distribution includes Rottnest and Bald Islands, and at least 25 sites on the mainland. All mainland populations occur within areas receiving greater than 600 mm/year rainfall and most are believed to live within areas receiving greater than 1,000 mm/year, which is likely to be due to the associated high vegetation cover and leafy digestible vegetation (DEC, 2013). In the Jarrah Forest, Quokka occupy dense forests and thickets, streamzone vegetation, heaths, shrublands, *Agonis linearifolia*-dominated swamps, and sometimes tea-tree thickets on sandy soils along creek systems. Habitat changes seasonally, with the core home range shifting to the periphery of the inundated wetlands during wetter months, leaving the species more exposed to predation (DEC, 2013). Total population was estimated at 2007 at approximately 9,000-13,000 individuals, of which 8,000-12,000 are on Rottnest Island (DEC, 2013). The NJF population is highly fragmented and unlikely to be functioning as a metapopulation (Spencer, Hayward, Hillyer, & Friend, 2020) and as of 2007 was estimated to comprise up to 210 individuals over five locations (Chandler Road, Rosella Road, Kesners Swamp, Hadfield, Victor Road) (DEC, 2013). The Southern Jarrah Forest and south coast support the most extensive distribution of the species and in 2007 were estimated to comprise approximately 1,000 individuals (DEC, 2013). The NJF populations are small, declining, genetically differentiated and show signs of historical genetic bottlenecks (Spencer, Bain, Hayward, Hillyer, & Friend , 2019). This is expected to be due to predominant open Jarrah Forest structure across the NJF, with Quokka highly restricted to small home ranges (7 ha) within dense riparian and swamp habitats (Spencer, Hayward, Hillyer, & Friend, 2020). Sub-adults disperse relatively small distances, with limited movements between stream systems due to the threat of predation, despite relatively short distances across ridges (Spencer, Hayward, Hillyer, & Friend, 2020). Habitats critical to the survival of Quokkas include *Taxandria linearifolia* swamps, including areas of natural vegetation where the understorey is sufficiently thick and complex to provide a predation refuge close to more open, recently burnt vegetation which is used as a food source (DEC, 2013).	Recorded	Likely	Recovery Plan (Department of Environment and Conservation, 2013): • Predation from foxes and cats; • Habitat destruction from feral pigs; • *Phytophthora* Dieback impact to forest structure, cover and food resources; • Clearing and timber harvesting; • Altered fire regimes; • Altered hydrological regimes and climate change; • Disease; and • Recreation disturbance (Rottnest).
Hydromys chrysogaster	Rakali	P4	-	The Rakali is a large semi aquatic rodent that is mostly carnivorous but known to eat a large range of food items (Olsen, 2008). This species is widespread around Australia in every state and territory (Olsen, 2008). Lives in the vicinity of permanent bodies of fresh, brackish, or marine water, lakes and farm dams,	Recorded	Recorded	Land clearing, habitat degradation, water body changes (hydrology) through agriculture or development,

Scientific Name	Common Name	Conservation Status		Habitat Preference	Likelihood of Occurrence		Key threatening processes (for threatened species)
		State	Commonwealth		Huntly	Willowdale	
				and on sheltered coastal beaches, mangroves and offshore islands (Olsen, 2008). In the south-west of WA they have been shown to prefer areas with riparian vegetation, better water quality and a degree of habitat complexity. This includes woody debris, rock ledges and wetland islands are likely to be important areas for feeding and refuge. Occasional vagrant to temporary waters. Water Rat's dens are made at the end of tunnels in banks and occasionally in logs (Olsen, 2008). The species has been known to traverse over land for considerable distances in search of suitable habitats (Olsen, 2008).			predation by introduced feral pest species (red fox (*Vulpes vulpes*), domestic and feral cats (*Felis catus*)), and potentially climate change via changes hydrology.
Isoodon fusciventer	Quenda	P4	-	The Quenda or Southern Brown Bandicoot is a small omnivorous marsupial (Paull, 2008) restricted to the southwest of Western Australia. The Quenda has a patchy distribution from around Geraldton to Cape Arid National Park and prefers dense scrubby, often swampy, vegetation with dense cover up to one metre high (Paull, 2008). Quendas occur in woodlands and may use less ideal habitat where this habitat occurs adjacent to the thicker, more desirable vegetation. Often feeds near to dense cover so the animal can retreat if disturbed (Paull, 2008).	Recorded	High	Land clearing, altered fire regimes, predation by introduced feral pest species (red fox (Vulpes vulpes), domestic and feral cats (*Felis catus*)), and competition for resources with the European rabbit (*Oryctolagus cuniculus*).
Myrmecobius fasciatus	Numbat	EN	EN	The Numbat formerly occupied a range of habitats across the southern half of Australia but is now restricted to a few populations of Jarrah Forest and Wandoo woodland (DPAW, 2017e). Numbats historically have been associated with a large variety of habitat types, including eucalypt forest, eucalypt woodland, Acacia woodland and *Triodia* grassland, however, now they only occupy a small area of their previous habitat types, therefore it is difficult to determine an accurate description of specific habitats critical to their survival. Due to the decline in range and occupied habitat types, an exhaustive description of habitat critical to the survival of the numbat cannot be provided, however key characteristics to be considered are: • Significant abundance of termites, • Presence of eucalypt species, • Sufficient cover near ground level, and • Sufficient openness in the understory for feeding activities ((Alcoa, 2022a) & (DPAW 2017)). Numbat activity changes throughout the year, corresponding to termite activity in the upper layer of the soil. In winter, Numbat activity peaks during the middle of the day, while in summer activity peaks during the morning and afternoon (DPAW, 2017e). Numbats feed near the cover of shrubs, hollows, and burrows, which they use as refuge from predators and as resting places during the day (DPAW, 2017e). Numbats have been recorded near the Myara Region of the Huntly Mine. While baseline surveys did not record individuals or their signs, the species is cryptic and difficult to record when at low densities. Given the extent and duration of fox control via Western Shield over the Northern Jarrah Forest, there is potential for Numbat to have recolonised in the vicinity of the DE and to occur at below detectable densities. They have been recorded within vegetation that maintains connectivity to this area as recently as 2013. Numbats are capable of dispersing away from sites where they have been released (SLR Consulting Australia, 2024b).	Potential*	Unlikely	Recovery Plan (DPAW, 2017e): • Fox predation; • Cat predation; • Altered fire regimes; • Habitat disturbance and fragmentation; and • Climate change.

Scientific Name	Common Name	Conservation Status		Habitat Preference	Likelihood of Occurrence		Key threatening processes (for threatened species)
		State	Commonwealth		Huntly	Willowdale	
Bettongia penicillata ogilbyi	Woylie	CR	EN	The species, in its various subspecies, once occupied most of the Australian mainland south of the tropics including the arid and semi-arid zones (DEC, 2012b). The distribution has reduced such that the last four remaining indigenous populations are in Perup, Kingston, Dryandra woodland and Tutanning nature reserve in southwest WA. The species has been re-established at 16 other locations within WA and at five locations interstate (DEC, 2012b). Population has declined dramatically since 2000, reducing from approximately 220,000 to 11,000 individuals in the Upper Warren (a 95% contraction), and other populations from approximately 45,000 to 15,000 (DEC, 2012b). Research indicates that increased cat predation is the predominant cause of loss of individuals (Marlow, Thomas, Williams, & McMahon, 2015). Scattered Woylie populations may be found throughout the Jarrah Forest in the south-west corner of WA, where predators have been controlled or excluded. Preferred habitat for the Woylie includes dense undergrowth, logs and rock-cavities and occasionally in burrows. Thickets and other suitable habitat types such as heath, provide refuges against predation (DEC, 2012b). Prior to widescale European Fox baiting, the species' distribution was reduced to locations with the common characteristic of the presence of *Gastrolobium* thickets. *Gastrolobium* are referred to as 'poison plants', containing monofluoroacetic acid, which is the compound present in the toxin '1080' now used to control introduced predators in the southwest region. It is thought that *Gastrolobium* thickets provided refuge from predators, partly through cover and also secondary poisoning (DEC, 2012b). Woylie is nocturnal, rests during the day in a well-concealed nest, built over a shallow depression. The nest is most commonly built using long strands of grasses, but other materials such as strips of bark are also used (in the forest). The species primarily feeds on the fruiting bodies of ectomycorrhizal fungi (DEC, 2012b).	Recorded	Likely	Recovery Plan (Department of Environment and Conservation, 2012): • Fox predation; • Cat predation; • Land clearing; • Altered fire regimes; • *Phytophthora* Dieback and climate change impacts impact to shelter and fungi foods; • Native predators; • Disease; and • Mining.
Pseudocheirus occidentalis	Western Ringtail Possum	CR	CR	In WA the Western Ringtail Possum is located in three key management zones considered the most important extant populations (DPAW, 2017c). These zones include: • Swan Coastal Plain Zone- peppermint woodlands and peppermint/tuart forests on, extending from north of Bunbury to Augusta, but mostly around Busselton • Southern Forest Zone – Jarrah forests near Manjimup • South Coast Zone – near-coastal limestone heath, riparian, jarrah marri thicket woodland and forest peppermint woodland and karri forest vegetation between Walpole and Cheynes Beach. The Proposal occurs within the Southern Forest Zone population. This population of Western Ringtail Possum are known to inhabit jarrah or marri dominated forests, within adjacent stands of riparian vegetation that have a flooded gum (*Eucalyptus rudis*) overstorey. Their habitat preference can also extend to wandoo (*Eucalyptus wandoo*) forests to the north-east of Manjimup and karri (*Eucalyptus diversicolor*) forests from Northcliffe to west of Manjimup (DPAW, 2017c). Potential suitable habitat for WRP comprises riparian forest habitat that may contain pockets of dense, overlapping (closed) canopy but excludes riparian or swamp woodland habitat that has a more open canopy or predominant shrub vegetation, which in combination with upland vegetation would be used for limited dispersal by the species. If pockets of closed riparian habitat occur	Potential*	Likely	Recovery Plan (Department of Parks and Wildlife, 2017d): • Habitat loss and fragmentation (i.e., vegetation / timber clearing); • Fox predation; • Cat predation; • Fire; • Competition for hollows with native species; • Disease; and • Unregulated relocation of orphaned, injured and rehabilitated western ringtail possums.

Scientific Name	Common Name	Conservation Status		Habitat Preference	Likelihood of Occurrence		Key threatening processes (for threatened species)
		State	Commonwealth		Huntly	Willowdale	
				within the Mine DE and are occupied by WRP, then these would be expected to comprise habitat critical to the survival of the species. The remainder of the habitat types within the Mine are not expected to comprise critical habitat.			
Falsistrellus mackenziei	Western False Pipistrelle	P4	-	Occurs in wet sclerophyll forest dominated by Karri and in high rainfall zones of the Jarrah and Tuart dry sclerophyll forests of south-western Australia (Churchill, 2008) The species has been recorded on the Swan Coastal Plain but only in tall Tuart woodlands and mixed Tuart/Jarrah woodlands (Start & McKenzie, 2004). Few roost sites have been identified but those described were up to 15 m above the ground in large hollows (in both Karri and Jarrah) where aggregates of bats (up to 30) have been recorded (Start & McKenzie, 2004). Additionally, seasonally the species may also sex segregate (into different suitable hollows) over the breeding season (Start & McKenzie, 2004). From available data, the species requires and persists around large, tall eucalypts with large hollows present.	Recorded	Likely	Loss of tree hollows, competition with feral honeybees, introduced bird species and removal of roost sites via clearing and timber harvesting (Start & McKenzie, 2004)

Scientific Name	Common Name	Conservation Status		Habitat Preference	Likelihood of Occurrence		Key threatening processes (for threatened species)
		State	Commonwealth		Huntly	Willowdale	
Reptiles							
Acanthophis antarcticus	Southern Death Adder	P3	-	The Southern Death Adder ranges from a small area in the south-west (Darling Range and Dryandra) of Western Australia, the Nullarbor onto Eyre Peninsula and the east coast (Wilson & Swan, 2017). Therefore, the habitats within this species range includes rainforest to shrublands and heaths and supportive habitat around granite outcrops. The Southern Death Adder is a cryptic ambush predator that relies on its camouflage, hiding under leaf litter and debris. Being a stout cryptic ambush predator it is likely the species utilises only small areas of suitable habitat. This species is declining in many areas, probably due to habitat destruction and altered fire regimes (Wilson & Swan, 2017).	Likely	Likely	Little information on the threats to the species in Western Australia however in eastern Australia the species is experiencing localised population decline (Hobson, Venz, Sanderson, Greenlees, & Dickman, 2018) from impacts from invasive species, anthropogenic processes (including fire and grazing) including remove ground cover and leaf litter and loss of habitat/destruction in general.
Aspidites ramsayi	Woma Python	P1	-	The Woma Python is a nocturnal, terrestrial snake that inhabits woodland, heaths, and shrublands, often with spinifex. It shelters in hollow logs, abandoned monitor and mammal burrows, and soil cracks (Wilson & Swan, 2021). It is usually restricted to arid and dry inland areas, however there is an isolated population in south-western Australia (Cogger, 2014). Within the Survey Area, both the Jarrah-Marri Forest and Drainage Line habitats provide suitable hunting and shelter resources for the species.	Highly Unlikely	Highly Unlikely	Major threats to the Woma Python are competition and predation of Cats and Foxes. Additionally, this species uses rabbit burrows to shelter in as are accidentally by warrens ripping and fumigating the area (South Australian Arid Lands Natural Resources Management Board, 2011).
Ctenotus delli	Dell's Ctenotus	P4	-	Dell's Skink is associated with Jarrah-Marri woodland that has a shrub-dominated understorey, on laterite, sandy or clay soils. It is found in the north Darling Range and inhabits dry sclerophyll forest on granite outcrops, stony hills and ranges. It is absent from the Swan Coastal Plain (Wilson & Swan, 2017).	Recorded	Likely	Specific threats for Dell's Ctenotus have not been identified, but it is not likely to be subject to major threats rather localised impacts from clearing and feral species. It is suggested climatic change may impact habitat. This species has been known to utilize rehabilitated mine sites, which may suggest it is at least somewhat adaptable to an altered habitat. It may be at some localized risk from fire (Craig, Gaikhorst, Ford, & Lloyd, 2017).
Invertebrates							
Euoplos inornatus	Inornate trapdoor spider	P3	-	The ecology of the *Euoplos inornatus* is poorly understood. *Euoplos inornatus* are known to occur in south-west Western Australia in open jarrah and marri forest habitats (Atlas of Living Australia, 2024b). These spiders are terrestrial predators that use burrows with thick, plug-like trapdoors to capture prey (Atlas of Living Australia, 2024b).	Likely	Likely	Specific threats for *Euoplos inornatus* are not well known, however, habitat fragmentation in the form of clearing, climate changes and environmental pollution are likely to contribute to the total

Scientific Name	Common Name	Conservation Status		Habitat Preference	Likelihood of Occurrence		Key threatening processes (for threatened species)
		State	Commonwealth		Huntly	Willowdale	
							population of the *Euoplos inornatus.* Future revisions of the FMP will include specific reference to *Euoplos inornatus.*

Conservation Status

CD= Conservation dependent fauna
CR = Critically endangered under the EPBC Act or BC Act
EN = Endangered under the EPBC Act or BC Act
VU = Vulnerable under the EPBC Act or BC Act
SP (S7) = Schedule 7, Special Protection under BC Act
P3 = Priority 3 under DBCA, poorly known species.
P4 = Priority 4 under DBCA, rare, near threatened and species in need of monitoring.

Likelihood of Occurrence

Recorded – Species was recorded during the survey.
Likely – Species has been recorded more than once in the last in the last 15 years and suitable habitat is present within the Survey Area.
Possible – There are existing records of the taxon within the Desktop Study Area, however the taxon has not been recorded within the Desktop Study Area in the last 15 years or suitable habitat within the Survey Area is marginal or limited in extent.
Unlikely – Suitable habitat is not present within the Survey Area, or the taxon is very infrequently recorded in the locality despite reasonable previous search effort, or the taxon is believed to be extinct or locally extinct.

* It is noted that the Desktop Assessment (GHD, 2024m) included in Appendix 27 provides a LOO for numbats and western ringtail possums as unlikely. Alcoa has adopted a more conservative LOO classification for the assessment given the proximity of the project to known populations and/or habitat and gaps in the survey area coverage.

5.3.4.4.1 Introduced Fauna Threats to Conservation Significant Fauna

Of the introduced species recorded during the terrestrial fauna surveys, the Feral Pig, Feral Cat, European Fox, and European Rabbit are considered key threatening processes to fauna listed under the EPBC Act that were recorded or likely to occur in the Proposal areas [SLR Consulting (2024b) and (2024d)].

During the targeted surveys conducted by SLR, evidence of Feral Pigs was observed within surveyed area. Feral Pigs are widespread in the south-west of WA. They contribute to a range of habitat changes, such as the destruction of plants, changing composition of plant communities, alteration of soil structure through digging and disturbing roots, increased invasion and spread of weeds, reduced water quality through disturbance of riparian zones, and the creation of suitable habitat for plant disease vectors. Feral Pigs also are reservoirs for endemic animal diseases or vectors for exotic animal and plant diseases [DEE (2017)]. The Feral Pig is a known threat to the Quokka and Woylie through the degradation of their habitat [DEC (2013)].

The Feral Cat is found across WA and lives in all types of habitats. The main impact that they have on native animals is through predation as live prey is their main source of food and mammals are their dominant prey. They have contributed to the extinction of small to medium sized mammals and ground nesting birds. They also pose a threat to native predators, such as Chuditch. Feral Cats may prey upon Chuditch and compete for food sources. Feral Cats host numerous disease-causing agents which can be transmitted to native species, particularly mammals [DoE (2015)]. In addition to the Chuditch, the Feral Cat is a known threat to the Quenda, Quokka, and Woylie [DEC (2013)].

The European Fox is present across the majority of WA, except the most northern regions. The main impact they have on native animals is through predation. Terrestrial critical-weight-range mammals (35–5500 g) and ground-nesting birds are at the greatest risk to predation by the fox [DEWHA (2008a)]. The European Fox is a known threat to the Rakali, Quenda, Western Brush Wallaby, Quokka, Woylie, and Chuditch [DEC (2013)].

The European Rabbit is present across the majority of WA, except the most northern regions, and causes a range of impacts to native fauna and their habitats. These impacts include competition for resources (food and shelter), preventing plant regeneration, general damage to plant species, reversing the normal processes of plant succession, altering ecological communities, and changing soil structure and nutrient cycling leading to erosion, and removal of habitat for arboreal mammals and birds. The European Rabbit is a known threat to the Quenda and Chuditch [DEE (2016)].

5.3.4.4.2 Feral Animal Control in the Northern Jarrah Forest

Alcoa has contributed funding to feral animal control in the NJF subregion from 1994 onwards, commencing with Operation Foxglove, which was the first broadscale baiting program in the NJF subregion. Operation Foxglove involved baiting over 550,000 ha of Jarrah Forest and demonstrated that baiting was effective at controlling European Fox but did not impact the Chuditch.

The success of Operation Foxglove in the NJF subregion led to the implementation of Western Shield, DBCA's flagship wildlife recovery program. Western Shield expanded baiting and feral animal control to cover large areas of DBCA managed lands in WA and resulted in the recovery of several CWR mammals including Woylie, Chuditch, and Quokka.

Due to the program's success, the species Quenda and Tammar Wallaby (*Macropus eugenii*) were de-listed as endangered species and the Chuditch re-listed from Endangered to Vulnerable under the BC Act and EPBC Act. Woylie was also de-listed, however, its population subsequently declined, primarily due to Feral Cat predation with the removal of European Fox as the top predator, and the species has been re-listed as Endangered under the EPBC Act.

Recognition of the increase in Feral Cat predation led to the development and deployment of Eradicat baits as part of Western Shield. During 2020-2021, approximately 3.8 million ha of DBCA managed and adjoining lands were baited using approximately 410,000 fox baits and 648,000 Eradicat baits. Integrated baiting has been demonstrated to reduce the abundance of European Fox by 80% and Feral Cat by 70%.

5.3.4.4.3 Black Cockatoo Habitat Assessment

Targeted Black Cockatoos assessments have been undertaken in the Huntly and Willowdale Mine DEs for many years. These Black Cockatoos assessments (as detailed in Table 5-27 and shown in Figure 5-32 and Figure 5-33) currently follow the methodology outlined in the following documentation and summarised in Table 5-36:

- Clause 4(1) of the exemption order:
    - provides a definition for Black Cockatoos nesting trees and Huntly Mine Black Cockatoos significant trees. To protect these that will be outlined with avoidance measures for these impacts determines in line with clause 4(2)(d) and 4(2)(e);
- Technical Guidance – Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA, 2016d);
- Survey guidelines for Australia's threatened birds [DEWHA (2010)];
- Referral guideline for 3 WA threatened Black Cockatoos species (DAWE, 2022); and
- Alcoa Fauna MP (Alcoa, 2024).

The most recent surveys were conducted by Western Environmental between July 2023 to February 2024 and May 2024 to June 2024 in the Willowdale Mine DE and the Huntly Mine DE, respectively. These surveys were conducted to satisfy the requirement of Alcoa's Mine Management Plan. The assessments aim to build on prior knowledge of Black Cockatoos habitat areas and confirm the presence of previously identified Black Cockatoos habitat areas. The areas assessed during the assessment does not encompass the entire Mine DEs. The definition of the tree types identified for Black Cockatoo will deviated from the Referral guideline for 3 WA threatened Black Cockatoos species (DAWE, 2022) as it will follow the definition set out in Clause 4(1) of the exemption order (Table 5-36) as this defines what is considered a restricted activity and best informs the project of requirements surrounding the works. Additionally, multiple years of assessment on Black cockatoos in the Mine DE have been conducted, most of which followed the definition set out in the exemption order, therefore maintaining this definition will provide a clearer interpretation of previous studies.

Prior to the development of clearing plans, targeted pre-clearance Black Cockatoos surveys are undertaken for all proposed disturbance areas to identify Black Cockatoos trees within 50 m. All nest trees with a suitable hollow (size, entry angle, position), regardless of evidence of use, are protected irrespective of where they are located. Significant trees, which include marri with a diameter at breast height (DBH) of >1500 mm and Jarrah with

DBH>2000 mm, are also protected everywhere in the landscape. Ten metre radius buffers are applied to all these tree types; however, after 2027 a 50 m buffer will need to be applied. Habitat trees, which include marri trees with DBH>500 mm, are avoided for haul road clearing, where possible.

Table 5-36: Black Cockatoo tree types and survey methodology

Black Cockatoo tree type	Definition	Survey methodology
Nest	A tree containing one or more hollows suitable as Black Cockatoo breeding habitat. A suitable hollow is based on hollow size, shape, and entry angle, irrespective of signs of use for breeding. Nest trees are considered the equivalent to known and suitable nesting trees and suitable nest hollows as per (DAWE, 2022). However, it is noted that suitable nest hollows may also occur in 300 mm DBH Wandoo and Salmon Gums trees and suitable nest hollows may occur in live and dead trees as long as they are standing.	Survey methodology for nest and possible nest trees is undertaken in two stages: • Stage 1 includes a survey from ground level using binoculars, of all species of trees above 500 mm DBH. (DBH for Wandoo and Salmon Gum is 300 mm). • Trees containing hollows which appear to have a suitable entrance (>100 mm diameter) and correct orientation to be used as a breeding hollow are picked up using handheld Global Positioning System (GPS). • Stage 2 of the survey involves a second ground assessment followed by an internal hollow inspection when considered necessary, using a pole camera or drone. Suitable hollows are determined by internal size, depth and condition of hollow floor. Trees containing nesting hollows are then marked with paint and numbered with a stainless-steel tag and scored using the Whitford Senescence Scale. Accurate DBH is also measured.
Significant	Healthy Jarrah trees with DBH≥2000 mm or healthy Marri trees with DBH≥1500 mm. These trees provide roosting and foraging sites.	Significant trees are Jarrah and Marri larger than 2000 mm and 1500 mm DBH respectively. These are picked up during the stage 1 search for nesting/habitat trees. Trees at or above the correct diameter must be healthy and in good condition. Significant trees are finally assessed by a suitably qualified/experience personnel Black Cockatoos expert in the stage 2 of the surveys. Trees meeting these criteria are marked with paint and numbered with a stainless-steel tag with a unique number.
Habitat	Trees on a haul road alignment that have the potential to provide nest hollows in the future. These are primarily marri trees with DBH ≥500 mm. The tree should already be starting to develop a hollow or have a form that is conducive to hollow formation. Habitat trees are considered the equivalent to potential nest trees (Trees that have a suitable DBH to develop a nest hollow, but do not currently have hollows) as DSEWPC (2012b).	Habitat trees on haul road alignments which are not on ore, and can be modified, are assessed for their suitability to provide future nesting hollows. These trees should be forming a hollow or have a shape conducive to forming a hollow. Trees considered habitat trees are picked up using handheld GPS and marked with paint.

Black cockatoo foraging habitat

Black cockatoo foraging habitat can be defined as being *'Plant species known to support foraging within the range of cockatoo species'* (DAWE, 2022).During the surveys, the value of Black Cockatoo foraging habitat was determined based on vegetation type. Foraging scores were calculated using the forage score tool outlined within (DAWE, 2022).

Due to the lack of survey data available for the Proposal areas, the information encompassing the entire Huntly and Willowdale mine will be discussed below, as it will provide a broader context of regional capacity to support Black Cockatoos. Fauna habitat derived from the previous vegetation type mapping completed by Mattiske over the period of 2008 to 2024 and Western Environmental (Western Environmental, 2024b) habitat IBSA data was used to determine the areas considered to be foraging habitat for Black Cockatoos, with the outcome shown in Table 5-37.

The total area of foraging habitat in the Huntly Mine DE is 22,612.4 ha, while the Willowdale Mine DE has 2,121.1 ha. In the Huntly Mine DE, key habitat types include 18,633.3 ha of Jarrah-Marri Forest, 2,828.8 ha of Drainage Line, 1,010.2 ha of Granite outcrop and 140.1 ha of *Melaleuca* dampland, as outlined in Table 5-37 and shown on Figure 5-41. In the Willowdale Mine DE, the key habitat type is 1,935.3 ha of Jarrah – Marri Forest, 183.9 ha of Drainage Line, and 1.9 ha of Granite outcrop, as seen in Table 5-37 and Figure 5-42. Mine rehabilitation provides a large proportion of foraging habitat, with 6,052 ha and 417 ha in the Huntly and Willowdale Mine DEs, respectively. Note that Drainage Lines include Blackbutt Forest, and Bullich forest as described by SLR (Section 5.3.4.2.1).

High quality habitat is more prevalent in the Huntly Mine DE than in the Willowdale Mine DE for all three species of cockatoo (Table 5-37). Each mine region can be described as containing the following foraging habitat:

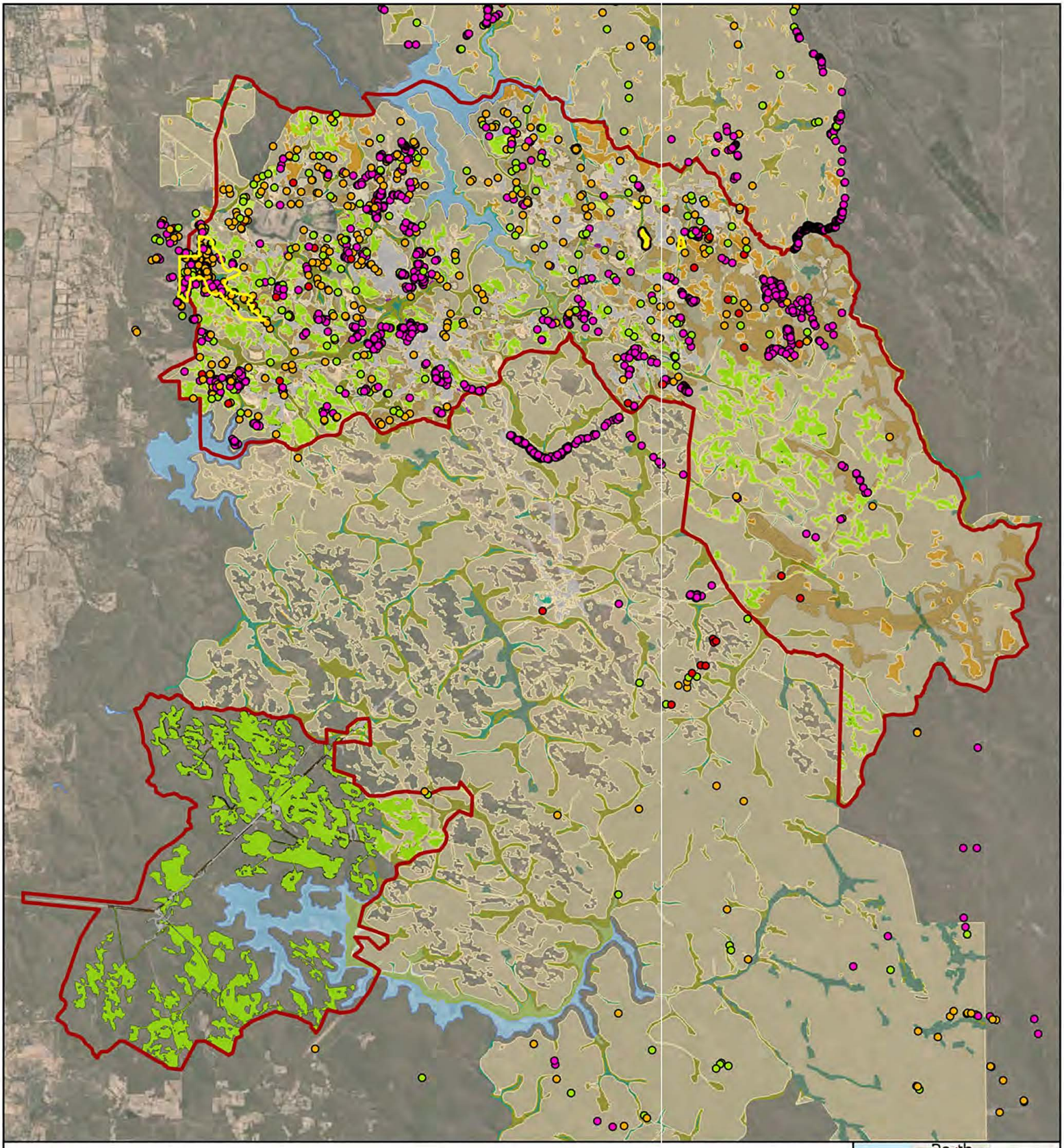
- High quality foraging habitat Huntly Mine DE:
    - Forest Red-tailed Black Cockatoo – 50% of Mine DE; and
    - Baudin's Cockatoo and Carnaby's Cockatoo – 47.7%
- High quality foraging habitat Willowdale Mine DE:
    - Forest Red tailed Black Cockatoo – 93.3% of Mine DE; and
    - Baudin's Cockatoo and Carnaby's Cockatoo – 90.6%
- Medium quality foraging habitat Huntly Mine DE:
    - Forest Red-tailed Black Cockatoo– 20.5% of mine DE; and
    - Baudin's Cockatoo and Carnaby's Cockatoo – 22.7%
- Medium quality foraging habitat Willowdale Mine DE:
    - Forest Red tailed Black Cockatoo – 25.4% of Mine DE; and
    - Baudin's Cockatoo and Carnaby's Cockatoo – 3.2%
- Low quality foraging habitat Huntly Mine DE:
    - Forest Red tailed Black Cockatoo – 2.8% of Mine DE; and
    - Baudin's Cockatoo and Carnaby's Cockatoo – 6.4% each for Mine DE

- Low quality foraging habitat Willowdale Mine DE:
    - All three species – ≤1% of Mine DE.

High-quality habitats in the Mine DEs primarily include Jarrah-Marri Forest with Drainage lines (Blackbutt Forest and Bullich forest) also providing some high quality and substantial medium-quality habitat.

Table 5-37: Black Cockatoo foraging habitat in the Huntly and Willowdale mine areas

Fauna habitat type	Huntly				Willowdale			
	Area (ha)	Foraging habitat quality			Area (ha)	Foraging habitat quality		
		Forest Red-tailed Black Cockatoo	Baudin's Cockatoo	Carnaby's Cockatoo		Forest Red-tailed Black Cockatoo	Baudin's Cockatoo	Carnaby's Cockatoo
Drainage Lines (Blackbutt forest)	874.10	High	Medium	Medium	57.70	High	Medium	Medium
Drainage Lines (Bullich forest)	1,954.70	Medium	Medium	Medium	126.20	Medium	Medium	Medium
Granite outcrop	1,101.20	Low	Low	Low	1.80	Low	Low	Low
Jarrah – Marri Forest	18,633.30	High	High	High	1935.30	High	High	High
Melaleuca dampland	140.1	None	Low	Low	0.00	None	Low	Low
Mine rehabilitation	6,052.00	Medium	Medium	Medium	417.00	Medium	Medium	Medium
Foraging habitat quality summary								
High		19507.4	18633.3	18633.3		1993.0	1935.30	1935.3
Medium		8006.7	8880.8	8880.8		543.2	600.9	600.9
Low		1101.2	1241.3	1241.3		1.8	1.8	1.8
None		4181.1	4041.0	4041.0		76.0	76.0	76.0
Total		32796.4	32796.4	32796.4		2614.0	2614.0	2614.0



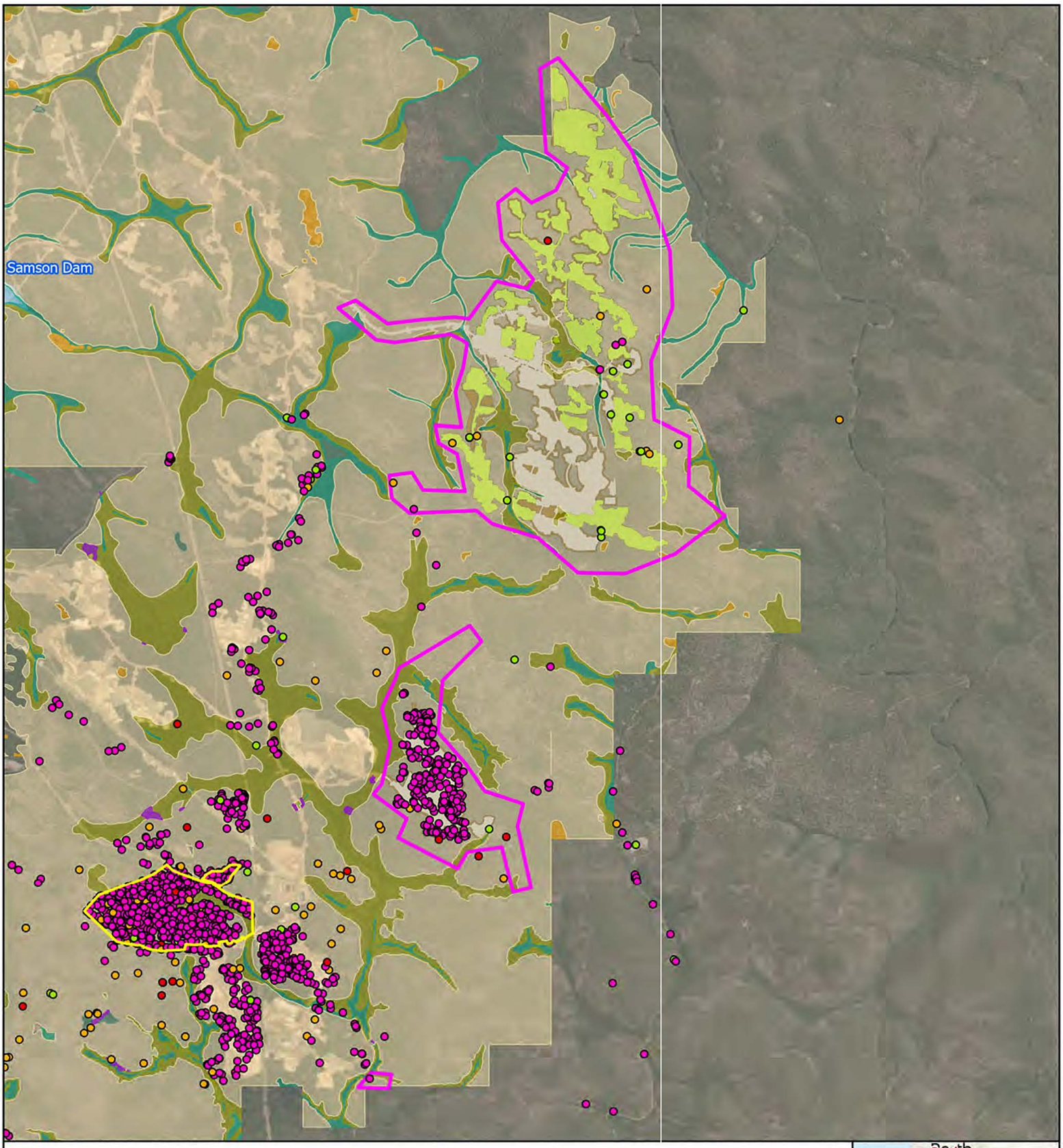
Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-41 Huntly Mine DE – Black Cockatoo Foraging Habitat and Black Cockatoo Trees

Scale: 1:175,000 at A4

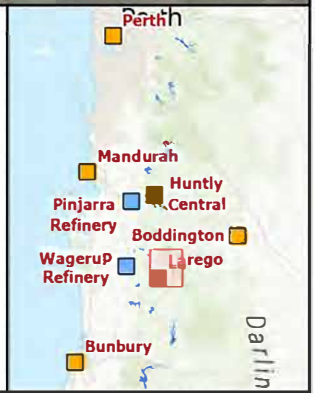
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Legend

- Black Cockatoo Protection Zones
- Black Cockatoo Tree Type
  - Habitat Tree
  - Nest Tree
  - Possible Nest Tree
  - Significant Tree
- Willowdale Mine DE
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Reservoirs
- Fauna Habitats / Foraging Habitat Quality
  - Blackbutt Forest (Medium - High)
  - Bullich Forest (Medium)
- Granite Outcrop Association (Low)
- Jarrah – Marri Forest (High)
- Melaleuca Dampland (None - Low)
- Drainage Line (Medium - High)



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-42 Willowdale Mine DE – Black Cockatoo Foraging Habitat and Black Cockatoo Trees

Kilometres
0 0.9 1.8 2.7 3.6 4.5 5.4

Scale: 1:75,060 at A4

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Black Cockatoo nesting habitat

Black cockatoos breed and nest in trees of a species known to form hollows. Hollows generally start to form in trees that have a DBH exceeding 50 cm, which indicates an age of approximately 100 to 150 years for Jarrah and Marri. Trees senesce at variable ages over this period, with hollows increasingly forming after 130 years of age.

Potential nest trees are therefore trees without suitable hollows at present but are at an age where they have potential to form hollows over a period of several decades. By comparison, trees with a DBH less than 50 cm are typically immature or juvenile and may take several decades to a century or more to reach an age where they have potential to form hollows.

Suitable black cockatoo nesting trees have hollows of suitable diameter, height above ground, and aspect that are potentially suitable for breeding and are not impacted by feral bees. Confirmed nesting trees are trees that have hollows with evidence of past use, such as a chewed entrance or are currently known to be used by Black Cockatoos. As mentioned in assessment conducted by Western Environmental (2024b), the most commonly used tree species used by Black Cockatoos for nesting include:

- *Eucalyptus marginata;*
- *Corymbia calophylla;*
- *Eucalyptus megacarpa;*
- *Eucalyptus patens;*
- *Eucalyptus rudis;*
- *Eucalyptus wandoo;* and
- *Eucalyptus accedens.*

Survey data does not include the total area of the Huntly and Willowdale mine DEs, therefore gaps in the information surrounding nesting trees within both DEs will be apparent. However, the following surveys either encompass part of the Mine DEs or is close proximity to the DEs and is further discussed below:

- Western Environmental (2024b) covered 437 ha in the Willowdale-Larego Mine region 20 km southeast of Waroona, a total of 13,267 potential, suitable or known nesting trees (DBH >50cm) were recorded within the survey area. Of these trees, three were known nesting trees (Bamford class 1 and 2), 396 trees were suitable nesting tree (Bamford Class 3) and 12,868 trees were potential nest trees (Bamford Class 4 and 5).
- Western Environmental (2024a) covered 674 ha in the Huntly – Myara Mine region reported a total of 216 potential, suitable or known nesting trees (DBH >50 cm) were recorded within the survey area. Of these trees, 25 were known nesting trees (Bamford class 1 and 2), 173 trees were suitable nesting trees (Bamford Class 3) and 18 trees were potential nest trees (Bamford Class 4 and 5).
- SLR (2024f) covered 501.7 ha in Huntly – Myara Mine region 20 km northeast of the Pinjarra townsite reported a total of 10,039 potential, suitable or known nesting trees (DBH >50 cm) were recorded within the survey area. Of these trees, five were known nesting trees (Bamford class 1 and 2) and 10,034 trees were potential nest trees (Bamford Class 4 and 5).

This data suggests that Black Cockatoos nesting habitat is varied across the Huntly and Willowdale Mine DEs, with concentrations of potential nest trees in pockets and sparse density elsewhere. The density of potential nest trees does not appear to be related to the

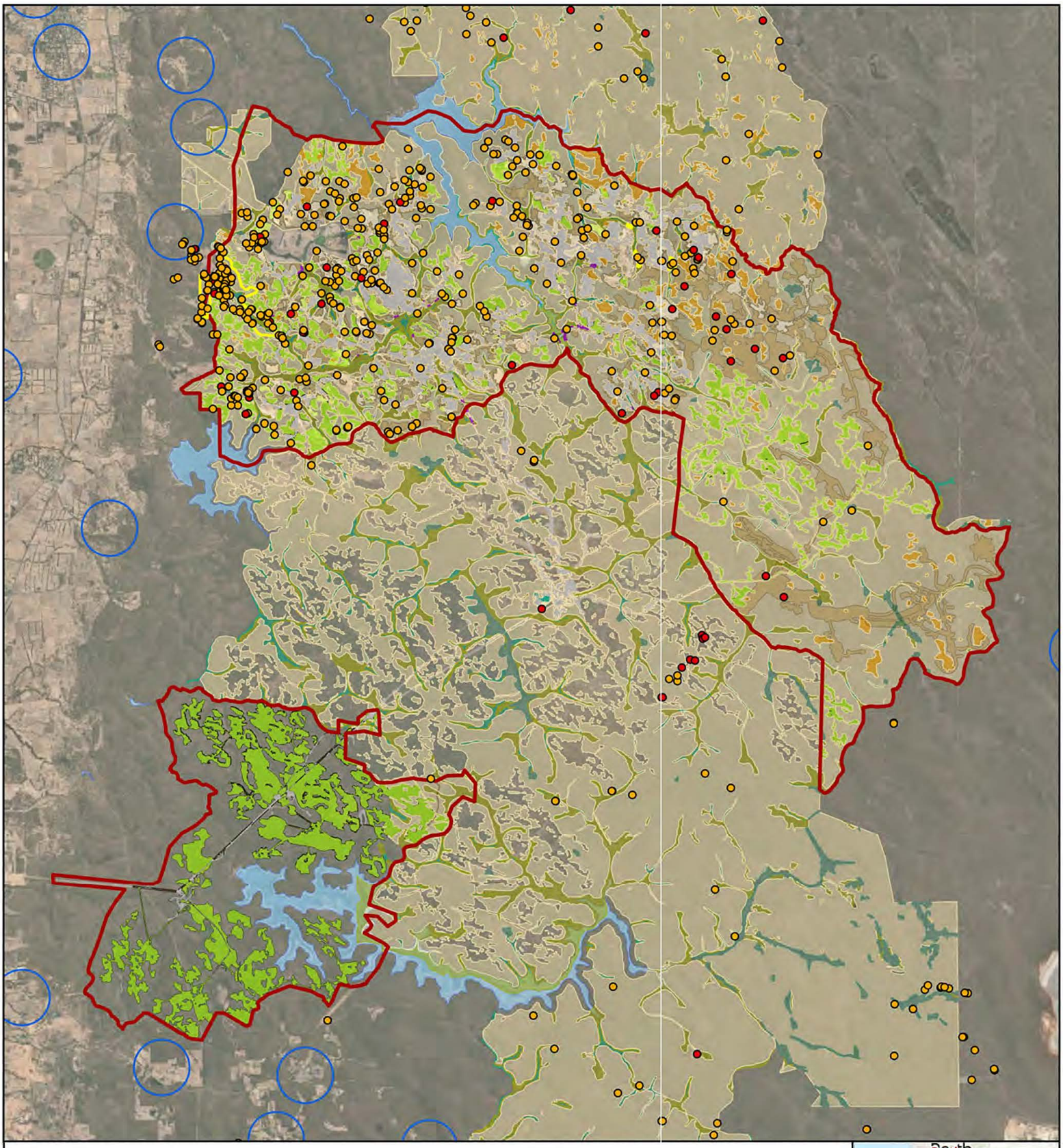
forest age, with potential nest trees occurring in areas that have been recently harvested for timber, or where older tress have been lost in past wildfires or from *Phytophthora* dieback.

Black Cockatoo roosting habitat

Night roosting habitat is defined as being '*habitat that contains one, or a group of known or potential roosting trees'* (DAWE, 2022). Roosting habitat was assessed on evidence of roosting activity (i.e., feathers, twig clips) and proximity of known local or regional roosting sites available from the desktop assessment and can be seen in Figure 5-43 and Figure 5-44.

During the (Western Environmental, 2024a) field survey, six locations within the survey area displayed evidence of having been used as a roost site. Potential roost sites were identified using secondary evidence such as feather, scats, and branch clippings. Opportunistic observations of birds during early mornings and late afternoon congregating at watering points and perching were recorded to assist in identifying potential roost sites.

During the SLR 2024 surveys, 11 Black Cockatoo roosting sites were recorded within the Survey Area (SLR Consulting Australia, 2024f). Of these sites, six were confirmed to be Forest Red-tailed Black Cockatoo roosting sites and five were unable to be attributed to a specific Black Cockatoo species. All Jarrah-Marri Forest and Drainage Line habitat was deemed to be potential night roosting habitat, and it is likely that additional roosting sites occur within these habitats that were not detected during the field surveys.

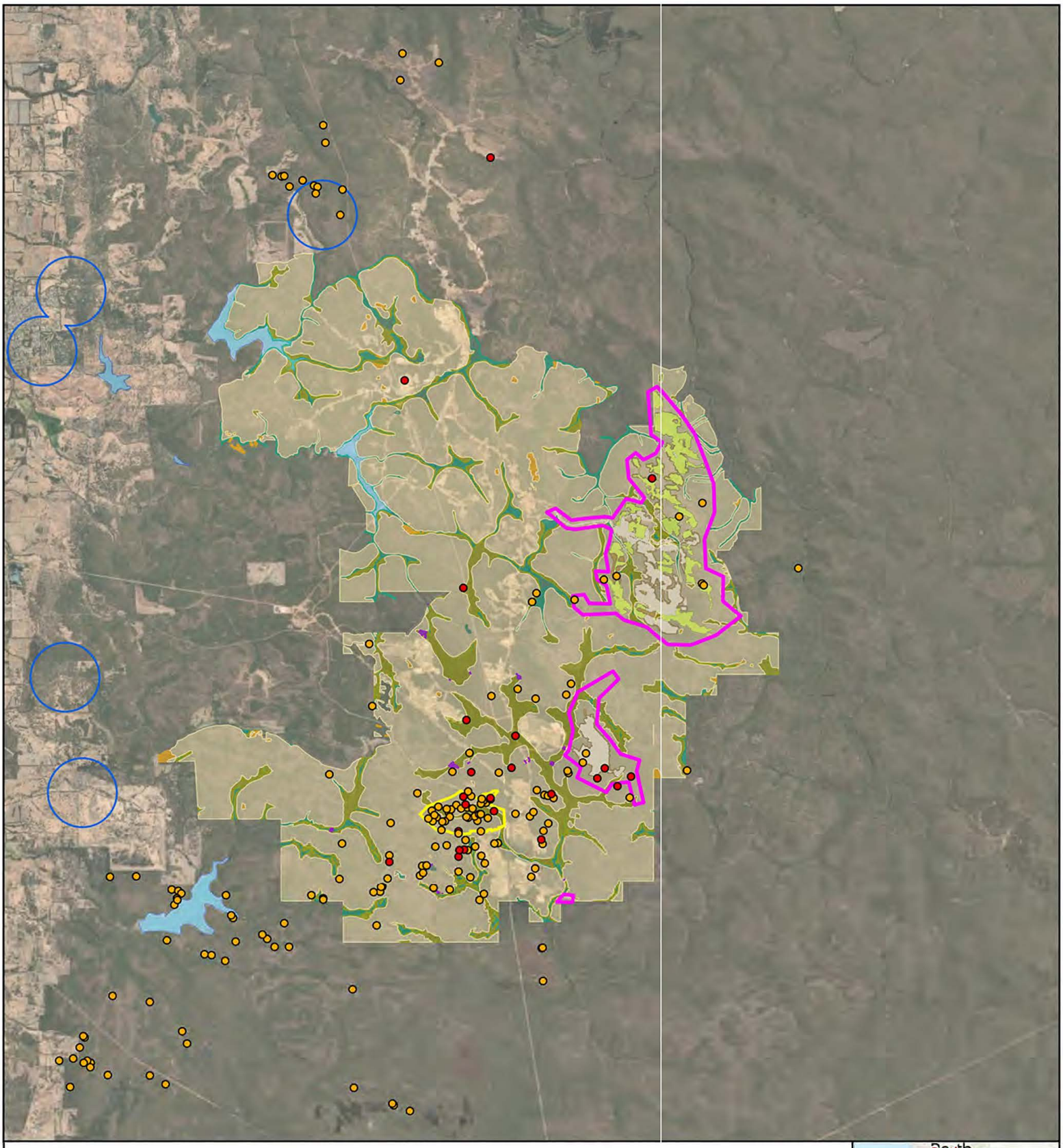


Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-43 Huntly Mine DE - Night Roosting Habitats

Scale: 1:185,926 at A4

Date Printed: 27/02/2025



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-44 Willowdale Mine DE - Night Roosting Habitats

Scale: 1:150,000 at A4

Date Printed: 27/02/2025

5.3.4.5 Introduced Fauna Species

The fauna surveys completed within the Huntly and Willowdale mines recorded six introduced species (in total) which are considered feral to the region, including:

- Feral Pig (*Sus scrofa*);
- European Fox (*Vulpes vulpes*);
- European Rabbit (*Oryctolagus cuniculus*);
- Black Rat (*Rattus rattus*);
- Feral Cat (*Felis catus*); and
- Laughing Kookaburra (*Dacelo novaeguineae*).

Further information on introduced fauna species is presented in Section 5.3.4.5 in relation to conservation significant fauna.

5.3.5 Aquatic Fauna

It is relatively well known that permanence of water is an overall determinant of aquatic fauna composition within Jarrah Forest ecosystems, such that headwater swamps and tributaries show distinctive communities compared to higher-order streams within the same sub-catchment. Communities in temporary waterbodies typically comprise a combination of species including those only found in temporary waters and those that periodically recolonise from adjacent permanent refuges. Seasonal and ephemeral waterbodies support important ecosystem processes and services, and often high biodiversity. Shallow sub-surface flows can be critical for the transport of energy, water, nutrients, and sediments to permanent surface waters downstream, and may support a diversity of hyporheic biota (Leigh, et al., 2013).

Many aquatic invertebrates in south-west WA are found only in temporary waters (Bunn, Davies, & Edward, 1989). They are specifically adapted to drying and refilling cycles and require a period of desiccation in order for further development to take place (Balla, 1994); (Williams & Hynes, 1977).

Carter's Freshwater Mussel surveys (SLR, 2024a) and (Biologic Environmental Survey, 2024a) in the Huntly – Myara and Willowdale – Larego Mine regions, respectively have been conducted. Incidental observations of other potential aquatic species were briefly mentioned in the studies. Neither study completed an aquatic habitat assessment within the Huntly and Willowdale Mine DE, therefore, the current condition and status of these aquatic habitats are uncertain. Both reports solely focus on the Carter's Freshwater Mussel and do not mention any other aquatic species or their habitat preferences. Due to the limited information surrounding other aquatic fauna within the Huntly and Willowdale Mine DEs Carter's Freshwater Mussel will be discussed in greater detail in Section 5.3.5.1.1 below.

During the Biologic Environmental Survey (2024a) assessment, incidental observation of various aquatic species were recorded which included:

- Schools of the native freshwater fish;
- Western minnow (*Galaxias occidental*);
- Rainbow trout (*Oncorhynchus mykiss*); and
- Koonac (*Cherax preisii*).

Overall, information on aquatic fauna present in the Huntly and Willowdale Mine DEs is limited.

5.3.5.1 Conservation Significant Aquatic Fauna

5.3.5.1.1 Carter's Freshwater Mussels

Recent studies have determined two genetically diverse Carter's Freshwater Mussels that have now been separated into two species, *Westralunio carteri* and *Westralunio inbisi* which are located north of Margret River and East of Margret River, respectively (Klunzinger, et al., 2022). To determine if *Westralunio carteri* can be split into multiple species evolutionarily significant units I, II and III were assigned to the *Westralunio carteri* collected. The Carter's Freshwater Mussels likely to be located within the study area is *Westralunio carteri I* (Klunzinger, et al., 2022)

Carter's Freshwater Mussels were not recorded during the survey conducted by SLR Consulting Australia (2024a) at the Huntly – Myara Mine region. It was determined that due to the poor water quality parameters (pH identified to be outside the desired range for Carter's Freshwater Mussel) and / or lack of sufficient volume of water it is unlikely that Carter's Freshwater Mussel will inhabit the assessed areas. During the survey, three survey locations lacked water. As Carter's Freshwater Mussels habitat require watercourses with a permanent flow, it is highly unlikely this is suitable Carter's Freshwater Mussels habitat.

A total of nine Carter's Freshwater Mussels were recorded during the survey conducted by Biologic Environmental at the Willowdale – Larego Mine region (SLR, 2024a). Eight of the nine observation were of dead Carter's Freshwater Mussels. The reason behind the loss of individual Carter's Freshwater Mussels is unknown but may be due to previous contamination event or spike in concentration of water quality analytes outside Carter's Freshwater Mussel's threshold (SLR, 2024a). The watercourses that contained the living and deceased Carter's Freshwater Mussels were both an unnamed watercourse that were tributaries to the Harvey River.

Conservation significant aquatic fauna recorded within the study area are listed in Table 5-38 below (Biologic Environmental Survey, 2024a).

Table 5-38: Conservation Significant Aquatic Fauna within the Study Area

Scientific Name	Common Name	Conservation Status		Habitat Preference	Likelihood of Occurrence		Key threatening processes (for threatened species)
		State	Commonwealth		Huntly	Willowdale	
Geotria australis	Pouched Lamprey	P3	-	This species utilises freshwater streams in the southwest (Perth to Albany) to breed and grow before migrating to the ocean to mature (Allen, Midgley, & Allen , 2002) Dams and weirs are the main obstacles for the species. Sporadic records exist throughout the Southwest Coast Drainage Division between Perth and Albany including the Swan, Canning, Serpentine, Margaret, Donnelly, Warren and Goodga rivers.	Low	Low	• Pollution of water • Climate change that will impact permanency of watercourses • Establishment of fish passage barriers such as dams, weirs and other natural or anthropogenic material that will block waterways.
Glacidorbis occidentalis	Minute Freshwater Snail	P3	-	This species of minute freshwater snail is known to inhabit streams within the jarrah forest. The snail have been previously found in freshwater streams with a gravel substrate with a riffle structure [Bunn & Stoddard (1983)]. Much about this snail's biology and habitat preference is unknown.	Medium	Low	• Pollution of water • Climate change that will impact permanency of watercourses
Westralunio carteri "I"	Carter's Freshwater Mussel	VU	VU	Carter's Freshwater Mussel inhabits watercourses that contain a stable but soft streambed, to allow for this species to burrow (DWER, 2024a). Although environmental tolerances of the Carter's Freshwater Mussel are not precisely	High	Recorded	• Pollution of water • Climate change that will impact permanency of watercourses

Scientific Name	Common Name	Conservation Status		Habitat Preference	Likelihood of Occurrence		Key threatening processes (for threatened species)
		State	Commonwealth		Huntly	Willowdale	
				understood, it known that they have a low salinity tolerance (DWER, 2024a). Formerly this species occurred widely through the southwest including interior rivers of southwest such as Avon, Murray and Blackwood, however Salination of many waterways has severely reduced this species distribution.			
Conservation Status *CD= Conservation dependent fauna* *CR = Critically endangered under the EPBC Act or BC Act* *EN = Endangered under the EPBC Act or BC Act* *VU = Vulnerable under the EPBC Act or BC Act* *SP (S7) = Schedule 7, Special Protection under BC Act* *P3 = Priority 3 under DBCA, poorly known species.* *P4 = Priority 4 under DBCA, rare, near threatened and species in need of monitoring.*				***Likelihood Occurrence*** ***Recorded –*** *Species was recorded during the survey.* ***Previously Recorded*** *– Species were previously recorded according to database search or literature review results.* ***High –*** *Species has been recorded more than once in the last in the last 15 years and suitable habitat is present within the Survey Area.* ***Medium –*** *There are existing records of the taxon within the Desktop Study Area, however the taxon has not been recorded within the Desktop Study Area in the last 15 years or suitable habitat within the Survey Area is marginal or limited in extent.* ***Low*** *Suitable habitat is not present within the Survey Area, or the taxon is very infrequently recorded in the locality despite reasonable previous search effort, or the taxon is believed to be extinct or locally extinct.*			

5.3.6 Short-range Endemic Invertebrate Fauna

There are limited short-ranged endemic (SRE) invertebrate studies that include the entire Proposal areas. Due to the limited ability of SRE species to disperse, only assessments conducted within the DEs will be discussed. The studies that will be assessed as a part of this ERD include:

- A field assessment of the O'Neil region of the Huntly Mine (Phoenix Environmental Sciences, 2024a); and
- A desktop assessment of the Mine DEs (Phoenix Environmental Sciences, 2024b).

5.3.6.1.1 Overview of Short-range Endemic Invertebrate Fauna

Short-range endemic (SRE) fauna are defined as animals that have restricted geographic distributions, nominally less than 10,000 km^2, that may also be disjunct and highly localised (Harvey, 2002). Short-range endemism in terrestrial invertebrates is believed to have evolved through two primary processes (Harvey, 2002):

- Relictual SREs – where drying climate has forced range contraction into small pockets with remaining moist conditions (e.g., south facing rock faces or slopes of mountains or gullies); and
- Habitat specialist SREs that may have settled in particular isolated habitat types (e.g., rocky or granite outcrops) by means of dispersal and evolved in isolation into distinct species.

SRE invertebrates have also been reported in more widespread habitats, such as spinifex plains or woodlands, mainly in groups with low dispersal capabilities, such as mygalomorph spiders and millipedes.

To identify the likelihood of invertebrates recorded in the Mine DE being SREs, (Phoenix Environmental Sciences, 2024a) adopted the SRE categorisation system presented in Table 5-39. The categorisation system is similar to that used by the WA Museum. There can be uncertainty in categorising a specimen as SRE, due to a number of factors including poor regional survey density, lack of taxonomic research and problems of identification (i.e., specimens that may represent SREs cannot be identified to species level based on the life stage at hand). Any SRE categorisation of a taxon is based on the information available at the time. As new information emerges from additional surveys, the SRE status may change.

Table 5-39: SRE fauna categories

SRE category	Criteria
Confirmed	Distribution <10,000 km^2. Taxonomy of the group is well known (but not necessarily published); group is well represented in collections, in particular from the region in question; high levels of endemism exist in documented species; inference is often possible from immature specimens.

SRE category	Criteria
Likely	Distribution <10,000 km^2. Taxonomically poorly resolved group but group is generally well-represented in collections; unusual morphology for the group (e.g., some form of troglomorphism); often recorded as singletons in survey and few, if any, regional records.
Potential	Distribution <10,000 km^2. Taxonomically poorly resolved group; patchy distribution, often common in certain microhabitats, but no other regional records; congeners (i.e., species in the same genus) often widespread.
Widespread	Distribution >10,000 km^2.

5.3.6.1.2 SRE Habitats

Phoenix Environmental Sciences (Phoenix) identified nine SRE habitat types in the O'Neil mine region and assigned a potential habitat rating (PHR) to each (2021b). The SRE fauna habitat types were identified and rated based on interpretation of vegetation mapping by Mattiske (2024b) and considering factors important to SRE fauna assemblages, including:

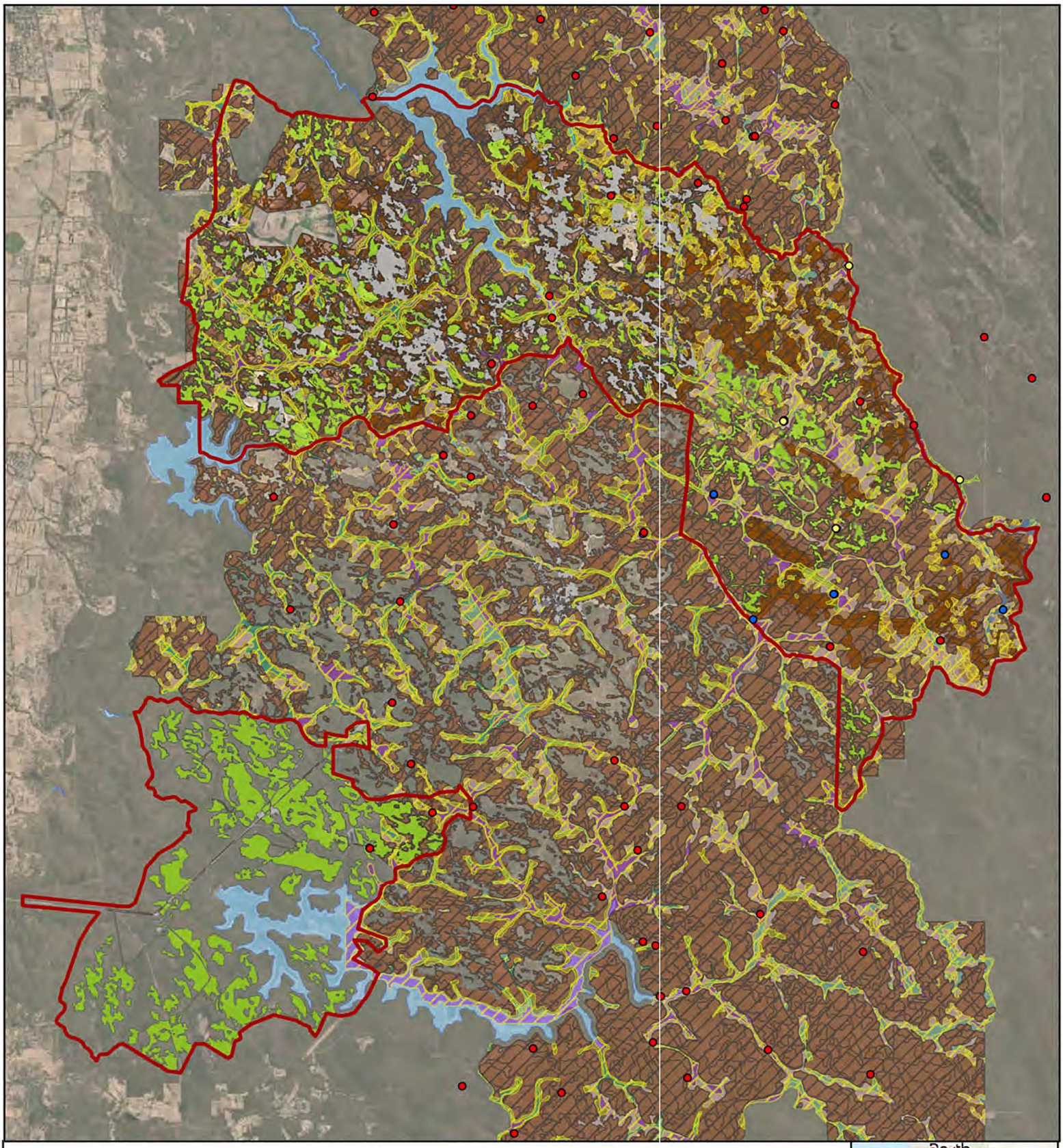
- Vegetation type and structure; and
- Substrate and position in the landscape.

The identified SRE habitats and their PHR ratings are described in Table 5-40 and mapped on Figure 5-45 (Huntly Mine DE) and Figure 5-46 (Willowdale Mine DE).

Of the vegetation types identified as SRE habitats, 7,485.4 ha (19.2%) and 256.6 ha (12.0%) within the Huntly and Willowdale Mine DEs, respectively, have been identified as a high potential habitat. Areas considered low potential habitat make up 19,205.8 ha (49.2%) and 1072.1 ha (50.2%) within the Huntly Mine DE and Willowdale Mine DE respectively. This data is provided in Table 5-40 and mapped on Figure 5-45 (Huntly Mine DE) and Figure 5-46 (Willowdale Mine DE).

Table 5-40: SRE fauna habitats present in Mine DEs

SRE habitat Code	Vegetation Type (Mattiske 2021, as per Phoenix 2021a)	Description	PHR	Huntly Mine DE (ha)	Proportion of Mine DE (%)	Willowdale Mine DE (ha)	Proportion of Mine DE (%)
1	A	Melaleuca woodlands/shrublands on seasonally wet or water-logged clays and clay-loams on valley floors	High	106.8	0.3%	-	-
2	AW,AW/CW,C,D,DA,DG,J,CW	Open Jarrah/Marri or Blackbutt woodlands on sands, clay-loam or sandy-gravel on lower slopes and valley floors	High	2694.4	6.9%	67.5	3.2%
3	GR,G,G1,R,RG	Heath/shrubland/woodland on shallow soils on granite or outcrops	High	1005.8	2.6%	2.0	0.1%
4	P,PS,PT,S,SP,ST,T,TS	Open forest to woodland of Jarrah/Marri on sandy-loam gravelly soils on mid-slopes and ridges	Low	13940.3	35.7%	1065.9	49.9%
5	WA,PW,SW,W,WD	Open forest of Jarrah/Marri Forest, seasonally moist, sandy gravels on slopes	High	2778.5	7.1%	152.0	7.1%
6	Cleared and Plantation	Cleared land (including plantations, dams)	NA	4107.0	10.5%	280.3	13.1%
7	AD,E	Open forest to woodland of Jarrah/Marri on slopes and less undulating hills	Low	137.8	0.4%	6.2	0.3%
10	AC,AX,AY	Open woodlands of Wandoo and Flooded Gum on seasonally wet or water-logged clays and clay loams on valley floors	High	899.9	2.3%	35.1	1.6%
11	M,Y,YG,YS	Open woodlands of Wandoo with clay-loams and some gravel on upper slopes	Low	25.7	0.1%	-	-
12	N/A	Rehabilitation (post-mining rehabilitation using mostly native species)	Low	5102.0	13.1%	-	-
-	N/A	Not Classified as SRE	N/A	7920.8	20.3%	527.0	24.7%
-	N/A	Unmapped Dam	N/A	329.0	0.8%	-	-
-	N/A	Total Area	N/A	39048.0	100%	2136.0	100%



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-45 Indicative SRE habitat – Huntly Mine DE

Kilometres

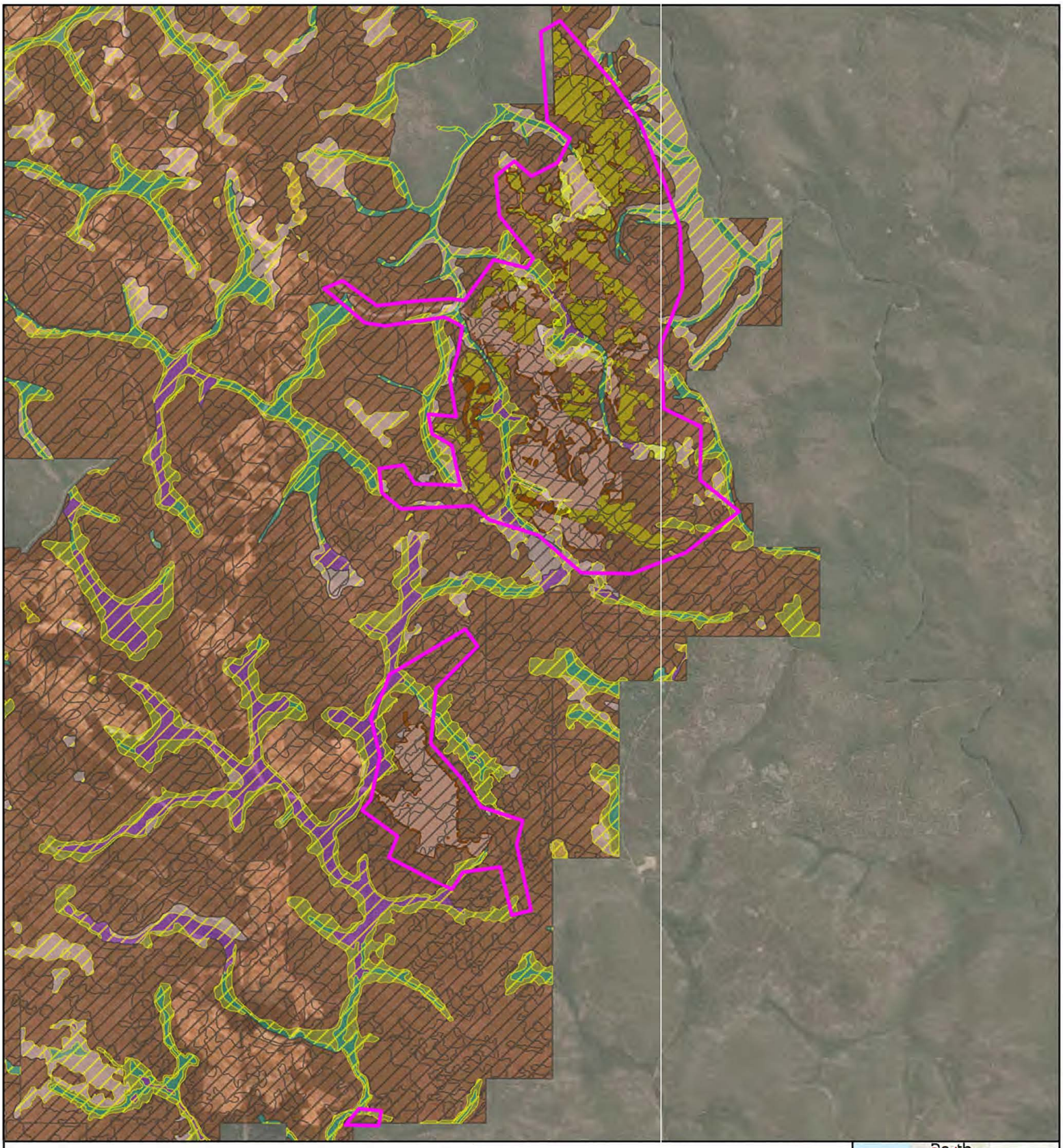
0 2 4 6 8 10 12

Scale: 1:175,000 at A4

Date Printed: 27/02/2025

N

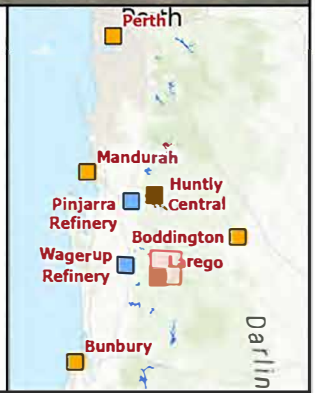
Alcoa



Legend

PHR Rating
- High
- Low
- Null

Fauna Habitat Type
- Blackbutt Forest
- Bullich Forest
- Flooded Gum Woodland
- Granite Outcrop Association
- Lowland Jarrah-Marri Forest
- Melaleuca Dampland
- Upland Jarrah-Marri Forest
- Willowdale Mine DE
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-46 Indicative SRE habitat – Willowdale Mine DE

Kilometres
0 0.9 1.8 2.7 3.6 4.5 5.4

Scale: 1:70,000 at A4

Date Printed: 27/02/2025

N

Alcoa

5.3.6.1.3 SRE Diversity

Phoenix conducted a desktop assessment of the Huntly and Willowdale Mine, identifying a total of 365 SRE taxa (2021b). Of these records, 46 are confirmed SRE taxa, five are likely SRE taxa and 243 are potential SRE taxa. The desktop assessment also identified one Priority 3 listed potential SRE taxa and one widespread Priority 3 SRE taxa.

Phoenix conducted a two season (July and October 2023) survey of SRE invertebrates over 17 sites within the O'Neil Mine area (Phoenix Environmental Sciences, 2024a). During the survey a total of 64 taxa from groups known to include SREs were collected. Of the 64 taxa, 45 taxa (70%) were classified as SREs as follows:

- Three confirmed SREs, represented by one millipedes, one pseudoscorpion, and one scorpion
- Five likely SREs, all represented by four isopods and one millipede
- 37 potential SREs, represented by:
    - 14 taxa of mygalomorphs (trap-door spiders);
    - six species of isopods (slaters);
    - two species of diplopods (millipedes);
    - seven species of opiliones (harvestmen spiders);
    - three species of land snail;
    - one species of araneomorph spider; and
    - four species of pseudoscorpions.

Of the 63 taxa identified, 19 taxa have been confirmed to have wider distributions than the O'Neil mine region, therefore are not considered SRE. These were represented by pseudoscorpions (4 taxa), millipedes (3 taxa), scorpions (3 species), slaters (4 species), mygalomorphs (2 species), land snails (2 species) and a velvet worm.

Of the remaining 45 SRE taxa from the survey, 28 species are described species or are morphospecies that were matched either morphologically or genetically to previously recorded species, seven are new species not previously known from morphological or molecular analysis and the remaining 10 were considered to be new or widespread species creating uncertainty around the taxa.

Specimens from SRE groups recorded in the O'Neil survey area are summarised in Table 5-41 below (Phoenix Environmental Sciences, 2024a).

Table 5-41: Specimens from SRE groups recorded in the O'Neil survey area (Phoenix Environmental Sciences, 2024a) Appendix 32

Higher Order/Family	Species	SRE Status	Presence outside SA	Presence within SA	SRE Habitat Code	Potential Habitat Rating	Comments
Class Arachnida, Infraorder *Mygalomorphae* (trapdoor spiders)							
Anamidae	*Aname* 'Phoenix0010'	Potential	Y	N	4	Low	Molecular match to a specimen from Holyoake and Holyoake East study area.
Anamidae	Anamidae sp. indet.	Potential	Y	N	10	High	specimen failed sequencing, likely represents a collected specimen.
Anamidae	*Proshermacha* 'MYG485'	Potential	Y	Y	5, 2	High	Previously recorded Myara North to Boddington (800 km^2) but it is more common in the Dwellingup area.
Anamidae	*Proshermacha* 'MYG495'	Potential	Y	Y	4	Low	Previously recorded within Holyoake and to Boddington.
Anamidae	*Proshermacha* 'MYG658'	Potential	Y	Y	2	High	Three other records in Myara North, Holyoake East and Collie.
Anamidae	*Proshermacha* 'Phoenix0027'	Potential	Y	Y	2, 3, 4, 5,10	High, Low	Recorded at two locations in Myara North.
Anamidae	*Teyl* 'MYG245'	Potential	Y	Y	5	High	Previously recorded at two locations SE of the study area, both 15 km NW of Boddington.
Anamidae	*Teyl* 'MYG355'	Potential	Y	Y	2, 5	High	Previously recorded at Holyoake East and Myara North.
Barychelidae	*Synothele michaelseni*	Widespread	Y	Y	2	High	Previously recorded in habitats near Perth and near Bindoon.
Barychelidae	*Synothele mullaloo*	Potential	Y	Y	2, 3, 4, 5, 10, 11	High, Low	Previously recorded in Holyoake, Holyoake East, Holyoake West, and near Boddington.
Idiopidae	*Bungulla harrisonae*	Potential	Y	Y	2	High	Previously recorded in Mundaring, approximately 140 km north of the study area.
Idiopidae	*Eucyrtops* 'MYG645'	Potential	Y	Y	5, 10,	High	Previously recorded in Holyoake, Holyoake East, Holyoake West and Quindanning.

Higher Order/Family	Species	SRE Status	Presence outside SA	Presence within SA	SRE Habitat Code	Potential Habitat Rating	Comments
Idiopidae	*Eucyrtops* 'Phoenix0029'	Potential	Y	N	2, 3, 4	High, Low	Previously recorded in two locations at Myara North.
Idiopidae	*Euoplos* 'Phoenix0211'	Potential	N	Y	5	High	Recorded 100 m from O'Neil boundary.
Idiopidae	*Idiosoma jarrah*	Widespread	Y	Y	4, 5	High, Low	Previously recorded in Holyoake, Myara North and Mundaring. Common near Mundaring.
Idiopidae	*Idiosoma* 'WAM T129362'	Potential	Y	Y	5, 11	High, Low	Recorded in Myara North and Holyoake East.
Class: Arachnida, Infraorder: Araneomorphae (araneomorph spiders)							
Selenopidae	*Karaops* sp. indet.	Potential	Y	Y	3, 11	High, Low	Likely represents a widespread species, either *K. jarrit* or *K. ellenae* which are both widespread throughout the Jarrah Forest.
Class: Arachnida, Order: Opiliones (Harvestmen spiders)							
Neopilionidae	*Ballarra longipalpus*	Potential	Y	Y	2, 3, 4, 5, 10	High, Low	Previously recorded in Holyoake East, Holyoake West, Myara North, Perth and Perth Hills.
Neopilionidae	*Megalopsalis* sp. indet.	Potential	Y	Y	2, 3, 4, 5, 10, 11	High, Low	This genus occurs in Holyoke East, Holyoake West, Perth and Perth Hills.
Neopilionidae	*Neopilionidae* sp. indet.	Potential	Y	Y	2, 3, 4, 5, 10	High, Low	This family occurs in Holyoake East, Perth and Perth Hills.
Triaenonychidae	*Triaenonychidae* 'genus 003' sp. indet.	Potential		Y	5	High	Other members of this genus occur near Boddington.
Triaenonychidae	*Triaenonychidae* 'genus 004' sp. indet.	Potential	Y	Y	2, 3, 4, 5	High, Low	Other members of this genus occur near Myara North.
Triaenonychidae	*Triaenonychidae* 'genus 008' sp. indet.	Potential	Y	Y	2, 3, 4, 5, 10, 11	High, Low	Other members of this genus occur at Myara North, Holyoake East, Holyoake, Holyoake West, and north to Mundaring.

Higher Order/Family	Species	SRE Status	Presence outside SA	Presence within SA	SRE Habitat Code	Potential Habitat Rating	Comments
Trigoniulidae	*Calliuncus* sp. indet.	Potential	Y	Y	2, 5	High	Other members of this genus occur at Myara North, Holyoake, Holyoake West, and near Boddington.
Class: Arachnida, Order: *Scorpiones* (scorpions)							
Bothriuridae	*Cercophonius sulcatus*	Widespread	Y	Y	2, 3, 4, 5, 10, 11	High, Low	Widespread and common, particularly on the SCP and near Mundaring. Other nearby records from Boddington, Waroona, Holyoake and Myara North.
Buthidae	*Lychas* 'austroccidentalis'	Widespread	Y	Y	2, 3	High	Widespread and common from SCP, Perth Hills, Boddington, Waroona, Holyoake and Myara North.
Urodacidae	*Urodacus novaehollandiae*	Widespread	Y	Y	2, 4, 5, 10, 11	High, Low	Widespread and common from SCP, Perth Hills, Boddington, Waroona, Holyoake and Myara North.
Urodacidae	*Urodacus planimanus*	Confirmed	Y	Y	2, 3, 4, 5	High, Low	Common in the Perth Hills to Myara North and Holyoake.
Class: Arachnida, Order: Pseudoscorpiones (pseudoscorpions)							
Atemnidae	*Oratemnus curtus*	Widespread	Y	Y	2, 4	High, Low	Widespread throughout the Southwest, from Perth to Albany.
Chthoniidae	*Austrochthonius* 'medium 2'	Potential	Y	Y	2, 3, 4	High, Low	Only recorded in study area and a reference site.
Chthoniidae	*Austrochthonius muchmorei*	Potential	Y	Y	2, 3, 4, 10, 11	High, Low	Commonly collected between Byford and Collie.
Chthoniidae	*Austrochthonius* 'PSE188, similis'	Potential	Y	Y	2, 4, 5, 10	High, Low	Common in the Southwest, also known from Mundaring, Perth, Myara North and Boddington.
Chthoniidae	*Austrochthonius* 'PSE191, grandis'	Potential	Y	Y	2, 3, 4, 5, 11	High, Low	Previously recorded in Holyoake, Myara North, and near Boddington.

Higher Order/Family	Species	SRE Status	Presence outside SA	Presence within SA	SRE Habitat Code	Potential Habitat Rating	Comments
Chthoniidae	*Lagynochthonius australicus*	Widespread	Y	Y	2, 4, 5	High, Low	Widespread across the Southwest and has been collected from Holyoake, Holyoake East and Holyoake West.
Geogarypidae	*Synsphyronus magnus*	Widespread	Y	Y	2, 4	High, Low	Widespread across the Southwest, Perth Hills, SCP and Manjimup.
Olpiidae	*Beierolpium bornemisszai*	Widespread	Y	Y	5	High	Previously recorded in Myara North, near Boddington and near Collie.
Pseudotyrannochthoniidae	*Pseudotyrannochthonius* 'Darling Range 2' ('DS2')	Confirmed	Y	Y	2, 3, 4, 5	High, Low	Previously recorded in Perth Hills, Myara North, Holyoake East and Holyoake West.
Class Myriapoda, Order Diplopoda (millipedes)							
Dalodesmidae	*Sphaerotrichopus* `sp. indet`	Potential	Y	-	10	High	This genus was previously recorded in Holyoake East. Likely the same species as the sequencing failed. Other members of this genus are known from the Jarrahdale and Mundaring areas.
Iulomorphidae	*Atelomastix nigrescens*	Widespread	Y	Y	2, 3, 4, 5	High, Low	Widespread species commonly recorded from Myara North, Holyoake, Holyoake East, Holyoake West and Boddington.
Iulomorphidae	*Podykipus collinus*	Potential	Y	Y	2, 3, 11	High, Low	Previously recorded in Holyoake East and Holyoake West.
Iulomorphidae	*Podykipus* 'DIP241'	Likely	Y	Y	5	High	A new species, which has previously been recorded in 2 sites at Holyoake East.
Iulomorphidae	*Podykipus leptoiuloides*	Widespread	Y	Y	4, 5, 10	High, Low	Widespread species commonly recorded from Myara North. Also recorded from Holyoake, Holyoake West and Boddington.
Paradoxosomatidae	*Antichiropus* 'Phoenix0217'	Confirmed	Y	Y	3, 5, 10, 4, 11	High, Low	A new species known only from 7 sites within or near O'Neil. Two of these sites are reference sites outside of the study area and another 2 sites are within 200 m of the study area boundary.

Higher Order/Family	Species	SRE Status	Presence outside SA	Presence within SA	SRE Habitat Code	Potential Habitat Rating	Comments
Paradoxosomatidae	*Antichiropus variabilis*	Widespread	Y	Y	2, 3, 4, 5, 10, 11	High, Low	Common, widespread species, most records are from Mundaring, Boddington, Myara North and Holyoake, however also known from north of Bindoon and south of Manjimup.
Class: Malacostraca, Order: Isopoda (slaters)							
Armadillidae	*Acanthodillo* '1'	Potential	Y	Y	2	High	Previously recorded in Holyoake and Holyoake East and near Boddington.
Armadillidae	*Armadillo flavus*	Potential	Y	Y	5, 11	High, Low	Previously recorded near Holyoake East, Holyoake West, Myara North, Collie and near Byford.
Armadillidae	*Buddelundia nitidissima*	Widespread	Y	Y	2, 3, 4, 5, 10, 11	High, Low	Commonly collected from Holyoake, Quindanning, Boddington and Myara North.
Armadillidae	*Buddelundia* 'sp. 04'	Potential	Y	N	3	High	Previously recorded near Boddington and Perth Hills.
Armadillidae	*Buddelundia* 'sp. 5'	Likely	Y	Y	2, 4, 5, 10	High, Low	Previously recorded in Holyoake, Holyoake East, Holyoake West and Myara North.
Armadillidae	*Pseudodiploexochus* 'Phoenix0214'	Likely	Y	Y	2, 4, 5, 10	High, Low	A new species recorded from 7 sites in or near O'Neil, and one reference site near Holyoake West.
Armadillidae	*Spherillo* '5'	Widespread	Y	Y	2, 3	High	Previously recorded in Myara North, Holyoake East, Boddington and Collie.
Philosciidae	*Laevophiloscia* '1'	Widespread	Y	Y	2, 3, 4, 5, 11	High, Low	Commonly collected throughout the Northern Jarrah Forest and near Perth on the SCP.
Philosciidae	*Laevophiloscia* '2'	Widespread	Y	Y	2, 3, 4, 5, 10,	High, Low	Commonly collected throughout the Northern Jarrah Forest and near Perth on the SCP.
Philosciidae	*Philosciidae* 'Phoenix0208'	Potential	N	Y	4	Low	Two specimens collected from a pitfall trap sequenced but unsuccessful.
Philosciidae	*Philosciidae* 'Phoenix0209'	Potential	N	Y	5	High	Two specimens collected from a foraging sample sequenced but no close matches.

Higher Order/Family	Species	SRE Status	Presence outside SA	Presence within SA	SRE Habitat Code	Potential Habitat Rating	Comments
Philosciidae	*Philosciidae* 's/1'	Likely	Y	Y	2, 3, 4, 5, 10,	High, Low	Commonly recorded from Myara North and Holyoake East. Also known from Holyoake, and Perth Hills.
Styloniscidae	*Styloniscus* '1'	Potential	Y	Y	2, 3, 4, 5, 10, 11	High, Low	Commonly recorded from Myara North, Holyoake East and Holyoake West. Previously recorded from Holyoake, Boddington and Collie.
Styloniscidae	*Styloniscus* '7'	Likely	Y	Y	2, 3, 5	High	Previously recorded in Holyoake East, Myara North, Boddington and Collie.
Polyzoniidae	*Polyzoniida* 'Phoenix0042'	Potential	-	-	3	High	Myara North – Mine.
Class Gastropoda, Order Eupulmonata (land snails)							
Bothriembryontidae	*Bothriembryon* cf. *bradshawi*	Widespread	Y	Y	2, 3, 11	High, Low	Collected from Holyoake and Holyoake East and Boddington.
Bothriembryontidae	*Bothriembryon* cf. *serpentinus*	Potential	Y	Y	2	High	Collected from near Boddington, Collie, Waroona, Dwellingup, and Jarrahdale.
Charopidae	*Annoselix* cf. *dolosa*	Potential	Y	Y	2	High	Collected from Holyoake West, Myara North and near Boddington.
Charopidae	*Luinodiscus* cf. sublesta	Widespread	Y	Y	2, 4	High, Low	Previously recorded from near Boddington.
Punctidae	cf. *Westralaoma* sp. indet.	Potential	Y	Y	2	High	Collected from Holyoake East.
Phylum: *Onychophora* (velvet worms)							
Peripatopsidae	*Occipperipatoides gilesii*	Widespread	Y	Y	2, 3, 11	High, Low	Previously recorded between Holyoake, Holyoake East, Holyoake West, Myara Norther and north to Mundaring.

Table 5-42 below summarises the SRE survey findings across the O'Neil area by SRE habitat PHR (Phoenix Environmental Sciences, 2024a). As presented, the survey recorded a much higher total number of SRE taxa in the high PHR habitats. The highest number of SRE taxa were recorded in SRE habitat 5, the most widespread habitat (open forest of Jarrah/Marri Forest, seasonally moist, sandy gravels on slopes).

Table 5-42: Summary of SRE fauna recorded in the O'Neil mine region by species group

SRE Taxa	SRE Habitat code					
	Low PHR				High PHR	
	25 survey sites				9 survey sites	
	10*	4*	11*	2*	3*	5*
Diplopoda	4	4	3	4	2	5
Isopoda	5	8	5	9	6	10
Mygalomorphae	4	7	2	9	2	11
Araneomorphae	-	-	1	1	-	-
Opiliones	5	5	4	6	4	5
Scorpiones	2	3	2	4	2	3
Pseudoscorpiones	3	8	4	7	4	5
Eupulmonata	-	2	1	5	1	-
Onychophora	-	-	1	1	-	-
Total	**23**	**37**	**23**	**46**	**21**	**39**

*SRE Habitat Code (see Table 5-40)

The Low PHR SRE habitats are relatively widespread and typically lack habitat features that facilitate SRE specialisation whereas areas with a High PHR that contain habitat attributes often give rise to specialisation or dependency in invertebrate fauna (Phoenix Environmental Sciences, 2024a).

Phoenix Environmental Service (2024a) noted that some SRE taxa were collected only from High PHR habitats (e.g., *Proshermacha 'MYG658'*, *Calliuncus* sp. indet. and *Podykipus 'DIP241'*) and it is possible these habitats harbour highly range-restricted species. However, many SRE taxa were recorded from both Low and High PHR SRE habitats, with some taxa having wider distributions than the O'Neil mine region as noted in Table 5-41 (Phoenix Environmental Sciences, 2024a).

Three taxa collected from the survey (*Euoplos 'Phoenix0211', Philosciidae 'Phoenix0208' and 'Philosciidae 'Phoenix0209'*); that are unique to the study area. These taxa are from single sites, although broader distributions outside the study area unknown. The remaining 62 taxa have been previously recorded outside of the O'Neil study area. This suggests that O'Neil study area does not support extreme range-restricted taxa; however, based on other studies conducted within the NJF similar habitat as seen in the O'Neil mine region has been known to contain habitat that can support several SRE taxa.

It is suggested that potential SRE fauna within the NJF subregion are not restricted to the granite outcrop, stream or swamp habitats but are likely to be found in the widespread upland Jarrah Forest habitats, such as those associated with Dwellingup vegetation complexes. This may be due to a relative abundance of mesic and differentiated habitats in the NJF subregion given the high rainfall, undulating topography, and the extensive forest coverage and associated litter, bark, shade and coarse woody debris. While individual SRE

taxa may have restricted ranges within the NJF subregion, the 1.11 million ha (~ 11,100 km^2) of largely contiguous forest over an undulating plateau and incised valleys may represent a biodiverse continuum of SRE fauna habitats and species.

5.3.6.1.4 SRE Previous Studies

Four studies have been conducted within proximity to the Huntly and Willowdale mine region since 2021. These studies include

- O'Neil (Phoenix Environmental Sciences, 2024a);
- Myara North (Phoenix Environmental Sciences, 2021a);
- Holyoake (Phoenix Environmental Sciences, 2021a); and
- Worsley (Phoenix Environmental Sciences, 2021b).

When reviewing all completed studies, it was noted that there were considerable differences in the SRE assemblages between various surveyed areas i.e., Myara North and Holyoake had only 36% SRE taxa found in both sites. Since O'Neil is located between these two survey areas it is expected that SRE taxa would have more overlap with Myra North and Holyoake, which proved to be true as the survey at O'Neil recorded 38 species / morphospecies in common with Myara North, and 39 species / morphospecies in common with Holyoake. Furthermore, 39 species / morphospecies from O'Neil were in common with taxa from Holyoake East, 22 from Holyoake West and 42 were in common with the Worsley studies. When all six studies were compared it was found that:

- 16 species / morphospecies were recorded during all 6 surveys;
- 12 species / morphospecies were recorded during 5 of the 6 surveys;
- 16 species / morphospecies were recorded during 4 of the 6 surveys;
- 32 species / morphospecies were recorded during 2 of the 6 surveys; and
- 89 species / morphospecies from 1 the 6 surveys.

Species assemblage is similar across all studies, with mygalomorph spiders being the dominant group, comprising (25-40% of all taxa), followed by isopods and millipedes (10-20% of all taxa), with the remaining SRE groups all representing less than 10% of the assemblage in each study area.

A comparison of SRE survey results in the Huntly Mine region from 2019 to present surveys is summarised in Table 5-43 below.

Table 5-43: Comparison of SRE survey results in the Huntly Mine region from 2021 to present surveys

Element	**O'Neil** (Phoenix Environmental Sciences, 2024a)	**Myara North and Hoyoake** (Phoenix Environmental Sciences, 2021a)	**Worsley Mine Expansion** (Phoenix Environmental Sciences, 2021b)
Baseline study area size (ha)	10,414.5 ha	28,132 ha	124,651 ha • 29,360 (CBME and WMDE) • 95,291 (regional study area)
Number of sites	17 sites	60 sites • 28 MN-MA • 22 H-MA • 5 MN-CC • 3 H-CC • 1 MN-HR • 1 H-HR	47 sites in total • 10 CBME (2019) • 22 WMDE (2019) • 15 regional study area (2020)
Number of taxa from SRE groups	64	117	134
Number of SRE taxa	• Confirmed: 3 • Likely: 5 • Potential: 37 • Total: 45	• Confirmed: 11 • Likely: 5 • Potential: 67 • Total: 83	• Confirmed: 9 • Likely: 12 • Potential: 77 • Total: 98
% of taxa from SRE groups that are SREs	70%	73%	73%
Number of families and genera	Families: 25 Genera: 34	Families: 19 Genera: 24	Families: 19 Genera: 30
Number of taxa in each group	• Mygalomorphs: 16 (25.0%) • Opiliones: 7 (10.9%) • Pseudoscorpions: 9 (14.0%) • Scorpions: 4 (6.25%) • Millipedes: 17 (22.7%) • Isopods: 7 (10.9%) • Land snails: 5 (7.8%) • Araneomorphs: 1 (1.6%) • Velvet worm: 1 (1.6%)	• Mygalomorphs: 35 (42.2%) • Opiliones: 7 (8.4%) • Pseudoscorpions: 2 (2.4%) • Scorpions: 2 (2.4%) • Millipedes: 16 (19.3%) • Isopods: 16 (19.3%) • Land snails: 5 (6.0%)	• Mygalomorphs: 40 (40.8%) • Opiliones: 8 (8.2%) • Pseudoscorpions: 4 (4.1%) • Scorpions: 0 • Millipedes: 19 (19.4%) • Isopods: 24 (24.5%) • Land snails: 3 (3%)

Element	**O'Neil** (Phoenix Environmental Sciences, 2024a)	**Myara North and Hoyoake** (Phoenix Environmental Sciences, 2021a)	**Worsley Mine Expansion** (Phoenix Environmental Sciences, 2021b)
Number of native habitat types	8	8	9
Number of sites in rehabititation survey	0	12	8

5.3.7 Potential Environmental Impacts

The following Proposal activities have the potential to impact terrestrial fauna:

- Construction of mine access and haul roads, conveyors and facilities;
- Extension of mining and operation of mining and haulage equipment; and
- Clearing of vegetation.

The Proposal may result in the following potential direct and indirect impacts to terrestrial fauna:

- Direct impacts to fauna as a result of:
    - Clearing of fauna habitat types leading to potential loss of fauna habitat and
    - Loss of fauna individuals as a result of fauna entrapment or vehicle/equipment collisions.
- Indirect impacts to fauna as a result of:
    - Introduction and/or spread of weeds,
    - Introduction and/or spread of *Phytophthora* Dieback potentially leading to habitat degradation;
    - Attraction of feral animals potentially leading to increased predation by introduced fauna species and habitat degradation;
    - Altered hydrological regimes potentially leading to degradation/alteration of foraging and dispersal habitat;
    - Disturbance from light, noise and/or vibration, and possible displacement of fauna associated with construction activity and mining operations
    - Spills and/or leaks from storage and handling of hazardous materials and waste;
    - Habitat fragmentation and barriers to fauna movement'
    - Habitat degradation associated with construction activities or mining activities and/or increased human activity including transmission of weeds and dust.

5.3.7.1 Direct Impacts

As described in Section 1.1, the Proposal will result in clearing of 4,042 ha at the Huntly Mine DE and will result in clearing of 77 ha at the Willowdale Mine DE between the period of approximately 2022 to 2027.

5.3.7.1.1 Direct Impacts on Habitat Loss

The Proposal will directly impact habitat for conservation significant species and priority species, that have either been recorded or assessed as likely to occur in the Mine DEs, as well as a diverse assemblage of common native flora and fauna species. This will impact and reduce the overall in situ and biodiversity (flora and fauna species abundance) within the study area and wider locality.

The removal of habitat will displace native fauna into adjacent retained habitats and create a level of intraspecific and interspecific competition for habitat resources for a period, until home ranges are re-established, and a biodiversity equilibrium is once again attained.

Important microhabitat features that will be removed during land clearing include:

- Groundcover containing hollow logs, coarse woody debris, dense vegetation and leaf litter suitable for sheltering by reptiles, amphibians and small mammals;
- Hollow bearing trees and stags providing sheltering and breeding habitat for a range of arboreal fauna such as hollow nesting parrots, owlet nightjars, microbats, and native bees; and
- Flowering eucalypts and other native trees providing suitable foraging habitat for native birds.

Vegetation clearing works also places some species at risk of direct Proposal-related impacts and potential loss of individuals. It is also likely to result in Project-related impacts to local populations of conservation significant species. The extent of habitat within the Mine DEs, which will be impacted by the Proposal is presented in Table 5-44.

As presented in Table 5-44, the majority of the clearing (3,918.5 ha or 95% of total clearing) is within the Jarrah-Marri Forest habitat type, due to its association with lateritic soils. This habitat type is anticipated to be subject to mining as well as infrastructure. The Jarrah-Marri Forest habitat is broadly comparable to the lateritic soil SVTs (P, S and T) which are relatively widespread within the NJF (Section 5.2.4.2). The Jarrah-Marri Forest provides high quality foraging habitat, scattered nesting habitat and dispersal habitat for a range of threatened species including Black Cockatoos, Chuditch, and Quokka.

The Jarrah-Marri Forest habitat was also mapped by Phoenix as low-quality habitat for SRE invertebrates; however, field survey results indicate a comparable prevalence of SRE invertebrates to that of more restricted habitats in the NJF (Phoenix Environmental Sciences, 2021a).

Approximately 95.6 ha (6.7% of the total clearing) of Drainage lines (Blackbutt and Bullich forest) and Melaleuca damplands habitat types are proposed to be cleared due to the Proposal. These habitat types are more restricted in extent than Jarrah-Marri Forest and are high value for threatened mammals (Chuditch, Woylie, Quokka and Western Ring Tail Possum), priority fauna and SRE invertebrates and high-quality foraging habitat for Forest-Red Black Cockatoo.

The Proposal is expected to result in limited clearing (51.2 ha or 1.3% of total clearing) to Granite outcrop associations. These habitats are the most restricted in extent within the NJF and provide high value habitat for Chuditch, Priority fauna and SRE invertebrates.

Impacts to conservation significant fauna and SRE fauna are considered further in Sections 5.3.4.4 and 5.3.6 respectively.

Table 5-44: Indicative estimates of direct impacts to terrestrial fauna habitats – Huntly and Willowdale Mine DEs

Fauna Habitat	Huntly Mine DE			Willowdale Mine DE			Total clearing in Mine DE (ha)	Proposal proportion of total Mine DE (%)
	Total (ha)	Clearing (ha)	Proportion of clearing (%)	Total (ha)	Clearing (ha)	Proportion of clearing (%)		
Drainage Line	14.0	13.9	0.3	0.0	0.0	0.0	13.9	0.0
Drainage Line (Blackbutt Forest)	860.1	11.9	0.3	57.8	1.4	1.8	13.3	0.0
Drainage Line (Bullich forest)	1,954.7	48.8	1.2	126.2	2.0	2.5	50.8	0.1
Jarrah-Marri Forest	18,633.3	3,845.3	95.2	1,935.3	73.2	95.6	3,918.5	9.5
Granite outcrop	1,010.2	51.2	1.3	1.9	0.0	0.0	51.2	0.1
Melalecua Damplands	140.1	17.6	0.4	0.0	0.0	0.0	17.6	0.0
Other (cleared, Rehabilitated and/or Plantation)	9,199.3	35.9	0.9	0.0	0.0	0.0	35.9	0.1
Unsurveyed	7,234.5	15.9	0.4	15.0	0.0	0.0	15.9	0.0
Total area	39,048	4,042	100	2,137	77	100	4,117	10

Direct loss of conservation significant fauna habitat

Indicative estimates of the Proposal direct impacts to conservation significant fauna habitats within the Huntly and Willowdale Mine DE are presented in Table 5-45. The high, medium and low rating is based on habitat usage of each species as outlined in Table 5-29, which is based on preferred habitat requirements of each species. As presented, the Proposal is expected to clear up to 4,119 ha (4,042 ha for Huntly and 77 ha for Willowdale) of habitat for 17 conservation significant fauna species, including eight Threatened, seven Priority species and two conservation dependent / other special protected species. These species utilise Jarrah-Marri Forest, Drainage Lines (Blackbutt and Bullich forest) and Granite outcrops habitat, that may be subject to mining.

The Jarrah-Marri Forest habitat type is widely distributed across the NJF and is expected to comprise important habitat for Black Cockatoos, Chuditch, Woylie, Brush-tailed Phascogale, Western Brush Wallaby, Peregrine Falcon, Masked Owl, Western False Pipistrelle, Western Ring Tail Possum, Dell's Skink, Southern Death Adder.

The Proposal is expected to clear a 95.6 ha of high value habitat for Quokka and Quenda, which prefer dense streamzone habitat (Drainage Line), with Jarrah-Marri habitat being of medium value for these species. Clearing of any streamzone habitat is expected to comprise of important habitat for Quokka.

Black Cockatoo habitat

The Jarrah-Marri Forest within the Huntly and Willowdale Mine DEs is expected to be representative of Black Cockatoo habitat within the wider NJF subregion, which has a comparable Jarrah-Marri tree coverage, forest age and fire history. The Proposal is expected to remove habitat for the Black Cockatoos; indicative estimates of the area to be cleared are provided in Table 5-45.

Previous surveys noted that the impacts will include the removal of approximately 131 habitat trees in the Huntly Mine DE and 36 habitat trees in the Willowdale Mine DE. However, a full assessment of the development area for the Mine DEs, such as the Huntly & Del Park (Huntly region) and the Keates & Tasman (Willowdale region), has not been undertaken. Only 29.8% (11,550.64 ha) and 80.4% (1,718.55) of the Huntly and Willowdale mine DE has been assessed. Of this 61.37% (8,469.45 ha) of the Huntly Mine proposed disturbance footprint and 61.56% (520.80 ha) of the Willowdale Mine proposed disturbance footprint have been surveyed. Therefore, these estimates are only indicative and may vary depending on the actual distribution of potential nest trees across the Mine DEs. This will be confirmed during Pre-clearance surveying. Alcoa has committed to avoiding clearing of known or suitable Black Cockatoo nest trees.

Table 5-45: Indicative estimates of direct impacts to conservation significant fauna habitats – Huntly and Willowdale Mine DEs

Species	Status		Likelihood of occurrence		Proposal clearing to potential habitat (ha)		
	EPBC Act	BC Act	Huntly Mine DE	Willowdale Mine DE	High value	Medium value	Low to no value
Birds							
Forest Red-tailed Black Cockatoo	Vulnerable	Vulnerable	Recorded	Recorded	3,931.8	86.7	82.7
Baudin's Cockatoo	Endangered	Endangered	Recorded	Recorded	3,918.5	113.9	68.8
Carnaby's Cockatoo	Endangered	Endangered	Recorded	Recorded	3,918.5	113.9	68.8
Peregrine Falcon	-	Special Protection (Schedule 7)	Recorded	Likely	3982.6	118.6	0.0
Masked Owl (southwest)	-	P3	Likely	Likely	4047.7	53.6	0.00
Mammals							
Western Ringtail Possum	Critically Endangered	Critically Endangered	Potential	Likely	3950.0	64.1	87.1
Woylie	Critically Endangered	Critically Endangered	Recorded	Likely	4014.1	87.1	0.00
Numbat	Endangered	Endangered	Potential	Unlikely	3918.5	81.7	101.0
Chuditch	Vulnerable	Vulnerable	Recorded	Recorded	4101.2	0.00	0.00
Quokka	Vulnerable	Vulnerable	Recorded	Likely	95.6	3969.7	35.9
Western False Pipistrelle	-	P4	Recorded	Likely	3996.5	104.7	0.00
Quenda	-	P4	Recorded	High	95.6	4005.6	0.00
Western Brush Wallaby	-	P4	Recorded	Recorded	4065.3	35.9	0.00
Brush tailed Phascogale	-	Conservation Dependent	Recorded	Likely	4047.7	53.6	0.00
Rakali	-	P4	Recorded	Recorded	31.5	115.8	3954.4
Reptiles							
Southern Death Adder	-	P3	Likely	Likely	3969.7	131.6	0.00
Dell's Skink	-	P4	Recorded	Likely	4101.24	0.00	0.00

Impacts to conservation significant fauna populations

The Mine DEs lie within the NJF subregion and are expected to comprise habitat critical to the survival of the following threatened species:

- Forest Red-Tailed Black Cockatoo;
- Baudin's Cockatoo;
- Chuditch;
- Carnaby's Cockatoo;
- Quokka;
- Western Ringtail Possum; and
- Woylie.

The temporary loss of habitat for the above species, including long term loss of potential nest trees for Black Cockatoos, may cause a significant impact to local populations, particularly in the context of cumulative impacts from other mining, fragmentation, historic timber harvesting, climate change, fire and other threatening processes in the NJF subregion.

Potential suitable habitat for Numbat is not considered habitat critical to the survival of the species, as there is no evidence of recent occupancy within the DE or surrounding land and it is uncertain whether there is currently adequate predator control or a suitable fire regime to support occupancy within the DE.

The Proposal has potential to clear potential suitable habitat for WRP, which comprises riparian forest habitat types that may contain pockets of dense, overlapping (closed) canopy. If such pockets of closed riparian habitat occur and are occupied by WRP then these would be expected to comprise habitat critical to the survival of the species. Alcoa will undertake targeted surveys within potential suitable habitat and avoid identified WRP populations. The remaining clearing for the Proposal is expected to occur over open vegetation including upland vegetation and open canopy riparian or swamp woodland, which is not expected to comprise habitat critical to the WRP and would only be used by the species for limited dispersal between nearby riparian forest habitats.

The Jarrah Marri Forest within the Huntly and Willowdale Mine DEs is expected to be representative of Black Cockatoo habitat within the wider NJF subregion, which has a comparable Jarrah Marri tree coverage, forest age and fire history. The Proposal is expected to remove habitat for the Black Cockatoos; indicative estimates of the area to be cleared are provided in Table 5-45.

The Proposal will result in limited clearing (78 ha; 0.18% of the total area of the Mine DEs and 2.6% of the existing Drainage Line habitat within the Mine DEs) of Drainage Lines (including Blackbutt Forest and Bullich forest), which are expected to comprise habitat critical to the survival of Quokka.

However, given the extent of similar available habitat within the vicinity (3,012.7 ha) of the Mine DEs it is unlikely the loss of 0.18% would cause a significant impact to local populations or adversely impact on habitat critical to the survival of the species, such that it would decline. The impact of fragmentation from haul roads on Quokka is assessed in the cumulative impact section (refer to Section 10.3.9).

The temporary loss of foraging habitat within the Huntly and Willowdale Mine DEs is not expected to cause a significant impact to any State listed priority, conservation dependent or other specially protected fauna. This is due to the following:

- The State listed species that are known or likely to occur within the Mine DEs generally have broad habitat requirements and are found across the wider NJF subregion or South-West region;
- The substantial avoidance of restricted fauna habitats within the Mine DE including granite outcrops, seasonal streams and swamps;
- The presence of similar fauna habitats in the surrounding forest; and
- The substantial extent and diversity of fauna habitats within the NJF subregion.

The extensive and diverse fauna habitats within the NJF subregion are expected to provide sufficient habitat for populations of State listed Priority, conservation dependent or other specially protected fauna such that these species are unlikely to become Threatened as a result of the loss of habitat within the Huntly and Willowdale Mine DE.

The Masked Owl (south-west), Western False Pipistrelle, Black Cockatoos, and Brush tailed Phascogale are examples of fauna species that require trees with large hollows to nest and/or roost. Known Black Cockatoo nesting trees will be avoided, however the long-term loss of potential nest trees for the other species from the Huntly and Willowdale Mine DE may impact local populations. However, given the extent of similar habitat in the NJF subregion it is unlikely to result in significant impacts to the species.

Aquatic fauna habitats

Recent work has shown that there is a number of ecologically significant groups within the population of the South West of WA (see (Klunzinger, et al., 2021)), therefore the disbursement of Carter's Freshwater Mussels is relatively unknown within the region, underlying the need for re-evaluation of distributions and population sizes.

Although targeted Carter's Freshwater Mussel surveys did not target the full Huntly and Willowdale Mine DEs, it is still expected the Proposal will not directly impact habitat for Carter's Freshwater Mussel, however, indirect impacts to water quality may occur in the form of sedimentation (from vegetation removal) and run-off that may impact water quality, however, with the implementation of mitigation and management measures these indirect impacts can be minimised.

As individuals (eight dead, one alive) were recorded in the Larego (Willowdale Mine) region, targeted Carter's Freshwater Mussel surveys will be undertaken if works are expected to impact a permanent watercourse.

Short range endemic invertebrate fauna

Short-range Endemic (SRE) invertebrate fauna are invertebrates that, as a result of evolutionary isolation, have small distributions (below 10,000 km^2) and are often characterised by low fecundity, confinement to disjunct habitats and poor dispersal capabilities (Harvey, 2002).

Some well-studied SRE species have been listed under Commonwealth or State legislation or as Priority species, however most are not listed often due to lack of knowledge or data scarcity.

Table 5-46 presents indicative estimates of the Proposal direct impacts to SRE invertebrate fauna habitats within the Huntly and Willowdale Mine DEs. As presented, the majority of the clearing (3,407 ha or 82.7% of the total clearing) will be in low value SRE habitat associated with Jarrah-Marri Forest. Clearing of potential high value SRE habitats is estimated to comprise approximately 15% (621 ha) of the total potential high value SRE habitats mapped within the Mine DEs. Clearing will be relatively distributed across a range of streamzone habitats within the Huntly and Willowdale Mine DEs and not concentrated within any one drainage line. It is therefore unlikely that impacts will substantially reduce the range of SRE species present within potential high value habitats.

At a regional scale, surveys indicate that potential SRE fauna within the NJF subregion are not restricted to the granite outcrop or streamzone habitats but are likely to be found in the widespread, upland Jarrah forest habitats, such as those associated with Dwellingup vegetation complexes (refer to Section 5.2.4.2). Clearing for the Proposal will be distributed across upland Jarrah Forest habitats within the Huntly and Willowdale Mine DE and unlikely to significantly reduce the range of individual SRE species present within these habitats. Clearing for the Proposal is estimated to comprise 2,499 ha; 60.7% of Dwellingup (D1, D2, and D4) complexes and approximately .37% of the 1.1 million ha native vegetation remaining in the NJF subregion that may contain comparable SRE habitats and species diversity. It is expected that the Proposal is unlikely to result in the loss of individual SRE species or substantial loss of SRE populations that could result in a significant direct impact to biodiversity or ecological integrity of the NJF subregion.

Table 5-46: Indicative estimates of direct impacts to SRE invertebrate fauna habitats –Mine DEs

SRE habitat Code	Vegetation Unit (Mattiske 2021, as per Phoenix 2021a)	Description	PHR	Mine DEs (ha)	Indicative clearing total (ha)	Total Proposal clearing in Mine DEs (ha)	Proposal proportion of total habitat area in Mine DEs (%)
1	A	Melaleuca woodlands/shrublands on seasonally wet or water-logged clays and clay-loams on valley floors	High	106.8	12.3	0.0%	0.0%
2	AW,AW/CW,C,D,DA,DG,J,CW	Open Jarrah/Marri or Blackbutt woodlands on sands, clay-loam or sandy-gravel on lower slopes and valley floors	High	2,694.4	165.3	0.4%	0.6%
3	GR,G,G1,R,RG	Heath/shrubland/woodland on shallow soils on granite or outcrops	High	1,005.8	55.4	0.1%	0.1%
4	P,PS,PT,S,SP,ST,T,TS	Open forest to woodland of Jarrah/Marri on sandy-loam gravelly soils on mid-slopes and ridges	Low	13,940.3	3,406.5	8.3%	10.9%
5	WA,PW,SW,W,WD	Open forest of Jarrah/Marri Forest, seasonally moist, sandy gravels on slopes	High	2,778.5	371.7	0.9%	1.3%
6	Cleared and Plantation	Cleared land (including plantations, dams)	NA	4,107		0.0%	0.7%
7	AD,E	Open forest to woodland of Jarrah/Marri on slopes and less undulating hills	Low	137.8	33.7	0.1%	0.1%
10	AC,AX,AY	Open woodlands of Wandoo and Flooded Gum on seasonally wet or water-logged clays and clay loams on valley floors	High	899.9	16.1	0.0%	0.1%
11	M,Y,YG,YS	Open woodlands of Wandoo with clay-loams and some gravel on upper slopes	Low	25.7		0.0%	0.0%
12	NA	Rehabilitation (post-mining rehabilitation using mostly native species)	Low	5,102	0.2	0.0%	0.0%
-		Not Classified as SRE	NA	7,920.8	55.8	0.1%	1.4%
-		Unmapped Dam	NA	329.0		0.0%	0.0%
		Total Area		39,048	4,117.0	10.0%	78.7%

5.3.7.1.2 Direct Impacts as a Result of Injury/Loss of Individuals from Fauna Entrapment or Vehicle/Equipment Collisions

Fauna within the Huntly and Willowdale DEs are at risk of injury or loss of individuals due to interaction with heavy and light vehicles undertaking vegetation clearing, transportation or mining activity associated with the Proposal. Fauna may also potentially become entrapped within mining infrastructure such as excavations. The likelihood of the impact occurring is expected to be similar to existing operations.

A monitoring study occurring over 2009 -2010 within the Huntly Mine reported roadkill statistics for Chuditch (McGregor R.A., 2014). The study determined that three of fourteen animals fitted with transmitters were found dead on the mine access road with evidence of road trauma, along with a micro-chipped animal and two untagged animals (McGregor R.A., 2014).

During the development of the Mine DEs, interaction between vehicles/machinery and fauna is most likely to occur during vegetation clearing activities as resident fauna could potentially be struck by vehicles undertaking the activity during either the clearing process or mobilisation to the site. Due to the Proposal location, and the progressive nature of mining, there is suitable similar native vegetation for fauna to take refuge or find suitable alternate habitat when clearing activities occur, provided they are allowed the opportunity to escape. Suitable management practices during planning and undertaking vegetation clearing will reduce the likelihood of death or injury to native fauna occurring as a result of this activity.

Fauna interaction with vehicles may also occur along transport routes within Huntly and Willowdale Mine although the risk is considered to be low, given fauna are more likely to inhabit areas away from mining activity and transport routes due to the associated noise, vibration and dust impacts.

5.3.7.2 Indirect Impacts

5.3.7.2.1 Introduction and/or Spread of Weeds

As detailed in Section 5.2.6.2, the Proposal has the potential to introduce and/or spread weeds within the Huntly and Willowdale DEs area through the following activities:

- Movement of earthmoving machinery, heavy and light vehicles;
- Topsoil movement from cleared to rehabilitated areas; and
- Stormwater runoff from stockpiles.

The Mine DEs contains vegetation communities vulnerable to weed invasion, particularly valley and swamp habitats that are restricted in distribution, retain soil moisture and provide important habitat for conservation significant fauna (Chuditch, Woylie, Rakali, and Quokka). Granite outcrops are typically (though not always) higher in the landscape but may still be located adjacent, downhill or downstream of weed invasion that may then spread into the outcrops. Granite outcrops can also retain moisture through seepage faces at the base of outcrops and provide important habitat for Chuditch, priority fauna and reptiles.

As detailed in Section 5.3.7.1, the Proposal is expected to have limited direct interface with swamps, valleys, and granite outcrops and the greatest potential for weeds to spread into these restricted distribution habitats will be via stormwater runoff and creek flow.

The spread of weeds into swamps and creeks may impact the floristic composition of these areas through competition with native understorey species, however the impact to fauna is uncertain. Weeds are not listed as a threatening process to any of the threatened fauna that are known or likely to occur in the Huntly and Willowdale Mine DE. There is potential for weed invasion to directly reduce the availability of native flora preferred by Quokka or indirectly reduce the ectomycorrhizal fungi (i.e., by outcompeting the plant host) preferred by Woylie. There is also potential for thick weed coverage to impede foraging effectiveness by Chuditch, noting that swamps and creeks typically have an existing thick native understorey.

Weed invasion may also influence the fire regime, increasing fuel loads, which is noted as a threatening process for Woylie and Quokka. However, prescribed burning is expected to have a greater effect on fuel load in the Jarrah Forest.

The impact of weeds to fauna habitats in streamzones and granite outcrops is likely to depend on whether there are existing weed invasions in these areas due to past public access, timber harvesting and forest management activities. Swamps, creeks and outcrops in isolated catchments that have remained free of weeds are expected to be in comparatively better condition and more vulnerable to impacts from weed invasion.

5.3.7.2.2 Introduction and/or Spread of *Phytophthora* Dieback

While the Proposal does not involve any deliberate importation of soil or earth materials from outside the Huntly and Willowdale DEs, it does have the potential to spread *Phytophthora* dieback through the following activities:

- Movement of earthmoving machinery, heavy and light vehicles;
- Topsoil movement from cleared to rehabilitated areas; and
- Stormwater runoff.

The effects of *Phytophthora* dieback on fauna can include a loss of Jarrah and proteaceous understorey foraging resources for Black Cockatoos, including the loss of potential nest trees (noting that Jarrah is less likely to form hollows than Marri). *Phytophthora* dieback (and other forest diseases) is listed as a threatening process for Carnaby's Cockatoo (DPaW, 2013).

Phytophthora dieback is also listed as threatening process for Woylie and Quokka due to the potential to impact native flora that host ectomycorrhizal fungi favoured by Woylie or changes to floristic composition and vegetation structure favoured by Quokka (DEC, 2013). Other herbivorous fauna may also be affected by the loss of flora diversity and vegetation structure cause by *Phytophthora* dieback.

5.3.7.2.3 Attraction of Feral Animals

As presented in Sections 5.3.4.4.1 and 5.3.4.4.2, the Huntly and Willowdale DEs and the wider Jarrah Forest subregion have established populations of feral animals. Alcoa has contributed funding to feral animal control in the Jarrah Forest subregion through Operation Foxglove and then Western Shield.

Construction and mining activities can potentially lead to an increased presence of feral animals through increased access from the creation of tracks and roads, and the increased availability of food and water supplies. Feral animals can exploit food and water supplies through scavenging food scraps from rubbish bins and litter at mine facilities, crib rooms and work areas in the field, and drinking or wallowing (for pigs) in artificial standing water in

stormwater drainage infrastructure and construction and temporary depressions in construction and mining areas. Feral Pig are regularly observed at the Huntly Mine, with 19 observations at the Myara mine region in 2020. European Fox and Feral Cat are not regularly observed at the Huntly Mine, which may be due to a combination of baiting effectiveness and the species nocturnal and stealthy behaviour.

Increased feral animal activity can result in increased predation, competition or habitat damage for native fauna, particularly CWR mammals, reptiles and birds. The wider Huntly and Willowdale mining area includes habitat for conservation significant CWR mammals that are vulnerable to feral animal pressure including Woylie, Chuditch, Quokka, and Quenda.

5.3.7.2.4 Noise and Light Emissions from Construction and Operational Equipment

Construction and mining operations generate noise and artificial light emissions which can disturb or displace fauna, causing them to potentially avoid using habitat in impacted areas. This impact effectively reduces the habitat available in the local area due to fauna avoiding areas affected by these impacts. To mitigate this issue construction and vegetation clearing will be limited to daytime operations, where practicable, however, mining, haulage, and mine facilities will operate 24 hours a day.

Construction areas operating at night will be illuminated by mobile towers. Mine facilities will be illuminated by permanent lighting whereas mine pits will be illuminated by mobile towers to ensure safe mining operations. Haul trucks conducting nighttime haulage will use headlights.

Nighttime noise and light emissions may disturb nocturnal fauna including Woylie, Chuditch, Quokka, Masked Owl and Western False Pipistrelle. Throughout the Huntly and Willowdale regions there are low baseline levels of noise and light emissions. Studies have shown that fauna that are sensitive to noise would leave their habitat quickly after noise generation begins, additionally species numbers higher in areas which mining activities were lowest or on small scale (Rehman, Hamayun, & Rahman, 2021). Species are unlikely to inhabit mining areas if it is beyond their tolerance as it can impact breeding and survival success, therefore species who remain within the region despite the noise and light emission are likely able to tolerate to current conditions.

5.3.7.2.5 Spills and/or Leaks from Storage and Handling of Hazardous Materials and Waste

The Proposal has the potential to affect terrestrial fauna and fauna habitats as a result of spills and/or leaks of hazardous materials or wastes. The potential for spills and/or leaks of hazardous materials or wastes to contaminate soils and water is detailed under Terrestrial Environmental Quality in Section 5.4 and Inland Waters in Section 5.5.

There is a potential that small spills of diesel and oil that escape detection and remediation will predominantly remain as in situ soil contamination rather than migrating into streams. All mine pits and haul roads will be rehabilitated post mining, and any un-identified minor soil contamination arising from small spills and leaks will be removed.

Majority of spills and leaks, particularly those from major incidents and involving large volumes, are expected to be identified quickly and the contaminated soils excavated and disposed off-site at a licenced waste facility. Smaller spills and leaks may potentially be undetected, and the contaminants leach through the unsaturated zone. These smaller spills

and leaks are expected to remain predominantly adsorbed to soil particles beneath the spill site. Small volumes of diesel and oil that escape detection and remediation are unlikely to result in substantial migration of hydrocarbons that reach streams and can be transported into reservoirs.

Accordingly, the storage and handling of hazardous materials during construction or operations is expected to pose a low risk to water quality and downstream seasonal or perennial aquatic habitats it will be required that hazardous material must be stored and used away for all waterways.

5.3.8 Mitigation

Alcoa's environmental management of the Mines incorporates the mitigation hierarchy consistent with Western Australian guidance, which is in order of priority:

- Impact avoidance;
- Impact minimisation; and
- Rehabilitation.

Table 5-47 below presents a summary of the avoidance and minimisation for impacts to terrestrial fauna. As presented, the mitigation measures are typically established practice or best practice and have a high certainty of effectiveness. Mitigation measures with a moderate certainty of effectiveness relate to the avoidance of daytime construction and night lighting arrangement, which will be undertaken as far as practicable.

Alcoa has developed and implemented the Fauna MP (Appendix 5), which is currently being implemented as part of existing operational practises and is expected to be revised to reflect the information, mitigations and outcomes provided in this ERD. Therefore, the ERD is considered to take precedence over the Fauna MP.

To mitigate impacts to SRE a mixture of mitigation measures used for more mobile vertebrates and flora retention and protection will be implemented. The following mitigation measures listed in Table 5-47 have been previously suggested / implemented in other studies to protect SREs:

- Further SRE surveys will occur within High PHR habitat with outcomes, mitigations and monitoring (if required) included within State Agreement Administrative Framework (MMPs and FCAs)
- Ensure no clearing within 30 m of confirmed SRE taxa where they are only known to occur within the Mine DE, unless known to occur within a Mining Avoidance Zone
- Weed management to protect microhabitats
- Where SRE are identified only within the Mine DE, developing a stormwater management plan to ensure sedimentation into small burrows does not occur
- Implement waste management measures to prevent contamination of surface and ground water
- Where SRE are identified only within the Mine DE, establishment of underpasses provided for conveyors and primary haul routes within the Mine DEs along swamp and streamzone crossings to allow for passage of SRE

5.3.8.1 Environmental Management System

Alcoa operates both the Huntly and Willowdale mines through a mature environmental management system that is to international standards, and which undergoes continual improvement. Alcoa has undertaken vegetation and fauna surveys within the Huntly and Willowdale Mine since the late 1980s to guide mine planning and the clearing approval process under State Agreements. Through continual improvement to its environmental management system, Alcoa now routinely protects all Black Cockatoo nest trees from clearing and has trialled used of fauna underpasses for haul road crossings over streamzones.

Alcoa manages noise emissions and contaminant discharges through established strategies and procedures and through continual improvement, which minimise the potential impacts to fauna habitats and populations. Alcoa commit to implementing a noise management plan for Mine operations to minimise noise impacts to sensitive receptors such as rural properties which will also reduce the potential for noise impacts to terrestrial fauna.

Alcoa's preventative risk management framework for drinking water quality incorporates multiple barriers to prevent contaminant discharges such as hydrocarbons or sediment. Though designed to protect drinking water quality, the multiple barriers will decrease the risk of discharges occurring that could impact fauna habitats and populations, including Carter's Freshwater Mussel and aquatic fauna in seasonally flowing streams.

5.3.8.2 Avoidance Measures

Alcoa has committed to the protection of key values and areas identified by environmental studies and stakeholder consultation.

Alcoa will carefully consider the terrestrial fauna key values and areas identified in the Mine DEs which include:

- Old growth and mature forest, which are expected to support more intact terrestrial fauna habitats;
- Black Cockatoo known and suitable nesting trees (Black Cockatoo Nest trees);
- Black Cockatoo Significant trees;
- Black Cockatoo confirmed night roosting trees;
- Active breeding Chuditch dens; and
- Woylie populations (i.e., more than one individual).

MAZs, incorporating the above values and areas, are developed through collaboration between Alcoa's mine planning, engineering and environmental teams. MAZs within the Huntly and Willowdale Mine DEs. MAZs currently comprise a total of 2,911 ha (7.5%) of the Huntly Mine DE and 484.8 ha (22.7%) of the Willowdale Mine DE and protect the following key values and areas relating to terrestrial fauna:

- All Old Growth Forest as classified by DBCA;
- Black Cockatoo known and suitable nest trees;
- Black Cockatoo Significant trees;
- Identified Woylie populations;
- Active breeding Chuditch dens; and

- where Numbat or Western Ringtail Possum (WRP) populations have been determined by surveys, the population will be avoided and contiguous suitable habitat provided.

Mining activities prohibited within the MAZs include all disturbance (with the exception of monitoring and management activities which have minimal impacts), such as clearing for pits, construction of haul roads, mine infrastructure and facilities, stockpiles and ROM pads etc.

All known and suitable nesting trees, Significant trees and confirmed nighttime roosting sites will be avoided with a suitable buffer (minimum 30 m radius), unless clearing is for Critical Infrastructure, groundwater bores, rehabilitation or low-impact exploration. Clearing within 30 m for Critical Infrastructure (predominately haul roads with limited flexibility for avoidance) will require a justification and approval for why a 30 m radius buffer can not be retained and subsequently a 10 m radius buffer will be implemented instead. Approximately 15% of the proposed disturbance footprint consists of haul road which may be considered critical infrastructure to access ore.

In 2021, Alcoa initiated a research programme to improve knowledge of the Black Cockatoo usage of retained nesting trees within mined landscapes. This research involves revisiting retained nesting trees at various timeframes following mining activities to determine whether Black Cockatoos utilise these trees and to identify factors influencing their usage. Key variables under investigation include time since disturbance, distance to clearing, and the proportion of vegetation cleared. While the data is still undergoing detailed analysis, preliminary findings indicate that approximately 80% of revisited retained nesting trees that remain viable have been used by Black Cockatoos since their initial disturbance.

Tree hollows suitable as breeding habitat for Black Cockatoos may take decades to centuries to develop, thus protecting trees with suitable hollows during the mining process is a critical component in avoiding and minimising mining-related impacts on these species (Alcoa, 2022b).

Limited Disturbance Areas (LDAs), in which mine pits are prohibited but infrastructure and haul roads are allowed are implemented for:

- Rock outcrops greater than one hectare with a 50 m buffer; and
- Mapped streamzone vegetation and a 100 m buffer.

Alcoa will implement other impact avoidance measures to protect terrestrial fauna key values and areas, such as avoiding or minimise clearing of restricted range vegetation types as far as practicable, including:

- Avoid disturbing recorded populations of Carter’s Freshwater Mussel as far as practicable;
- Minimise clearing of granite outcrop vegetation;
- Minimise clearing of streamzone vegetation; and
- Minimise clearing of potential GDEs.

The predicted high level of avoidance within the Huntly and Willowdale Mine DEs is consistent with, and empirically validated by, the protection of these fauna habitats in the Huntly and Willowdale Mine to date, which has involved the same mining and haulage method over similar geology and landforms.

Vegetation mapping over the existing and historic mine regions of the Huntly Mine indicates that the clearing from 1989 to 2022 has avoided:

- More than 91% of granite outcrop habitat;
- More than 98% of swamps; and
- More than 96% of streamzone habitat.

The avoidance of restricted range habitats is therefore predicted at a high confidence, although specific avoidance zones cannot be mapped within the Mine DE at this time. The substantial avoidance of restricted range fauna habitats will protect the associated fauna populations such as Quokka, reptiles, and SRE invertebrates, contributing to the maintenance of the biodiversity and ecological integrity of the NJF.

For all terrestrial fauna values to be protected “as far as practicable”, where disturbance is proposed to occur to these values, Alcoa will investigate alternatives to avoid disturbance, such as alternative infrastructure routes or locations. Where avoidance of the key environmental values is not practicable, Alcoa will document the findings and present to relevant stakeholders (e.g., DBCA) to determine appropriate mitigation of impacts.

Mining Avoidance Zones (MAZs) and Limited Disturbance Areas (LDAs) will be demarcated in spatial data and demarcated in clearing boundaries to guide personnel. As mine planning progresses, the area to be considered within MAZs and LDAs may be further expanded to protect additional areas.

5.3.8.3 Rehabilitation

Rehabilitation is a critical component to Alcoa’s environmental management system in protecting the biodiversity and ecological integrity of the NJF. Alcoa’s rehabilitation approach has demonstrated performance over more than three decades against completion criteria approved by DBCA. The completion criteria aim to meet the objective of a self-sustaining Jarrah Forest ecosystem that meets multiple forest uses (refer to Sections 2.2.4 and 6.1). The completion criteria have evolved in response to research and practice, with ongoing publication of research findings in the scientific literature.

Alcoa’s success in implementing and evolving its rehabilitation program provides confidence in the capacity to adapt as the objective for rehabilitation changes into the future. This may include new State Government objectives for the NJF due to the cessation of timber harvesting and release of the 2024-2033 FMP (Conservation and Parks Commission, 2023) and the potential requirement for enhanced resilience to future climate change and changing fire regimes. Alcoa remains committed to collaborating with DBCA and other agencies to ensure that the Huntly and Willowdale Mine rehabilitation achieves outcomes that protect the biodiversity and ecological integrity of the NJF.

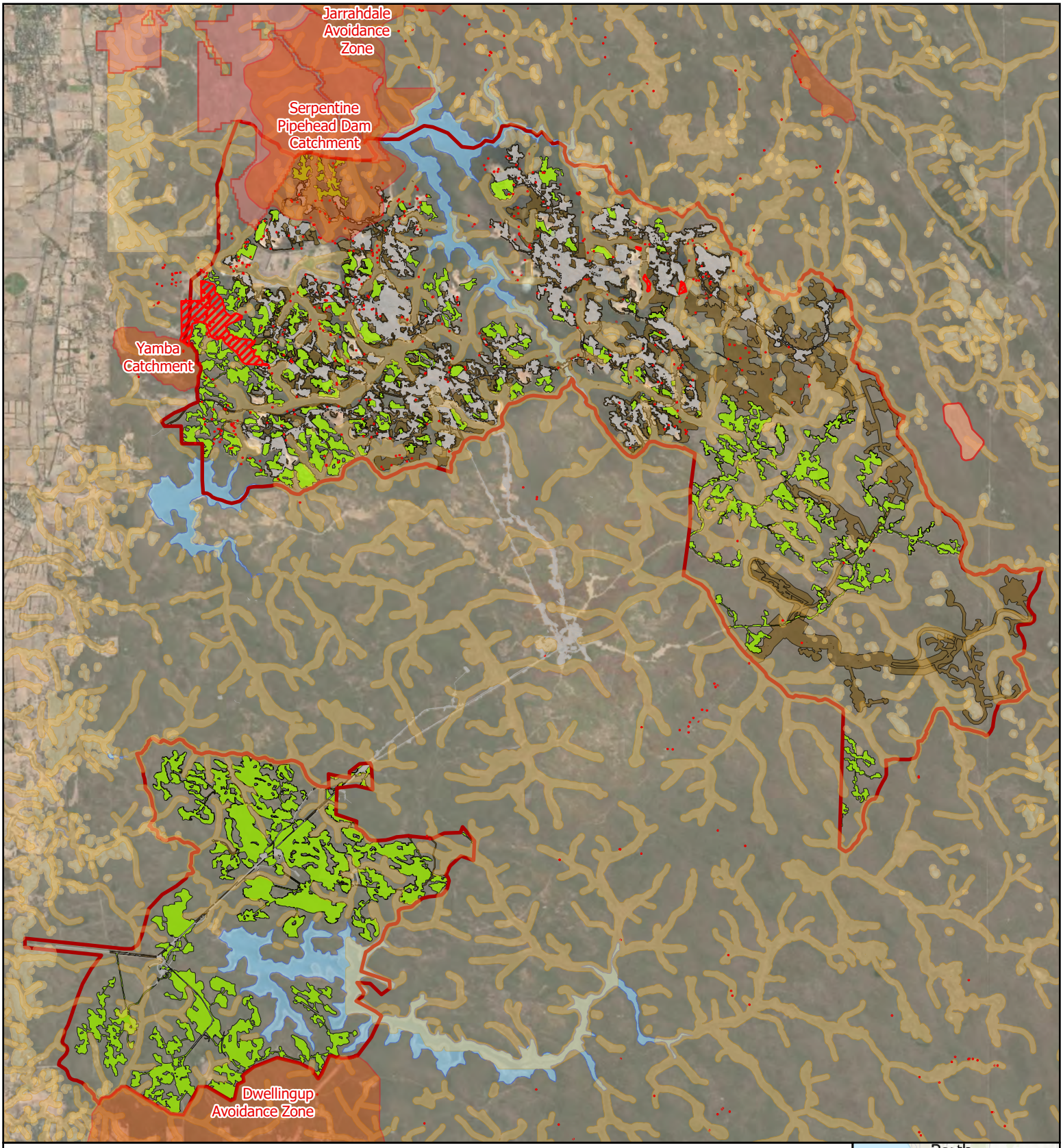
Table 5-47: Avoidance and minimisation of potential impacts to terrestrial fauna

Potential Impacts and mitigations	Industry standard, best practice and certainty of effectiveness
Direct impacts to terrestrial fauna as a result of cleaning	
Avoid	
Provision of MAZs, whereby no clearing activities for mining or infrastructure will occur. MAZs, as shown in Figure 5-47 and Figure 5-48, will be implemented for the following: • Old Growth Forest as identified by DBCA (Alcoa, 2023b) • National Parks and Nature Reserves (Alcoa, 2023b)	Established practice at Huntly and Willowdale Mine, high certainty.
Pre-clearance Targeted Black Cockatoo surveys will occur in potential habitat to identify nest, significant and habitat trees. Provision of MAZs, as shown in Figure 5-47 and Figure 5-48 whereby no clearing activities for mining or infrastructure will occur. MAZs will be implemented for the following (Minister for State Development, 2023) • Black Cockatoo Nest trees, Black Cockatoo Significant trees and confirmed night roosting trees (buffered 30 m). For critical infrastructure (e.g., haul roads), a reduced buffer zone of 10 m may be implemented subject to the Minister for State Development approval as part of the State Agreement Administrative Framework. Exploration activities, groundwater bores and rehabilitation are excluded.	Proposed practice at Huntly and Willowdale Mine, high certainty.
Black Cockatoo Protection Zones (classified as MAZs), as shown in Figure 5-47 and Figure 5-48, may be developed for areas which include high quality foraging habitat, high density of nest and/or habitat trees or permanent water sources.	Established practice at Huntly & Willowdale Mine, high certainty
Further SRE surveys will occur within High PHR habitat with outcomes, mitigations and monitoring (if required) included within State Agreement Administrative Framework (MMPs and FCAs). Implement a MAZ within 30 m of confirmed SRE taxa where they are only known to occur within the Mine DE, unless known to occur within a Mining Avoidance Zone	Proposed practice at Huntly and Willowdale Mine, moderate certainty.
Pre-clearance Targeted Fauna surveys will occur in Threatened Fauna potential habitat. Provision of MAZs, whereby no clearing activities for mining or infrastructure will occur. MAZs will be implemented for the following: • Known Woylie population/s – MAZ will be designed with appropriate stakeholders taking into account conservation advice, feedback, condition requirements and landscape and connectivity. The MAZ will be designed to ensure the ongoing viability of the population due to the Proposal and a Threatened Species Management Plan will be developed and implemented. The current Woylie MAZ (outside of Mine DEs) was developed by identifying the core habitat that supported the population (more than one individuals) and a 200 m buffer applied, with consideration to continuity of access to core habitat outside of disturbance footprint. A 6 ha MAZ of contiguous suitable habitat for the species for each recorded population is expected. • Identified active breeding Chuditch den/s; • Recorded populations of Carter's Freshwater Mussel, as far as practicable; • Where Numbat population/s have been determined by surveys, they will be avoided and contained within a 50 ha MAZ of contiguous suitable habitat for the species for each recorded population; and • Where WRP population/s have been determined by surveys, they will be avoided and contained within a 2.7 ha MAZ of contiguous suitable habitat for the species for each recorded population	Established practice at Huntly & Willowdale Mine, moderate certainty
Minimise	
Provision of LDAs, as shown in Figure 5-47 and Figure 5-48, whereby no clearing activities for mining will occur, however clearing for haul roads and infrastructure may occur. LDAs will be implemented for the following: • mapped streamzone vegetation and 100 m buffer; • Major granite outcrops (>1 ha + buffered by 50 m) (Alcoa, 2023b); and • Clearing within 50 m of a mapped Quokka population extent, with fauna underpasses established for all infrastructure crossings adjacent to Quokka populations.	Established practice at Huntly & Willowdale Mine, high certainty
Pre-clearance surveys within the Mine DEs of all proposed waterway crossings (100 m downstream and 50 m upstream) for Carter's Freshwater Mussel and Minute Freshwater Snail. Re-alignment of proposed waterway crossings to avoid recorded Carter's Freshwater Mussel **and/or** and Minute Freshwater Snail populations**,** where practicable. Provision of LDAs, whereby no clearing activities for mining will occur, however clearing for haul roads and infrastructure may occur. If disturbance to a recorded Carter's Freshwater Mussel and/or and Minute Freshwater Snail population/s cannot be avoided, relocation and / or translocation of the population/s will be undertaken, in accordance with a Relocation or Translocation Management Plan. This plan will need to be developed in consultation with the DBCA and approved under the BC Act.	Established practice at Huntly & Willowdale Mine, high certainty Species resilient to translocation as demonstrated by other translocation projects (Paice & Beatty, 2022)
Removal of vegetation can result in sedimentation / erosion of the landscape. Where SRE are identified only within the Mine DE, a stormwater management plan and/ or erosion sediment control plan should be developed to ensure sedimentation does not impact small burrows or other potential habitats used by SRE	Best practice, moderate certainty (Invertebrate Solutions, 2018)
Weed management to protect SRE microhabitats	Best practice, limited certainty (Invertebrate Solutions, 2018)
SREs- Implement waste management measures to prevent contamination of surface and ground water	Best practice, limited certainty (Invertebrate Solutions, 2018)
Where SRE are identified only within the Mine DE, establishment of underpasses provided for conveyors and primary haul routes within the Mine DEs along swamp and streamzone crossings to allow for passage of SRE	Best practice, moderate certainty (Invertebrate Solutions, 2018)
Haul roads, conveyors and other infrastructure are planned to minimise the area of disturbance of fauna habitats within the riparian area in the Mine DEs, as far as practicable.	Best practice, moderate certainty

Potential Impacts and mitigations	Industry standard, best practice and certainty of effectiveness
Minimise clearing within 30 m of Black Cockatoo Nest trees. Where clearing cannot be avoided, Alcoa must provide, to the satisfaction of the State Development Minister, a written report explaining why the relevant avoidance cannot be met prior to the clearing being undertaken.	Established practice at Huntly & Willowdale Mine, high certainty
Rehabilitation to meet Completion Criteria and to reinstate potential fauna habitat, including installation of constructed fauna habitat (see Section 0).	Established practice at Huntly & Willowdale Mine, high certainty
Direct impacts to terrestrial fauna as a result of injury/loss of individuals from fauna entrapments or vehicle/equipment collisions	
Avoid	
Clearing to generally occur during daytime hours, avoiding peak nocturnal animal activity and reducing the likelihood of fauna strikes during construction. Construction during night-time hours will be avoided as far as practicable but may be required.	Established practice at Huntly & Willowdale Mine, high certainty
MAZs, as shown in Figure 5-47 and Figure 5-48, will be implemented for the following: • Old Growth Forest • National Parks • formal conservation reserves • Black Cockatoo Nest trees, Black Cockatoo Significant trees and confirmed night roosting trees (buffered 30 m). For critical infrastructure (e.g., haul roads), a reduced buffer zone of 10 m may be implemented subject to the Minister for State Development approval as part of the State Agreement Administrative Framework. Exploration activities, groundwater bores and rehabilitation are excluded. • Known Woylie population/s – MAZ will be designed with appropriate stakeholders taking into account conservation advice, feedback, condition requirements and landscape and connectivity. The MAZ will be designed to ensure the ongoing viability of the population due to the Proposal and a Threatened Species Management Plan will be developed and implemented. The current Woylie MAZ (outside of Mine DEs) was developed by identifying the core habitat that supported the population (more than one individual) and a 200 m buffer applied, with consideration to continuity of access to core habitat outside of disturbance footprint. A 6 ha MAZ of contiguous suitable habitat for the species for each recorded population is expected. • Identified active breeding Chuditch den/s; • Recorded populations of Carter's Freshwater Mussel, as far as practicable; • Where Numbat population/s have been determined by surveys, they will be avoided and contained within a 50 ha MAZ of contiguous suitable habitat for the species for each recorded population; • Where WRP population/s have been determined by surveys, they will be avoided and contained within a 2.7 ha MAZ of contiguous suitable habitat for the species for each recorded population; and • Within 30 m of confirmed SRE taxa where they are only known to occur within the Mine DE, unless known to occur within a Mining Avoidance Zone	Established practice at Huntly & Willowdale Mine, moderate certainty
Provision of LDAs, as shown in Figure 5-47 and Figure 5-48, whereby no clearing activities for mining will occur, however clearing for haul roads and infrastructure may occur. LDAs will be implemented for the following: • mapped streamzone vegetation and 100 m buffer; • Major granite outcrops (>1 ha + buffered by 50 m) (Alcoa, 2023b); and • Clearing within 50 m of a mapped Quokka population extent, with fauna underpasses established for all infrastructure crossings adjacent to Quokka populations.	Established practice at Huntly & Willowdale Mine, high certainty
Minimise	
Pre-clearing displacement, monitoring and trapping for conservation significant fauna to be undertaken as per Fauna MP. A suitably qualified and experienced fauna spotter will undertake appropriate conservation significant fauna monitoring or relocations in accordance with methodologies described within authorisation/s under the BC Act and in accordance with DBCA Standard Operating Procedures.	Established practice at Huntly & Willowdale Mine, moderate certainty
Clearing conducted in a progressive manner to allow fauna to relocate, as far as practicable.	Established practice at Huntly & Willowdale Mine, moderate certainty
If disturbance to a recorded Carter's Freshwater Mussel population/s cannot be avoided, undertake permanent translocation of population/s, in accordance with a Translocation Management Plan approved under the BC Act.	Species resilient to translocation as demonstrated by other translocation projects
Construction and operational vehicle and equipment movements limited to designated roads, access tracks and cleared areas, as far as practicable.	Established practice at Huntly & Willowdale Mine, high certainty
Establish speed limits appropriate for location and commensurate with fauna strike risk, with Speed limit audits/checks.	Established practice at Huntly & Willowdale Mine, low certainty
Procedures in place to ensure the humane treatment and care of trapped or injured vertebrate fauna.	Best practice, high certainty
Staff and contractors inducted on the conservation significant vertebrate fauna species, and requirements for preventing and reporting impacts from entrapment, collisions and feral animals.	Established practice at Huntly & Willowdale Mine, high certainty
Indirect impacts to fauna as a result of introduction and/or spread of weeds	
Weed management as presented in Table 5-23 (Section 5.2.7).	See Section 5.2.7.

Potential Impacts and mitigations	Industry standard, best practice and certainty of effectiveness
Curtail the establishment of weeds within the Mine DE to avoid impacts to microhabitats used by SRE. Establish and implement a weed management plan to avoid the infestation of weeds.	Best practice, moderate certainty (Invertebrate Solutions, 2018)
Indirect impacts to fauna as a result of introduction and/or spread of *Phytophthora* dieback	
Phytophthora dieback management as presented in Table 5-23 (Section 5.2.7).	See Section 5.2.7.
Indirect impacts to fauna as a result of attraction of feral animals	
All construction and operational food wastes stored in containers with secured lids and disposed off-site at a licenced waste facility. Prohibition on construction or operational workforce feeding feral or native animals or keeping domestic animals on site (e.g., dogs and cats)	Established practice at Huntly & Willowdale Mine, high certainty
Sightings of feral animals in construction and mining areas to be recorded by Alcoa for improved understanding and ongoing monitoring purposes.	Established practice at Huntly & Willowdale Mine, high certainty
Indirect impacts to fauna from noise and light emissions from construction and operational equipment	
Minimise	
Clearing to generally occur during daytime hours, avoiding peak nocturnal animal activity. Construction during night-time hours will be avoided as far as practicable but may be required subject to the construction program.	Best practice, moderate certainty
Permanent and temporary lighting positioned to minimise the artificial light directed to adjacent native vegetation, adjacent fauna underpasses, streamzone and swamp habitats, while maintaining a safe working environment for employees.	Best practice, moderate certainty
Indirect impacts to fauna from spills and/or leaks from storage and handling of hazardous materials and waste	
Hazardous material and waste management as presented in Table 5-23 (Section 5.2.7).	See Section 5.2.7.
Indirect impacts to fauna as a result of habitat fragmentation	
Avoid	
MAZs, as shown in Figure 5-47 and Figure 5-48, will be implemented for the following: • Old Growth Forest • National Parks • formal conservation reserves • Black Cockatoo Nest trees, Black Cockatoo Significant trees and confirmed night roosting trees (buffered 30 m). For critical infrastructure (e.g., haul roads), a reduced buffer zone of 10 m may be implemented subject to the Minister for State Development approval as part of the State Agreement Administrative Framework. Exploration activities, groundwater bores and rehabilitation are excluded. • Known Woylie population/s – MAZ will be designed with appropriate stakeholders taking into account conservation advice, feedback, condition requirements and landscape and connectivity. The MAZ will be designed to ensure the ongoing viability of the population due to the Proposal and a Threatened Species Management Plan will be developed and implemented. The current Woylie MAZ (outside of Mine DEs) was developed by identifying the core habitat that supported the population (more than one individuals) and a 200 m buffer applied, with consideration to continuity of access to core habitat outside of disturbance footprint. A 6 ha MAZ of contiguous suitable habitat for the species for each recorded population is expected. • Identified active breeding Chuditch den/s; • Recorded populations of Carter's Freshwater Mussel, as far as practicable; • Where Numbat population/s have been determined by surveys, they will be avoided and contained within a 50 ha MAZ of contiguous suitable habitat for the species for each recorded population; • Where WRP population/s have been determined by surveys, they will be avoided and contained within a 2.7 ha MAZ of contiguous suitable habitat for the species for each recorded population; and • Within 30 m of confirmed SRE taxa where they are only known to occur within the Mine DE, unless known to occur within a Mining Avoidance Zone	Established practice at Huntly & Willowdale Mine, high certainty

Potential Impacts and mitigations	Industry standard, best practice and certainty of effectiveness
Provision of LDAs, as shown in Figure 5-47 and Figure 5-48, whereby no clearing activities for mining will occur, however clearing for haul roads and infrastructure may occur. LDAs will be implemented for the following: • major granite outcrops (>1ha + 50 m buffer) • mapped streamzone vegetation and 100 m buffer and • Clearing within 50 m of a mapped Quokka population extent, with fauna underpasses established for all infrastructure crossings adjacent to Quokka populations. Haul roads, conveyors and other infrastructure within the Mine DEs planned to limit crossing of mapped swamp and streamzone fauna habitats to the minimum required for safe mining, as far as practicable. If disturbance to mapped swamp and streamzone fauna habitats cannot be avoided, minimise disturbance within swamp and streamzone fauna habitats, as far as practicable.	Established practice at Huntly & Willowdale Mine, high certainty
Fauna (including SRE) underpasses provided for conveyors and primary haul routes within the Mine DEs along swamp and streamzone crossings, where practicable.	Best practice, moderate certainty (Invertebrate Solutions, 2018)



Legend

Mining Avoidance Zones

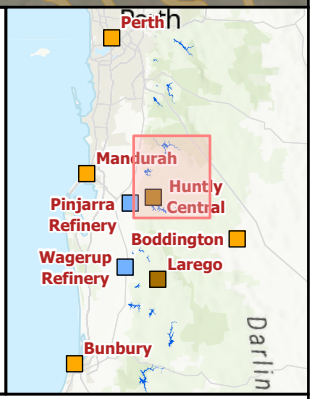
- Mining Avoidance Zones
- National Parks
- Conservation Parks
- Black Cockatoo Protection Zones

- Known Woylie Population
- Black Cockatoo Nest & Significant Trees

Limited Disturbance Areas

- Mapped & Derived Stream Vegetation 100m Buffer
- Rock Outcrops >1ha 50m Buffer

- Huntly Mine DE
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-47 Huntly Mine DE – Mining Avoidance Zones and Limited Disturbance Areas (Conservation Significant Species)

Kilometres

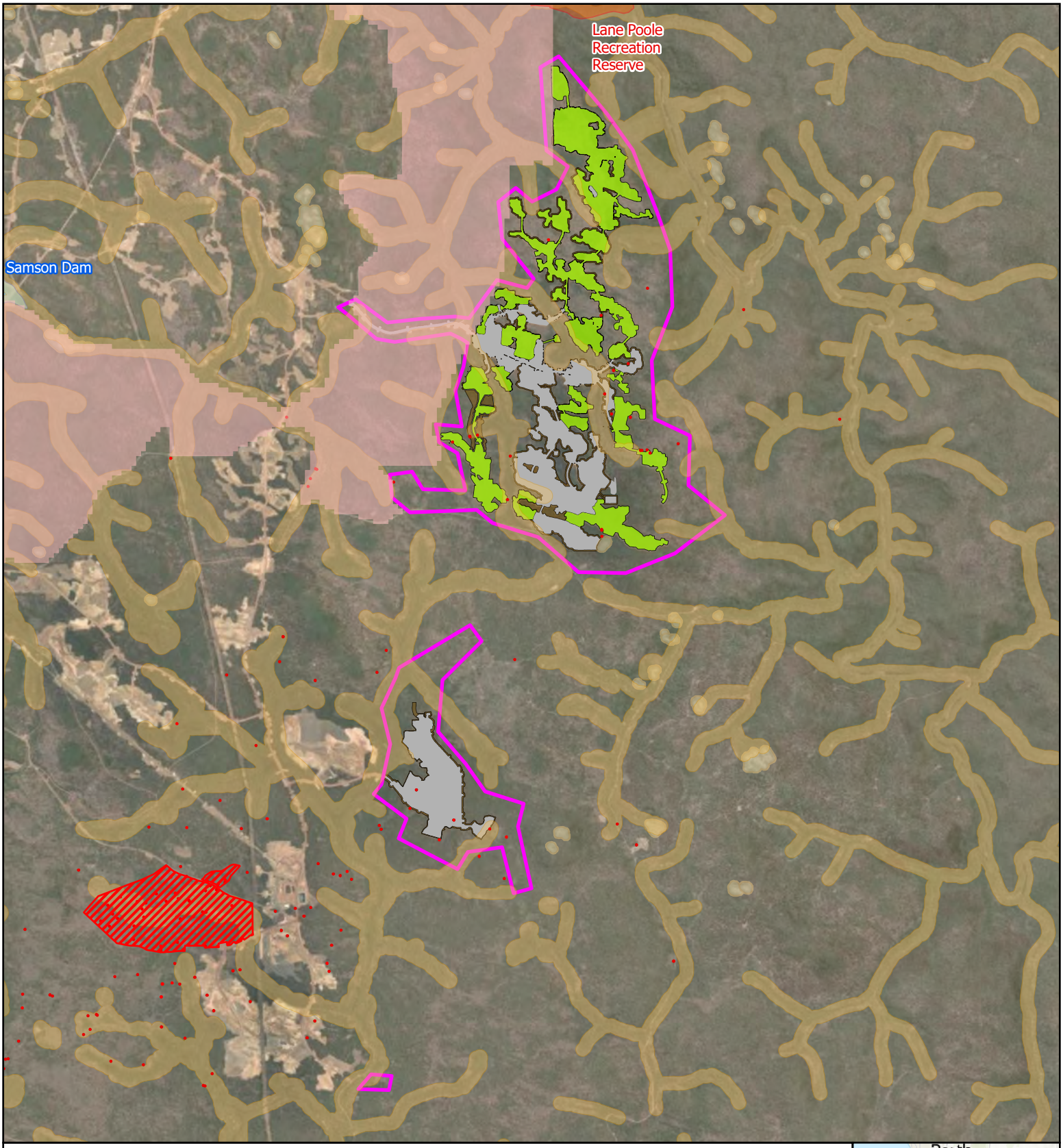
0 2 4 6 8 10 12

Scale: 1:175,000 at A4

Date Printed: 27/02/2025

N

Alcoa



Legend

Mining Avoidance Zones

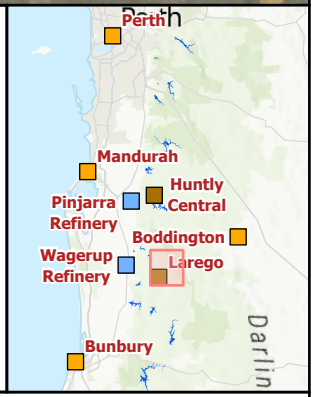
- Mining Avoidance Zones
- National Parks
- Conservation Parks
- Black Cockatoo Protection Zones

- Black Cockatoo Nest & Significant Trees

Limited Disturbance Areas

- Mapped & Derived Stream Vegetation 100m Buffer
- Rock Outcrops >1ha 50m Buffer

- Willowdale Mine DE
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-48 Willowdale Mine DE – Mining Avoidance Zones and Limited Disturbance Areas

Kilometres

0 0.9 1.8 2.7 3.6 4.5 5.4

Scale: 1:75,000 at A4

Date Printed: 27/02/2025

N

Alcoa

5.3.9 Assessment and Significance of Residual Impact

Table 5-48 summarises the potential residual impacts to terrestrial fauna from the Mine component of the Proposal. As presented, the Proposal may cause significant residual impacts to terrestrial fauna from the following:

- Clearing of 4,042 ha within the Huntly Mine DE and 77 ha within the Willowdale Mine DE will result in a partial loss of fauna diversity and ecological integrity over the medium to long term. This area represents 0.37% of the 1.1 million ha of native fauna habitat remaining within the NJF subregion. The impact will reduce the quality of habitat for conservation significant fauna species and occur in the context of more widespread cumulative impacts from historic timber harvesting, historic mine rehabilitation under past prescriptions, climate change, fire and dieback.
- The loss of high-quality habitat in the period between clearing and establishment of rehabilitation may cause a significant impact to local populations of threatened Black Cockatoos, Woylie, and Chuditch, but is unlikely to significantly impact State listed priority or conservation dependent fauna species (e.g., resulting in a species becoming listed as threatened) due to the extent and diversity of habitats remaining in the NJF subregion. The loss of small areas (7.2% within Huntly Mine DE and 8.6% within the Willowdale Mine DEs) of drainage lines containing swamp and streamzone habitat within the Mine DE is unlikely to significantly impact Quokka populations or impact any populations of Carter's Freshwater Mussel. Although Quokka prefer drainage habitats, they are known to inhabit Jarrah Marri Forest, albeit a lesser extent. Clearing may result in the fragmentation of these habitat for Quokka, resulting in a residual impact.
- Fragmentation of Jarrah-Marri Forest habitat over a period of 15-20 years in each mine region may cause a significant impact to local populations of Chuditch and Woylie. Quokka dispersal along streamzones may be disrupted by clearing for haul road crossings and there is uncertainty as to the species use of constructed fauna underpasses, which may also be subject to higher feral predator activity. Mammal populations impacted by fragmentation are expected to recover in the medium-term following establishment of rehabilitation and removal of haul road crossings. The impact of fragmentation will occur in the context of existing fragmentation from the mine region and the presence of reservoirs and public roads. Fragmentation is unlikely to cause significant impact to populations of Black Cockatoos, which are highly mobile, or to State listed priority or conservation dependent fauna species, due to the extent and diversity of habitats remaining in the NJF subregion.

The direct loss of native fauna during clearing is expected to be low and not cause a significant impact, as clearing will occur with a fauna spotter and on a progressive basis and staged manner and adjacent to large, contiguous areas of fauna habitat. This will give fauna the opportunity to escape and find refuge in suitable alternate habitat within the Huntly and Willowdale Mine DE when clearing activities occur. Suitable management practices during planning and undertaking vegetation clearing will reduce the likelihood of death or injury to native fauna occurring as a result of this activity. These management practices are detailed in the Fauna MP (provided in Appendix 5).

Alcoa has proposed substantial avoidance, mitigation, and rehabilitation to reduce the residual impacts to be a low as reasonably practicable. This includes avoidance of all DBCA

mapped Old Growth Forest and the majority of mature forest and restricted distribution fauna habitats.

Alcoa's ongoing support for feral animal control will continue to contribute to the suppression of feral animal predators and maintenance of populations of CWR mammals across approximately 0.69 million ha (approximately 62%) of native fauna habitat in the NJF subregion. This contributes to maintaining populations of threatened species such as Woylie, Chuditch, and Quokka that may otherwise become locally extinct, as well as ensuring that de-listed species (e.g., Tammar Wallaby, and Quenda) do not become threatened.

The effectiveness of rehabilitation under past prescriptions has been demonstrated through long-term research and is at a high level of confidence. There is moderate confidence in contemporary rehabilitation prescriptions improving fauna habitat values (e.g., for Black Cockatoos and reptiles) compared to past prescriptions (e.g., 1980s-1990s) studied in the literature.

Alcoa propose an offset strategy to counterbalance the potential significant residual impacts, which is presented in Section 8.

Table 5-48: Residual impacts to Terrestrial fauna – Huntly and Willowdale Mine

Impact	Residual Impact	Likelihood of significant impact
Direct impacts to terrestrial fauna as a result of clearing.	The Proposal will result in clearing of 4,117 ha with the majority of the clearing (3,918.5 ha or 95.2% of the total clearing) within the Jarrah-Marri forest habitat type, as this is associated with lateritic soils and is subject to mining as well as infrastructure. The Proposal is expected to clear approximately 4,117 ha of habitat for 18 conservation significant fauna species, including eight Threatened, seven Priority species and two conservation dependent / special provision species. The Proposal is expected to clear approximately 4,117 ha of predominantly high value habitat for Woylie, which also uses Jarrah-Marri forest habitat – however, further surveys will confirm habitat values. The Proposal is expected to clear a smaller area (95.6 ha) of high value habitat for Quokka and Quenda, which prefer dense riparian and swamp habitat, with Jarrah-Marri habitat being of medium value for these species. The clearing within each fauna habitat type is less than 5% of the area within the Proposal area, with the exception of Jarrah-Marri habitat (95% for Huntly Mine DE and Willowdale mine DE). Overall, the clearing will not significantly reduce the extent of any fauna habitat type.	Likely: Black Cockatoos, Chuditch, Quokka, Woylie Unlikely: Priority fauna, conservation dependent fauna, other specially protected fauna
Direct impacts to terrestrial fauna as a result of injury/loss of individuals from fauna entrapment or vehicle/equipment collisions.	Within the Huntly and Willowdale Mine DEs there is a risk of injury or loss of individuals to fauna due to interaction with heavy and light vehicles undertaking vegetation clearing, transportation or mining activity associated with the Proposal. Fauna may also potentially become entrapped within mining infrastructure such as water storage areas or excavations. This impact is not new as mining activity is already occurring within the area and has been for over 50 years. The Proposal will not result in an increase in mining vehicle; therefore, fauna collision impacts during the operation of the mine is expected to be low. There may be an increase in the risk of collision during construction due to clearing of native vegetation (fauna habitat). However, due to the Proposal's location and the progressive nature of mining, there is suitable similar native vegetation for fauna to take refuge or find suitable alternate habitat within and outside the Mine DE when clearing activities occur. Suitable management practices during planning and undertaking vegetation clearing will reduce the likelihood of death or injury to native fauna occurring as a result of this activity. Fauna interaction with vehicles may also occur along transport routes within the Mine DE although the risk is considered to be low, given fauna are more likely to inhabit areas away from mining activity and transport routes due to the associated noise, vibration and dust impacts.	Unlikely

Impact	Residual Impact	Likelihood of significant impact
Introduction and/or spread of weeds.	Vegetation within the Huntly and Willowdale Mine DEs appears to have relatively limited weed invasion, however there is potential for significant weeds to be present in cleared and disturbed areas, creek lines or valley floors. The Proposal has the potential to cause localised spread of existing weeds during construction and mine operations, with limited potential to introduce weeds due to the lack of imported soil or mulch. Rehabilitation is anticipated to have limited weeds due to the local reuse of topsoil and overburden within mine pits. Weed coverage of existing rehabilitation has been demonstrated to be less than 0.3% and decline to less than 0.1% after 20 years from establishment. Pre-clearance weed surveys will be undertaken in clearing areas. Significant weeds will be treated in accordance with Government guidance and weed hygiene will be undertaken during clearing to prevent the introduction or spread of weeds. The Proposal is unlikely to introduce or spread weeds that results in a significant residual impact to terrestrial fauna values.	Unlikely
Introduction and/or spread of *Phytophthora cinnamomi* Dieback.	The Huntly and Willowdale Mine DEs comprises a mix of infested and uninfested areas, with uninfested areas having predominantly moderate to high vulnerability to dieback impact. Alcoa has a mature *Phytophthora* Dieback management system for the Huntly Mine, which has been demonstrated to minimise the spread of dieback to 0.0006-0.007 ha/ha cleared. The Proposal is unlikely to introduce or spread *Phytophthora* Dieback that results in a significant residual impact to fauna values. The assessment of the introduction and/or spread of dieback against the relevant biodiversity indicators demonstrates the Proposal is likely to be consistent with the ongoing ecological integrity of the NJF.	Unlikely
Attraction of feral animals.	Mining activity can potentially lead to an increase in the presence of introduced fauna species within an area primarily due to the ready availability of access to food and water supplies. Introduced fauna compete with native fauna for food and shelter, and also predate native fauna, particularly smaller mammals, reptiles, and birds. The Mine DE has established populations of feral animals and includes habitat for conservation significant CWR mammals that are vulnerable to feral animal pressure including Woylie, Chuditch, Quokka, and Quenda. Alcoa's support for Western Shield will contribute to the suppression of feral animals across 0.69 million ha (approximately 62%) of native fauna habitat within the NJF subregion. The assessment of the attraction of feral animals against the relevant biodiversity indicators demonstrates the Proposal is likely to be consistent with the ongoing ecological integrity of the NJF.	Unlikely

Impact	Residual Impact	Likelihood of significant impact
Light emissions from infrastructure.	The Proposal will introduce artificial illumination at the mine facilities, transfer stations, vehicle headlights and mobile LED towers at mine pits. Nighttime light emissions may disturb nocturnal fauna including Woylie, Chuditch, Quokka, Western False Pipistrelle, and Masked Owl. The Mine Regions within the DE have low baseline levels of light emissions and local fauna populations in those regions; however, it is expected give the long history of mining that fauna within the local are likely to be accustomed to noise or light impacts. The Proposal may result in localised movements of nocturnal fauna to habitats further away, either temporarily until they become accustomed, or until the light emissions cease. Native fauna has been observed in operational areas of the Huntly Mine as well as in urban settings, including Quokka who have been observed in the fringes of Jarrahdale town. This suggests the capacity for some fauna to become accustomed to anthropogenic disturbance. The effect of light emissions on fauna will be localised and temporary for the duration of construction or mine pit operations in given area, following which sensitive fauna are expected to recolonise the area. Mine facilities and primary haul roads will operate over a longer timeframe of up to ten years, which may result in a longer period of disturbance to sensitive fauna.	Unlikely
Noise emissions from construction and operational equipment.	Nighttime noise emissions may disturb nocturnal fauna including Woylie, Chuditch, Quokka, Western False Pipistrelle, and Masked Owl. The Mine DEs have low baseline levels of light emissions and local fauna populations in those regions; however it is expected give the long history of mining that fauna within the local are likely to be accustomed to noise or light impacts. The Proposal may result in localised movements of sensitive fauna to habitats further away, either temporarily until they become accustomed, or until the noise emissions cease. Native fauna have been observed in operational areas of the Huntly Mine as well as in urban settings, including Quokka who have been observed in the fringes of Jarrahdale town. This suggests the capacity for some fauna to become accustomed to anthropogenic disturbance. Blasting will occur progressively through the landscape as mine pits are developed, which may accustom fauna to blast overpressure as mining approaches their habitat. There may be a higher risk of disturbance from blasting where mine pits are developed at some distance from existing pits and so fauna have not been exposed to progressively increasing blast overpressure. The effect of noise emissions on fauna will be localised and temporary for the duration of construction or mine pit operations in given area, following which sensitive fauna are expected to recolonise the area. Mine facilities and primary haul roads will operate over a longer timeframe of up to ten years, which may result in a longer period of disturbance to highly sensitive fauna.	Unlikely

Impact	Residual Impact	Likelihood of significant impact
Spills and/or leaks from storage and handling of hazardous materials and waste.	All storage and the majority of handling of hazardous materials and wastes will occur at mine facilities, within bunded and sealed areas. Refuelling and maintenance of earthmoving equipment will occur in the field and may result in spills or leaks. There is also potential for vehicle accidents to result in spills in the field. The majority of spills and/or leaks that occur outside of sealed and bunded facilities are expected to be contained and cleaned up with no impact to vegetation. All mine pits and haul roads will be rehabilitated post-mining, and any un-identified minor soil contamination arising from small spills and leaks will be overlaid with overburden, topsoil and establishing native vegetation. Pockets of soil contamination remaining in the rehabilitation are expected to biodegrade over time and may result in localised impact to vegetation condition, which are unlikely to cause significant impact to terrestrial fauna values. Small volumes of diesel and oil that escape detection and remediation are unlikely to result in substantial migration of hydrocarbons that reach streams and can be transported into reservoirs. Accordingly, the storage and handling of hazardous materials during construction or operations is expected to pose a low risk to water quality and downstream seasonal or perennial aquatic habitats.	Unlikely

5.3.9.1 Conservation Significant Species

Table 5-49 provides an assessment of significance of the proposed impact on conservation significant fauna species with potential to occur within the Mine DEs.

Table 5-49: Significance of impacts to conservation significant species

Taxa	Significance assessment
Baudin's Cockatoo (*Zanda baudinii*) (Commonwealth – EN; State – EN). Carnaby's Cockatoo (*Zanda latirostris*) (Commonwealth – EN; State – EN). Forest Red-Tailed Black Cockatoo (*Calyptorhynchus banksii naso*) (Commonwealth – VU; State – VU).	The Proposal is likely to have a significant impact on the local extent of foraging habitat, as well as the future local extent of nesting habitat for this species. The proposed clearing represents approximately 5.7% of high value habitat and approximately .1% of medium value habitat of total mapped extents. Clearing represents approximately 0.4% of the remaining native vegetation in the NJF. The proposed clearing will be restricted to distributed mine pits (from a few to several hundred metres wide) and linear infrastructure corridors, surrounded by un-mined forest and will therefore not fragment current populations. Impacts on the Black Cockatoos associated with the Proposal is expected to be largely confined to the direct clearing of habitat. The proposed clearing will impact potentially suitable habitat trees or potential nesting trees for Baudin's Cockatoo, Carnaby's Cockatoo, Forest Red-Tailed Black Cockatoo which may result in a decline in the population of the Black Cockatoo species. All confirm night roosting, significant and nest trees (suitable and known nest trees) will be retained. However, the Proposal will reduce the number of trees within the Mine DEs available to support nesting in the future. This also has the potential to reduce roosting habitat. The clearing of roosting and potential nesting habitat is inconsistent with the measures within the 2013 Recovery Plan (DPaW, 2013). No new predators that could be harmful to the species are likely to be introduced as a result of the proposed clearing. While there is potential for localised spread of weeds in habitat downslope / downstream of construction/mining, this is not expected to significantly impact habitat quality for foraging, nesting or roosting.
Woylie (*Bettongia penicillata*) (Commonwealth – EN; State – CR).	The Proposal is likely to have a significant impact on this species, given it is likely to occur within the Mine DEs. The Proposal will impact the local extent of habitat for this species and due to the unknown population levels within the Mine DE, the impacts to this species may be significant. During a 2024 survey Woylies have been confirmed to inhabit the area within the Huntly Mine DEs. Observations of the species occurred on 13 and 30 September 2024 and 19 October 2024. The proposed clearing represents approximately 16.9% of high value habitat and approximately 0.2% of medium value habitat within the Mine DEs. Clearing represents approximately 0.4% of the remaining native vegetation in the NJF. The proposed clearing will cause progressive fragmentation of habitat as mine pits and infrastructure are developed and then decline as rehabilitation establishes. The total duration of fragmentation impacts is expected to be about 15 to 20 years for the mine regions impacted by the Proposal, being the cumulative timeframe for mining, rehabilitation, and fauna recolonisation. This fragmentation may disrupt breeding, though the species is expected to occur below detectable levels only and occupies small home ranges.
Chuditch (*Dasyurus geoffroii*) (Commonwealth – VU; State – VU).	The Proposal is likely to have a significant impact on the local extent of habitat for this species. The proposed clearing represents approximately 16.5% of high value habitat within the Mine DEs. Clearing represents approximately 0.4% of the remaining native vegetation in the NJF. The proposed clearing will cause progressive fragmentation of habitat as mine pits and infrastructure are developed and then decline as rehabilitation establishes. This fragmentation may cause localised disruption of breeding by Chuditch as it may break up the overlapping ranges of males and females, and obstruct dispersal of juveniles in this short lived species. Chuditch have a relatively high fecundity and any effects of fragmentation are expected to be temporary and local populations to recover in the short to medium term following completion of rehabilitation. The total duration of fragmentation impacts is expected to be about 15 to 20 years for each mine region, being the cumulative timeframe for mining, rehabilitation, and fauna recolonisation.
Numbat *(Myrmecobius fasciatus*) (Commonwealth – EN; State – EN).	The Proposal is unlikely to have a significant impact on this species and it is considered unlikely to occur within the Willowdale Mine DE. The Numbat is considered potential to occur within the Huntly DE, however has not been recorded, noting the species is cryptic and difficult to record at low densities. The species, if present within the Mine DE, is considered to be below detectable densities. Targeted pre-clearance surveys will be undertaken and avoidance measures will be designed and implemented as per the FMP. The proposed clearing represents approximately 19% of high value habitat within the Mine DE. Clearing represents approximately 0.4% of the remaining native vegetation in the NJF. This species had a large range throughout the NJF, with suitable habitat extending throughout, due to their decreased range over the years, it is hard to determine accurate description of specific habitats critical to their survival. However, historically numbats have been associated with a variety of habitat types, therefore the fragmentation and habitat loss as a result of the project will not significantly impact this species as they can use similar habitats in the surrounding area.
Quokka (*Setonix brachyurus*) (Commonwealth – VU; State – VU).	The Proposal is likely to have a significant impact on both the local extent and connectivity of habitat for this species. Clearing represents approximately 3% of high value habitat and approximately >0.01% of medium value habitat within the Mine DE. This species is unlikely to be affected by fragmentation of the upland Jarrah Forest in which the majority of operational clearing will occur; however, high value habitat (streamzone and swamp habitats), may be fragmented by haul road which are expected to be dispersal corridors for the species.
Peregrine Falcon (*Falco peregrinus*) (State – OS).	The Proposal is unlikely to have a significant impact on this species. The proposed clearing represents approximately 16.8% of high value habitat within the Mine DE. Clearing represents approximately 0.4% of the remaining native vegetation in the NJF. This species has a large range throughout the NJF, with suitable habitat extending throughout. The proposed clearing will impact potentially suitable breeding habitat. Some suitable nesting trees will be retained, in conjunction with the avoidance of all potential Black cockatoo nesting trees. The Proposal will reduce the number of trees within the Mine DE available to support local breeding in the future; however, this is not expected to limit the potential for the species to breed given the large home range of the species (20 to 30 km^2) (BirdLife Australia, 2024).
Masked Owl (*Tyto novaehollandiae novaehollandiae*) (State – P3).	The Proposal is unlikely to have a significant impact on this species. The proposed clearing represents approximately 16.4% of high value habitat within the Mine DE. Clearing represents approximately 0.4% of the remaining native vegetation in the NJF. The proposed clearing will impact potentially suitable breeding habitat, potentially impacting local populations as the species is territorial and can have a small home range. However, this impact is not expected to be significant as the species has a large range throughout the NJF, with suitable habitat extending throughout.

Taxa	Significance assessment
Western False Pipistrelle (*Falsistrellus mackenziei*) (State – P4).	The Proposal is unlikely to have a significant impact on this species. The proposed clearing represents approximately 16.9% of high value habitat within the Mine DE. Clearing represents approximately 0.4% of the remaining native vegetation in the NJF. The proposed clearing will impact potentially suitable foraging, roosting and breeding habitat and will reduce the number of trees within the Mine DE available to support roosting and breeding in the future. Some suitable nesting trees will be retained, in conjunction with the avoidance of all potential Black Cockatoo nesting trees. This species has a large range throughout the NJF, with suitable habitat extending throughout. The proposed clearing is unlikely to cause fragmentation of populations due to the ability for the species to disperse.
Western Ringtail Possum (*Pseudocheirus occidentalis)* (Commonwealth – CE; State – EN).	The Proposal is unlikely to have a significant impact on this species, given its only considered likely to occur at the Willowdale mine region in Jarrah Forest habitat and only up to 73 ha of proposed disturbance is proposed within the Willowdale Mine DE. It is considered potential to occur within the Huntly Mine DE. Targeted pre-clearance surveys will be undertaken and avoidance measures will be designed and implemented as per the FMP. The proposed clearing represents approximately 19% of high value habitat within the Mine DEs. Pre-clearance surveys and pre-clearing displacement will minimise any impacts on individuals.
Western Brush Wallaby (*Notamacropus irma*) (State – P4).	The Proposal is unlikely to have a significant impact on this species. The Proposal will impact the local extent of habitat for this species; however, due to the mobile nature of the species, population level impacts are unlikely. The proposed clearing represents approximately 16.4% of high value habitat within the Mine DEs. Clearing represents approximately 0.4% of the remaining native vegetation in the NJF. This species has a large range throughout the NJF, with suitable habitat extending throughout. The proposed clearing is unlikely to cause fragmentation of populations due to the ability for the species to disperse over large distances. The species has been recorded within rehabilitation areas of age 8 years and older, demonstrating that the impact to habitat is temporary.
Quenda (*Isoodon fusciventer*) (State – P4).	The Proposal is unlikely to have a significant impact on this species. Clearing represents approximately 3% high value habitat and approximately 18.5% of medium value habitat within the Mine DEs. This species is unlikely to be affected by fragmentation of the upland Jarrah Forest in which the majority of operational clearing will occur; however, streamzone and swamp habitats, may be fragmented by haul road, which are expected to be dispersal corridors for the species. This fragmentation may impact populations at a local level; however, the impact is not expected to be significant given the species ability to persist in disturbed environments, and the currently patchy distribution within the NJF suggests that populations are not limited by habitat availability. The species has been recorded within rehabilitation areas of age 8 years and older, demonstrating that the impact to habitat is temporary.
Rakali (*Hydromys chrysogaster*) (State – P4).	The Proposal is unlikely to have a significant impact on this species. The proposed clearing represents approximately 20.4% of high value habitat within the Mine DE. Clearing represents approximately 0.4% of the remaining native vegetation in the NJF. Implementation of buffers around permanent water courses and the management of impacts to surface water quality will minimise potential indirect impacts to the species' habitat.
Brush tailed Phascogale (*Phascogale tapoatafa wambenger*) (State – CD).	The Proposal may have a significant impact on this species. The proposed clearing represents approximately 16.4% of high value habitat and 3.8% of medium value habitat within the Mine DE. Clearing represents approximately 0.4% of the remaining native vegetation in the NJF. This species has a large range throughout the NJF, with suitable habitat extending throughout. The proposed clearing will impact potentially suitable breeding habitat. Some suitable nesting trees will be retained, in conjunction with the avoidance of all potential Black cockatoo nesting trees. The proposed clearing will impact potentially suitable breeding habitat, potentially impacting local populations as the species is territorial and can have a small home range.
Southern Death Adder (*Acanthophis antarcticus*) (State – P3).	The Proposal is unlikely to have a significant impact on this species. The proposed clearing represents approximately 18% of high value habitat within the Mine DE. Clearing represents approximately 0.4% of the remaining native vegetation in the NJF. The Proposal may impact the local extent of habitat for this species as it has low mobility and poor dispersal. However, due to the low population levels within the Mine DE, and the species has a large range throughout the NJF, with suitable habitat extending throughout, impacts to this species are unlikely to be significant.
Dell's skink (*Ctenotus delli*) (State – P4).	The Proposal is unlikely to have a significant impact on this species. The proposed clearing represents approximately 16.5% of high value habitat within the Mine DE. Clearing represents approximately 0.4% of the remaining native vegetation in the NJF. The Proposal may impact the local extent of habitat for this species as it has low mobility and poor dispersal. Granite outcrops may be used as refugia for populations outside of fire prone habitat, with no clearing occurring within these areas. However, the species has a large range throughout the NJF, with suitable habitat extending throughout, impacts to this species are unlikely to be significant.

5.3.9.2 Quantification of Significant Residual Impact

Implementation of the Proposal will directly impact terrestrial fauna as a result of habitat loss from clearing of vegetation. Following the application of mitigation measures, as described in Section 5.3.9.2, the Proposal will result in the direct loss of 4,101 ha of fauna habitat within the Huntly and Willowdale Mine DE. This will result in a reduction in the extent of available fauna habitat at a local scale. However, it is unlikely to have a significant impact on the extent of vertebrate fauna habitat at a regional scale as the habitats proposed to be cleared are well represented more widely in the NJF. Progressive rehabilitation undertaken by Alcoa will also mitigate this impact as it will restore fauna habitat over the life of the mine.

5.3.9.3 Determining Significant Residual Impact for conservation significant species

The residual impact is the remaining impact after the mitigation hierarchy (avoidance, mitigation and rehabilitation measures) has been implemented. This residual impact is termed the significant residual impact (SRI) of the Proposal.

Alcoa has undertaken an assessment to determine the SRI for conservation significant species that are likely to be significantly impacted. To inform this assessment, Alcoa has based its assumptions on the outcomes of the flora and vegetation surveys undertaken by Mattiske (2021a), (2021b), and (2024b), and the terrestrial fauna surveys undertaken by SLR [(2024d) (2024c)] and GHD (2024d)). Additionally, this assessment considered WA Environmental Offsets Guidelines (Government of Western Australia, 2014) and Significant Impact Guidelines 1.1 – Matters of National Environmental Significance (DEWHA, 2013).

5.3.9.3.1 Method and quantification

Quantum of impact (habitat quality scoring)

To determine the current quality of the fauna habitat that will be impacted, Alcoa has utilised a unique scoring system for each conservation significant species – the *Fauna habitat scoring tool – explanatory report* (GHD, 2024a), (Appendix 47). Further information on the scoring system and its implementation can be found within Section 6.6.2.2 of the Pinjarra Alumina Refinery Revised Proposal (Assessment 2253) ERD.

For the three species of Black Cockatoo, the Black Cockatoo Habitat Scoring System considers the site condition and site context of foraging habitat for each Black Cockatoo species (Carnaby's Cockatoo, Baudin's Cockatoo and FRTBC), with site condition weighted as 40% and site context and species stocking rate both weighted 30%.

For Chuditch, Quokka and Woylie (critical weight range mammals), the Habitat Scoring System considers the site condition and species stocking rate to be weighted 30%, and site context is weighted 30%.

Given the amount of survey data available (Section 5.3.3.1), a conservative approach with regards to habitat quality has been taken. Current fauna habitat quality scores are detailed in Table 5-50. It is proposed that further studies (vegetation condition, targeted fauna surveys and fauna population analysis) are undertaken to confirm habitat quality.

5.3.9.3.2 Rehabilitation and Future Quality

The DWER Environmental Offsets Calculator (DWER, 2021) enables the user to determine the environmental value of onsite rehabilitation that would reduce the significant impacts of the Proposal. Alcoa is committed to rehabilitation of all areas cleared within the Mine DE, with rehabilitation occurring on a rolling basis throughout the lifecycle of each mine region and following closure. Alcoa's rehabilitation objectives, process and performance are described in detail in Section 6.1.

To be consistent with past practices across Alcoa's historical mining operations, the assumption has been made that 80% of the Mine area that will be cleared will be rehabilitated (refer to Section 6.1). The remaining 20% will not be rehabilitated within a similar timeframe. This is based on these areas being required for long-term infrastructure, such as haul roads, access roads, conveyors and other development and access requirements. The reuse of the semi-permanent haul roads and infrastructure will ultimately reduce unnecessary clearing by allowing ongoing and efficient access to ore bodies throughout the mine region. These remaining areas will be rehabilitated as soon as practicable once no longer required. Therefore, in the long-term, it is intended that 100% of the Mine footprint will be rehabilitated.

Historically, Alcoa has achieved 80% floristic diversity in rehabilitated areas when compared to un-mined forest control plots and has met targets for native overstorey and understorey species. Additionally, areas of rehabilitation are known to support conservation significant species, such as the Chuditch, Quokka, Carnaby's, Forest Red-Tailed Black Cockatoo, and Baudin's Cockatoo.

Alcoa's rehabilitation standards and techniques have evolved over time, and are likely to continue to evolve, being informed by interactions in research and practice. Despite the success of Alcoa's rehabilitation, a conservative approach has been taken when attributing a value to future quality of habitat. For input into the DWER Environmental Offsets Calculator, a value of six has been given consistently for future quality following rehabilitation efforts.

5.3.9.3.3 Time until ecological benefit and confidence in result

For an area of rehabilitation to provide an ecological benefit, the time frame needs to consider two variables, the time it will take from initial clearing to rehabilitation and the time it will take for rehabilitation to provide adequate benefit to conservation significant fauna in the area. Ecological benefit from rehabilitation would imply that the species planted have grown enough foliage to provide shelter for species that traverse through the area or that each species planted has matured and begun to reproduce, creating seed which may be a food source for conservation significant species.

It is assumed that rehabilitation will occur at an average of three years post-clearing. Once the cleared area has been rehabilitated, the vegetation will provide an ecological benefit to each species at differing time intervals. Section 0 outlines the use of rehabilitation by conservation significant species based on a range of studies undertaken in Alcoa's previous rehabilitation.

The Chuditch is considered opportunistic and adaptable and is able to rapidly recolonise the rehabilitated environment (McGregor R.A., 2014). In determining the SRI, it has been assumed that five years after rehabilitation completion would provide ecological benefit to the Chuditch.

The Woylie requires ample vegetation particularly tall eucalypt forest and woodland, dense myrtaceous shrubland and kwongan (proteaceous) or mallee heath which they use to forage, shelter and escape predation from feral species. This species is particularly susceptible to feral predation, therefore for the rehabilitation of habitat to be benifi cal to the Woylie, refuge from or controlling of feral animals will need to be established (Department of Environment and Conservation, 2012). It has been assumed that vegetation will provide ample refuge in conjunction with other habitat requirements in five to ten years.

For the Quokka, who thrive in dense streamzone habitats, rehabilitation has an ecological benefit when it can provide dense, leafy coverage along protective corridors. This enables the Quokka movement throughout its range where it can be protected from predators. Alcoa have a streamzone specific seed mix for rehabilitation of these streamzone areas which are high quality habitat for the Quokka. The streamzone seed mix promotes the establishment of dense riparian vegetation, which provides the ecological benefit for the Quokka. A period of seven years is considered a suitable timeframe for riparian vegetation to be beneficial to the Quokka.

For the Black Cockatoos it has been assumed that trees will provide foraging resources ten years after rehabilitation.

Confidence in result

Confidence in rehabilitation is high based on the successful large-scale rehabilitation across Alcoa's operations, particularly over the past 20 years, therefore the confidence in result of this rehabilitation is given a value of 90%.

5.3.9.4 Significant Residual Impact Calculations

The SRI calculations for conservation significant species affected by the Proposal is presented in the Offset Strategy (Appendix 13) as calculated in accordance with the methodology presented above. A summary of SRI for each conservation significant species is provided in Table 5-50.

Table 5-50: Significant Residual Impact in the Mine DEs

Conservation Significant Fauna	Significant impact (ha)	Site Condition	Site Context	Species Stocking Rate	Habitat value	Proposed rehabilitation (80% of significant impact)	Future quality without rehabilitation	Future quality with rehabilitation	Time until ecological benefit (years since first impact)	Confidence in rehabilitation result	Significant residual impact (ha)
Forest Red-tailed Black Cockatoo (VU)	3,931.8	4	3	3	10	3,145.5	0	6	10	90%	2,266.88
Baudin's Black Cockatoo (EN)	3,918.5	4	3	3	10	3,134.8	0	6	10	90%	2,416.06
Carnaby's Black Cockatoo (EN)	3,918.5	4	3	3	10	3,134.8	0	6	10	90%	2,416.06
Woylie (CR)	4,014.1	2	3	2	7	3,293.6	0	6	10	90%	1,960.70
Chuditch (VU)	4,101.2	2	3	3	8	3281.0	0	6	8	90%	1,537.31
Quokka (VU)	95.6	2	3	3	8	76.5	0	6	10	90%	35.99

5.3.10 Environmental Outcomes

Table 5-51 presents proposed environmental outcomes with respect to terrestrial fauna. The proposed environmental outcomes:

- reflect specific and measurable environmental states;
- have a clear boundary, size, extent, or limit; and
- are consistent with the EPA's objective to protect terrestrial fauna so that biological diversity and ecological integrity are maintained.

The Fauna MP will be updated to reflect the outcomes detailed.

Table 5-51: Proposed environmental outcomes – Terrestrial fauna

Potential environmental impact	Environmental outcome	Other statutory approval that will assure outcome	Monitoring of outcomes
Direct impacts to terrestrial fauna as a result of clearing	No direct impacts (excluding monitoring and management activities) in defined Mining Avoidance Zones	State Agreement Administrative Framework – Assessment and approval of the MMP and subsequent FCAs include consultation with key regulatory agencies.	Internal spatial data sets and disturbance tracking.
	Clearing of no more than 4,042 ha and 77 ha of native fauna habitat within the Huntly and Willowdale Mine DEs respectively.		
	No clearing within 30 m of Black Cockatoo nest trees or confirmed night roosting trees within the Mine DE, unless required for critical infrastructure, groundwater bores, rehabilitation or low-impact exploration		
	Pre-clearance surveys for Threatened fauna species and SRE invertebrates considered likely to occur will be undertaken. Prior to undertaking any clearing, pre-clearance surveys are completed, where required, and outcomes, mitigation measures & monitoring proposed and impacts provided to Minister for State Development for endorsement through the State Agreement Administrative Framework		
	Ensure no fauna species or ecological community is placed into a higher category of threat as a result of the Proposal		Population monitoring
	Clearing of up to 4,101 ha of suitable habitat for Chuditch		Internal spatial data sets and disturbance tracking.
	Clearing of up to 96 ha of critical habitat for Quokka		

Potential environmental impact	Environmental outcome	Other statutory approval that will assure outcome	Monitoring of outcomes
	Clearing of up to 4,117 ha of potentially suitable habitat for Woylie	State Agreement Administrative Framework – Assessment and approval of the MMP and subsequent FCAs include consultation with key regulatory agencies.	Internal spatial data sets and disturbance tracking. Population monitoring
	Clearing of up to 3,932 ha of high quality foraging habitat for FRTBC		
	Clearing of up to 3,919 ha of high quality foraging habitat for Baudin's Cockatoo		
	Clearing of up to 3,919 ha of high quality foraging habitat for Carnaby's Cockatoo		
	Ensure ongoing viability of any Woylie or Chuditch populations recorded within the Mine DE is not loss due to the Proposal		
	No clearing of active breeding Chuditch dens		
	Each confirmed WRP population extent will be placed in a 2.7 ha Mining Avoidance Zone of contiguous suitable habitat for the species.		
	Each confirmed Numbat population extent will be placed in a 50 ha Mining Avoidance Zone of contiguous suitable habitat for the species.		
	Clearing will be avoided within a 50 m buffer of a mapped Quokka population extent, unless this is not viable due to clearing for Critical Infrastructure.		
	Each confirmed Woylie population extent will be placed in a 6 ha Mining Avoidance Zone of contiguous suitable habitat for the species.		
	Fauna underpasses established for all infrastructure crossings adjacent to recorded Quokka populations.		
	No clearing within a 100m buffer of a mapped population extent of Carter's Freshwater Mussel, unless this is not viable due to clearing for Critical Infrastructure, whereby the population will be permanently translocated in accordance with the FMP.		

Potential environmental impact	Environmental outcome	Other statutory approval that will assure outcome	Monitoring of outcomes
	Clearing of no more than 621 ha of high value SRE invertebrate habitat.		
	Ensure no clearing within 50 m of short-range endemic fauna where they are only known to occur within the Mine DE, unless known to occur within a Mining Avoidance Zone		
	All cleared areas within Mine DE rehabilitated to Jarrah Forest ecosystem in accordance with approved completion criteria.	Rehabilitation Management Plan and Schedule developed in accordance with MMP approval conditions and aligns with the Rehabilitation Completion Criteria reviewed by DBCA and approved by the Department of State Development.	Annual monitoring and reporting of rehabilitation extent and performance against completion criteria

Table 5-52: Preliminary offset triggers – Residual Impact Significance Model

Part IV Environmental Factor	Terrestrial Fauna			
	Conservation areas	High biological diversity	Habitat for fauna	Other
Residual impact that is environmentally unacceptable or cannot be offset	No clearing will occur in conservation reserves	None identified	-	-
Significant residual impacts that will require an offset – All significant residual impacts to species and ecosystems protected by statute or where the cumulative impact is already at a critical level	No clearing will occur in conservation reserves	None identified	-	-
Significant residual impacts that may require an offset – Any significant residual impact to potentially threatened species and ecosystems, areas of high environmental value or where the cumulative impact may reach critical levels if not managed	No clearing will occur in conservation reserves		**Direct clearing of habitat for Threatened Fauna** Clearing of 3,918.5 ha within the Jarrah-Marri Forest habitat type, which provides high quality foraging habitat, scattered nesting habitat and dispersal habitat for five Threatened fauna species (Black Cockatoos, Woylie, Chuditch). Clearing of 95.6 ha of Drainage lines (Blackbutt and Bullich forest) and Melaleuca damplands habitat types, which provide high value habitat for four threatened species (Forest Red-tailed Cockatoo, Woylie, Chuditch and Quokka). Clearing of 51.2 of Granite outcrop habitat, which provides high value habitat for one Threatened species (Chuditch). Black Cockatoo Protection Zones, may be developed for areas which include high quality foraging habitat, high density of nest and/or habitat trees or permanent water sources. Pre-clearance Targeted Fauna surveys will occur in Threatened fauna potential habitat. Provision of MAZs, whereby no clearing activities for mining or infrastructure will occur. MAZs will be implemented for Black Cockatoo nest, significant and confirm night roosting trees, known Woylie population/s and identified active breeding Chuditch den/s.	**Direct clearing of habitat for other Conservation Significant Fauna** Clearing of 3,918.5 ha within the Jarrah-Marri Forest habitat type, which provides high quality foraging habitat, scattered nesting habitat and dispersal habitat for six species listed as Priority or specially protected at State level. Clearing of 95.6 ha of Drainage lines (Blackbutt and Bullich forest) and Melaleuca damplands habitat types, which provide high value habitat for eight species listed as Priority or specially protected at State level, and SRE invertebrates. Clearing of 51.2 of Granite outcrop habitat, which provides high value habitat for eight species listed as Priority or specially protected at State level, and SRE invertebrates.

Part IV Environmental Factor	Terrestrial Fauna			
	Conservation areas	High biological diversity	Habitat for fauna	Other
Residual impacts that are not significant	No clearing will occur in conservation reserves	A total of 12 conservation significant fauna species have been recorded within the Mines DEs during Targeted fauna surveys in 2023-2024, with a further eight identified as having a medium to high likelihood of occurrence at either of the Mine DEs. Desktop assessment within a 20 km buffer of the Mine DEs Desktop assessment within a 20 km buffer of the Mine DEs showed that 218 terrestrial vertebrate fauna species have potential to occur within the Huntly Mine DE and 189 species within the Willowdale Mine DE.	**Direct clearing of Black Cockatoo habitat trees** Clearing of Black Cockatoo habitat trees (potential nest trees) in the Mine DEs. Pre-clearance Targeted Black Cockatoo surveys will occur in potential habitat to identify nest, significant and habitat trees. MAZs, whereby no clearing activities for mining or infrastructure will occur, be implemented for Black Cockatoo confirmed night roosting, nest and significant tree/s and their buffer (within 30 m (or 10 m for critical infrastructure, exploration, rehabilitation or groundwater bores)).	**Direct loss of fauna due to entrapment or collision** Injury/fatality is most likely to occur during vegetation clearing activities as resident fauna could potentially be struck by vehicles undertaking the activity during either the clearing process or mobilisation to the site. Fauna underpasses are provided for conveyors and primary haul routes within the Mine DEs along streamzone crossings, where practicable. **Direct loss of aquatic fauna habitat** The Proposal will not directly impact habitat for Carter's Freshwater Mussel. Pre-clearance surveys will be conducted within the Mine DEs of all proposed waterway crossings (100 m downstream and 50 m upstream) for Carter's Freshwater Mussel and Minute Freshwater Snail. Proposed waterway crossings will be re-aligned to avoid recorded Carter's Freshwater Mussel and/or and Minute Freshwater Snail populations, where practicable. **Direct clearing of high potential SRE habitat** Clearing of potential high value SRE habitats is estimated to comprise approximately 15% of the total potential high value SRE habitats mapped within the Mine DEs. Clearing will be distributed across a range of streamzone habitats within the Huntly and Willowdale Mine DEs and not concentrated within any one drainage line. It is therefore unlikely that impacts will substantially reduce the range of SRE species present within potential high value habitats.

5.4 Key Environmental Factor – Terrestrial Environmental Quality

This section aims to address Task 18 as outlined in the ESD, focusing on terrestrial environmental quality within the Huntly Mine DE and the Willowdale Mine DE, with an emphasis on terms of the exemption order related to:

- the proposed management of areas post-clearing and drilling, to ensure the retention of soil integrity, condition and quality within the Proposal areas
- the proposed measures to ensure soil stabilisation during and after implementation of the Proposal
- with reference to clause 5, in the event of a de-stabilisation or drainage incident, the proposed measures to return terrestrial environmental quality to pre-disturbance baseline conditions.

5.4.1 EPA Objective

The EPA's environmental objective of the factor 'Terrestrial Environmental Quality' is:

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

For the purpose of EIA, the EPA defines Terrestrial Environmental Quality as the chemical, physical, biological and aesthetic characteristics of soils. Soils are the layer of organic and inorganic weathered material that accumulates at the Earth's surface (EPA, 2016e).

The objective recognises the fundamental link between soil quality and the protection of ecological and social values that good soil quality supports. Therefore, the focus of this factor and its associated objective is how changes to soil quality impact environmental values (EPA, 2016e).

5.4.2 Relevant Policy and Guidance

5.4.2.1 EPA Policy and Guidance

- Environmental Factor Guideline – Terrestrial Environmental Quality (EPA, 2016e);
- Instructions on how to prepare an Environmental Review Document (EPA, 2024c); and
- Instructions on how to prepare *Environmental Protection Act* 1986 Part IV Environmental Management Plans (EPA, 2024b).

5.4.2.2 Other Policy and Guidance

- Statutory Guidelines for Mine Closure Plans (DMIRS, 2023);
- National Acid Sulphate Soils Guidance (DAWE, 2018d);
- Identification and investigation of acid sulphate soils and acidic landscapes (DER, 2015a);
- Treatment and management of soil and water in acid sulphate soil landscapes (DER, 2015b);
- Contaminated Sites Regulations 2006; and
- AS1940: The storage and handling of flammable and combustible liquids.

5.4.3 Knowledge and survey gaps addressed in Pinjarra Alumina Refinery Revised Proposal (Assessment 2253)

The Pinjarra Alumina Refinery Revised Proposal (Assessment 2253) addresses additional terrestrial environmental quality impacts within Section 7. While Assessment 2253 covers different clearing areas than this Proposal and does not include Willowdale, the cumulative impact information for surrounding mines is considered relevant and should be considered. The information from Assessment 2253 has been reviewed and extrapolated to address knowledge and survey gaps within the current Proposal.

5.4.4 Receiving Environment

5.4.4.1 Geology

5.4.4.1.1 Regional Geology

The Proposal areas lie within the Darling Plateau, an undulating lateritic regolith over Archaean granite with dolerite intrusions. The Darling Plateau occupies the south-western fringe of the Yilgarn Craton and is bordered by the Darling Fault and Perth Basin to the west. Bedrock underlying the Huntly Mine is over two billion years in age and predominantly comprises granite with areas of granitic gneiss. Faults run in an approximate south-east to north-west direction.

Dolerite dykes are common, intruding through the granite mostly in a north-northwest direction and ranging from 1-200 m thick (about 10 m average) (Hickman, Smurthwaite, Brown, & Davey, 1992). The presence of granite, gneiss or dolerite is a major determinant on the characteristics of the regolith which overlies most of the bedrock. The bedrock outcrops in pockets throughout the Darling Plateau, including on hills or ‘monadnocks’ as well as within incised valleys where rivers have eroded through the regolith material. The bedrock has an irregular topography, with pinnacles and isolated boulders occurring at shallow depths in the regolith, at places reducing the thickness of laterite (Hickman, Smurthwaite, Brown, & Davey, 1992)

The regolith that covers the bedrock was formed through a long period of bedrock weathering, and averages about 30 m thick over the Darling Plateau (Hickman, Smurthwaite, Brown, & Davey, 1992). The upper layers of the regolith are lateritic, being rich in iron and aluminium derived from the bedrock, with a characteristic rusty-red colour. The regolith has a complex vertical sequence, which is generalised as follows (from surface to bedrock) (Hickman, Smurthwaite, Brown, & Davey, 1992):

- Overburden, comprising sandy gravels about 0.2-4 m thick (average 0.5 m);
- Lateritic bauxite about 4-6 m thick, comprising two distinct layers:
    - Duricrust or caprock, comprising iron or aluminium cemented rock about 1-2 m thick; and
    - Friable fragmental layer about 2 m or more thick.
- Mottled and pallid clays (saprolite) about 20-30 m thick; and
- Saprock, comprising rock fragments about 2-5 m thick that define a basal interface between saprolite and bedrock.

The regolith is partially or fully eroded in valleys that dissect the Darling Plateau, with the upper lateritic layers often absent and replaced by colluvial or alluvial deposits (Hickman, Smurthwaite, Brown, & Davey, 1992). In some areas, the regolith is fully eroded to expose bedrock (Fordyce, et al., 2007).

5.4.4.1.2 Local geology

The majority of the Mine DEs overlay residual or relict material including ferruginous, siliceous, and calcareous duricrust. The Huntly Mine DE includes minor pockets of alluvium in drainage channels, floodplains, and deltas; and exposed rock, saprolite, and saprock (Chief Geoscientist, 2018). Detailed geological mapping at a 1:250,000 scale was undertaken for the Pinjarra region and published by the Department of Energy, Mines, Industry Regulation and Safety (DEMIRS) (Baxter, Lipple, Playford, Low, & Lowry, 1980). The surficial geology is consistent with the wider geology of the Darling Plateau, predominantly comprising lateritic regolith (30,690,10 ha or 74.5% of the Mine DEs) interspersed by Quaternary deposits (5,686.9 ha or 13.80% of the Mine DEs) in streams and swamps, and Archaean rock outcrops (4,828.3 ha or 11.7% of the Mine DEs) in hills and incised valleys. The Huntly Mine DE has a greater prevalence of Archaean rock outcrops associated with the Serpentine River Valley and with Mount Solus, whereas the Willowdale has limited rock outcrops.

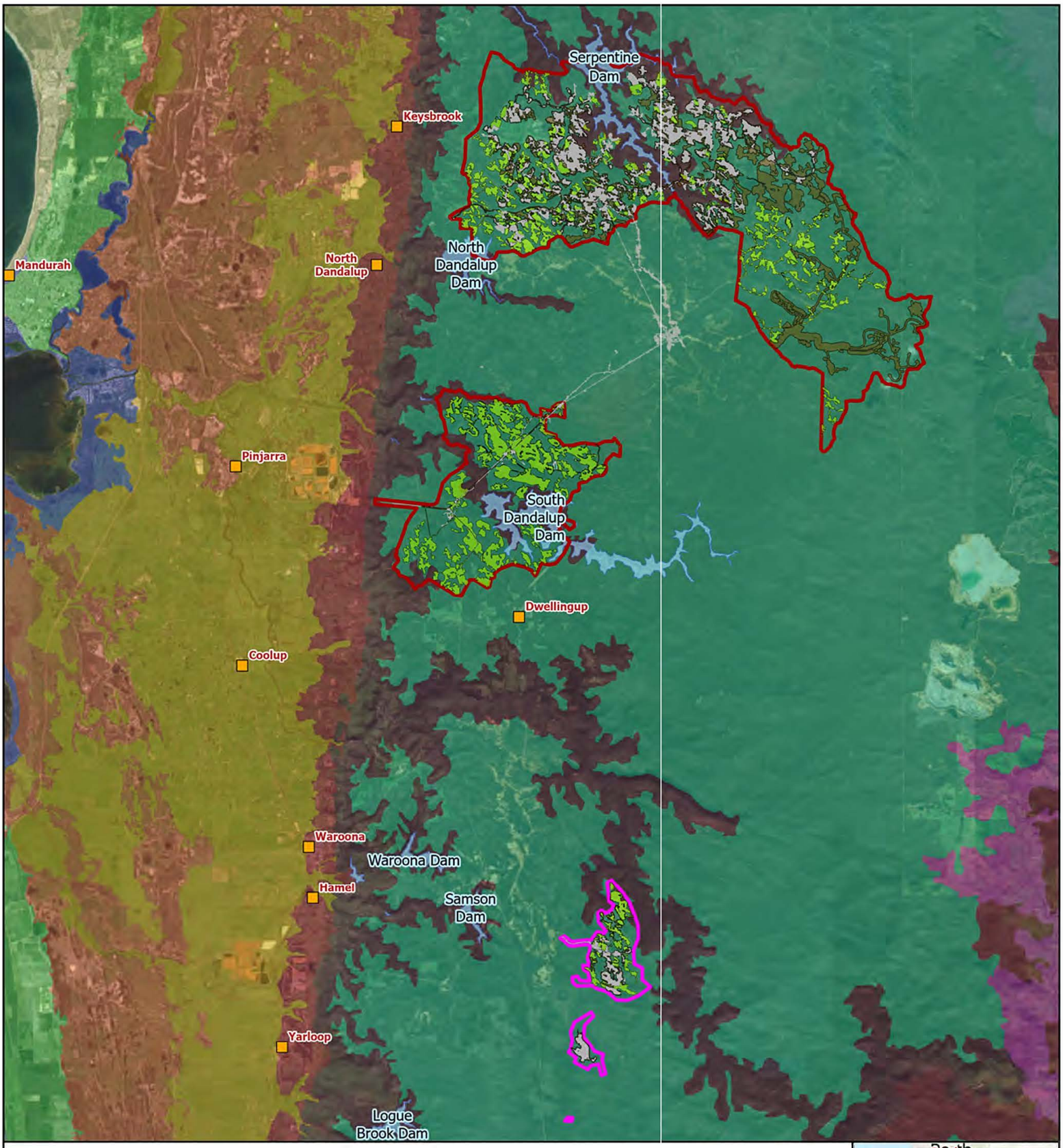
Dolerite dykes are too small to be mapped on surficial geology but they comprise about 15% of bedrock and are important determinants of regolith characteristics (Biggs & Wide, 1980).

Table 5-53 Surficial Geology present in the Mine DEs

Mapping Unit	Description	Huntly Mine DE (ha)	Willowdale Mine DE (ha)
Archaean Rock Outcrops			
Age	Even-grained granitic rocks – fine to coarse-grained granodiorite, adamellite and granite.	2,286.5	-
Age/Blo	Overprint, indicating bedrock largely obscured by residual and colluvial deposits on Age.	1,380.8	0.9
Agp	Porphyritic granite – medium to coarse-grained granite with microcline megacrysts.	226.8	1.2
Agp/Blo	Overprint, indicating bedrock largely obscured by residual and colluvial deposits on Agp.	147.5	30.0
Agv	Fine to medium grained adamellite and granite with scattered microcline megacrysts.	371.6	-
Agv/Blo	Overprint, indicating bedrock largely obscured by residual and colluvial deposits on Agv.	16.1	-
Am	Migmatite – banded and nebulitic, often strongly contorted.	266.0	20.7
Am/Blo	Overprint, indicating bedrock largely obscured by residual and colluvial deposits on Am.	48.0	31.4

Mapping Unit	Description	Huntly Mine DE (ha)	Willowdale Mine DE (ha)
Anp	Porphyritic granite gneiss, course-grained with abundant tabular megacrysts of microcline.	0.8	-
Laterite			
Czl	Laterite – chiefly massive but includes overlying pisolithic gravel and lateritised sand.	28,616.1	1,870.7
Czs	Sand overlying laterite – yellow, white or grey.	203.3	-
Quaternary Deposits			
Qa	Alluvium and minor colluvium developed on laterite of the Darling Range.	2,197.3	10.8
Qrc	Colluvium, including valley-fill deposits, variably lateritised and podsolized.	2,111.8	167.8
Qrcs	Colluvium, sand associated with older drainage courses.	72.6	-
Water	Reservoir – geology not mapped.	1,126.6	-
Total		39,071.8	2,137.4*

*3.9 ha unclassified



Legend

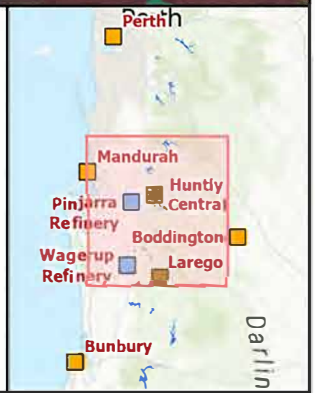
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Huntly Mine DE
- Willowdale Mine DE

Places

- City/Town
- Reservoirs

Soil Landscape Mapping - Systems (DPIRD-064)

- Bassendean System
- Darling Plateau System
- Forrestfield System
- Marradong Upland System
- Murray Valleys System
- Pinjarra System
- Quindalup South System
- Quindanning System
- Spearwood System
- Vasse System
- Wundowie System



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-49 Soil Landscape Systems of the Mine DEs

Kilometres

0 4 8 12 16 20 24

Scale: 1:320,000 at A4

Date Printed: 27/02/2025

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Alcoa

Development of bauxite ore has been especially pronounced along the flanks and upper slopes or ridges. It generally occupies gently sloping (3° to horizontal) upland areas with an average elevation of 280 to 300 m above sea level, and high annual rainfall, although is limited and sometimes absent in the lower lying valleys, where it has been eroded.

Steeper slopes may have a thin cover of partly transported laterite with bedrock near the surface. Above 340 m the laterite is often penetrated by bedrock which rises above the general topographic level. Below 200 m drainage has removed pre-existing laterite. Blocks of laterite, released by headward erosion of streams, decay to lateritic gravels on the lower slopes of valleys, which pass laterally into alluvial sands and silt in the valley floors (Hickman, Smurthwaite, Brown, & Davey, 1992).

Bauxite deposits typically occur as irregularly shaped lenses on the flanks of plateaus. Critical to this is the laterite position on the slopes (see Plate 5-1 below); erosion generally dominates on steeper slopes which prevent accumulation and effective bauxite formation, whereas flat areas lack the necessary subsurface water flows which drive the removal of clays and the enrichment of soluble silicate minerals.

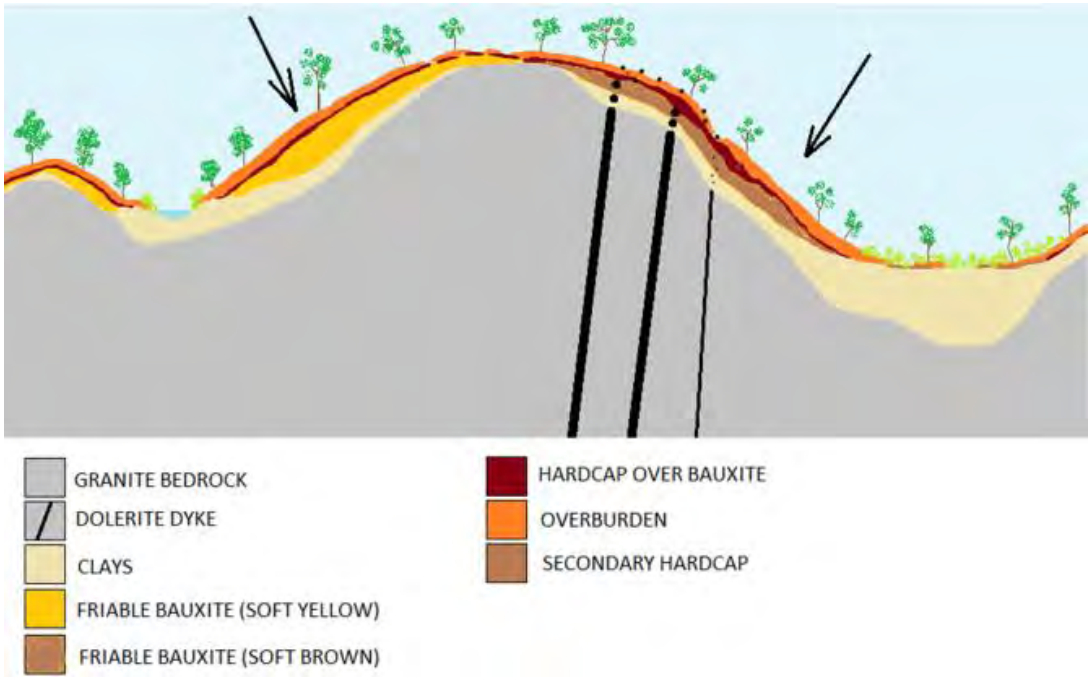


Plate 5-1 Bauxite deposit formation along the Darling Scarp (WSP, 2024)

5.4.4.2 Land Systems

The Mine DEs lie within the Western Darling Range Zone which is characterised as a moderately dissected lateritic plateau on granite with deeply incised valleys, including the Darling Scarp on the western margin. Soils are formed in laterite, lateritic colluvium and weathered in situ granite and gneiss (DPIRD, 2017a). The zone is further broken down into a series of land systems of which two intersect the Mine DEs; the Darling Plateau land system and the Murray Valleys land system as presented in Table 5-54. The Darling Plateau land system comprises an undulating lateritic plateau which is the remnant of a once extensive peneplain (Hickman, Smurthwaite, Brown, & Davey, 1992).

The Murray Valleys land system comprises deeply incised valleys of larger rivers such as the Serpentine River and Murray River and the lower reaches of smaller rivers (e.g., South

and North Dandalup) as they approach and cut through the Darling Scarp. The Darling Plateau system is associated with the predominant lateritic surficial geology of the region whereas the Murray Valleys system has a higher prevalence of exposed bedrock.

Table 5-54: Land systems present in the Mine DEs

Land System	Mapping Unit	Total Extent (ha)	Huntly Mine DE (ha)	Willowdale Mine DE (ha)	Proportion of Current Extent (%)
Darling Plateau System	255Dp	820,265.7	32,801.6	2,029.0	4.3
Murray Valleys System	255Mv	132,255.6	6,245.2	107.1	4.8

5.4.4.2.1 Landforms / land subsystems

The landforms of the Darling Plateau have been described by Churchward and McArthur (1980) and are presented as land subsystems in Table 5-55.

The Darling Plateau lies in a region of rejuvenated and active drainage, which is distinct from the ancient drainage to the east in the Avon-Wheatbelt region (Penn, 1999). The rejuvenated and active drainage is characterised by deep incised river valleys, such that the predominant lateritic upland and minor valley landforms of the Darling Plateau are dissected by major valley and valley floor landforms.

Over the Mine DEs, the lateritic uplands comprise the Dwellingup system and the minor valleys comprise the Yarragil system, which are widespread across the high rainfall zones of the western Darling Plateau. These two systems comprise approximately 72% of the Mine DEs.

The major valleys comprise the Murray system and within the Mine DEs are primarily associated with the Serpentine River, North and South Dandalup Dams in the Huntly Mine DE and the Murray River to the east of the Willowdale Mine DE. The system comprises approximately 15% of the Mine DEs.

The Darling Plateau includes pockets of hills that can host concentrations of granite outcrops, which comprise the Cooke system. Within the Huntly Mine DE, the Cooke system includes Mount Solus and Wells hilly topography. The Cooke system is also prevalent in the Monadnocks Conservation Park to the northeast of the Huntly Mine DE and the White Horse Hills to the east.

Regional land system mapping provides a broad, qualitative indication of slope across the Mine DEs. The elevation over the Darling Plateau, in the Mine areas typically ranges from about 200 to 400 meters above sea level.

Slope analysis has been completed for the Myara and historic mining areas within the Huntly Region. The detailed slope analysis based on available LiDAR data shows the Myara mining area is comprised of 26% of land with a slope greater than 16% rise, with 41% of the land having a rise between eight and 16%. Historic Huntly mine areas show a similar trend with 16% of land with a slope greater than 16% rise, with 39% of the land having a rise between eight and 16%. Less than 11% and 16% of the areas respectively are relatively flat with a slope of less than four percent (Alcoa, 2022a).

Table 5-55: Regional soil landscape mapping in the Mine DEs

Underlying landform	Soil landscape mapping units	Description	Total Extent (ha)	Area within Huntly Mine DE (ha)	Area within Willowdale Mine DE (ha)	Proportion of Extent in the Mine DEs (%)
Cooke: Hills rising above general plateau level, mainly mantled by laterite with some rock outcrop.	Cooke Subsystem (3996)	Crests and upper slopes dominated by granite outcrop and very shallow yellow duplex soils, and yellow and brown massive earths.	14,044.4	2,381.8	-	16.7
Dwellingup: Gently undulating landscape with duricrust on ridges; sands and gravels in shallow depressions.	Dwellingup 1 Phase (3997)	Crests and gently inclined (<10%) terrain dominated by lateritic duricrust and very shallow gravelly brownish sands, pale brown sands and earthy sands.	762.5	0.8	-	0.1
	Dwellingup 2 Phase (3998)	Very gently to gently undulating terrain (<10%) with well drained, shallow to moderately deep gravelly brownish sands, pale brown sands and earthy sands overlying lateritic duricrust.	65,466.4	492.4	-	0.8
	Dwellingup Rock Outcrops phase (1100)	Granite rock outcrop with stony soils and shallow gravels.	574.8	-	33.5	5.8
	Dwellingup Subsystem (1097)	Divides, lower to upper slopes and hillcrests. Duplex sandy gravels and loamy gravels with minor areas of shallow gravels, deep sandy gravels, yellow deep sands and yellow and pale deep sands, often gravelly.	231,143.3	18,288.1	1,284.9	8.5

Underlying landform	Soil landscape mapping units	Description	Total Extent (ha)	Area within Huntly Mine DE (ha)	Area within Willowdale Mine DE (ha)	Proportion of Extent in the Mine DEs (%)
Hester Predominantly flat to gently undulating, with some areas exhibiting low hills; soils vary including sandy soils and clay-rich soils.	Hester subsystem (1107)	Ridges and hill crests on laterite and gneiss, relief 5-40 m, slopes 5-15%. Soils are sandy gravels, loamy gravels and loamy earths.	27,237.6	753.5	-	2.8
	Hester subsystem – Murray (6998)	Ridges and hill crests on laterite and gneiss, relief 5-40 m, slopes 5-15%. Soils are sandy gravels, loamy gravels and loamy earths.	1,347.5	12.5	-	0.9
Murray: Deeply incised valleys with red and yellow earths on slopes; narrow alluvial terraces.	Murray rock outcrop phase (6339)	Deeply incised valley of the Murray River; areas of shallow soils and scattered rock outcrops.	1,826.3	-	21.4	1.2
	Murray subsystem (4738)	Deeply incised valley of the Murray River; red and yellow earths and minor duplex soils; occasional rock outcrops; narrow sandy terrace.	61,5749.4	4131.6	85.7	6.9
	Murray Valleys DR1 phase (4013)	Gentle to moderate slopes of scarp face (5-25%) with red and yellow gradational earths and duplex soils with variable depth and common rock outcrop.	9,898.5	38.8	-	0.4
	Murray Valleys DR2 phase (4014)	Gentle to moderately inclined slopes (3-20%) with red and yellow gradational earths and duplex soils with variable depth and common rock outcrop.	2,675.2	11.7	-	0.4
	Murray Valleys DR3 phase (4015)	Deeply incised tributary valleys with slopes (<30%). Red and yellow gradational earths and duplex soils with variable depth and common rock outcrop.	2,349.1	0.01	-	<0.01

Underlying landform	Soil landscape mapping units	Description	Total Extent (ha)	Area within Huntly Mine DE (ha)	Area within Willowdale Mine DE (ha)	Proportion of Extent in the Mine DEs (%)
Pindalup: Very gentle to gently sloping concave valleys in the central and eastern portions of the plateau. These are characteristically broader and sandier and less incised than Yarragil valleys	Pindalup hillslope phase (7096)	Side slopes of minor valleys.	16,507.2	1,332.3	-	8.1
	Pindalup subsystem (1147)	Shallow minor valleys (5-20 m) with gentle side slopes (3-10%). and broad swampy floors. Soils are loamy gravels, and deep sands, and non-saline wet soils on the valley floors.	27,874.8	139.7	-	0.5
	Pindalup swampy valley floor phase (7097)	Swampy floors of minor valleys.	7,767.1	452.8	-	5.8
Yarragil: Valleys of the western part of the plateau; sandy gravels on the slopes; orange earth in swampy floors.	Yarragil 1 phase (4000)	Very gentle to moderately inclined concave sideslopes. Moderately well drained yellow duplex soils and yellow and brown massive earths and gravels. Woodland of *E. wandoo*, *E. marginata*, *E. Accedens*. *Casuarina obesa* on salt affected areas.	13,843.5	12.3	-	0.1
	Yarragil 2 phase (4001)	Very gentle to gently inclined (<10%) valley headwaters with deep rapidly drained grey, yellowish brown or brown siliceous or bleached sands.	388.0	2.3	-	0.6
	Yarragil 4 phase (4003)	Valley floors with some poorly drained mottled yellow duplex soils and gentle lower slopes with moderately well to well drained loamy and sandy earths, gravels	5,026.7	10.6	-	0.2

Underlying landform	Soil landscape mapping units	Description	Total Extent (ha)	Area within Huntly Mine DE (ha)	Area within Willowdale Mine DE (ha)	Proportion of Extent in the Mine DEs (%)
		and duplex soils. Low woodland of *E. wandoo*, *E. marginata* and *Acacia spp*.				
	Yarragil downstream valleys phase (1188)	Shallow, narrow valleys. Relief 20-40 m, slopes 3-10%. Valley floor is narrower than upstream phase. Soil parent materials are laterite, granite and gneiss. Soils are loamy gravels, loamy earths and deep sandy gravels	17,854.1	35.6	-	0.2
	Yarragil DpYGh phase (6820)	Very gentle to moderately inclined (<20%) concave valley side slopes. Moderately well drained yellow duplex soils and yellow and brown massive earths	22,362.9	2,219.2	119.3	10.5
	Yarragil rock outcrop phase (6412)	Shallow, narrow, upper valleys. Areas of rock outcrop.	198.8	-	6.9	3.5
	Yarragil subsystem (1187)	Shallow, narrow, upper valleys of the deeply dissected Murray, Bindoon and Helena units. Alluvial, clay and loam soils, moderately well drained, often gravelly, with some sands and loams. Salt prone. Woodland of *E. wandoo*, *E. accedens*.	71,930.8	6,243.5	572.1	9.5
	Yarragil Swamp phase (6360)	Level to very gently inclined valley floors. Swampy river flats and terraces in granitic rocks; loamy and sandy duplex, wet soils, non-cracking clays and loams.	5,373.9	299.5	12.3	5.8

Underlying landform	Soil landscape mapping units	Description	Total Extent (ha)	Area within Huntly Mine DE (ha)	Area within Willowdale Mine DE (ha)	Proportion of Extent in the Mine DEs (%)
	Yarragil Upstream Valleys phase (1189)	Relief 5-20 m, slopes 3-10%. Valley floor is broader than downstream phase. Soil parent material is mainly laterite. Soils are gravels and sands.	23,550.0	137.3	-	0.6

5.4.4.3 Soils

A generic soil and bedrock profile was developed by Anand and Paine (2002) and is presented in Plate 5-2 below. In this figure, quartz-rich (Zm) regolith is composed mostly of quartz and kaolin (kaolinite and/or halloysite) with various amounts of iron oxide cementation. This material occurs in the arenose zone and parts of the mottled zone using the terminology of Anand and Paine (2002). The arenose zone derived from granite represents a concentration of angular quartz grains in a grain-supported fabric (Kew & Giles, 2006). The mottled zone consists of segregations of subdominant red and orange colours, which are partly or wholly cemented by goethite and/or hematite. In contrast, clay-rich (Zp) regolith has a clay-supported fabric typical of the plasmic zone (Anand & Paine, 2002) and where segregations of goethite and hematite are less abundant.

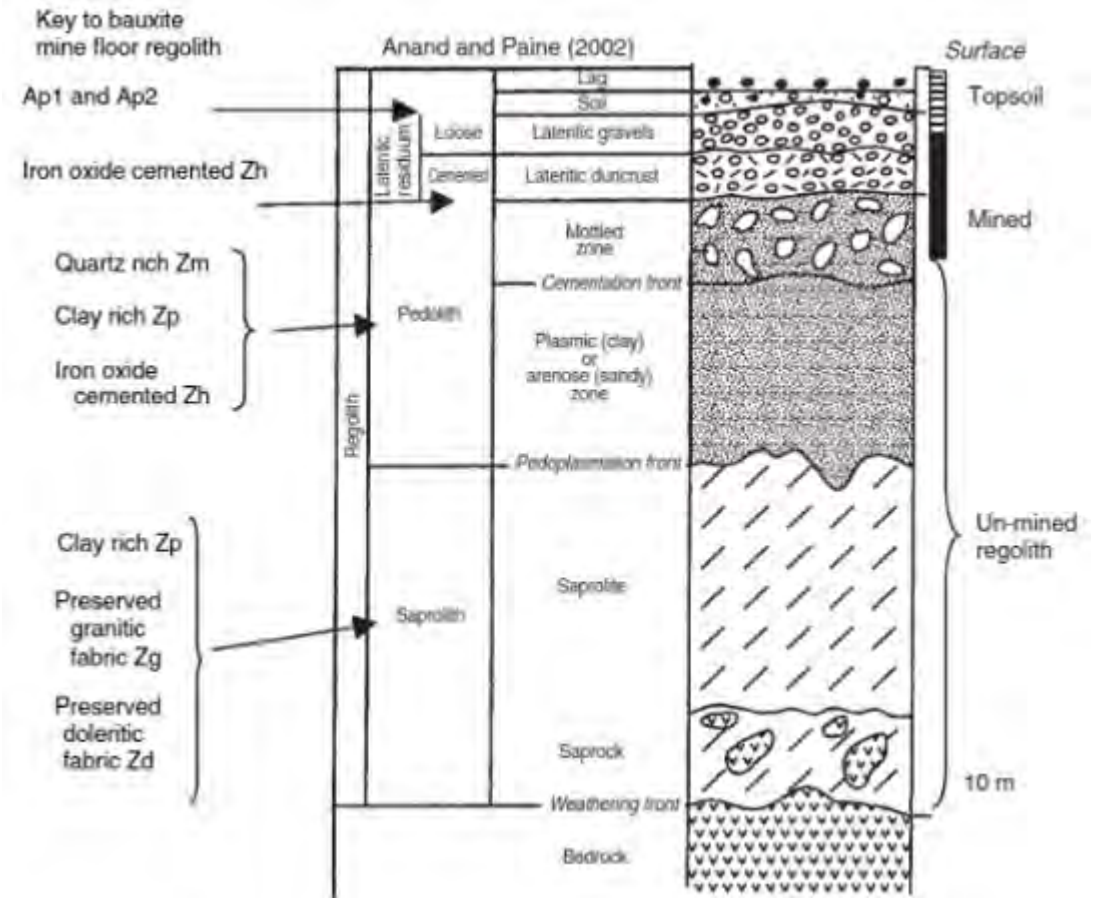


Plate 5-2 Bauxite mine floor regolith (Anand & Paine, 2002)

No site-specific material characterisation has been undertaken within the Mine DEs. Information available within the public domain, mostly published by the DPIRD can be used to make broad assessments on the potential properties of soils within the Mine DEs. The data is derived from a risk mapping exercise undertaken by the DPIRD using land quality attributions associated with soil-landscape mapping at the subsystem/phase level as developed by van Gool, Tille and Moore (2005).

The Huntly Mine DE is comprised of topsoil that is mostly considered neutral to alkaline with approximately 66.56% of the area considered to have a less than three percent chance of a pH <4.5, with an additional 17.51% of area considered to have a three to ten percent chance (DPIRD, 2023a).

Soils associated with waterbodies are considered with the highest likelihood at 10 to 30%. This is similar for subsoils of which 84.17% of the Huntly Mine DE is considered to have a less than three percent chance of a pH <4.5 (DPIRD, 2023a), and the remaining area a 10 to 30% chance (beneath water bodies).

Surface salinity is also considered to be low with 97.71% of the Huntly Mine DE considered to have a less than three percent chance of being saline. The risk associated with the salinity is considered higher though with 21.56% of the Huntly Mine DE having a three to 50% chance of being saline. The risk is highest in the eastern most extent of the Huntly Mine DE, potentially a result of cleared land associated with other mining or pastoral activities (DPIRD, 2017b).

The ranges within the Huntly Mine DE carry an erosion risk of 10 to 30%, while waterbodies are considered with a higher risk of 30 to 50% (DPIRD, 2017c). Subsurface compaction throughout the DE is considered to have a greater than 10% risk, with 24.72% of the DE having a risk greater than 70% (DPIRD, 2017d). Therefore, the risk of soils becoming waterlogged is low for majority of the DE. Likelihood results are summarised by area in Table 5-56 for the Huntly Mine DE.

Table 5-56: Soil risk derived potential of for area (ha) within Huntly Mine DE

Element	Area within DE (ha)					
Likelihood	<3%	3-10%	10-30%	30-50%	50-70%	>70%
Surface Acidity (pH<4.5)	26,006.5	6,840.3	6,224.9	-	-	-
Subsurface Acidity (pH<4.5)	32,885.7	-	6,186.1	-	-	-
Surface salinity	38,176.9	139.8	755.1	-	-	-
Salinity Risk	30,647.0	7,529.9	441.7	453.2	-	-
Water Erosion Risk	2,727.9	20,386.9	8,838.6	6,779.0	339.3	-
Subsurface Compaction Risk	38.8	0.8	2,836.6	151.4	26,385.7	9,658.5
Waterlogging Risk	24,228.8	7,519.3	6,420.4	150.4	752.9	-

The Willowdale Mine DE is considerable smaller than the Huntly Mine DE and does not intersect any waterbodies or significant streams or rivers. The potential risk within the Willowdale Mine DE of topsoil and subsoil acidity is considered low with 69.3% and 96.0% of the footprint respectively, considered to have a less than three percent likelihood of a pH<4.5 (DPIRD, 2023a). Similarly, 99.43% of the Willowdale Mine DE is considered with a likelihood of less than three percent being saline (DPIRD, 2017b). Erosion and waterlogging potential risk are also considered relatively low, with the greatest potential risk being attributed to soil compaction whereby 97.11% of the Willowdale Mine DE has a greater than 50% likelihood (DPIRD, 2017d). Likelihood results are summarised by area in Table 5-57 for the Willowdale Mine DE.

Table 5-57: Soil risk derived potential of for area (ha) within Willowdale Mine DE

Element	Area within DE (ha)					
Likelihood	<3%	3-10%	10-30%	30-50%	50-70%	>70%
Surface Acidity (pH<4.5)	1,479.2	572.5	85.7	-	-	-
Subsurface Acidity (pH<4.5)	2,051.7	-	85.7	-	-	-
Surface salinity	2,125.2	-	12.3	-	-	-
Salinity Risk	2,039.5	85.7	12.3	-	-	-
Water Erosion Risk	119.4	1,326.1	572.5	107.2	12.3	-
Subsurface Compaction Risk	-	-	28.3	33.5	1,858.2	217.4
Waterlogging Risk	1,466.9	85.7	572.5	-	12.3	-

Site specific soil and sub material characterisation remains a data gap across the DEs which could be potentially limiting rehabilitation potential and resulting in unknown impacts. Alcoa puts substantial effort into rehabilitation planning and trials of which additional soil attributes are determined. Alcoa have undertaken a series of research programs to understand the recovery of soil processes in rehabilitation at various stages of succession along with assessments of resilience to disturbances such as prescription burning and thinning in comparison to non-mined Northern Jarrah Forest. Broadly, these studies have demonstrated that soil organic matter and microbial biomass re-establishes over time in these rehabilitation sites, although recovery of organic matter (as measured by total organic C) is slower than the recovery of microbial biomass and in 18–26 years old rehabilitation remains below that of the non-mined forest mean (Banning & Murphy, Effect of heat-induced disturbance on microbial biomass and activity in forest soil and the relationship between disturbance effects and microbial community structure, 2008; Jasper, 2007).

Superficial soils on the Darling Plateau comprise a thin veneer of topsoil (typically less than 0.1 m thick), which contains sand, silt and the majority of the seedbank, over a sandy gravel overburden layer (Hickman, Smurthwaite, Brown, & Davey, 1992). Soil types are expected to vary across the Mine DEs based on the properties of the landscape mapping (as summarised in Table 5-55), but no specific local soil characterisation has been undertaken. The overburden ranges from about 0.2–4 m thick and averages about 0.5 m. The overburden is underlain by lateritic bauxite, which is approximately 4–6 m thick and comprises a caprock (duricrust) layer and underlying friable fragmental layer. The caprock layer is discontinuous and varies from absent to a thickness of a few metres (Kew, Gilkes, & Smith, 2007).

The soil catena (the lateral variation in soils over a hillslope) of the Darling Plateau varies from the lateritic uplands (Dwellingup system) to the valleys (Yarragil system). Uplands show a topographical sequence of very gravelly soils (sandy gravels) and ferruginous duricrust on the crests to mid slopes. Sandy gravels increase in thickness to more than 1 m in mid-slope and lower slope positions, where they overlie various forms of ferruginous duricrust, which in turn overlies bauxite zone. The gravels become finer downslope (Anand & Paine, 2002). On lower slopes, the gravels merge with sand and the profile shows a layered sequence, being interleaved with sand. ‘Orange earths’ dominate the valley floor, but in some situations yellow-brown sand may extend on to them (Churchward & McArthur, 1980). The regolith is partially eroded in minor valleys, with the upper lateritic layers often absent and replaced by colluvial or alluvial deposits (Hickman, Smurthwaite, Brown, & Davey, 1992). Podzolic soils and cracking clays also dominate some valley floors. Pockets of goethite-rich ‘bog iron’,

formed by chemical or biochemical precipitation of hydromorphically dispersed Fe, may occur in valley floors. In such areas, duricrust is absent and the soils overlie saprolite. Fresh rock outcrops are rare as overlying cover is rarely removed through erosion or tectonic uplift, where the rock may be exposed (or crop out) (Anand & Paine, 2002).

5.4.4.4 Acid Forming Materials

Acid sulphate soils (ASS) and potential acid sulphate soils (PASS) are significant environmental concerns, particularly in coastal and low-lying regions. These soils are characterized by the presence of iron sulphides, primarily pyrite, which can oxidize upon exposure to air, leading to the production of sulphuric acid. This acidification can severely impact soil health, water quality, and surrounding ecosystems. PASS are soil materials which contain RIS such as pyrite with undisturbed field pH of more than 4 (commonly neutral to alkaline, pH 7-9). These soil materials are invariably saturated with water in their natural state. Their texture may be peat, clay, loam, silt or sand. PASS refer to areas that have not yet been disturbed but possess the potential to develop acidity if exposed to oxygen. Actual ASS are soil materials which contained RIS such as pyrite that have undergone oxidation. This oxidation results in low pH (that is pH less than 4) and often a yellow (jarosite) and/or orange to red mottling (ferric iron oxides) in the soil profile Actual ASS contains Actual Acidity, and commonly also contains RIS (the source of Potential Sulfuric Acidity) as well as Retained Acidity.

The Darling Plateau has not been mapped by State Government for the presence of PASS nor are there published studies into the presence of acid forming materials in the regolith or bedrock. Within Western Australia, PASS are known to be present within the following landforms (DER, 2015a)

- riverine, estuarine and coastal lowland areas, such as mangroves, brackish lakes, tidal flats, salt marshes, salt pans, swamps and seasonally-inundated plains
- wetland areas
- beneath the water table in podsolised sandy soils that contain limited amounts of carbonate minerals (e.g., Bassendean Sands)
- saline inland areas.

Soils or sediments that are of most concern for PASS is those which formed within the last 10,000 years, when seawater inundated coastal plains and sulphate mixed with land sediments containing iron oxides and organic matter (DER, 2015a). This results in the formation of ASS as iron sulphides in waterlogged environments. Such processes are not expected to have occurred in the Darling Plateau given its elevation and lack of recent sea inundation. ASS may also form in inland wetlands where there is sufficient iron, sulphate and organic matter. Sulphate may originate from rainfall and groundwater.

Groundwater monitoring conducted to the north and south of the Huntly Mine DE indicate low levels of sulphate in groundwater, ranging from 5 to 107 mg/L (average 23 mg/L) over the Myara North mine region and ranging from 8-248 mg/L (average 50 mg/L) over the Holyoake mine region. This suggests limited sulphate with which to form strong ASS; however, there remains the potential for some ASS to have formed in the seasonally waterlogged / inundated swamps in valley floors. The surface waters of the Mine DEs are seasonal and swamps are expected to be subject to seasonal drying, which may have increased due to the observed decline in groundwater levels in the regolith (refer to

Section 5.5). Any PASS within the swamps may therefore have already been subject to oxidation. However, there is a lack of site-specific soil and groundwater data with which to confirm the presence or absence of ASS in swamps within the Mine DEs.

The Australian Soil Resource Information System (ASRIS) 'Atlas of Australian Acid Sulphate Soils' (CSIRO, 2011) which takes into account soil type, hydrography and landscape features, has been reviewed for comparison of ASS risk within the Mine DEs. The interpretation of this dataset concludes that all soils within the DE (with the exception of those underlying the lakes) identified as having 'extremely low' (1 to 5% of occurrence) probability of PASS occurrence. Areas underlying the dams are classified with a 'high' probability (>70%).

The Department of Primary Industries and Regional Development (DPIRD) risk map for soil surface acidification (DPIRD, 2023a) for the region is typically consistent with the CSIRO ASRIS risk mapping with areas associated with inland waters (dams, rivers, tributaries and streams) considered to have a 10 to 30% likelihood of having acidic soils (pH(Ca) of <4.5). The likelihood decreases with distance from waterways with most of the Mine DEs considered with a below 3% risk of surface soil acidification. This differs significantly in the risk ratings for subsurface materials in which DPIRD (2023b) considers the majority of the Mine DEs to have a greater than 70% risk of being or are presently acidic.

Acid forming materials can be present as sulphide bearing minerals in rocks. Chemical assay of granite and dolerite bedrock to about 0.1% has not identified the presence of sulphur (Hickman, Smurthwaite, Brown, & Davey, 1992). It is therefore unlikely that trace quantities of sulphur in bedrock have sufficiently accumulated in the lateritic upper regolith during the weathering process such that there is a high risk of acid formation during mining. PASS is therefore not expected to be present in the lateritic uplands, which comprise gravelly sands that are well drained and have limited organic matter apart from a thin veneer of topsoil (less than 0.1 m thick).

5.4.4.5 Contaminated Sites

There are no contaminated sites within the Mine DEs as recorded in the DWER Contaminated Sites Database under the *Contaminated Sites Act 2003* (CS Act).

Unrecorded soil contamination may be present in the Mine DEs due to past land uses such as equipment and vehicles for timber harvesting and forest management, or historic use of PFAS for fire response activities. Alcoa has given notice to DWER of four known or suspected contaminated site given under section 15 of the CS Act, where the historic use of PFAS was undertaken but suitable studies have not been completed. Only one of these locations, the Myara Mine Site is within the Huntly Mine DE, with the other three (McCoy, Orion and Arundel Mine Sites) all located outside of the Mine DEs. Detailed Site Investigations (DSIs) assess various locations to delineate and assess the risk of PFAS and other chemicals of potential concern (COPCs) associated with mining activities and will be managed through the CS Act.

5.4.5 Potential Environmental Impacts

The following Proposal activities have the potential to impact terrestrial environmental quality:

- Clearing of native vegetation
- Alteration of natural drainage regimes
- Waste disposal
- Storage and handling of contaminants
- Closure and decommissioning.

The Proposal may result in the following potential impacts to terrestrial environmental quality:

- Soil salinisation as a result of mining-induced saline groundwater rise
- Disturbance of potential ASS
- Erosion of post-mining landforms
- Contamination from spills and/or leaks from storage and handling of hazardous materials and waste.

Potential impacts associated with Terrestrial Environmental Quality are summarised in Table 5-58 and further explained in the following sections.

5.4.5.1 Direct Impacts

5.4.5.1.1 Soil Salinisation as a result of Mining-induced Saline Groundwater Rise

The Proposal may cause groundwater mounding beneath and in the vicinity of mine pits, due to the clearing of native vegetation and increased recharge of rainfall (Section 5.5). Groundwater level mounding, typically ranging from 1 to 10 m, is predicted to occur in the Mine DEs as mining progresses, noting the extent and expected impact will be considerably less in Willowdale based on the extent of the DE. The highest groundwater rise is predicted to occur in the vicinity of mined areas, with more limited groundwater rise in valleys where shallow groundwater may occur. The latter observation arises from enhanced recharge in previously mined areas (Myara), even after rehabilitation (GHD, 2023b). Groundwater levels are predicted to rise throughout mining and continue over the 15 years following rehabilitation until vegetation establishes and LAI returns to pre-mining levels. Greater mounding is predicted for wetter climatic conditions. The Proposal is not expected to cause groundwater declines.

Groundwater salinity information from nearby and adjacent mining regions, indicates that the average salinity, predominately fresh, of the groundwater increases from west to east. At the Huntly Mine, an average of close to 200 mg/L TDS in the western parts increases to an average of close to 400 mg/L TDS in the eastern parts (based on 5 km spaced north-south windows) (GHD, 2021c). The groundwater salinity trends at Huntly mine (observed in Myara North sub region) appears to be relatively stable over the three decades of monitoring (1990 to 2020).

Due to the predominantly freshwater quality of groundwater recorded in the region, it is unlikely that mining-induced groundwater rise will result in widespread salinity impacts to soils. Groundwater monitoring data indicates that there may be pockets of saline groundwater that have potential to increase salinity in the overlying regolith in the event of

groundwater rise over these pockets. This is supported by salinity risk profiles discussed in Section 5.4.4.3. The majority of groundwater rise will occur over the deeper regolith beneath mine pits on middle to upper slopes, with more limited rise occurring beneath valleys.

Groundwater rise that is close to the surface, and may impact soils, will be predominantly in valleys that have been subject to shallow groundwater in the past, prior to the decline of groundwater levels with declining rainfall (see Section 5.5). Rising groundwater levels will likely result in some discharge to streams. Accordingly, the modest groundwater rise expected near valleys that may result in shallow groundwater depths is likely to return soil salinity to past levels to which vegetation would be adapted.

5.4.5.1.2 Disturbance of Potential Acid Sulphate Soils

PASS may potentially be presented in swamps within the Mine DEs but is not expected to occur in lateritic soils, nor are strongly acid forming materials expected to occur in the regolith.

Mining occurs above the groundwater table and no dewatering is undertaken in mine pits. Any potential acid forming materials in the regolith are therefore expected to already be oxidised at the depths to which mining occurs. There is no waste rock storage within the mine, with all the overburden replaced on rehabilitation. Overburden comprises predominantly gravelly sands which are not expected to be PASS.

Mining will not occur in any streamzones, as these areas are devoid of economic bauxite and a MAZ will be implemented. Streamzones may be disturbed for infrastructure crossings such as haul roads and conveyors. Depending on geotechnical requirements, swamp deposits may require excavation and replacement with engineered fill for the infrastructure crossings. Streamzones that may have been subject to prolonged drying with declining groundwater levels and PASS if present may have already been subject to oxidation to actual ASS. However, there is a lack of site-specific soil and groundwater data with which to confirm the presence or absence of potential or actual ASS in swamps within the Mine DEs. Accordingly, excavation of streamzone deposits for infrastructure crossings may have potential to cause disturbance to potential or actual ASS.

5.4.5.1.3 Erosion of cleared areas and post-mining landforms

The mine development stage involves stripping and stockpiling the superficial soils and blasting or ripping the caprock layer to remove the bauxite caprock and friable fragmental layers. These are transported to stockpiles, then crushed and conveyed to the refineries.

The pit floor remaining after mining contains a diverse range of lateritic regolith materials from the lower mottled, pallid clay and saprolite layers, which mostly comprise sandy loams and clays (Mengler, Gilkes, & Hancock, 2006). In areas where the regolith is thin and has been mostly removed by mining, the mine floor may contain partly weathered material that retains the texture of the original bedrock. Other areas of the regolith have existing root channels, adequate structure and stable aggregates that support root exploration and plant re-establishment. The majority of pit floors require ripping to create macrostructure and alleviate high strength and high bulk density (Mengler, Gilkes, & Hancock, 2006). Soils derived from dolerite dykes (about 15% of bedrock) tend to be more clay rich and have more pedal structure, whereas soils derived from granite typically contain macropores (Raper & Croton, 1996).

Following the completion of mining, rehabilitation is undertaken including pre-ripping of compacted floors to at least 1.2 m, landscaping batters, spreading overburden and topsoil (typically 300 mm combined depth), then contour ripping to create a furrowed surface (refer Section 2.2.4).

Erosion may result in:

- loss of topsoil – Topsoil is rich in nutrients (such as nitrogen and phosphorus) and organic matter essential for plant growth, with the loss not only resulting in diminished fertility but also reduction in its ability to support healthy plant life (SoilsWest, 2024).
- poor soil structure – Erosion often leads to a breakdown of soil structure, resulting in compacted soils that are prone to surface sealing, which inhibits water infiltration and increases runoff. This compaction can create a hardpan that restricts root growth and limits access to moisture and nutrients, further exacerbating the decline in soil health. This is exacerbated by plash erosion that disrupts pore spaces and decreases infiltration rates caused by a lack of vegetation cover; and,
- reduced water infiltration – Water infiltration is crucial for maintaining soil moisture levels necessary for plant growth. Erosion contributes to reduced infiltration rates by compacting soil and sealing off pores, resulting in diminished infiltration capacity of the soil and increased surface runoff. Increased runoff not only furthers the erosion and loss of topsoil but also leads to sedimentation in waterways, negatively affecting water quality.

Soil degradation can have severe consequences for productivity and sustainability, in turn impacting on rehabilitation performance and ecosystem quality.

The net effect of bauxite mining of Northern Jarrah Forest soils is the removal of an approximately 4-6 m thick layer of caprock and friable fragmental material. The resulting void is then filled with seed rich topsoil and overburden, placed over a ripped, friable substrate of sandy loams and clays. The total depth of friable material created is about 1.5 m, including topsoil, overburden and ripped substrate.

5.4.5.1.4 Vegetation Use of Northern Jarrah Forest Soils

The Leaf Area Index (LAI) of Northern Jarrah Forest vegetation is dominated by the predominant canopy tree Jarrah (*Eucalyptus marginata*), which comprises about 60% to 80% of the LAI depending on the presence of other trees (Crombie, 1992). Shallow rooted vegetation (i.e., small shrubs and groundcovers with roots confined to shallow soils above the caprock) is estimated to comprise less than 10% of LAI and medium rooted vegetation (i.e., larger shrubs with roots that penetrate the caprock but not far into the underlying clays) approximately 10% of LAI (Crombie, 1992).

Jarrah trees (*E. marginata*) have a dimorphic root system, comprising dense lateral roots in the topsoil and overburden above the caprock, from which ‘sinker’ roots extend vertically to penetrate cracks and fissures in the caprock and gain access to moisture bearing clay through ancient root channels (Dell & Havel, 1989). Dell *et al* (1989) suggest that each tree may access 100-200 ancient root channels of up to 40 m from the surface. The root channels are permanent features of the profile and occupied by successive generations of trees.

Carbon *et al* (1980) report that the bulk of Jarrah roots are in shallow soils (topsoil and overburden) above the caprock, which has the greatest potential to supply water in winter

but dries over the summer and autumn. Measurements by Carbon *et al* (1980) indicate that the shallow soils have root density (root depth per area of ground surface) about an order of magnitude greater than the deeper sandy loam and clay layers.

While trees have deeper roots, substantial groundwater use is limited to shallower depths, being recorded in Northern Jarrah Forest at sites with depths of 6 mbgl, but not at 14 mbgl or 30 mbgl (Farrington, Turner, & Gailitis, 1996). Deeper rooted vegetation such as Jarrah and large shrubs can maintain higher photosynthetic activity into summer and autumn compared to shallow rooted vegetation (Crombie, 1992). However, both deep and shallow rooted vegetation exhibit daily cycling of water potentials and stomatal conductance and a rapid response following rainfall during summer (Crombie, 1992). This suggests that Northern Jarrah Forest vegetation remains physiologically active during summer and is tolerant of low water potentials, which would be necessary to enable deeper rooted vegetation to use water held in clayey subsoils (Crombie, 1992).

The establishment of a 1.5 m thick friable layer of topsoil, overburden and ripped substrate provides a comparable, though generally thicker, stratum than the topsoil and overburden present above the caprock prior to mining. The friable layer enables development of a dense root structure of Northern Jarrah Forest vegetation as occurs in the topsoil and overburden present prior to mining. Deeper rooted vegetation establishing within the friable layer is expected to re-colonise ancient root channels present in the underlying regolith materials, as have been used by successive generations of trees prior to mining (Dell, Bartle, & Tacey, 1983). There is expected to be a partial loss of soil water capacity, due to the removal of the bauxite friable fragmental layer, which comprised about 2 m of loamy soils that previously were accessed by deep and medium rooted vegetation. Loss of this layer represents approximately 10% of the regolith thickness, however the loamy layer may have had a higher plant available water than that of the underlying mottled and pallid clays. Loss of the bauxite caprock layer is not expected to substantially reduce the soil water capacity, as the layer was primarily cemented material that provided discrete pathways for water and roots to enter the underlying un-cemented layers.

Loss of the bauxite friable fragmental layer has not been observed to result in impaired growth or health of rehabilitation (see Section 6.1). During the 2010-2011 drought and heat waves, Northern Jarrah Forest canopy die-off was observed at sites across the NJF, including un-mined forest and some areas of rehabilitation (see Section 6.1). Widespread die-off of rehabilitation did not occur nor was rehabilitation affected in greater proportion than un-mined forest.

The results of monitoring demonstrate that Alcoa's rehabilitation establishes and persists, including during drought and heat wave events, indicating that the 1.5 m thick friable substrate over regolith containing ancient root channels is an effective growth medium. Accordingly, mine rehabilitation vegetation is expected to be sustained over the long-term, with resilience to climate change comparable to that of un-mined Northern Jarrah Forest. Mine rehabilitation is therefore expected to provide long term protection of soils from erosion and associated sediment discharge to streams and reservoirs.

5.4.5.1.5 Erosion during Rehabilitation Establishment

The skeletal topsoil (are those characterised by high coarse fragments, nutrient and organic matter deficiency and poor water retention) and overburden materials are distinct to most agricultural soils and mining waste, due to the low combined clay and silt contents and very

high gravel contents, which develop with time a protective surface layer of gravel covering 70-80% of the land surface. The high porosity and coarse texture also enable rapid infiltration of rainfall within the topsoil, overburden and ripped regolith material. Thinly applied topsoil and overburden can be effectively integrated with finer-grained pit floor materials during contour ripping, which presents an opportunity to enhance soil diversity. This mixing can improve the overall texture of the shallow subsurface, potentially enriching the soil profile with clayey materials that contribute to improved moisture retention and nutrient availability. The regolith beneath the ripped zone generally comprises lower permeability sandy loams and clays, therefore rainfall infiltration is generally slower and confined to preferential flow pathways with deeper recharge, as opposed to the overburden and ripped zoned. Surface runoff occurs following extended rainfall periods that fill up the permeable materials.

Gullies may form in the rehabilitated landform through an erosion sequence (Mengler, Gilkes, & Hancock, 2006). The fine grained content is displaced from the coarser topsoil/overburden, depositing within the furrows and filling their volume such that surface water overflows and erodes through the fine grained materials in downslope furrows. The gully that is initially created in the fine grained materials concentrates flow pathways and creates knickpoints that enable erosion of the coarser topsoil/overburden and underlying ripped regolith materials.

Analysis of gully erosion at the Huntly, Willowdale and Boddington bauxite mines suggested a minimum catchment of 0.3 ha for gully development, with gully volumes typically remaining small (20-100 m^3) but potentially increasing for higher slopes (> 10°) and shallower topsoil/overburden placement (< 200 mm). Erosion was highest in the first two to three years following rehabilitation completion until sufficient vegetation establishes, though there was a lack of long-term data with which to compare the erodibility of rehabilitation to that of un-mined Northern Jarrah Forest (Mengler, Gilkes, & Hancock, 2006) . For the period at higher risk of erosion, the major triggers for gully erosion were identified as:

- directing excessive off-site runoff into the rehabilitation
- poor surface completion (e.g., ripping that does not adhere to contours) that concentrates flow or impairs infiltration
- insufficient depth of returned topsoil and overburden (< 200 mm combined).

The Rehabilitation Management Plan and Schedule included in Appendix 8 provides a detailed description of the practices and procedures for minimising erosion of the post-mining landscape and creating a safe, stable post-mining landforms.

5.4.5.2 Indirect Impacts

5.4.5.2.1 Contamination from Spills and/or Leaks from Storage and Handling of Hydrocarbons

Contamination of land and soils may precede from the inadvertent loss from fuel and chemical storage leaks. Diesel is the predominant hazardous material used at the Mine, with hydraulic and lubricating oils also used. Minor quantities of other hazardous materials include solvents, adhesives and other chemicals that are used for vehicle and equipment maintenance or water treatment.

The Huntly and Willowdale Mines are a diesel-only fuel site, with no storage or handling of unleaded petrol. Diesel is predominantly used for haul trucks, excavators and other large earthmoving equipment, and light vehicles. The storage and handling of diesel creates a potential hazard for spillage of diesel that may enter environment. Haul trucks, some wheeled earthmoving equipment and light vehicles are refuelled at fuel bays. Planned major maintenance of haul trucks, light vehicles and some earthmoving equipment is undertaken at workshops. The fuel bay and workshop buildings are located at mine facilities and have roofs and sealed floors, which are expected to capture spills or leaks during refuelling or maintenance. Diesel and oil storage tanks are located at mine facilities and are double-lined and above ground to minimise and detect leaks. Smaller quantities of hazardous materials stored at mine facilities inside buildings or on sealed floors.

Due to the high volume and frequency of storage and handling of diesel, oils, and other chemicals at the mine facilities, there is potential for localised soil contamination to occur that requires remediation.

Excavators, bulldozers, and other earthmoving equipment will be refuelled and maintained in the field. Refuelling and maintenance in the field have potential to cause spills and leaks that contaminate soils. There is also potential for ongoing, small volumes of oil leaks from vehicles and equipment, and rare collisions that result in fuel or oil spills.

The majority of spills and leaks, particularly those from major incidents and involving large volumes, are expected to be identified quickly and the contaminated soils excavated and disposed off-site at a licenced waste facility. Smaller spills and leaks may potentially be missed, and the contaminants leach through the unsaturated zone. The smaller spills and leaks are expected to remain predominantly adsorbed to soil particles beneath the spill site. Diesel and particularly oil contain larger chain hydrocarbons that are weakly water soluble and readily adsorb to soils with organic matter and clay content and therefore are unlikely to result in substantial migration of hydrocarbons.

All mine pits and haul roads will be rehabilitated post mining, and any identified minor soil contamination arising from small spills and leaks will be overlaid with overburden, topsoil and establishing native vegetation (Section 2.2.4). Pockets of soil contamination remaining in the rehabilitation are expected to biodegrade over time and may result in localised impact to vegetation condition in the rehabilitation.

5.4.5.2.2 Contamination from Spills and/or Leaks from Storage and Handling of Pesticides, Herbicides and Fertilisers

Pesticides, herbicides, and fertilisers are used for weed control and to promote vegetation growth during rehabilitation activities. These compounds are of variable solubilities and mobilisation rates in groundwater and surface water systems, and often do not remain ‘stationary’ in area where they are applied. Alcoa implements strict controls for the use of pesticides, herbicides and fertilisers (Sections 5.4.6 and 5.4.6).

The inappropriate use, storage and/or disposal of pesticide, herbicide and fertiliser compounds can result in changes to soil chemistry, waterways and ecological communities.

5.4.5.2.3 Waste Generation and Disposal

Waste materials have the potential to contaminate soils. All operational and construction wastes will be transported off-site for recycling or disposal at licenced waste facilities. Operational and construction wastes will be temporarily stored at the mine facilities and construction compound, respectively, in designated containers. Liquid wastes (e.g., waste oils) will be stored in double-walled above-ground tanks or other secondary containment systems (e.g., drums on bunded pallets). Construction and mine operations in the field will use portable toilets or demountable ablution blocks that are zero discharge systems and are pumped out by tanker or transported off-site, with the sewage disposed at an off-site licenced waste facility. The discussion of waste does not encompass per- and polyfluoroalkyl substances (PFAS), which will be addressed below.

5.4.5.2.4 Contamination from Spills and/or Leaks from Storage and Handling of Sewage

Sewage in both Mine DEs is treated and either (i) reused by operations, or (ii) discharged to the environment. With respect to the latter, treated wastewater from the McCoy (Huntly) and Larego (Willowdale) wastewater treatment plants (WTPs) must achieve the required water quality standards identified in Part V licences L6210/1991/10 and L6465/1989/10 respectively, prior to its release.

Pathogens (such as *E. coli* or other faecal bacterium) and increased nutrients may enter the environment as a result of sewage overflow, subsurface leaching, sewage irrigation, and WTP breakdowns, failures or leaks. There is potential for soil contamination to accumulate at the effluent irrigation area, including nutrients and metals, which may require remediation when a facility is decommissioned. Water treatment plants and other containment infrastructure are located outside of Reservoir Protection Zones (RPZ) and within buffered areas surrounding streams and tributaries.

5.4.5.2.5 Use of Per- and Polyfluoroalkyl Substances (PFAS)

Between 2013 and 2021, Alcoa used C6 aqueous film forming foams as a fire suppressant on its heavy vehicle mining fleet. This was found to contain low traces of PFAS and was replaced across both the Huntly and Willowdale mines in December 2021 with an approved fluorine-free foam. Due to the absence of existing substantial contamination, any hydrological changes are not expected to mobilise substantial quantities of PFAS. Any indirect mobilisation of historic PFAS from catchments due to construction and mining is expected to pose a low risk to water quality due to containment infrastructure restricting pathways for mobilisation to the environment and negligible detected amounts.

Alcoa has committed to using PFAS-free fire-fighting foams for the mine regions within the DEs. All water supplies to construction and operations in these mine regions will be sourced from public drinking water sources, captured on-site stormwater or from licenced on-site water treatment facilities, approved for reuse on the Mine. PFAS is limited to minor quantities in materials such as workforce clothing, paper packaging, carpets or wire insulation, which are unlikely to be discharged to the environment as all wastes will be recycled or disposed off-site at licenced waste facilities.

5.4.6 Mitigation

Mitigation measures associated with Terrestrial Environmental Quality impacts are detailed in Table 5-58. As presented, the mitigation measures are typically established practice, best practice or industry standard and have a high certainty of effectiveness. Mitigation measures with a moderate certainty of effectiveness relate to the timing of rehabilitation and avoidance of swamp and streamzones, which will be undertaken as practicable. Objectives, triggers, and contingency actions are presented in Table 5-59.

The Environmentally Hazardous Material Management Plan (EHMMP) (Appendix 7) is currently being implemented as part of existing operational practises and is expected to be revised to reflect the information, mitigations and outcomes provided in this ERD. Therefore, the ERD is considered to take precedence over the EHMMP.

Table 5-58: Avoidance and minimisation of potential impacts to terrestrial environmental quality

No.	Potential Impacts and Mitigations	Industry standard, best practice and certainty of effectiveness
Soil salinisation as a result of mining-induced saline groundwater rise		
Minimise		
	Where salinity risk has been identified through previous data, rehabilitation will be completed as soon as practicable after mining has been completed.	Established practice at Huntly and Willowdale Mine, high certainty
	Rehabilitation within the Mine DEs will be undertaken as presented in Sections 1.4 and 2.2.4	Established practice at Huntly and Willowdale Mine, high certainty
Disturbance of potential acid sulphate soils		
Minimise		
	Haul roads, conveyors, and other infrastructure within the Mine DEs planned to limit crossing of mapped swamp and streamzones, to the minimum required for safe mining, as far as practicable. If disturbance to mapped swamp and streamzone cannot be avoided, minimise disturbance within swamp and streamzones, as far as practicable.	Best practice, moderate certainty
	Where excavation of 100 m^3 or more or dewatering of swamp sediments is required a PASS investigation will be undertaken in accordance with *Identification and investigation of acid sulphate soils and acidic landscapes* (DER, 2015a)	Industry standard, high certainty
	Where ASS is confirmed as present within the excavation or groundwater drawdown area, construction will be reviewed to avoid disturbance as far as practicable. Where ASS disturbance is not avoidable, an ASSMP will be prepared in accordance with *Treatment and management of soil and water in acid sulphate soil landscapes* (DER, 2015a)	Industry standard, high certainty
	Monitoring and validation will be undertaken in accordance with the approved ASSMP (to be developed as per No. 6.5-5)	Industry standard, high certainty
Erosion of cleared areas and post-mining landform		
Minimise		
	Detailed design of clearing, pits and haul roads and associated drainage controls is also undertaken, which takes into account clearing and development activities and site-specific activities.	Established practice at Huntly and Willowdale Mine, high certainty
Rehabilitation		
	Vertical faces re-shaped to achieve acceptable grades that blend in with the surrounding natural forest landscape (< 18º slope). Slopes must always be less than 18 degrees. No landscaped pit is to have a slope greater than 15 degrees for more than 20 metres unless it is on contour of the surrounding forest floor.	Established practice at Huntly and Willowdale Mine, high certainty
	Open and mined areas are rehabilitated as soon as practicable, with rehabilitation undertaken as presented in Section 2.2.4.	Established practice at Huntly and Willowdale Mine, high certainty
	Ripping carried out on contour with a multi-tyne. Some batters and banks need not be deep ripped, but must be scarified or shallow ripped, to avoid bringing up rocks. Interceptor banks constructed during contour ripping on steeper areas to assist in erosion control.	Established practice at Huntly and Willowdale Mine, high certainty
	Establishment of a soil profile resembling undisturbed areas, as far as practicable, which includes an approximately 1.5 m thick, friable layer of topsoil, overburden and ripped substrate.	Established practice at Huntly and Willowdale Mine, high certainty
	Vegetation establishment through rehabilitation aids ground stabilisation.	Industry standard, high certainty
	Topsoil and overburden are appropriately stripped and stored for use in rehabilitation. Alcoa proactively identifies areas for rehabilitation in close proximity to stripping areas to enable rehabilitation materials to be used without storage where practicable to do so.	Established practice at Huntly and Willowdale Mine, high certainty
	Mine and open areas are planned to minimise disturbance where possible by utilising existing roads, conveyors and open areas.	Established practice at Huntly and Willowdale Mine, high certainty
	Rehabilitation targets ensure open areas are minimised, with a prioritisation process utilised and increase rehabilitation area completed each consecutive year, to achieve a minimum of 3,159 ha between 2024 to 2027.	Established practice at Huntly and Willowdale Mine, high certainty
	Rehabilitation pit slope storage capacity is designed utilising the rehabilitation water model based upon 1% annual exceedance probability (AEP) 24-hour design event, whereby any surface water run-off and associated erosion is contained within the pit.	Established practice at Huntly and Willowdale Mine, high certainty
	Rehabilitation will meet completion criteria set out in the Rehabilitation Management Plan and Schedule (Appendix 8).	Established practice at Huntly and Willowdale Mine, high certainty
	Ripping (pre-landscaping, post-landscaping and contour ripping) of rehabilitated areas occurs to improve infiltration and control surface water run-off	Established practice at Huntly and Willowdale Mine, high certainty
	Rehabilitation will be monitored as presented in Section 2.2.4. Post rehabilitation UAV survey and analysis – collected in the second winter to identify any erosion that does not meet completion criteria or effects trafficability of the area.	Established practice at Huntly and Willowdale Mine, high certainty

No.	Potential Impacts and Mitigations	Industry standard, best practice and certainty of effectiveness
	Visual inspections of rehabilitated areas for stability.	Established practice at Huntly and Willowdale Mine, high certainty
	If required, remediation plans are developed and rehabilitation rework is completed as soon as practicable.	Established practice at Huntly and Willowdale Mine, high certainty
Contamination from spills and/or leaks from storage and handling of hazardous materials and wastes		
Avoid		
	Construction and operational vehicles and equipment will use PFAS free fire-fighting foams.	Established practice at Huntly and Willowdale Mine, high certainty
	Wastes apart from treated sewage effluent will be transported off-site for recycling or disposal at a licenced waste facility. PFAS is treated on site treatment plant.	Established practice at Huntly and Willowdale Mine, high certainty
Minimise		
	Haul trucks and light vehicles will be refuelled as far as practicable at designated fuel bays.	Established practice at Huntly and Willowdale Mine, high certainty
	Mobile fuel tankers that service heavy equipment in the field will be limited to 15 m^3 capacity.	Established practice at Huntly and Willowdale Mine, high certainty
	Storage of all hydrocarbon and chemicals within the Mine DEs will be undertaken within appropriately sized secondary containment in accordance with *Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 1997* as applicable to specific materials. Storage will take into consideration the requirements of WQPN 56 Tanks for fuel and chemical storage near sensitive water resources (DWER, 2018)	Industry standard, high certainty
	Planned major maintenance of operations and construction vehicles and equipment will occur within workshops, as far as practicable.	Established practice at Huntly and Willowdale Mine, high certainty
	Hazardous materials and wastes will be stored at designated construction compounds or other storage facilities in accordance with *Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 1997* as applicable to the specific materials. Storage will take into consideration the requirements of WQPN 56 Tanks for fuel and chemical storage near sensitive water resources (DWER, 2018) and WQPN 65 Toxic and hazardous substances (DWER, 2015)	Industry standard, high certainty
	All wastes will be temporarily stored in designated containers and compounds prior to transport off-site for recycling or disposal at a licenced waste facility.	Established practice at Huntly and Willowdale Mine, high certainty
	Construction and operations will have an emergency response plan that includes the requirements of WQPN 10 *Containment spills – emergency response plan* (DWER, 2020)	Industry standard, high certainty
	Spill response equipment will be maintained at the designated construction compound during construction, or mine facilities during operations in accordance Huntly Mine Emergency Response Plan.	Established practice at Huntly and Willowdale Mine, high certainty
	Staff will be trained in spill response and clean up to enable effective and efficient clean-up of any spills which may occur.	Established practice at Huntly and Willowdale Mine, high certainty
	All spills or leaks will be reported and remediated as soon as practicable, in accordance with Alcoa procedures.	Established practice at Huntly and Willowdale Mine, high certainty
	Incident reporting and investigation will be conducted in accordance with Alcoa's procedures to reduce the likelihood of similar incidents occurring.	Established practice at Huntly and Willowdale Mine, high certainty
	Contaminated areas within the Huntly and Willowdale Mine will be identified at closure and remediated.	Best practice, high certainty
	Inspection of spill locations after clean-up is completed to ensure all contaminated soil is removed and managed accordingly.	Established practice at Huntly and Willowdale Mine, high certainty

Table 5-59 Objectives, triggers and contingency actions for terrestrial environmental quality

Potential Impact	Objective	Trigger	Contingency action
Soil salinisation as a result of clearing for mining	• Where salinity risk has been identified through previous data, rehabilitation is completed as soon as practicable after clearing.	• Rehabilitation of a mine pit has not commenced within three years of clearing.	• Review remaining mining activities scheduled for mine pit and coordinate mining completion as soon as practicable. • Coordinate rehabilitation resources to prioritise commencement of rehabilitation in the mine pit as soon as practicable.
Disturbance of potential ASS	• Avoid disturbance of potential ASS where practicable	• Excavation of more than 100 m^3 of soils or dewatering within swamp deposits for an infrastructure crossing.	• ASS investigation in accordance with the Department of Environment Regulation (DER) (2015b) guidance.
	• Manage ASS disturbance in accordance with approved ASSMP.	• ASS investigation confirms presence of ASS in swamp deposits to be excavated or dewatered.	• ASSMP in accordance with DER (2015b) guidance.
Erosion of post-mining land	• The mine pit areas are landscaped to be stable and to blend in with the surrounding forest.	• Visual inspection identifies erosion features (rills, gullies, tunnelling, etc) on post-mining landforms. • Visual inspection identifies inadequate vegetation establishment to stabilise the post-mining landform. • 24-month rehabilitation erosion monitoring.	• Alcoa to provide documentation and advice to DBCA, where self-certification has resulted in non-standard outcomes. • If DBCA finds that any rework is required based on occasional inspection, then they will state this in writing to Alcoa within three months of the completed inspection. • Alcoa will undertake and monitor remedial works to ensure areas meet the landscape design standard.
Contamination from spills and/or leaks from storage and handling of hazardous materials and wastes	• No contamination of soils from the storage and handling of hazardous materials or waste.	• Spills or leak of hazardous material or waste to soils outside of containment infrastructure	• All spills or leaks will be reported and remediated as soon as possible. • All contaminated soil identified at the spill or leak site will be excavated and the site assessed as clean, visually for minor spills or through soil testing where required. • All contaminated soil from spill or leak sites will be transported off-site for treatment or disposal at an appropriately licenced waste facility.

5.4.7 Assessment of Significant Residual Impact

Alcoa has proposed substantial mitigation that appropriately minimise environmental impacts, as far as reasonably practicable, identified in relation to the Proposal, and adopts rehabilitation processes and standards developed and implemented across Alcoa's operations. This includes avoidance of PFAS in fire-fighting foams and water supplies. Soil contamination will be substantially mitigated through concentrating storage and handling at designated facilities within construction compounds and mine facilities.

Pit and haul road water storage controls will be provided with freeboard and a low permeability liner to minimise the likelihood of overflows or seepage, and monitoring will detect any substantial leakage at an early stage to enable contingency actions (see Section 5.5). The effectiveness of mine rehabilitation, including resilience during drought and heat waves, has been demonstrated through long-term research and monitoring (see Section 6.1), and is at a high level of confidence.

As presented in Table 5-60, the Proposal is not expected to cause significant residual impacts to terrestrial environmental quality.

5.4.8 Environmental Outcomes

Table 5-60 identifies where another statutory decision-making process can mitigate the potential environmental impacts of the Proposal on the environment to be consistent with the EPA's factor objective. As presented, compliance with existing Part V environmental licences are expected to regulate outcomes relating to waste disposal, and requirements under the *Contaminated Sites Act 2003* are expected to regulate outcomes with respect to mine facilities contamination.

Table 5-61 outlines proposed environmental outcomes with respect to terrestrial environmental quality. The proposed environmental outcomes:

- Reflect specific and measurable environmental states;
- Have a clear boundary, size, extent, or limit; and
- Are consistent with the EPA's objective to maintain the quality of land and soils so that environmental values are protected.

Table 5-60: Residual impacts to terrestrial environmental quality

Potential impact	Residual Impact	Likelihood of significant impact
Soil salinisation as a result of clearing for mining	• The Proposal is unlikely to result in widespread salinity impacts to soils. This is due to the predominantly freshwater quality of groundwater (as determined by records from surrounding mine regions). • There are likely to be pockets of saline groundwater within the DE. Groundwater rise that is close to the surface, and may therefore impact soils, will be predominantly in valleys that have been subject to shallow groundwater in the past prior to the decline of groundwater levels with declining rainfall. Accordingly, the modest groundwater mounding expected near valleys that may result in shallow groundwater depths is likely to return soil salinity to past levels. • Rehabilitation will be completed as soon as practicable after clearing to minimise the potential for pockets of saline groundwater mounding.	Unlikely
Disturbance of potential acid sulphate soils	• Mining is not expected to result in oxidation of PASS. Mining occurs above the groundwater table and no dewatering will be undertaken of mine pits. Any potential acid forming materials in the regolith are therefore expected to already be oxidiSed at the depths to which mining occurs. • PASS may potentially be presented in swamps, which will not be subject to mining. Swamps may be disturbed for infrastructure crossings such as haul roads and conveyors, which may cause localised oxidation in the event that ASS are present. • Disturbance to swamps will be minimised and where substantial excavation or dewatering is proposed, ASS investigation will be undertaken. Where ASS is confirmed as present, construction will be in accordance with an approved ASSMP which is expected to effectively mitigate the risk of soil contamination.	Unlikely
Erosion of cleared areas and post-mining landform	• Rehabilitation of cleared areas is expected to provide long-term protection of soils from erosion. Rehabilitation materials (topsoil and overburden) are appropriately stored and used in rehabilitation activities as soon as practicable to reduce the risk of soil degradation and improve rehabilitation outcomes. Appropriate controls and design elements are implemented during engineering stages to reduce the risk of erosion during operations and post closure. • The results of monitoring collectively demonstrate that Alcoa's rehabilitation establishes and persists, including during drought and heat wave events, indicating that a 1.5 m thick friable substrate over regolith containing ancient root channels is an effective growth medium. Accordingly, mine rehabilitation vegetation is expected to be sustained over the	Unlikely

Potential impact	Residual Impact	Likelihood of significant impact
	long-term with resilience to climate change comparable to that of un-mined Northern Jarrah Forest. Mine rehabilitation is therefore expected to provide long-term protection of soils from erosion and associated sediment discharge to streams and reservoirs. • Detailed topographical analysis has not been undertaken over the DEs, however global terrain mapping and historic LiDAR analysis has identified areas where slope angles will be steeper. Most of the land has a slope of less than eight percent. The level of disturbance proposed by the Proposal is minimal compared to historic operations and as such rehabilitation practices established over long-term operations are suited to preventing gully formation. • Monitoring and further rehabilitation is undertaken as necessary.	
Contamination from spills and/or leaks from storage and handling of hazardous materials and wastes	• The potential for soil contamination will be substantially mitigated through all storage and most of the handling of hazardous materials and wastes occurring at designated construction compounds and mine facilities. These will enable provision of containment measures to prevent and contain spills and leaks. Mine facilities will be subject to site investigation and, if required, remediation of contamination upon decommissioning. • All wastes, except for treated sewage effluent, will be transported off-site for recycling or disposal at licenced waste facilities. • The majority of spills and leaks in the field, particularly those from major incidents and involving large volumes, are expected to be identified quickly and the contaminated soils excavated and disposed off-site at a licenced waste facility. Smaller spills and leaks that escape detection are expected to result in localised pockets of soil contamination. These pockets will be overlaid with rehabilitation overburden, topsoil and native vegetation. Pockets of soil contamination remaining in the rehabilitation are expected to biodegrade over time. • Construction and operational vehicles and equipment will use PFAS-free fire-fighting foams. Water supplied for construction and operations will come from public drinking water sources, captured on-site stormwater or from licenced on-site water treatment facilities, where approved for reuse on the Mine. Accordingly, construction and mining are unlikely to cause discharge of PFAS that results in significant soil contamination.	Unlikely

Table 5-61: Proposed environmental outcomes – terrestrial environmental quality

Potential environmental impact	Environmental outcome	Other statutory approval that will assure outcome	Monitoring of outcomes
Soil salinisation as a result of clearing for mining. Erosion of cleared areas and post-mining landform.	All cleared areas within Mine DE rehabilitated to Jarrah Forest ecosystem in accordance with approved completion criteria.	Rehabilitation Management Plan and Schedule developed in accordance with MMP approval conditions and aligns with the Rehabilitation Completion Criteria reviewed by DBCA and approved by the Department of State Development.	Annual monitoring and reporting of rehabilitation extent and performance against completion criteria
Contamination from spills and/or leaks from storage and handling of hazardous materials and wastes.	No operational waste disposal areas located within the Mine DEs, with the exception of mine facilities treated sewage effluent irrigation area.	Environmental licence under Part V of EP Act *Contaminated Sites Act 2003*	Annual reporting of waste disposal.
	PASS study is undertaken for any PASS areas and if required, Management Plans developed.	*Contaminated Sites Act 2003*	Detailed site investigation, remediation action plan and validation report upon facilities decommissioning
	Ensure no acid sulphate soil contamination within the Mine DE or elsewhere attributable to the proposal.		

5.5 Key Environmental Factor – Inland Waters

This section aims to address Tasks 14–17 outlined in the ESD, focusing on inland waters within the Mine DEs and focuses on the following:

- Analyse the significance of key environmental values and anticipated impacts in local and regional contexts. Key significant environmental values to be address, such as:
    - wetlands, including mapped valley floors and associated buffers
    - major waterways, rivers, creeks, and tributaries
    - lakes, riparian areas, and associated buffers
    - groundwater and surface water resources
    - public drinking water areas
    - waterbodies which provide habitat for threatened, priority or conservation significant aquatic fauna, and
    - dam reservoirs.
- Preparation of a public drinking water catchment assessment which considers key risks to significant values from the Proposal and any associated mitigation measures.
- Clarification of:
    - The baseline hydrogeological regime and development of an ecohydrological conceptual model which demonstrates the interactions between water streams and the environment;
    - Beneficial use and an assessment of the potential impacts to inland water values associated with surface water and groundwater abstractions;
    - Pre-disturbance activities that will be undertaken to ensure maximum avoidance and or management of impacts;
    - Any additional measures to ensure avoidance and management of impacts to water reservoirs and the Serpentine Pipehead Dam Catchment Area;
    - Assessment of the environmental outcome of the provisioned 1 km setback;
    - The rehabilitation of stabilised areas and how it has been successful, to ensure impacts to inland water values are minimised; and
    - Where impacts are expected, provide information consistent with EPAs mitigation hierarchy to demonstrate the EPA factor can be met.
- Identify and describe monitoring strategies and governance arrangements for ongoing impact management within the Proposal areas. Where measures are already being implemented, demonstrate how they are successful in minimising impacts to inland water values.

5.5.1 EPA Objective

The EPA's environmental objective of the factor 'Inland Waters' is:

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

For the purpose of EIA, the EPA defines Inland Waters as *the occurrence, distribution, connectivity, movement, and quantity (hydrological regimes) of inland water including its chemical, physical, biological and aesthetic characteristics (quality)* (EPA, 2018).

5.5.2 Relevant Policy and Guidance

5.5.2.1 EPA Policy and Guidance

- Environmental Factor Guideline – Inland Waters (EPA, 2018);
- Instructions on how to prepare an Environmental Review Document (EPA, 2024c); and
- Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans (EPA, 2024b).

5.5.2.2 Other Policy and Guidance

- Preventing acid and metalliferous drainage – Leading practice sustainable development program for the mining industry (Department of Industry, Science and Resources, 2016);
- Western Australian water in mining guidelines (Department of Water, 2013);
- Water Quality Protection Note 15 – Basic raw materials extraction (DWER, 2019);
- Water Quality Protection Note 44 – Roads near sensitive water resources (Department of Water, 2006);
- Water Quality Protection Note 52 – Stormwater management at industrial sites (Department of Water, 2010);
- Water Quality Protection Note 81 – Tracks and trails near sensitive water resources (Department of Water, 2015);
- Water Quality Protection Note 83 – Infrastructure corridors near sensitive water resources (Department of Water, 2007a);
- Statutory Guidelines for Mine Closure Plans (DMIRS, 2023);
- Australian Drinking Water Guidelines (NHMRC, NRMMC, 2011);
- Strategic policy: Protecting public drinking water source areas in Western Australia (Department of Water, 2016);
- Manual for the application of Health-based Targets for Drinking Water Safety (Water Services Association of Australia, 2015);
- Serpentine Dam Catchment Area and Serpentine Pipehead Dam Catchment Area Drinking Water Source Protection Plan (Department of Water, 2007b);
- South Dandalup Dam & South Dandalup Pipehead Dam Catchment Areas Drinking Water Source Protection Plan – WRP 55 (Department of Environment, 2005);
- Ecological Character Description of the Peel-Yalgorup Ramsar Site (Hale & Butcher, 2007);
- Peel-Yalgorup System Information Sheet on Ramsar Wetland (RIS) (Department of Conservation and Land Management, 2003a); and
- Significant Impact Guidelines 1.1 – Matters of National Environmental Significance (DoE, 2013a).

Alcoa has applied the Environmental Factor Guideline for Inland Waters to the activities described within the Proposal. Alcoa has actively taken steps to identify areas that may require additional protection and applied the mitigation hierarchy to protect the quality of surface and groundwaters, and by extension, those species that may exist within these environments. These protection measures are outlined in Section 5.5.8. Protection measures discussed in this section demonstrate Alcoa's commitment to protecting hydrological regimes and their associated values.

5.5.3 Receiving Environment

A description of the receiving environment is presented in the Inland Waters Baseline Report presented in Appendix 48. A summary of that information presented in the Inland Waters baseline report regarding the hydrological and hydrogeological settings at the Willowdale and Huntly DEs is presented in the following sections.

5.5.3.1 Baseline Studies

Key inland waters studies undertaken to support this ERD are summarised in Table 5-62; studies 5 to 7, 10, and 11 are provided in Appendix 49 to Appendix 52 and Appendix 48 respectively. These studies and surveys support the EIA process and provide confidence in the current knowledge within the Mine DEs and surrounding area.

5.5.3.2 Knowledge and Survey Gaps

This ERD has been developed utilising the Pinjarra Alumina Refinery Revised Proposal (Assessment 2253) ERD and associated studies as a comparison. In addition, given the time bound nature of this Proposal, cumulative impacts are addressed within the Assessment 2253 ERD.

Publicly available data has been utilised to define conservation category wetlands, resource enhancement wetlands, major waterways, lakes, rivers, creeks and tributaries, water and public drinking water resources in combination with any Alcoa specific information on stream zone locations and associated vegetation. In some instances, a desktop review has occurred, however further site assessments (for example, definition of conservation category and resource enhancement wetlands) is required. In these instances, Alcoa is committed to undertaking pre-clearance surveys and ensuring impacts are avoided or minimised as per the WRMP and this ERD's associated outcomes.

Surface water quality and flow, particularly in the Willowdale region, remains inadequately characterised due to the absence of hydrodynamic modelling for the North Dandalup, Conjurnup Pipehead, Stirling, and Samson Brook reservoirs. This gap limits the comprehensive understanding of the existing conditions in these reservoirs, which are relevant to the catchments associated with Mine DE locations.

The generalised hydrogeology of these Mine DEs has not been thoroughly assessed; current hydrogeological conditions are presumed to be like those of adjacent catchments, based on limited studies. Furthermore, there is insufficient groundwater monitoring data and analysis for potential GDEs and potential impacts within both Mine DEs.

Current groundwater data analysis regarding levels and chemistry of the baseline environment, existing disturbance and proposed Disturbance Footprint is limited. It is noted that additional groundwater bores and monitoring is occurring, with outcomes included in relevant Drainage Control Management Plans. The historical groundwater data at Willowdale Mine DE is insufficient due to the historical nature of the majority of existing disturbance, noting limited proposed disturbance is planned. The Water Resource Management Plan (WRMP) also provides describes the current state of knowledge, future study opportunities along with the risk-based monitoring program being deployed to inform water related key environmental objectives and knowledge gaps.

The following publicly available third-party information has been utilised in the Proposal baseline study (Appendix 55), as is considered to be accurate and representative of baseline conditions:

- Bureau of Meteorology historical weather and climatic information
- Stream flow data from DWER gauging stations
- Historical surface water quality, microbiological, health-related and aesthetic-related and geochemistry data from DWER and Government of Western Australia. The historical information has been utilised for North Dandalup Reservoir, Serpentine Dam, Big Brook, Serpentine River, and South Dandalup tributaries and Reservoir, Conjurup Creek Reservoir and Stirling Dam

The baseline study and Assessment 2253 studies (Appendix 56, 57 and 59) have been utilised to undertake a public drinking water catchment assessment (Appendix 58).

Numerical modelling could be employed to support quantitative impact assessments that consider climate variables and cumulative mining effects, including uncertainty analysis. Moreover, modelling scenarios that incorporate both baseline conditions and mining activities, alongside mitigation strategies, could clarify the benefits of key interventions, such as rehabilitation efforts within specified timeframes. Lastly, fate and transport modelling for key contaminants from known source areas (e.g., PFAS concentrations in dams) could provide critical insights into potential environmental impacts.

To address drinking water protection, a quantitative risk assessment is necessary to evaluate potential contaminants based on specific quantities and source locations. Contaminant modelling is required to estimate concentrations upon interaction with drinking water sources, alongside a comprehensive identification of all potential contaminants that could affect these sources. Currently a qualitative approach has been undertaken, with consideration to adjacent studies.

Table 5-62: Inland Waters studies

Year	Author	Study Name	Study details	Appendix
2007	Croton, J. T., & A. J. Reed	Hydrology and bauxite mining on the Darling Plateau	Published review of the interaction between bauxite mining, mine rehabilitation and Darling Plateau hydrology based on Alcoa's operations in Perth's water supply catchments. Study focussed on three hydrological issues, namely stream turbidity, yields and salinity.	Appendix 54
2013	Croton, J. T., G. T. Dalton, K. A. Green and J. A. Dalton	Hydrological response of the O'Neil to McCoy mining area	Study undertaken to assess hydrological responses associated with Alcoa's operations in the O'Neil-to-McCoy mine area. Study consisted of a review of groundwater elevation, groundwater salinity and surface water salinity measurements in combination with estimates of stream inflow and water storage volume for the Serpentine Reservoir, culminating in an estimation of the effect of mining on the reservoir salinity.	Appendix 55
2017	Grigg, A. H.	Hydrological response to bauxite mining and rehabilitation in the Jarrah Forest in southwest Australia	Published review of the hydrological response to bauxite mining in the Jarrah Forest, which was considered by the author to differ from other land uses due to the excavation and removal of the regolith during mining activities. Review consisted of monitoring of streamflow, rainfall, groundwater levels and salinity, and leaf area index (LAI) in three catchments – one subject to mining, a second subject to intensive forest thinning treatment, and the third an untreated control area – over a 36-year period.	n/a
2019	Dixon, R. N. M., A. H. Grigg and M. S. Alam.	Modelling long-term flow and salinity response to bauxite mining in the Upper Serpentine catchment	Investigation into the potential effects of bauxite mining on stream flows and stream salinity into the Serpentine Reservoir. Assessment included using the semi-distributed conceptual catchment hydrology model, *LUCICAT™*, to consider possible long-term mine plans and a projected changing climate over a 40-year planning horizon.	n/a
2021	GHD	Hydrological setting and understanding – Myara North and Holyoake	Report presenting an understanding of (i) the surface water and groundwater settings in the Myara North and Holyoake mine areas, and (ii) potential impacts on the hydrology of these mining areas from bauxite mining at the Huntly mine.	Appendix 49
2022	GHD	Hydrology and water quality assessment for the Huntly Mine	Technical study presenting an (i) understanding of the setting of the Huntly Mine, and (ii) known impacts to environmental receptors because of bauxite mining and related activities.	Appendix 50

Year	Author	Study Name	Study details	Appendix
2022	GHD	Drinking water risk assessment (DWRA) Serpentine, Serpentine Pipehead, South Dandalup, and Wungong Brook Catchments	Surface hydrology model development over the Myara North and Holyoake mine regions, which covered the Serpentine, Serpentine Pipehead and South Dandalup public drinking water source areas (PDWSAs). A DWRA was also completed to determine impacts to these reservoirs from mining activities.	N/A
2024	GHD	Bore Completion Report, O'Neil	This study included the installation and development of 15 bores screened in water-bearing units, and the completion of in situ falling-head and/or rising-head (hydraulic) tests in those bores with sufficient saturated thicknesses.	N/A
2020	Grigg and Kinal	On the contribution of groundwater to streamflow in laterite catchments of the Darling Range, south-western Australia.	The study indicated a more variable, and overall, a more significant, contribution by groundwater to streamflow in laterite catchments of the Darling Range in south-western Australia than has been previously acknowledged. It demonstrated processes leading to groundwater recharge are more important to streamflow generation and does not support conceptualisations of downslope shallow throughflow, disconnected by bauxite mining, as the dominant process.	Appendix 56
2024	WSP	Public Drinking Water Catchment Risk Assessment.	Public DWRA of the proposed Huntly and Willowdale Mine DEs. The purpose of this assessment is to identify potential risks to the PDWSAs from Alcoa's proposed mining activities within the Huntly and Willowdale Mine DEs, with the considerations of all significant risks associated with the Proposal and any mitigation measures.	Appendix 51
2024	WSP	Baseline Inland Water Assessment – Huntly and Willowdale.	This report describes existing (baseline) hydrological and hydrogeological conditions for the two Mine Development Envelopes (DEs) where mining operations are planned (Huntly and Willowdale).	Appendix 48

5.5.4 Surface Water Systems

5.5.4.1 Regional Hydrology

The Huntly and Willowdale DEs are in the catchments of the Serpentine, Murray, and Harvey rivers. These rivers originate within the Darling Plateau, an undulating lateritic regolith over Archaean granite (with dolerite intrusions) generally elevated between 250 and 350 m above sea level (asl), and flow westward off the Darling Plateau, via incised valleys in the Darling Scarp, and onto the Swan Coastal Plain (SCP).

The Darling Plateau retains extensive forested land of the Northern Jarrah Forrest (NJF). Land use around the Huntly mine region includes a mix of agricultural land, native bushland, state forest, and small settlements. Further south at Willowdale, the land use is a mix of agricultural land, conservation park, native bushland, and forested areas. The Darling Scarp marks the separation of the Darling Range from the Swan Coastal Plain.

Approximately 61% of the Huntly Mine DE is situated within the regulated sub-catchments of the Serpentine Dam catchment. An additional 26% falls within the regulated catchments of Conjurunup Creek Pipehead Dam, North Dandalup Dam, and South Dandalup Dam (Table 5-63). Approximately 5,100 ha (13%) of the Mine DE are located within the unregulated catchments (Table 5-63).

More than half of the Willowdale Mine DE (~79%) lies within the unregulated sub-catchment of Middle Murray. Approximately 21% is located within the regulated sub-catchment of Stirling Dam, and approximately 1% crosses into the Samson Brook sub-catchment area (Table 5-64).

The Serpentine, Murray, and Harvey rivers wind through the SCP towards the coast and discharge to the Peel-Harvey Estuary, which itself also forms part of the Peel-Yalgorup Ramsar site, a designated *Ramsar* Wetland of International Importance. Across the SCP, the region has been heavily developed for urban and agricultural use.

Extensive farming on the Pinjarra Plain has led to high nutrient levels and pollution in the Peel-Harvey Estuary.

Rainfall is greatest along the western edge of the Darling Plateau near the Darling Scarp, decreasing to the north and to the east. Average annual rainfall ranges from 500 mm in the northeast of Darling Scarp to around 1,300 mm near the Huntly DE. At Willowdale average annual rainfall ranges between about 900 and 1,100 mm.

Public water supply dams have been developed along the Darling Scarp to exploit the water resources created by the relatively high rainfall over the forested regolith, and the relative elevation that enables gravity supply to urban and agricultural water demand on the Swan Coastal Plain (SCP) (Figure 5-50 and Figure 5-51). The water supply dams have substantially reduced riverine flows within the SCP downstream and have been subject to declining rainfall and inflows since the 1970s.

The Serpentine River and Big Brook Causeway lie within the Huntly DE and flow north-westwards before reaching the Serpentine Dam.

The Murray River's upper catchment lies east of the NJF and covers extensive agricultural land uses of the Avon-Wheatbelt, which results in elevated salinity in this river (DWER, 2024b). The main channel of the Murray River is not dammed for water supply, though major

tributaries of the river comprising the North and South Dandalup rivers lie over forested catchments and are dammed.

The Harvey River intersects the majority of the Willowdale mine. The catchment is highly regulated with seven large dams managed for different purposes:

- The Harvey Dam, Waroona Dam, Drakes Brook Dam and Wokalup Creek Pipehead Dam are used to supply the Harvey and Waroona irrigation districts.
- The Stirling Dam and Samson Brook Dam are used to supply the Integrated water supply scheme (IWSS).

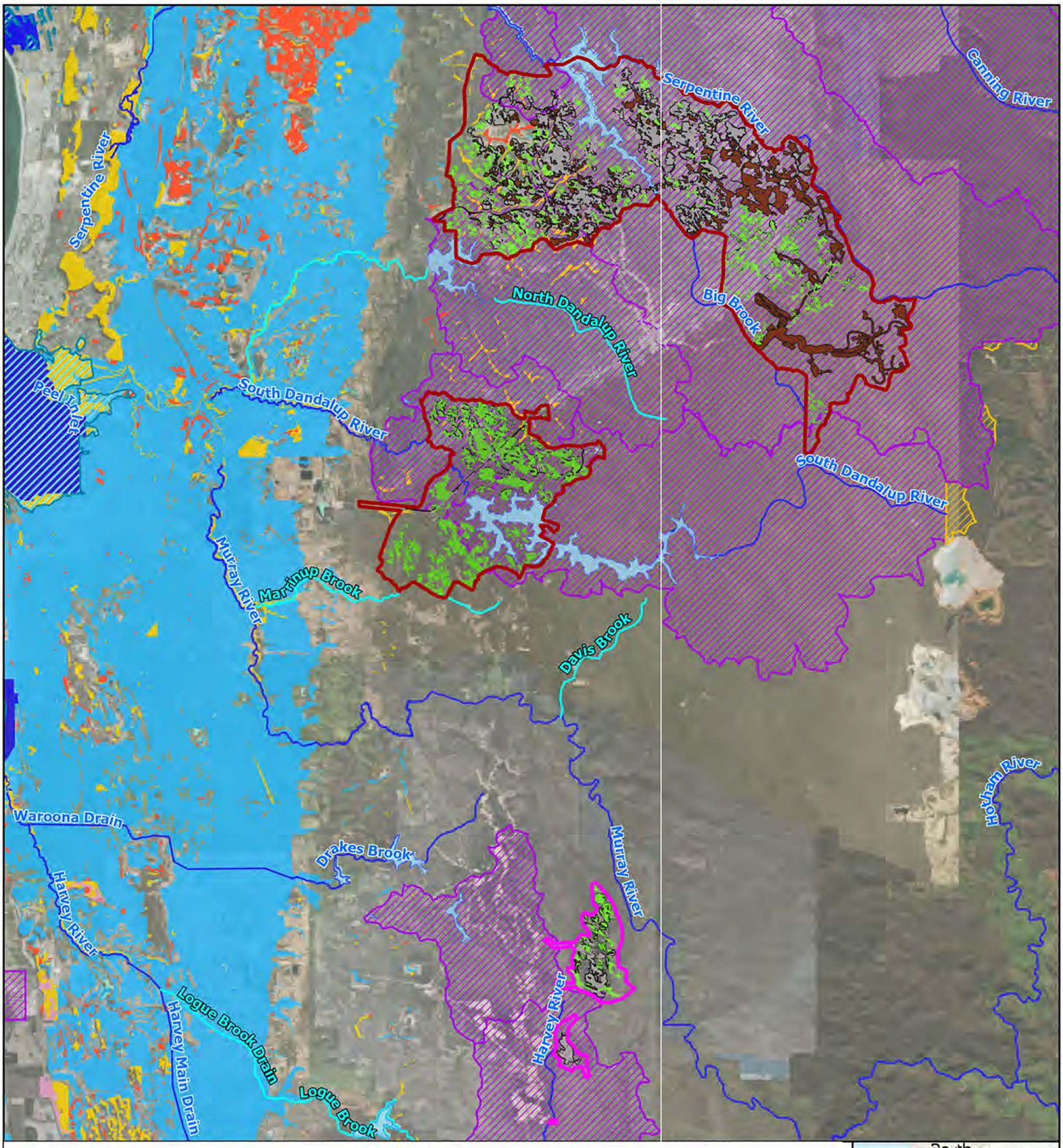
Inland water features from a regional context, and for the Huntly Mine DE, and Willowdale Mine DE are shown on Figure 5-50, Figure 5-51, and Figure 5-52 respectively.

Table 5-63: Regional hydrology – Huntly Mine DE

Catchment	Sub-catchment	Catchment area (ha)	Catchment area within DE (ha)	Proportion of catchment within DE (%)	Open area (ha)	Open area proportion of catchment (%)	Rehabilitation Area (ha)	Rehabilitation area proportion of catchment (%)
Unregulated sub-catchments								
Serpentine River Catchment	Dirk/Karnet	13945.1	2679.9	19.2	308.5	2.2	154.0	1.1
Murray River Catchment	Oakley	4796.4	318.8	6.6	8.5	0.2	0.0	0.0
	Marrinup Brook	7759.5	2100.4	27.1	23.4	0.3	0.0	0.0
Unregulated sub-catchment area subtotal		26500.9	5099.1	19.2	340.4	1.3	154.0	0.6
Regulated sub-catchments								
Serpentine River Catchment	Serpentine Dam Catchment Area	66160.9	22526.9	34.0	2800.8	4.2	1561.8	2.4
	Serpentine Pipehead Dam Catchment Area	2881.3	1146.7	39.8	72.6	2.5	14.7	0.5
Murray River Catchment	Conjurunup Creek Pipehead Dam Catchment Area	3921.7	1582.2	40.3	39.0	1.0	0.0	0.0
	North Dandalup Pipehead Dam Catchment Area	15141.1	2827.5	18.7	401.4	2.7	121.3	0.8
	South Dandalup Dam Catchment Area	30804.5	3984.7	12.9	8.5	0.0	0.0	0.0
	South Dandalup Pipehead Dam Catchment Area	3854.5	1883.1	48.9	40.7	1.1	0.0	0.0
Regulated sub-catchment area subtotal		122764.0	33951.2	27.7	3363.0	2.7	1697.8	1.4

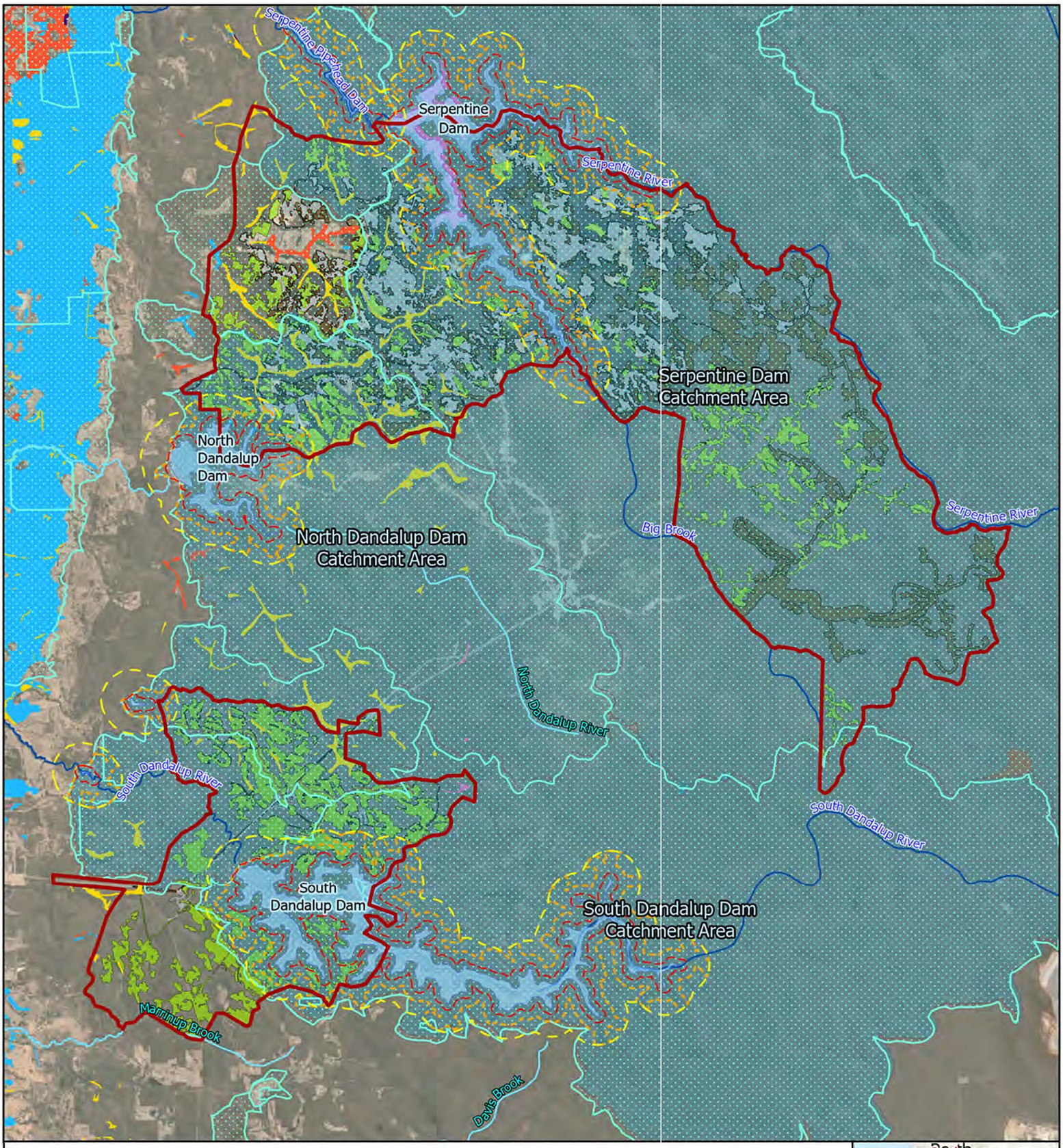
Table 5-64: Regional hydrology – Willowdale Mine DE

Catchment	Sub-catchment	Catchment area (ha)	Area within DE (ha)	Proportion of catchment within DE (%)	Open area (ha)	Open area proportion of catchment (%)	Rehabilitation Area (ha)	Rehabilitation area proportion of catchment (%)
Unregulated sub-catchments								
Murray River Catchment	Middle Murray	94814.9	1677.4	1.8	222.2	0.2	169.5	0.2
Unregulated sub-catchment area subtotal		94814.9	1677.4	1.8	222.2	0.2	169.5	0.2
Regulated sub-catchments								
Harvey River Catchment	Samson Brook Catchment Area	7451.7	32.0	0.4	3.8	0.0	0.4	0.0
	Stirling Dam Catchment Area	25366.6	426.7	1.7	110.2	0.4	62.8	0.2
Regulated sub-catchment area subtotal		32818.3	458.7	1.4	114.0	0.3	63.2	0.2



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-50 Inland Waters Regional Context – Mine DEs



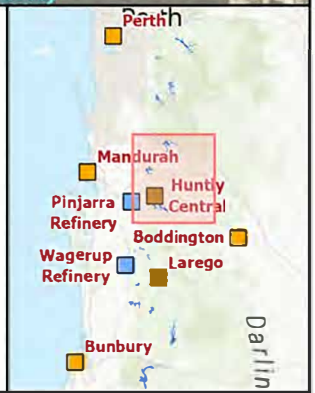
Legend

- Proposed Disturbance Footprint
- Open Areas
- Proposed Rehabilitation Footprint
- Huntly Mine DE
- 1km Reservoir Protection Zone (RPZ) TWL
- OCA1
- OCA2
- Reservoirs

Hydrography Linear (Hierarchy) (DWER-031)
- Major Rivers
- Minor Rivers
- Catchments

Public Drinking Water Source Areas (DWER-033)
- P1
- P2

Geomorphic Wetlands, Swan Coastal Plain (DBCA-019)
- Conservation
- Multiple Use
- Not Applicable
- Not Assessed
- Resource Enhancement



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-51 Huntly Mine DE - Inland Waters Regional Context

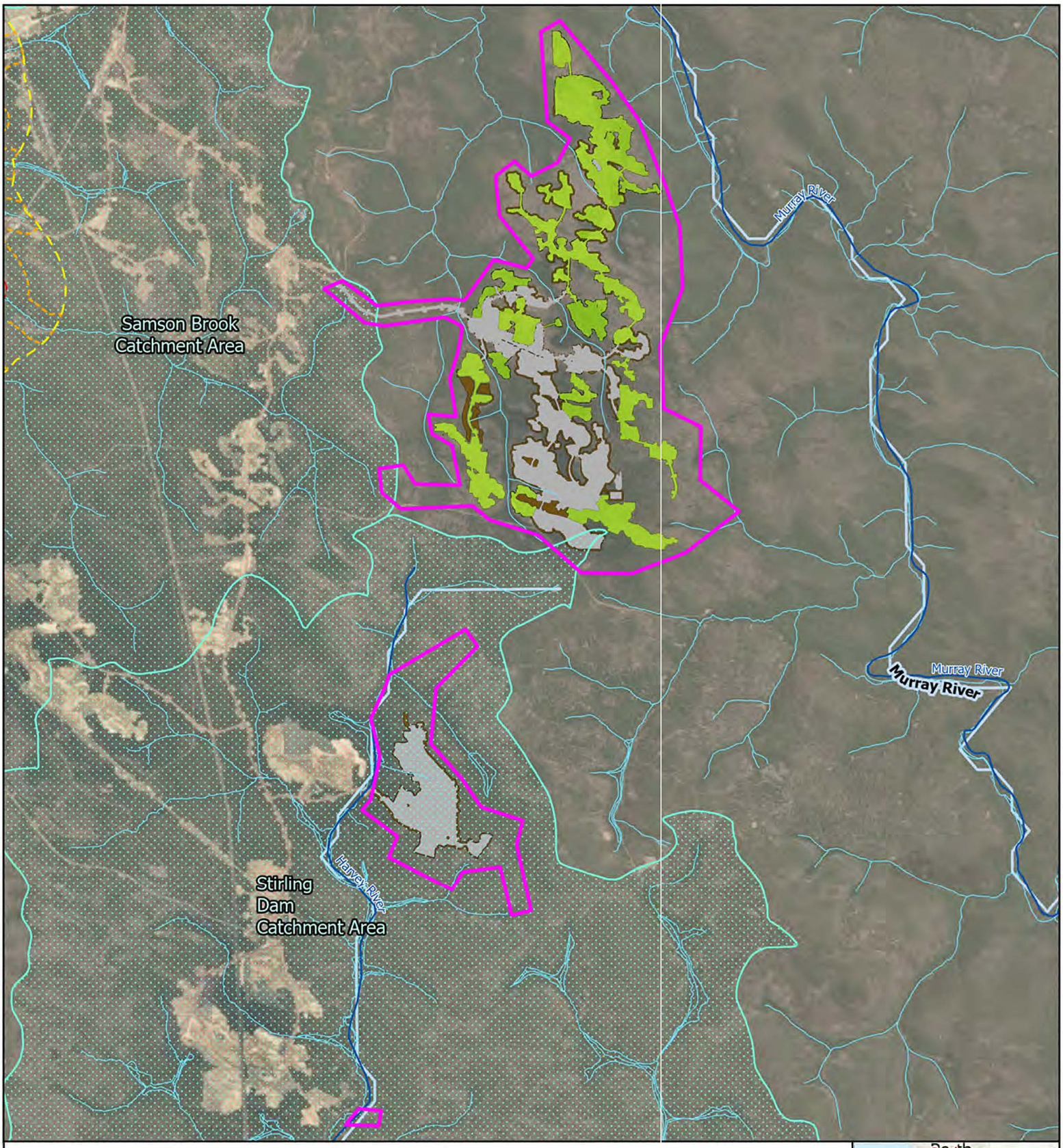
Kilometres
0 2 4 6 8 10

Scale: 1:185,926 at A4

Date Printed: 27/02/2025

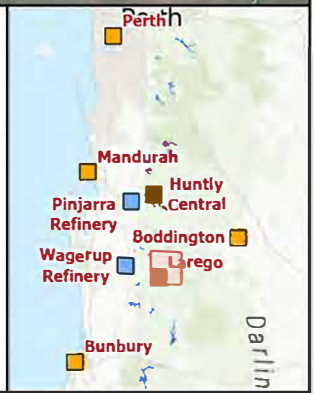
N

Alcoa



Legend

- Willowdale Mine DE
- 1km Reservoir Protection Zone (RPZ) TWL
- OCA1
- OCA2
- Hydrography Linear (Hierarchy) (DWER-031)
- Major Rivers
- Catchments
- Streams
- Rivers
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-52 Willowdale Mine DE - Inland Waters Regional Context

Kilometres

0 0.75 1.5 2.25 3 3.75 4.5

Scale: 1: 70,000 at A4

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Alcoa

5.5.4.2 Water Relevant land Use and Activities

The surface waters and catchments located within the Mine DEs are utilised for social, cultural and economic land uses as follows.

- Huntly DE:
  - Recreation and tourism uses: Serpentine Dam wall, Serpentine River downstream;
  - Cultural heritage sites: registered Aboriginal cultural heritage sites along the Serpentine and South Dandalup rivers;
  - Public water supplies: Serpentine, Serpentine Pipehead, North Dandalup and South Dandalup dams;
  - Agricultural site: farm adjacent to the Serpentine Main Dam; and
  - Industry (timber).
- Willowdale DE:
  - Recreational uses: camping, swimming and canoeing along Murray River downstream of Willowdale mining DE, including Logue Brook;
  - Cultural heritage sites: Murray River registered Aboriginal cultural heritage site;
  - Public water supply: Stirling and Samson Brook dams; and
  - Industry (timber).

5.5.4.2.1 Public Drinking Water

Alcoa's mining lease is located within drinking water catchments which are classified as a Priority 1 Public Drinking Water Source Area (PDWSA). Both mining DEs are located within drinking water catchment areas.

The Water Corporation (WC) has a responsibility for controlling access within PDWSAs and Reservoir Protection Zones (RPZs). RPZs are defined in the *Metropolitan Water Supply, Sewerage, and Drainage By-laws 1981*, and generally extend to 2 km from the top water level of any reservoir, back into the defined PDWSA. RPZs are located within both mine sites, surrounding the Serpentine Main, Serpentine Pipehead, North Dandalup, South Dandalup, Samson, and Stirling dams.

At Huntly, the mining areas intercept Serpentine, Serpentine Pipehead, North Dandalup, Conjurunup Creek Pipehead, South Dandalup, and South Dandalup Pipehead PDWSAs. These PDWSAs form part of the Integrated Water Supply Scheme (IWSS) that supplies water to the metropolitan areas in Western Australia. The two water supply dams (Serpentine and North Dandalup) release limited flows (<10% of inflow) to maintain downstream beneficial uses. Alcoa has some minor infrastructure located within the South Dandalup PDWSA.

Desalination inputs from the Integrated Water Supply Scheme (IWSS) are released to these reservoirs. These inputs are substantial and are projected to make up an increasing proportion of the source water in the future.

The Willowdale mine region intercepts the catchments of the Harvey, Stirling, Logue Brook, and Sampson Brook dams. Two of these dams, Stirling, and Sampson Brook, are used for drinking water purposes and their catchments comprise PDWSAs.

Catchment access is restricted, with permissible activities listed in Source Water Protection plans for each PDWSA. The PDWSAs at Huntly and Willowdale are predominantly managed as Priority 1 with small areas of private land managed as Priority 2. Source water is treated with chlorine, and then transferred to the Integrated Water Supply Scheme (IWSS) for distribution to downstream customers.

5.5.4.2.2 Mining

The region is part of an ancient landscape with deeply weathered soils and lateritic profiles, which are ideal for bauxite formation. Mining occurs within the Huntly and Willowdale DEs, specifically for bauxite (noting that copper and gold is mined on the eastern margin of the Darling Plateau at the Boddington Mine).

5.5.4.2.3 Agriculture

In addition to mining, the regions also support agricultural activities on the margins of the Darling Plateau. The Mediterranean climate, with hot, dry summers and mild, wet winters, is conducive to livestock farming and crop cultivation.

5.5.4.2.4 Timber Industry

The landscape features a mix of native bushland, and forested areas, particularly jarrah forests. The Jarrah Forest is an interim Australia bioregion which is divided into two sub-regions, the Northern Jarrah Forest (NJF) and Southern Jarrah Forest (SJF).

The NJF has been subject to widespread timber harvesting since the 1870's. The NJF subregion within ML1SA predominantly comprises juvenile to immature forest structures (assuming maturity as early as 70 years), reflecting the widespread timber harvesting over the last century (Alcoa 2023–2027 MMP).

5.5.4.2.5 Parklands and Reserves

A review of the Western Australia regional land use mapping (Landgate, 2024) indicates State Forest is the predominant regional land use within both DEs. Approximately 370 ha of the Huntly DE is within the Serpentine National Park, whilst approximately 80 ha of the Willowdale DE is within Lane Poole Reserve.

5.5.4.3 Local Hydrology

5.5.4.3.1 Huntly Mine DE

The Huntly mining DE spans both the Serpentine Dam, North Dandalup Dam, and South Dandalup Dam catchments. In the Serpentine Dam catchment, tributaries generally flow from the southeast, continuing northwest to join the Serpentine River and Big Brook Causeway before reaching the Serpentine Dam.

5.5.4.3.1.1 Serpentine River

The majority of the Serpentine River within and upstream of the Huntly DE (Myara and O'Neil mine regions) is regulated by the Serpentine Dam. This dam was constructed in 1961 and supplies the Serpentine Pipehead Dam (Figure 5-51), constructed in 1957.

The Serpentine Dam collects water from a 664 km^2 catchment and has a full supply capacity of 137.7 gigalitres (GL). It diverts most flow from its catchment for this beneficial use. The

catchment is proclaimed under the *Metropolitan Water Supply Sewerage and Drainage Act 1909* (MWSSD Act), and primarily classified as a Priority 1 Public Drinking Water Source Areas (PDWSA), with some private lands within the catchment classified as Priority 2. The Dam is surrounded by a 2 km wide 'reservoir protection zone' (RPZ), extending from the reservoir top water level, includes the reservoir itself but does not extend outside the catchment area.

Releases to the Serpentine River downstream of the Pipehead Dam are managed according to the Serpentine allocation statement (Department of Water and Environmental Regulation, 2017). This allows for the release of 0.8 GL/year for 'low-inflow' years (inflow to dam less than 30 GL) and 0.86 GL/year for 'standard' years (inflow to dam greater than 30 GL). For average inflows of approximately 14 GL/year, as was recorded over 2008-2015 (Department of Water and Environmental Regulation, 2017), Serpentine Dam would divert more than 94% of inflow from the Serpentine River catchment upstream, with less than 6% released downstream. For average inflows of approximately 33 GL/year, as was recorded between 1975-2008 (Department of Water and Environmental Regulation, 2017), the dam would divert more than 97%, with less than 3% released downstream.

Plate 5-3 below presents the recorded and projected inflows into the Serpentine Dam, reproduced from the Serpentine River allocation statement (Department of Water and Environmental Regulation, 2017). As presented, inflows have decreased from an average of approximately 87 GL/yr over 1960-1974 to approximately 33 GL/yr over 1975-2008, to approximately 14 GL/yr over 2008-2015 (Department of Water and Environmental Regulation, 2017).

There are two active gauging stations located at Serpentine River (614035) and Big Brook (614037), both upstream of the Serpentine Main Dam. Plate 5-3 to Plate 5-5 inclusive below show the long-term streamflow seasonality Serpentine River and Big Brook, respectively. Each 'box whisker' represents the maximum (top blue line), 75th percentile (top of solid blue bar), mean (grey line), 25th percentile (bottom of solid blue bar) and minimum (bottom blue line) for each month. The long-term values are calculated using the entire record of monthly mean data for that month.

The observed data indicates that the streamflow is seasonal, with higher variability during the winter months. The Serpentine River and tributaries typically flow from June to November.

The seasonal streams are interspersed by headwater swamps that occupy colluvial and alluvial sediments in valley floors. The swamps comprise seasonally waterlogged wetlands with distinct vegetation types (Section 5.5.5.6.1).

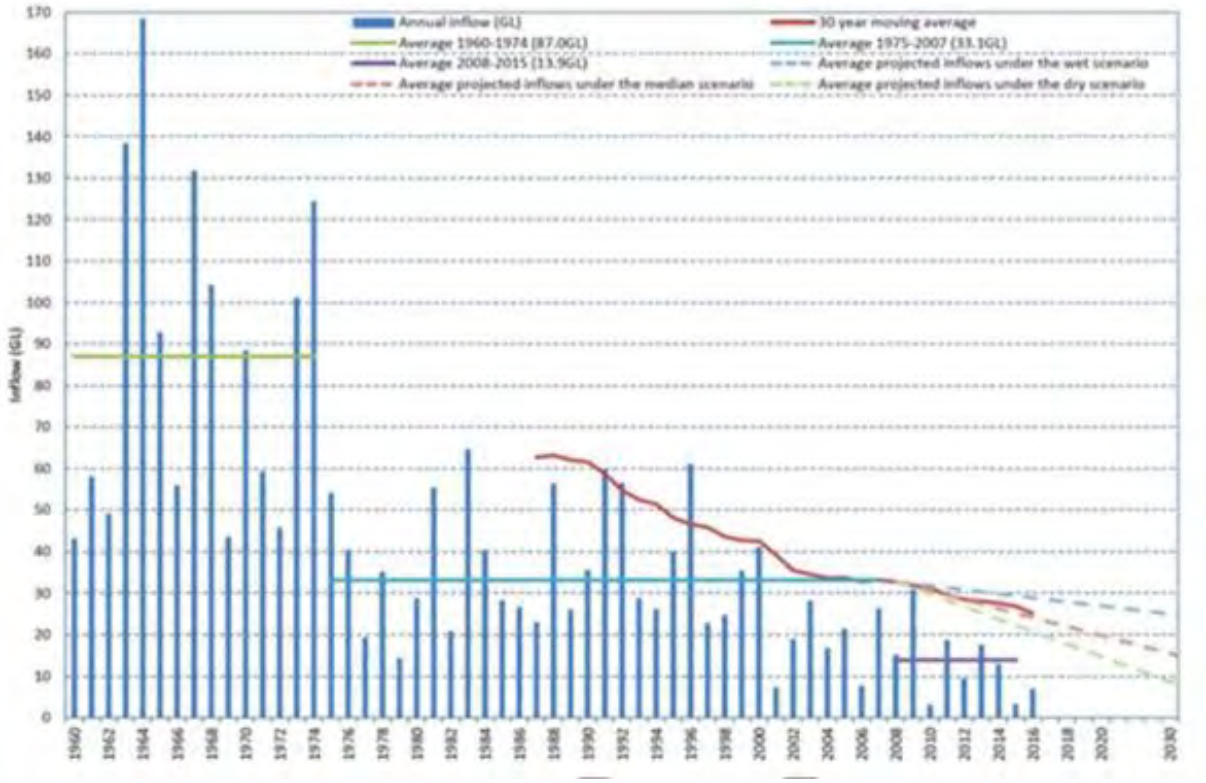


Plate 5-3: Inflows into Serpentine Dam as presented in Serpentine River allocation statement (Department of Water and Environmental Regulation, 2017)

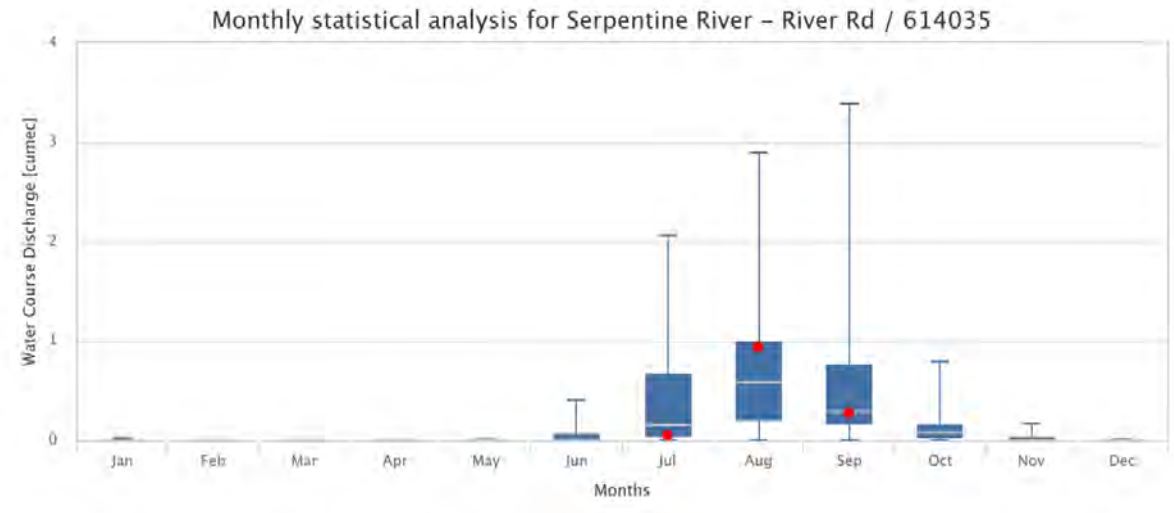


Plate 5-4: Long-term (1982-1998, 2008-September 2024) flow seasonality at Serpentine River (614035) over monthly average streamflow for 2022 (red dot)

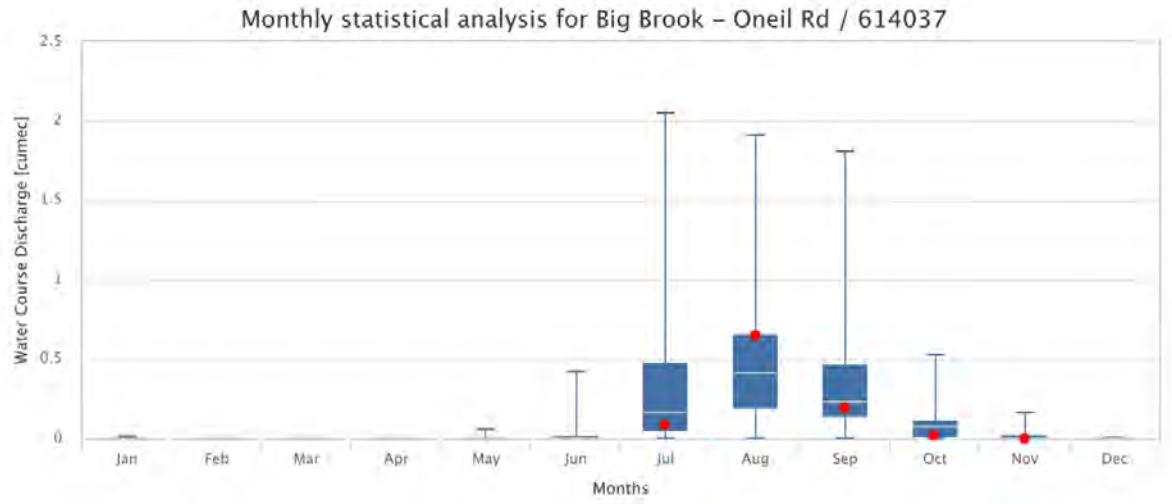


Plate 5-5: Long-term (1983- September 2024) flow seasonality at Big Brook (614037) over the monthly average streamflow for 2022 (red dot)

5.5.4.3.1.2 South Dandalup River

The South Dandalup River is the major tributary of the South Dandalup Dam catchment. It flows from east to west before reaching the South Dandalup located on the western extent of the Darling Plateau.

The South Dandalup Dam has a capacity of 208.2 GL and is the largest reservoir supplying the Integrated Water Supply Scheme (IWSS). Its catchment covers 311 km^2 and is proclaimed under the *MWSSD Act 1909*. Like the Serpentine Dam, its catchment is predominantly classified as a priority 1 PDWSA, with a small area of private land managed as a priority 2 PDWSA.

The South Dandalup Dam is also connected to the South Dandalup Pipehead Dam, which acts as a pump back for South Dandalup Dam, adding to the available water for supply (Alcoa, 2023b).

Plate 5-6 below illustrates the long-term seasonality of streamflow at the South Dandalup Tributary (614007). This data indicates streamflow is seasonal, with greater variability during winter months. However, the range of flow remains relatively small, with the highest recorded streamflow being less than 0.05 cubic metres per second (m^3/s) in winter.

The South Dandalup River is regulated by South Dandalup Dam. This dam was constructed in 1974, resulting in the development of Lake Banksiadale (Figure 5-51), and now supplies the South Dandalup Pipehead Dam which was constructed in 1971.

South Dandalup Dam and the South Dandalup Pipehead are used for public drinking water supply, including that from the Integrated Water Supply Scheme (IWSS); there are no releases from the dams to the South Dandalup River downstream.

Annual inflow to the South Dandalup Dam averaged 36.5 GL between 1948 and 1974, and decreased to an average of 18.8 GL/year between 1974 and 2003.

The South Dandalup Dam is supplied by seasonal streams including the South Dandalup River and un-named tributaries. The South Dandalup River is located upstream and outside of the Huntly/Del Park mine region but a few un-named tributaries originate within the Mine DE. There is limited flow gauging in the South Dandalup Dam catchment with gauging

stations on the South Dandalup River at Gordon (614060) upstream of the Mine DE, as well as on un-named tributaries at Skeleton Road (No. 614059) and Pindalup (No. 614043). South Dandalup River is seasonal with flow predominantly in June to November as presented in Plate 5-6 below.

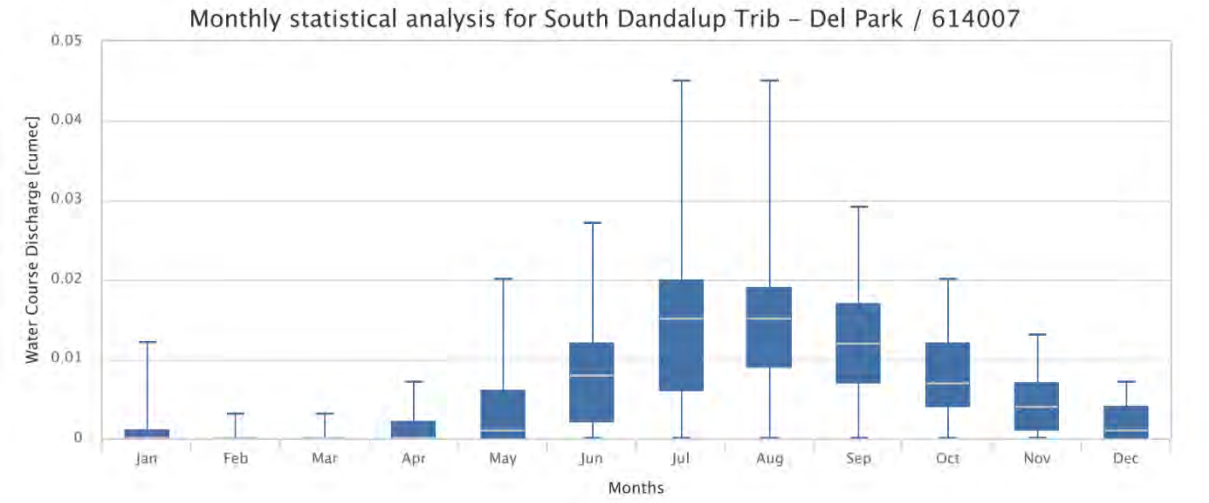


Plate 5-6: Long-term (1974-2017) flow seasonality at South Dandalup Tributary (614037)

5.5.4.3.1.3 North Dandalup River

The Huntly Mine DE lies partially in the catchment of the North Dandalup River, which is regulated by North Dandalup Dam (Figure 5-51). North Dandalup Dam was constructed in 1994 and supplies the IWSS.

North Dandalup Dam is used for public drinking water supply and diverts most of the flow from its catchment for this beneficial use. Releases from the dam to North Dandalup River downstream are managed according to the North Dandalup allocation statement (DWER, 2017), which allows for the release of 0.46 GL/year for 'low-inflow' years (inflow to dam less than 30 GL) and 0.51 GL/year for 'standard' years (inflow to dam greater than 30 GL). Accordingly, for average inflows of approximately 8 GL/year, as was recorded over 2008-2015 (DWER, 2017), North Dandalup Dam would divert more than 95%, with less than 5% released downstream. For inflows exceeding 30 GL/year, the dam would divert more than 9%, with less than 2% released downstream.

The North Dandalup Dam is supplied by the North Dandalup River. There is a stream gauging station at North Road (No. 614036), approximately 1 km upstream of the reservoir. Annual flows in the North Dandalup River and North Dandalup Dam have declined from an average of 37.6 GL/year between 1960-1974, to an average of 17.1 GL/year between 1975-2007, to finally an average of 8.4 GL/year between 2008-2015 (DWER, 2017).

The North Dandalup River is interspersed by a series of headwater swamps that occupy colluvial and alluvial sediments in valley floors. The North Dandalup River downstream of the dam meanders to the west then south-west for approximately 24 km, through predominantly cleared agricultural land, joining with the South Dandalup River and discharging into the Murray River (Figure 5-51). The Dandalup River confluences with the Murray River approximately 8 km downstream of Pinjarra town and approximately 17 km upstream of the Peel Inlet.

5.5.4.3.1.4 Conjurunup Creek

The Huntly / Del Park mine region of Huntly DE lies partially in the catchment of Conjurunup Creek, also known as Little Dandalup Creek, which is regulated by the Conjurunup Pipehead Dam. Conjurunup Pipehead Dam was constructed in 1992 and is used to pump back to North Dandalup Pipehead Dam, which supplies the IWSS.

Annual streamflow in Conjurunup Creek was 9.5 GL between 1948 to 2000, decreasing to 7.4 GL between 1975 to 2004, and finally decreasing to an average of 1.5 GL/year between 2008 to 2018. The Conjurunup Pipehead Dam was generally subject to annual overflows from 2000 to 2010 and during 2013, however, overflows have generally not occurred during the lower rainfall period from 2011 to 2020.

Conjurunup Creek downstream of the Pipehead meanders west for approximately 6.7 km through State Forest, the Darling Scarp and agricultural land on the SCP before discharging to the South Dandalup River (Figure 5-51). The South Dandalup River meanders west from the confluence with Conjurunup Creek, flowing for approximately 12 km through agricultural land on the SCP and joining with the North Dandalup River.

5.5.4.3.2 Willowdale Mine DE

The Willowdale mining DE extends over the catchments of both the Murray and Harvey rivers. The Willowdale mine region intercepts the catchments of Harvey Dam, Stirling Dam, Logue Brook Dam and Sampson Brook Dam (Figure 5-52). Two of these dams, Stirling and Sampson Brook, are used for drinking water and their catchments comprise PDWSAs.

5.5.4.3.2.1 Murray River

The Murray River is one of few rivers close to Perth that has no dams used for public water supply, leaving its natural flow and beauty intact. The Murray River flows into the Peel Inlet and stretches 134 km into the Peel Region. The river flows approximately 25 km downstream of Pinjarra townsite and discharges into the Peel Inlet, part of the Peel-Yalgorup System Ramsar wetlands.

The Keats mine region predominantly lies within the Murray River catchment. Downstream of the Willowdale DE, the Murray River runs through Lane Poole Reserve, a protected forest area with several recreational facilities enabling camping, swimming and canoeing activities.

5.5.4.3.2.2 Harvey River

The Wills and Tasman mine regions of the Willowdale DE lie fully within Harvey River catchment. The Harvey River is regulated by five dams, two of which (Stirling and Samson Brook) supply the IWSS.

The Stirling Dam catchment has an area of 254 km² and is primarily classified as a Priority 1 PDWSA. Elevation in the catchment ranges from 80 m Australian height datum (AHD) at the reservoir to 320 m AHD at the head of the catchment. Water inflow to the reservoir is mostly from surface runoff over the winter months. However, there is subsurface flow year-round due to the gravelly nature of the geology in the Darling Range.

Samson Brook Dam impounds a reservoir of 8 GL. It has a catchment area of about 1 km^2 at top water level of 245 m AHD, with the estimated average annual streamflow into the reservoir estimated to be about 16.6 GL from a catchment area of 64 km² (Alcoa, 2023b).

An active streamflow monitoring station is located upstream of Stirling Dam (613002 at Harvey River, Dingo Road). This station however is located 15 km downstream of the Willowdale Mining DE and therefore has not been considered in this assessment.

5.5.4.4 Surface Water Quality

Surface water quality is described in this section. Where available, these discussions and accompanying assessments have been based on those data sets, interpretations and understandings presented in the Inland Waters Baseline Report provided in Appendix 48. Where data gaps were present, however, inference and interpretations from surface waters in similar, analogous, catchments and scenarios in other nearby DEs have been used to assess the likely impacts of the proposed activities on surface water quality.

5.5.4.4.1 Salinity

DWER monitors salinity and water temperature at several locations within the Huntly Mine DE. Data ranges for Big Brook and South Dandalup tributary monitoring stations are presented in Table 5-65.

There are no DWER water quality monitoring stations within the Willowdale Mine DE; this is recognised as a data gap. It is noted however, that whilst the upper reaches of the Harvey River flows adjacent to Keats and Wills mine regions of Willowdale Mine DE, there are no major tributaries of either the Murray or Harvey Rivers emanating from within the DEs.

Table 5-65: Surface water quality monitoring stations relevant to Huntly DE

Site ID	Site name	Data type	Data temporal range
614037	Big Brook – Oneil Road	Temperature	1995 – present
		Electrical conductivity	1995 – present
614007	South Dandalup Trib – Del Park	Temperature	2001 – 2009
		Electrical conductivity	2001 – 2009

The long-term salinity trend at Big Brook is shown in Plate 5-7 below. The data shows a generally fresh system, with a long-term average electrical conductivity typically below 350 microSiemens per centimetre (µS/cm). Salinity levels are higher and more variable during winter and spring months, coinciding with periods when groundwater discharge is expected to increase due to seasonally high groundwater levels. On the contrary, during the summer autumn months salinity measurements are more reflective of episodic rainfall runoff only.

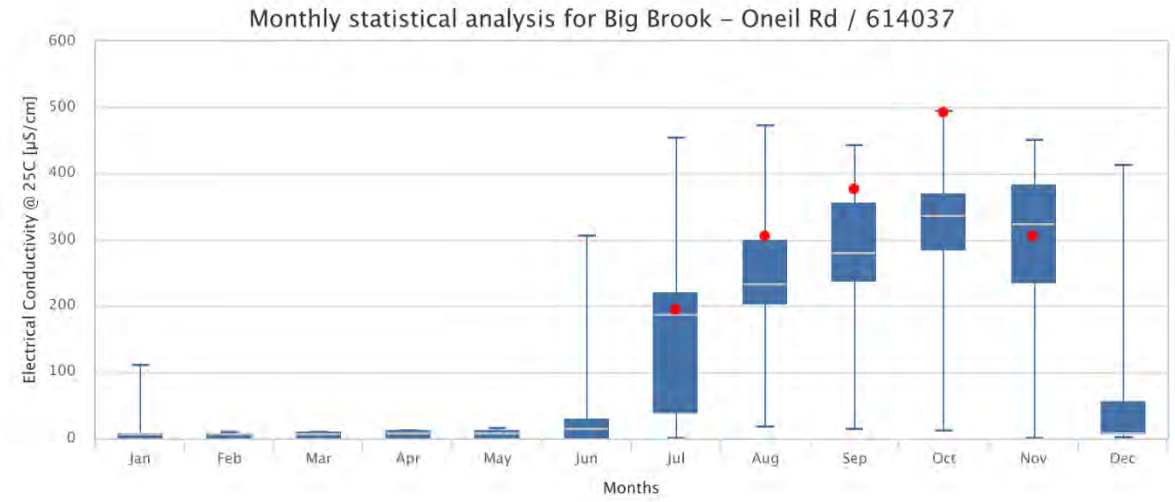


Plate 5-7: Long-term salinity trend at Big Brook (614037) over the monthly average salinity for 2022 (red dot)

Plate 5-8 below presents long-term salinity trends in the South Dandalup Tributary. Surface waters are generally fresh, with a long-term average of less than 300 µS/cm. There is less variability from August to January, as shown by the smaller 25th to 75th percentiles on each box plot. Whilst not studied in detail, salinity trends observed may indicate a greater reliance on groundwater baseflow throughout the year, with seasonal variations in groundwater levels having a lesser influence on surface water salinity, compared to monitoring data from Big Brook. The discontinuation of salinity data monitoring post 2009 has created a data gap.

Salinity monitoring reported by GHD (2022a), and provided in Appendix 52, reported that salinity levels measured across the Huntly Mine region were fresh ranging from 109 µS/cm to 587 µS/cm between August 2020 and January 2021.

At the Willowdale Mine DE, surface water salinity remains a data gap. However, the Keats mine region forms part of the Murray River catchment, which is known to be elevated in salinity due to its headwaters commencing in agricultural districts east of the forested Darling Range. The Tasman and Wills mine regions of Willowdale Mine DE are in the headwater catchment area of the Harvey River, where salinity may be comparable to other undeveloped forested catchment areas of the Darling Range.

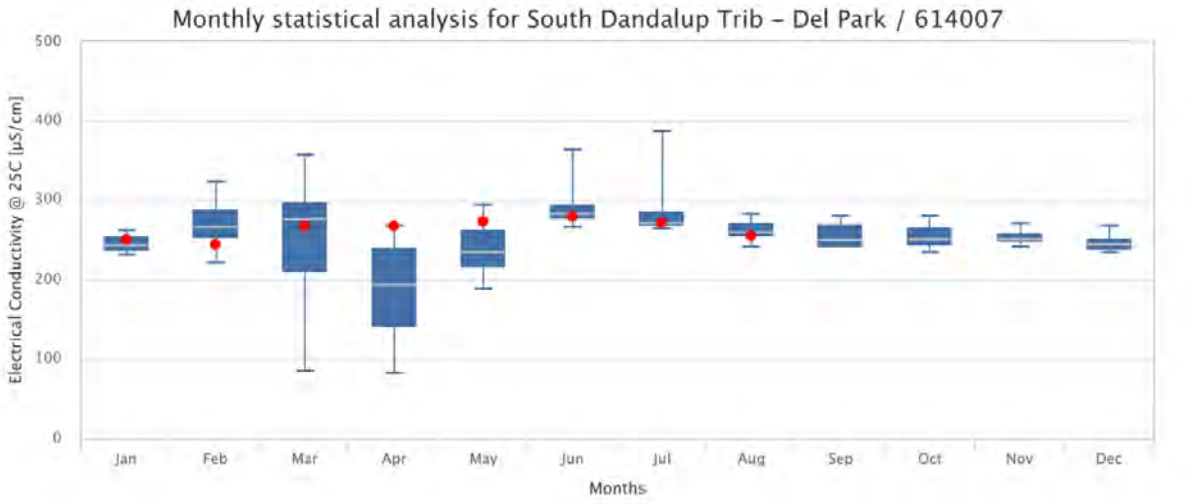


Plate 5-8: Long -term salinity trend at South Dandalup Tributary (614007) over the monthly average salinity for 2009 (red dot)

5.5.4.4.2 Turbidity

Recent turbidity sampling has been completed by GHD (2022a), and provided in Appendix 52, in 2020 and 2021 in the Huntly mine region, outside the Proposal Mine DEs. Turbidity was sampled along the Serpentine River and at a few tributary confluences along the Serpentine River as well as east of the South Dandalup Dam along the South Dandalup River and other tributaries draining into South Dandalup Dam. No turbidity sampling was conducted from within the Mine DE.

Overall, the surface water at monitored locations was reported to be relatively clear, with turbidity to 10 nephelometric turbidity units (NTU) in proximity to Myara and O'Neil, and turbidity to 40 NTU east of Huntly and Del Park mine regions (GHD, 2022a).

For both Huntly and Willowdale DE, continuous turbidity data has recently been collated (Rare Environment, 2024a) by Alcoa using its Water Quality Monitoring Systems (WQMSs). Under Schedule 1, Division 2 ("Controls on activities") of the Environmental Protection (Darling Range Bauxite Mining Proposal) Exemption Order 2023, a drainage incident is defined as 'runoff from a disturbance area to the surrounding environment of surface water that has a turbidity of at least 25 NTU for a period of at least 1 hour'. Aligning with this definition (Rare Environment, 2024a)":

> *"a 'true' stream turbidity exceedance event is that is caused by an actual increase in stream water turbidity, whilst a 'false' stream turbidity exceedance event is that caused by factors other than an actual increase in stream water turbidity (i.e., organic debris covering the monitor such as sticks, leaves, algae, stream water turbulence or air bubbles and fluctuating water levels that intermittently cover the monitor lens and then recede)".*

For the Huntly DE, a total of 10 potential drainage or 'true' incidents were identified from that data collected during May 2024, with subsequent investigations indicating these events were not mining related (Rare Environment, 2024b). For June 2024, 38 potential turbidity events identified, but no evidence of mining contribution was found (Rare Environment, 2024c).

For Willowdale DE, a total of three events were flagged in May 2024 where turbidity levels above 25 NTU occurred for an hour or more. In June 2024, one potential turbidity event during the reporting period for further investigation, with the outcome of this suggesting this incident was not mining related (Rare Environment, 2024c).

The above results demonstrate that whilst there are occasional turbidity exceedances (as monitored and reported by Alcoa) within the catchments relevant to Huntly DE and Willowdale DE, investigations to date indicate these short turbidity exceedance events are not mining related.

5.5.4.4.3 Metals

Dissolved metal concentrations have been measured in the Myara North and the Holyoake mine region surface water sampling events between August 2020 to January 2021 (GHD, 2022a) (Appendix 52).

For both regions, concentrations of arsenic, beryllium, boron, cadmium, chromium, mercury, selenium, and vanadium were below the lower order of analytical reporting (LOR) for all samples.

When detected, concentrations of other heavy metals were below drinking water guidelines. There were though a few occasional exceedances of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG) 95% and 99% freshwater species protection assessment criteria for zinc.

No other exceedances of the ANZG 95% or 99% freshwater species protection criteria were reported.

Overall, the surface water metal concentrations are typical of ‘natural’ conditions and representative of the geological setting (GHD, 2022a).

5.5.4.4.4 Nutrients

Monitoring of nutrient concentrations conducted at the Huntly mine region confirms nutrient concentrations are typically low and consistent with the land use (i.e., predominantly undeveloped and forested catchment with a lack of applied nutrients or point sources) (GHD, 2022a) (Appendix 52). At most sample sites nutrient concentrations reported less than the LOR or below available criteria with the following exceptions:

- occasional detections of total nitrogen and NOx;
- occasional exceedances of total phosphorus for Australian and New Zealand Environment and Conservation Council (ANZECC) upland river guideline criteria; and
- some sample exceedances of total nitrogen and total Kjeldahl nitrogen for ANZECC South-western Australia.

5.5.4.4.5 Microbiological Contaminants

Escherichia coli (E. coli) and enterococci are used as the primary indicator of faecal contamination of drinking-water supplies (NHMRC, NRMMC, 2011). The Australian Drinking Water Guidelines (ADWG) suggests that the E. coli and enterococci should not be detected in any 100 mL sample of drinking water. According to the World Health Organization (WHO), a zero count of E. coli per 100 mL of water is considered safe for drinking. A count of 1 to 10 MPN/100 mL is regarded as low risk; 11 to 100 MPN/100 mL is regarded as a medium

risk (Odonkor & Mahami, 2020). Note that the use of either MPN or cfu is based on the method used for the detection of E. coli and both are valid measurements for E. coli limits.

Microbiological testing in Serpentine and South Dandalaup catchments, adjacent to or upstream of the Huntly Mine DE (GHD, 2022a) (Appendix 52), identified detections of microbiological parameters such as enterococci and E. coli at all sampling sites. This widespread detection is consistent with the presence of fauna species within the land use setting. E. coli concentrations ranged from less than 1 organism/100 mL to 200 organisms/100 mL, while enterococci concentrations ranged from less than 1 organism/100 mL to 90 organisms/100 mL (GHD, 2022a). No sampling from within the Huntly Mine DE has been completed and whilst this remains a data gap, the catchment conditions are expected to be similar to results from adjacent catchment areas.

No sampling has been conducted from within or adjacent to the Willowdale DE, however the undeveloped nature of the catchment is likely to have similar conditions to those observed at Huntly due to the presence of fauna species within the forested land use setting.

The Government of Western Australia conducts testing on raw water at the adjacent dams within and downstream of the mine DE, including Serpentine Main Dam, South Dandalup Dam, and Samson Brook Dam, for the purpose of drinking water source protection reporting. A review of the testing results is provided:

- For Serpentine Main Dam, water is tested on a weekly to monthly basis, particularly during summer and autumn for the period of January 2000 to March 2006. The analysis concluded that positive E. coli counts were recorded in 40% of samples, with 1% of the positive samples exceeding 20 cfu/100 mL (DoW, 2007).
- For North Dandalup Dam, the values were taken for the period November 2013 to October 2018. Positive E. coli counts were recorded in 22.2% of samples. However, none of the samples had E. coli counts greater than 20 MPN/100 mL during the review period (DWER, 2019).
- For South Dandalup Dam, test was conducted for the period of July 1999 to July 2004, positive E. coli counts were recorded in 34% of samples from South Dandalup Dam, with 7% of the positive samples exceeding 20 cfu/100 mL (DoE, 2005a).
- For Conjurunup Creek Pipehead Dam, positive thermotolerant coliform counts were recorded in 90% of samples, with 44% of the positive samples exceeding 20 cfu/100 mL during the review period of July 1999 to July 2004 (DoE, 2005b).

The review of the government data suggests there is very little-to-no difference in the presence of microbiological communities and counts within the raw water samples collected during periods of mine activity or mine inactivity, within the dam catchment areas.

5.5.4.4.6 Other Potential Contaminants

Water quality sampling for potential surface water contaminants of concern (due to contamination sources) were assessed by GHD (2022a) within the Serpentine and South Dandalup Dam catchments, outside of the Mine DE. The summary of the monitoring outcomes is as follows:

- All samples analysed for the following volatile and semi-volatile organic compounds returned results below laboratory LORs:
  - Benzene, toluene, ethylbenzene and xylene compounds, known as BTEX;
  - Total recoverable hydrocarbons compounds[10]; and
  - Explosives.
- Per- and polyfluoroalkyl substances (PFAS) compounds were below the LOR in all but nine locations, with all detections below the drinking water assessment criteria.
- Samples analysed for pesticides were below the LOR in all but one location; dieldrin (an organochlorine pesticide which has a low solubility and therefore is persistent in the environment) was detected in one sample at a concentration less than the drinking water assessment criteria.
- Samples analysed for polycyclic aromatic hydrocarbons (PAHs) were below the LOR in all but one location, noting this sample was collected immediately after a controlled burn through the catchment. Burnt soil and wildfire ash are known to be natural sources of PAHs (Choi, 2014).

Detailed site investigations for areas within the Huntly Mine DE and to the west of the Willowdale Mine DE have been undertaken at locations considered as potential contaminated sites. These studies have been summarised in Section 5.4.4.5.

5.5.4.5 Reservoir Aesthetic and Health Related Water Quality

In addition to microbial data, the Government of Western Australia assessed health-related and aesthetic water quality for Serpentine Main Dam, South Dandalup Dam, and Samson Brook Dam.

5.5.4.5.1 Huntly DE

From the Serpentine Dam, aesthetic water quality analyses for raw water monitored from January 2000 to February 2006 reported occasional exceedances of aesthetic water quality guidelines, the median values for all parameters over the six-year sampling period fall within the ADWG guideline values (DoW, 2007). It is noted that Alcoa were not conducting mine operations within the Serpentine Dam catchment during the monitored period.

For the North Dandalup Dam, raw water was analysed for aesthetic water quality and health-related chemicals between November 2013 to October 2018. While there have been occasional exceedances of aesthetic water quality guidelines, the median values for all parameters over the five-year sampling period fall within the ADWG guideline values (DWER, 2019). Additionally, there have been no recorded exceedances of health-related guidelines.

[10] Total recoverable hydrocarbons analysis is a nonspecific quantitative screening tool used to determine the quantity of organic compounds in a water sample, including petroleum hydrocarbons, and is limited to those organic compounds that can be extracted by solvent (dichloromethane) and detected by GC-FID (gas chromatography-flame ionisation detector).

For the South Dandalup Dam, there have been occasional exceedances of aesthetic water quality guidelines during the monitored period from July 1999 to July 2004, however the median values for all parameters over the entire sampling period fall within the ADWG guideline values (DoE, 2005a), (WSP, 2024).

Health-related water quality parameters (including inorganics, heavy metals, industrial hydrocarbons, and pesticides) were monitored at South Dandalup Dam between July 1999 and July 2004. Results indicate there have been no recorded exceedances of health-related guidelines (DoE, 2005a).

For Conjurunup Creek Pipehead Dam, water quality analyses for raw water were conducted from July 1999 to July 2004. The results have been compared with the ADWG values set for drinking water. While there have been occasional exceedances of aesthetic water quality guidelines, the median values for all parameters over the entire sampling period fall within the ADWG guideline values (DoE, 2005b). Raw water is also analysed for chemicals potentially harmful to human health, including inorganics, heavy metals, industrial hydrocarbons, and pesticides. There have been no recorded exceedances of health-related guidelines.

Topographic elevation and slope with reference to surface water of the Huntly Mine DE is shown on Figure 5-53 and Figure 5-55 respectively.

5.5.4.5.2 Willowdale DE

Water quality monitoring was undertaken within at the Stirling Dam, from April 1998 to March 1999 at the dam outlet. All parameters (turbidity, pH, colour, iron, manganese and aluminium) over the entire sampling period fall within the NHMRC ADWG guideline values, (Water and Rivers Commission, 2000).

A review of water quality sampling and analysis completed at Serpentine Main Dam, North Dandalup Dam, South Dandalup Dam, South Dandalup Pipehead Dam, Conjurunup Creek Pipehead Dam, and Stirling Dam indicate that both health-related and aesthetic parameters generally fall within acceptable Australian Drinking Water Guidelines. Although there are occasional exceedances of aesthetic guidelines, the median values over extended monitoring periods remain within ADWG standards, and there have been no recorded exceedances of health-related guidelines.

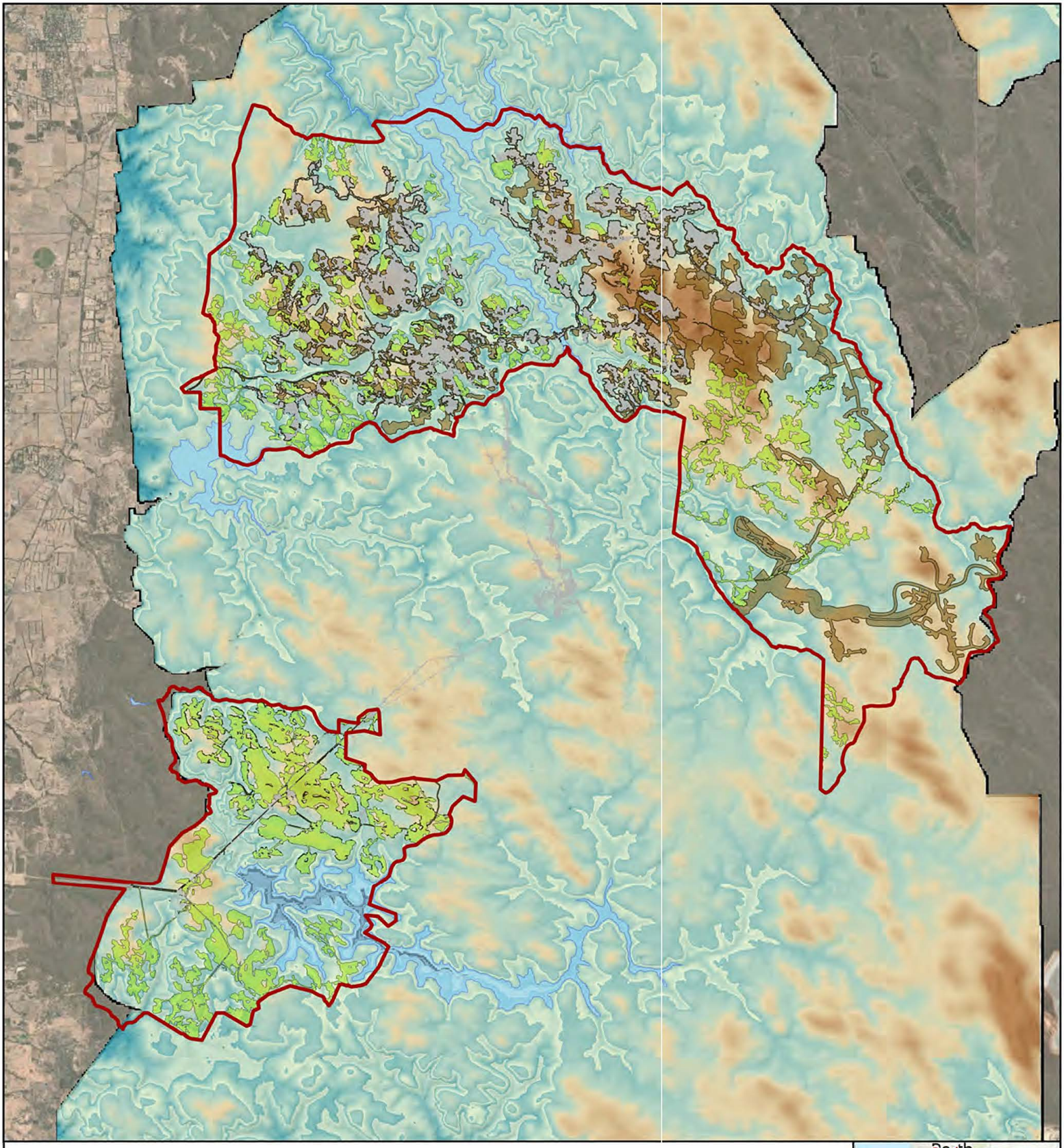
In the absence of specific guidelines for raw-water quality, all results have been compared with the ADWG values set for drinking water, which define the quality requirements at the customer's tap. However, the raw-water data presented does not represent the quality of drinking water distributed to the public.

Potential data gaps in the water quality assessments for the public drinking water source dams are noted as follows:

- Temporal gaps: there may be periods without data collection, which could miss seasonal variations or short-term extreme events;
- Spatial gaps: sampling taken at the dams might not be near or at the downstream of the mining DEs;
- Parameter gaps: not all possible/relevant contaminants have been tested for, notably metals and metalloids; and

- Frequency of monitoring: infrequent sampling might not capture rapid changes in water quality.

Topographic elevation and slope with reference to surface water of the Willowdale Mine DE is shown on Figure 5-54 and Figure 5-56 respectively.



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-53 Huntly Mine DE - Topographic Elevation

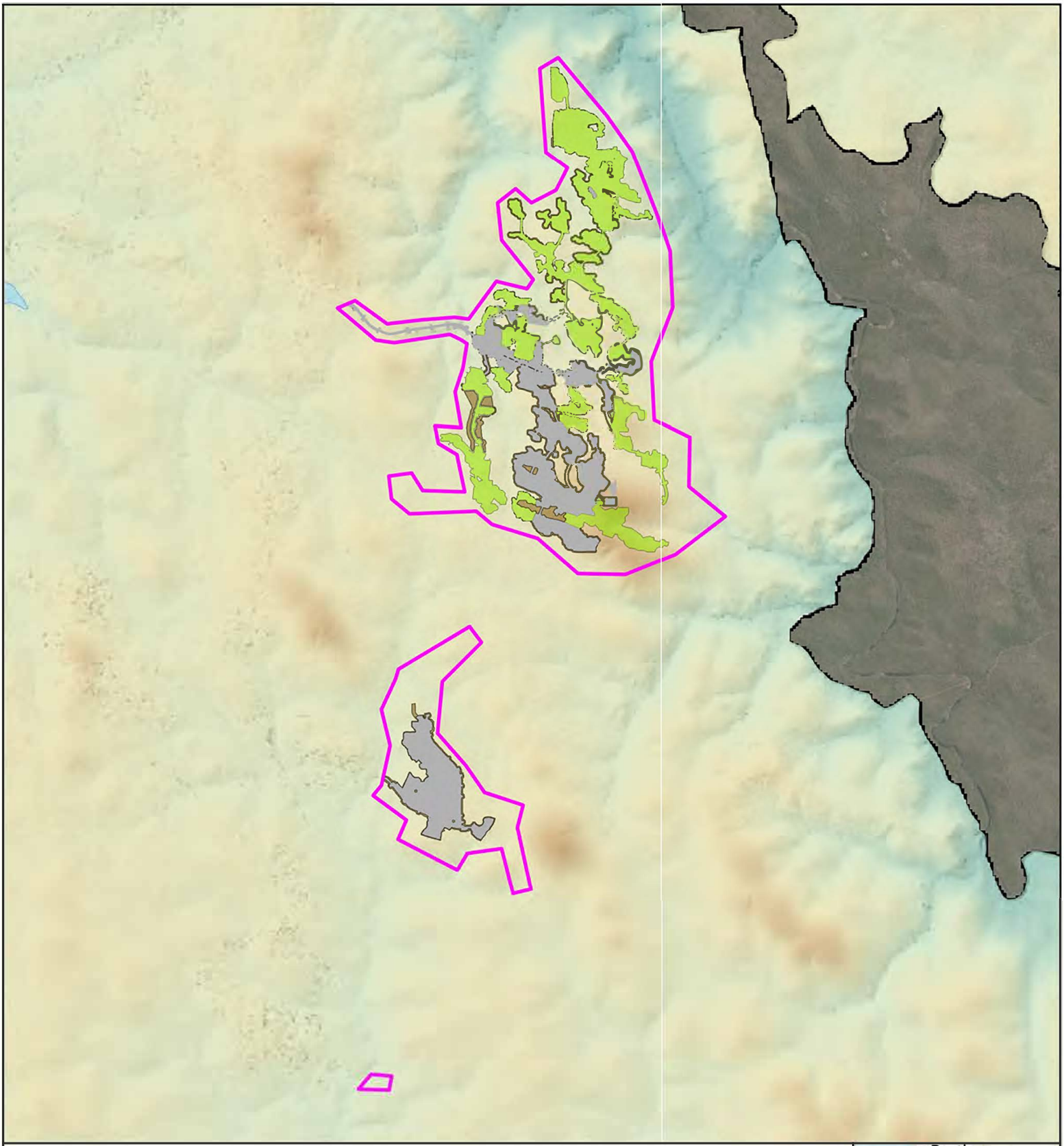
Kilometres
0 2 4 6 8 10 12

Scale: 1:185,926 at A4

Date Printed: 27/02/2025

N

Alcoa

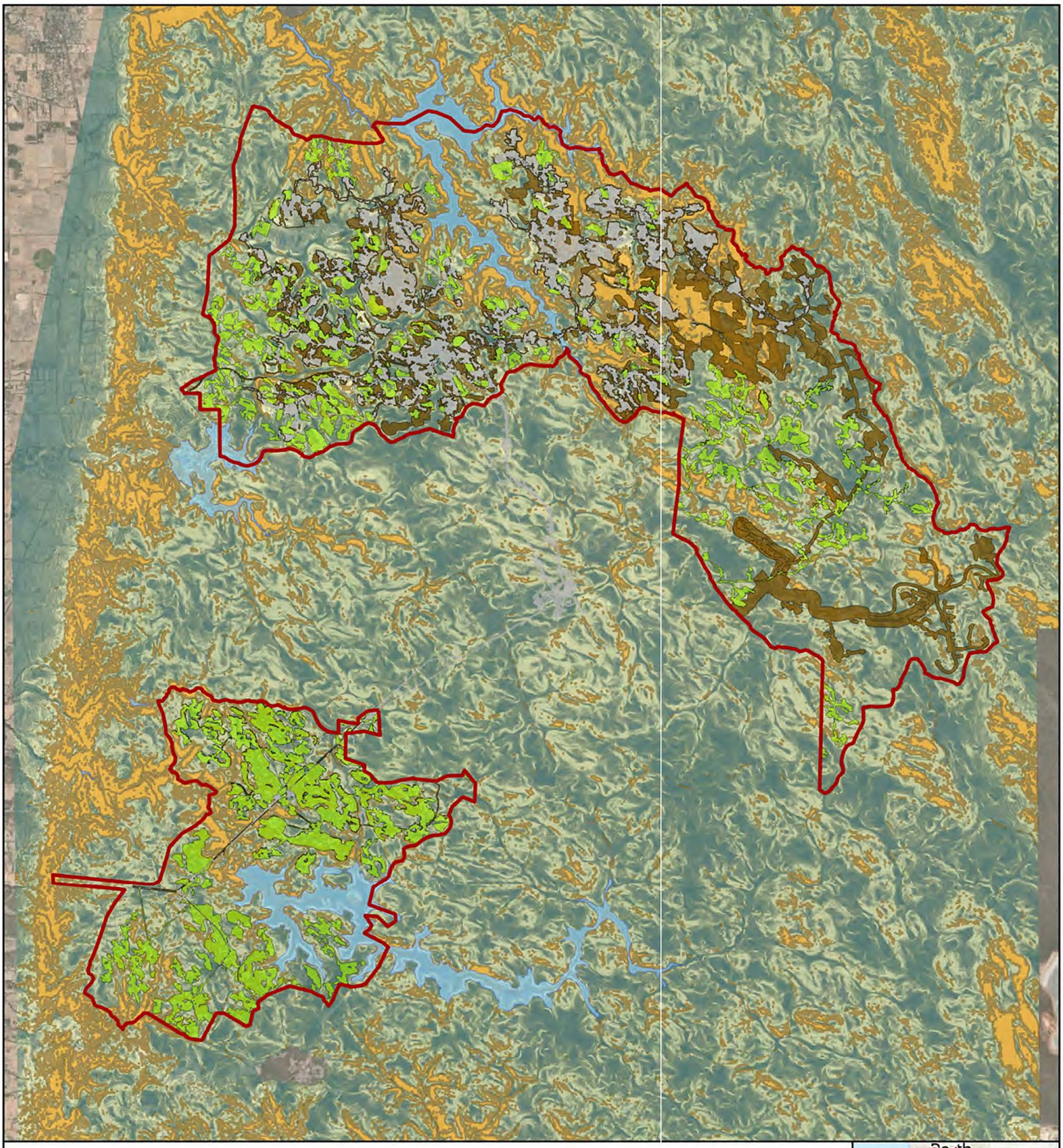


Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-54 Willowdale Mine DE - Topographic Elevation

Scale: 1:75,060 at A4

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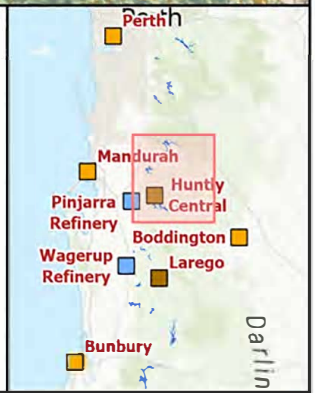
Legend

- Huntly Mine DE
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Reservoirs
- Government (DOLA) Slope >=16%

Slope (%) Derived from Gov't Contours

Value

20
15.04
10.04
5.04
0



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-55 Huntly Mine DE - Topographic Slope

Kilometres

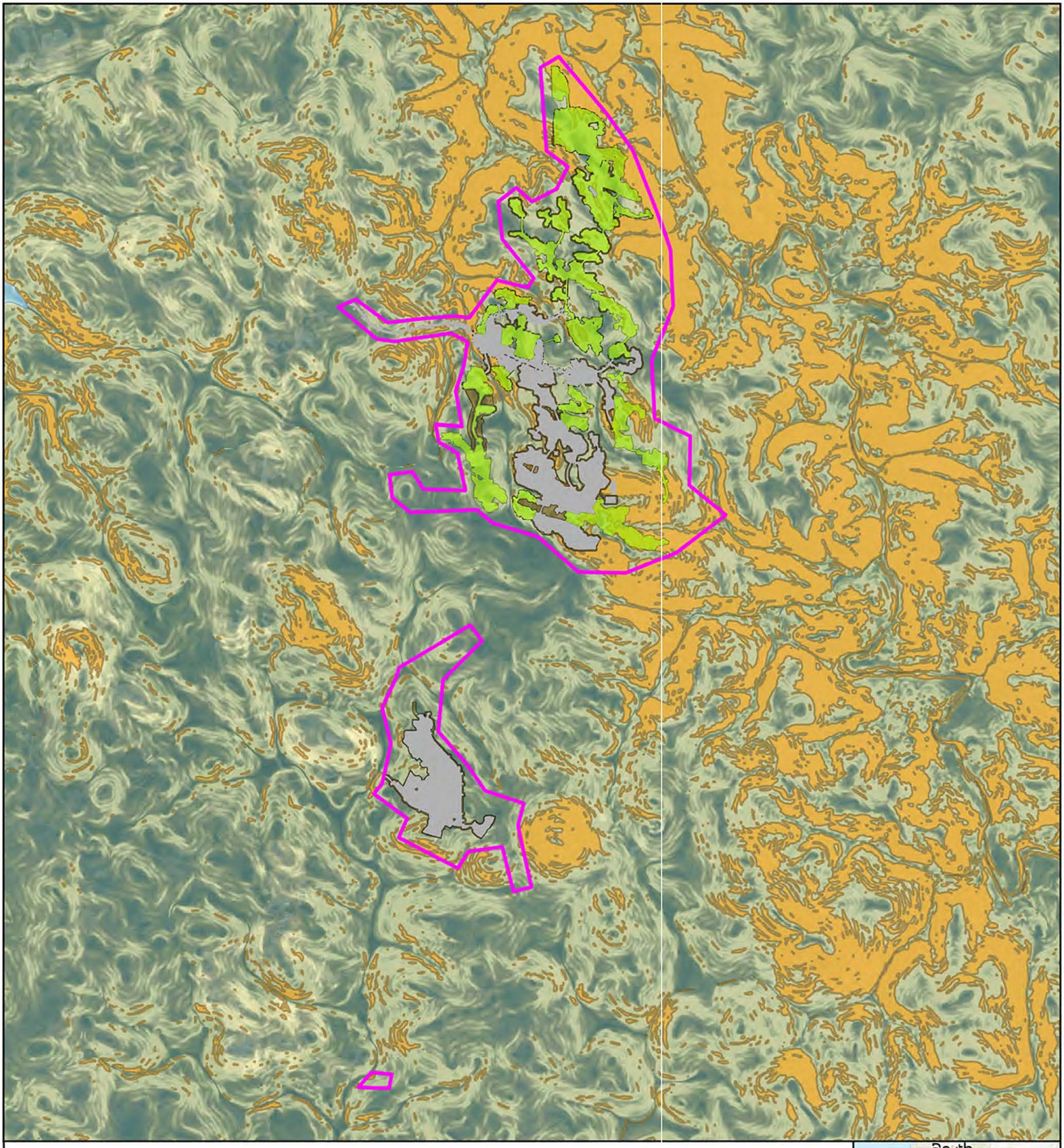
0 2 4 6 8 10 12

Scale: 1:185,926 at A4

Date Printed: 27/02/2025

N

Alcoa



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-56 Willowdale Mine DE - Topographic Slope

Kilometres

0 0.9 1.8 2.7 3.6 4.5 5.4

Scale: 1:75,060 at A4

Date Printed: 27/02/2025

N

Alcoa

5.5.4.6 Reservoir Hydrodynamics

GHD (2023b) undertook hydrodynamic modelling of the Serpentine, Serpentine Pipehead and South Dandalup reservoirs, based on synthetic bathymetries and input data on catchment inflows, withdrawals and meteorology.

No hydrodynamic modelling has been undertaken with respect to North Dandalup, Conjurnup Pipehead, Stirling or Samson Brook reservoirs. This remains a data gap in understanding the existing conditions of reservoirs which catchments are relevant to Mine DE locations.

Plate 5-9 below presents the monthly water balance developed by GHD (2023b) for the Serpentine, Serpentine Pipehead and South Dandalup reservoirs, which indicates the following key patterns:

- Catchment inflows and withdrawals from both Serpentine and South Dandalup dams have decreased over the past 20 years. In particular, Serpentine Dam withdrawals have decreased substantially over the past decade with very low extractions to supply Serpentine Pipehead Dam from July 2017-October 2019.
- The primary water source of Serpentine Pipehead Dam has transitioned from Serpentine Dam withdrawals before 2006 to external transfers from other sources.

GHD (2023b) selected a modelling period from 1 July 2017 to 1 October 2019, corresponding to low reservoir water levels in Serpentine and South Dandalup dams and two relatively wet winters in 2017 and 2018 and then a dry 2019 winter. In contrast, Serpentine Pipehead Dam maintained a relatively constant level due to the highly managed balance between external transfers and withdrawals to the IWSS.

Plate 5-10 to Plate 5-12 below present the simulated seasonal patterns of thermal stratification for the three reservoirs for 2017–2019 period. The charts present water levels, patterns of thermal stratification (as isotherms through the water column with time at each assessment site), and withdrawal temperatures at three representative assessment sites per reservoir, being the dam wall near the intake towers and tow up-reservoir sites. The Serpentine and South Dandalup dams demonstrated thermal stratification patterns as follows:

- Seasonal thermal stratification is maintained at the up-reservoir sites, but more so with the substantially cooler hypolimnetic temperatures at the dam site.
- The increase of water levels by several metres during the 2018 winter resulted in seasonal thermal stratification that was more pronounced in the up-reservoir sites than the previous season at lower water levels.
- Short-term (~1 day) fluctuations in hypolimnetic temperatures are simulated at the dam sites over the thermally stratified period. These fluctuations are caused by sustained high wind events that induce internal waves via tilting of the thermocline at the dam wall. During such events, higher rates of vertical mixing occur.

In Serpentine Pipehead Dam, seasonal thermal stratification was not maintained, but brief periods (days to weeks) of intermittent thermal stratification were simulated.

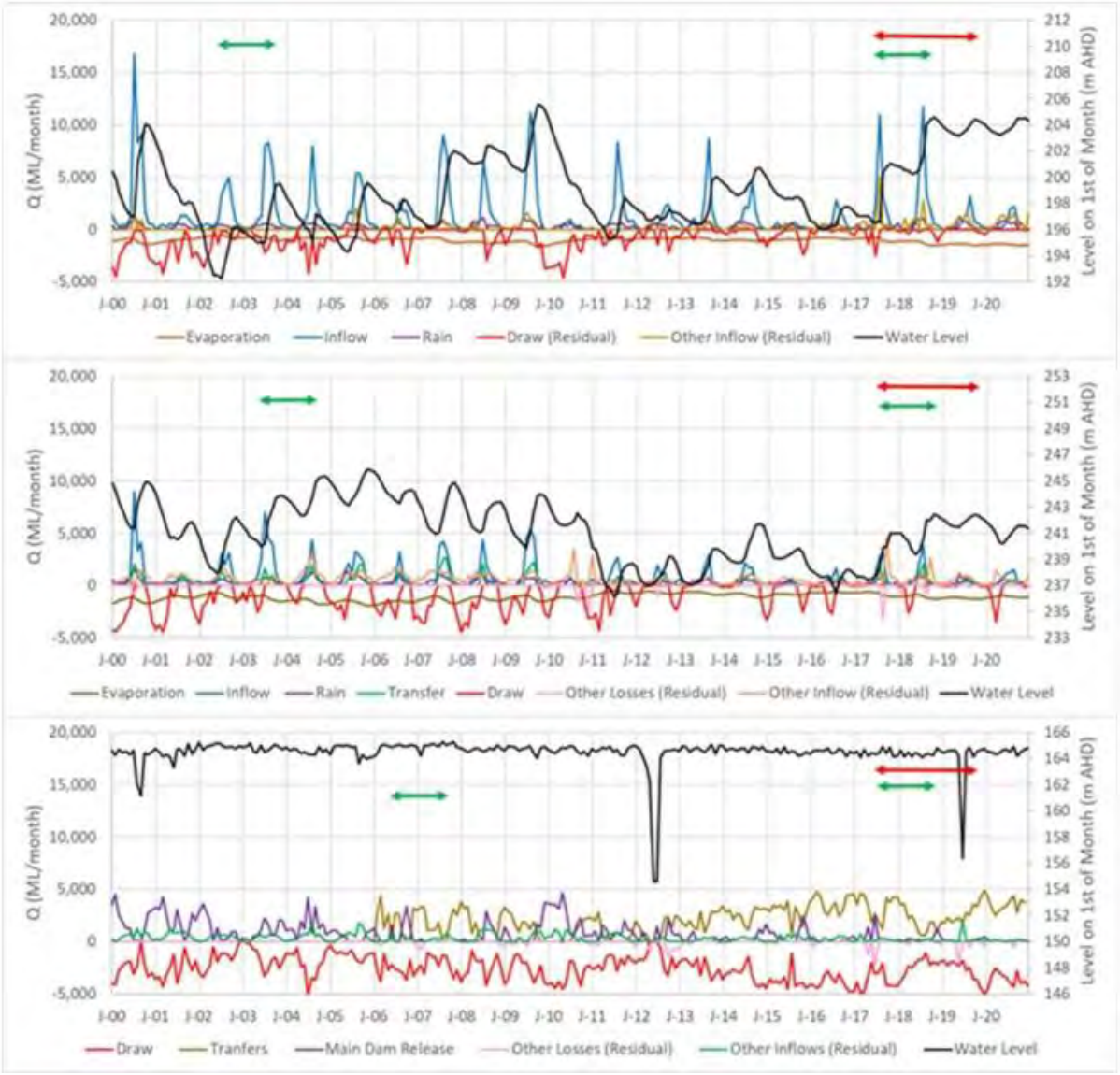


Plate 5-9: Water balance (2000-2020) for Serpentine Dam (top), South Dandalup Dam (middle), and Serpentine Pipehead Dam (bottom)

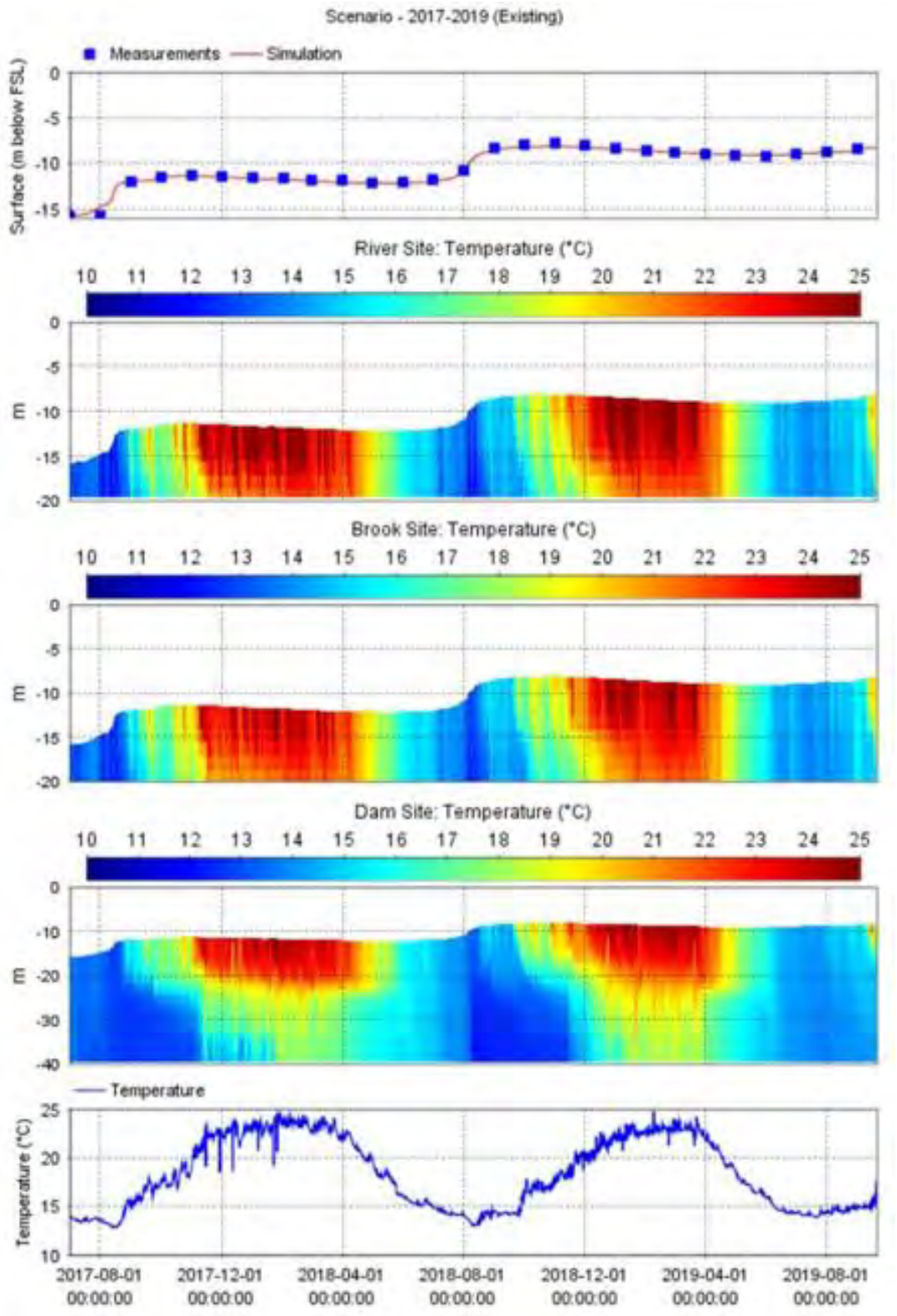


Plate 5-10: ***Simulated and measured Serpentine Dam water levels (top), simulated isotherms at dam (upper middle), river (middle) and brook (lower middle) and simulated withdrawal temperatures (bottom)***

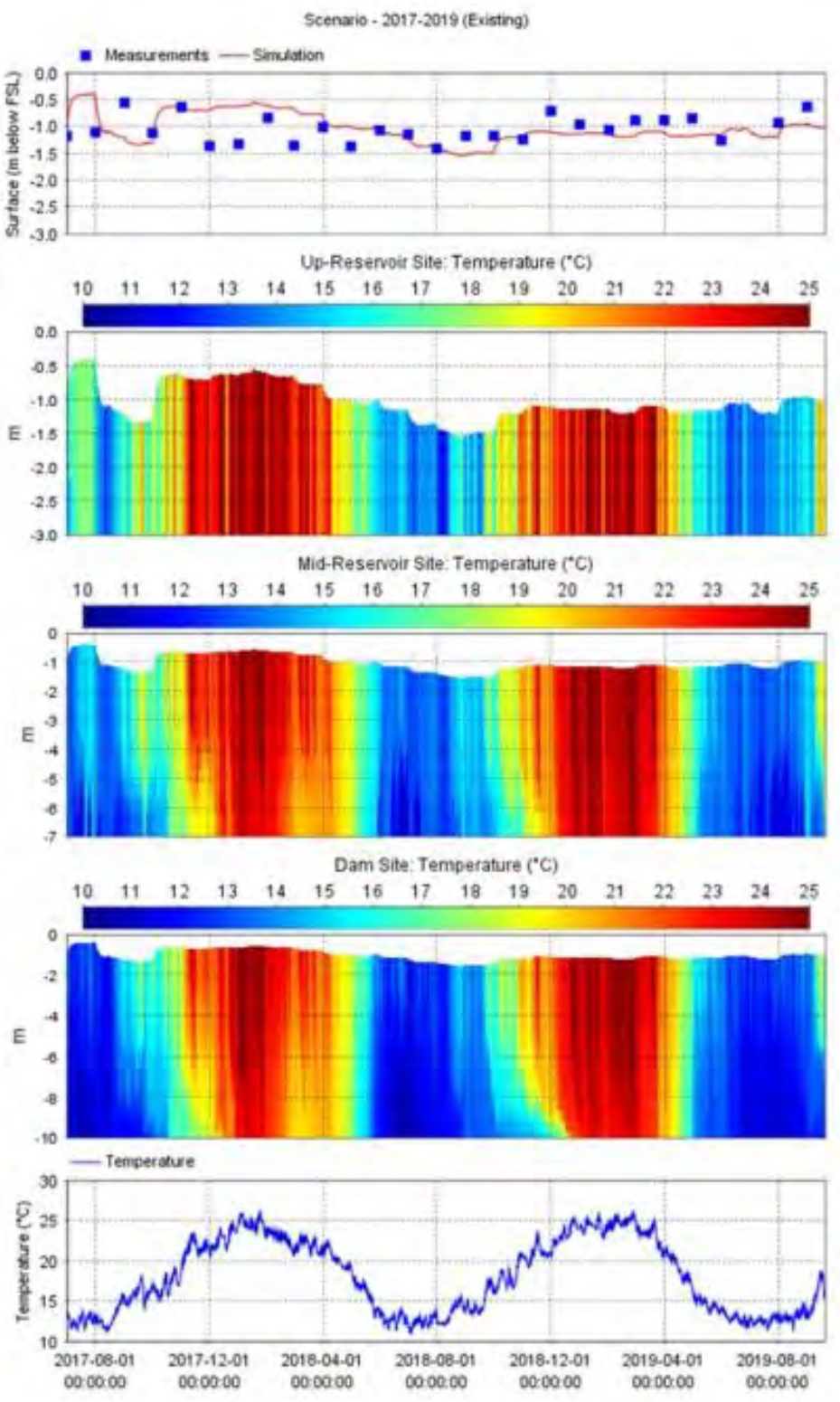


Plate 5-11: ***Simulated and measured Serpentine Pipehead Dam water levels (top), simulated isotherms at dam (upper middle), river (middle) and brook (lower middle), and simulated withdrawal temperatures (bottom)***

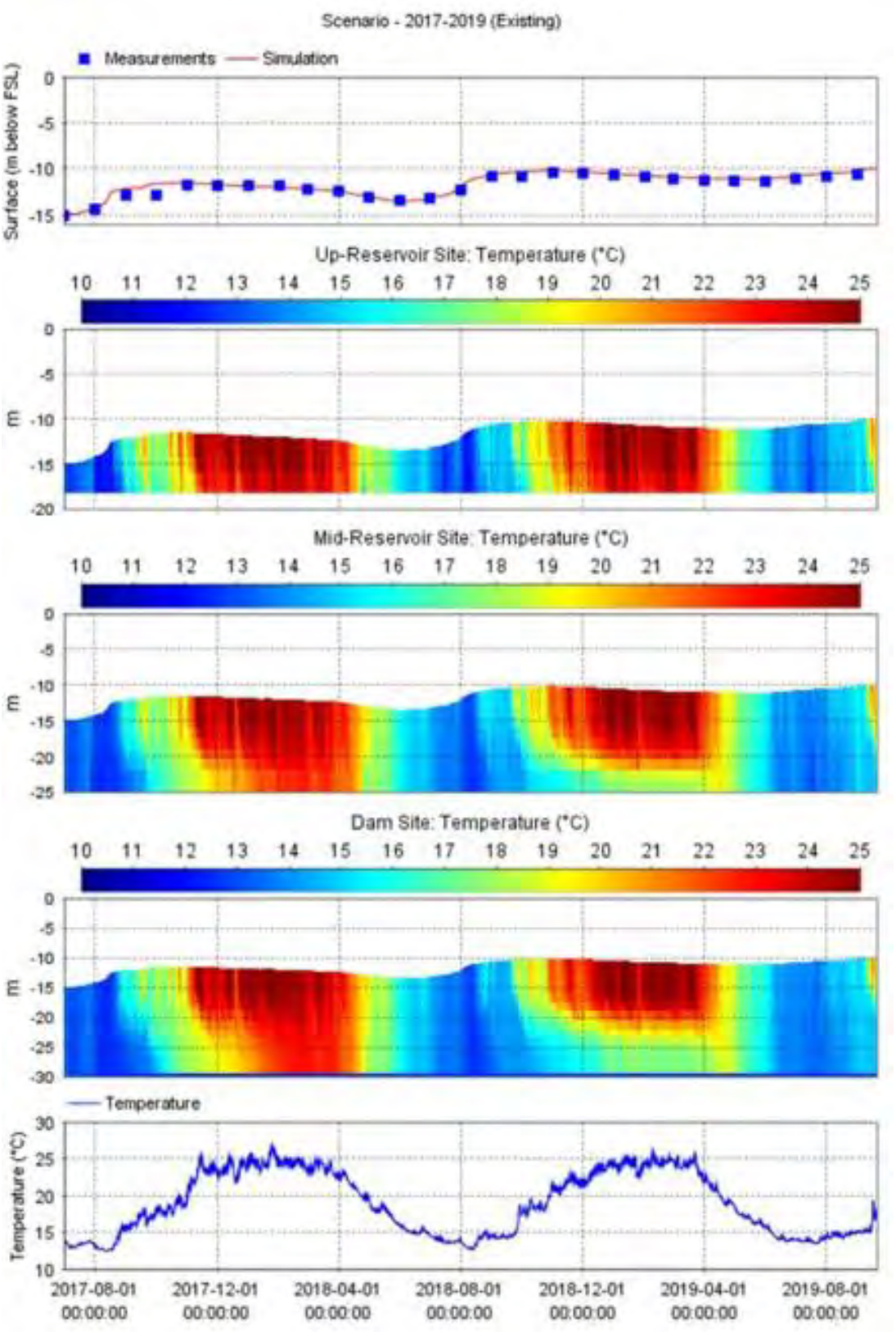


Plate 5-12: ***Simulated and measured South Dandalup Dam water levels (top), simulated isotherms at dam (upper middle), river (middle) and brook (lower middle), and simulated withdrawal temperatures (bottom)***

5.5.4.7 Surface Water Beneficial Uses

The surface waters within the Mine DEs are utilised for ecological, social and economic beneficial use and are described in this section.

5.5.4.7.1 Huntly (Myara, O'Neil, Huntly, and Del Park)

The surface waters within and downstream of the Huntly Mine DE are used for the following social and economic uses:

- Cultural heritage
- Recreation and tourism
- Public water supply, and
- Agricultural site: farm adjacent to the Serpentine Main Dam.

5.5.4.7.1.1 Cultural Heritage

Registered cultural heritage sites are present along the Serpentine River, North and South Dandalup River, and include the rivers themselves.

Cultural heritage values of the Serpentine River Aboriginal heritage site are presented under the Social Surroundings factor in Section 5.6.3.2.

5.5.4.7.1.2 Recreation

Recreational values are realised at Serpentine Dam, Serpentine River downstream, South Dandalup Dam, North Dandalup Dam. The Water Corporation maintains recreational facilities at the South and North Dandalup dams. There is a lookout and picnic facilities at the South Dandalup Dam, above the dam wall near the spillway. There is a lookout at the North Dandalup Dam, with picnic facilities below the dam wall.

The Serpentine Dam provides recreational and tourism amenities including the Serpentine Dam Café and picnic grounds adjacent and below the dam wall. Picnic facilities are maintained by the Water Corporation. The Serpentine Falls recreational area is located downstream of the confluence of Gooralong Brook and Serpentine River and includes trails, viewing and picnic areas within Serpentine National Park. Recreational facilities within the National Park and State Forest are maintained by the Western Australian DBCA. The recreational and tourism values of Jarrahdale, Serpentine National Park and Serpentine Dam are presented under the Social Surroundings factor in Section 5.7.3.

5.5.4.7.1.3 Public Drinking Water and Agricultural Use

The Huntly Mine DE is situated within catchments relevant to the Serpentine Dam, Serpentine Pipehead Dam, North Dandalup and South Dandalup Dam, Conjurunup Pipehead Dam.

At Huntly, the mining areas intercept Serpentine and North Dandalup PDWSAs. The two water supply dams (Serpentine and North Dandalup) release limited flows (<10% of inflow) to maintain downstream beneficial uses. Alcoa has some minor infrastructure located within the South Dandalup PDWSA.

Serpentine Dam and Pipehead Dam

The Serpentine Dam has a full supply capacity of 137.7 GL and collects water from a 664 km^2 catchment. The catchment is proclaimed under the *Metropolitan Water Supply*

Sewerage and Drainage Act 1909 (MWSSD Act), and primarily classified as a Priority 1 PDWSA, with some private lands within the catchment classified as Priority 2.

The reservoir is surrounded by a 2 km wide 'Reservoir Protection Zone' (RPZ) around its top water level, which includes the reservoir itself, although does not extend outside the catchment area.

Approximately 22,527 ha of the Huntly DE region lies within the Serpentine Dam PDWSA, comprising approximately 34% of the PDWSA, of which a portion will be disturbed by construction and mining. The existing mine regions of the Huntly Mine also occupies a portion of the PDWSA.

Water Corporation's current allocation licence for Serpentine Dam and Serpentine Pipehead Dam (Licence No. 56737) totals 53.89 GL/annum and is issued to provide water for public potable water supply and irrigation.

Source water arising from the Serpentine and Pipehead Dam PDWSAs is drawn from the Pipehead Dam and treated with chlorine. Treated water is transferred to the IWSS for distribution to downstream customers.

North Dandalup Dam

The North Dandalup Pipehead Dam Catchment Area was proclaimed in 1982 under the Metropolitan Water Supply, Sewerage, and Drainage (MWSSD) Act 1909. The dam, with a capacity of 75 GL, captures and stores water from the North Dandalup River catchment, which covers only 153 km².

The current allocation licence for the North Dandalup Pipehead Dam (Licence No. 0056735) allows the Water Corporation to divert up to 22.2 GL per annum from the North Dandalup Reservoir.

Approximately 2,828 ha of the Huntly DE region lies within the North Dandalup Dam PDWSA, comprising about 19% of the PDWSA, which will be disturbed by construction and mining activities.

Conjurunup Pipehead Dam

The Conjurunup Creek Pipehead Dam Catchment Area was proclaimed under the MWSSD Act 1909 in 1982. The Conjurunup Creek Pipehead Dam, with a capacity of 190 ML, captures water from the Conjurunup Creek catchment, which has a total area of 39.2 km². Water from the Conjurunup Creek Pipehead Dam is pumped back to the North Dandalup Pipehead Dam, which supplies the Integrated Water Supply Scheme (IWSS).

The current allocation licence for the Conjurunup Creek Pipehead Dam (Licence No. 56736) allows the Water Corporation to divert up to 6 GL per annum from Conjurunup Creek. This licence is issued for the purpose of providing potable water for public water supply.

Approximately 1,582 ha of the Huntly DE region lie within the Conjurunup Pipehead Dam PDWSA, comprising about 40% of the PDWSA. This area will be disturbed by construction and mining activities. The existing mine regions of the Huntly Mine also occupy a portion of the PDWSA.

South Dandalup Dam

The 208.2 GL capacity South Dandalup Dam is the largest reservoir supplying the IWSS. The catchment covers 311 km^2 and is proclaimed under the MWSSD Act. Similar to Serpentine Dam, the catchment is predominantly classified as a priority 1 PDWSA, with a small area of private land managed as a priority 2 PDWSA. The South Dandalup Dam is also connected to the South Dandalup Pipehead Dam, which acts as a pump back for South Dandalup Dam, adding to the available water for supply. Water from the South Dandalup Pipehead Dam is chlorinated before pump back to the South Dandalup Dam.

Approximately 3985 ha of the Huntly / Del Park mine region of Huntly DE lies within the South Dandalup Dam PDWSA, comprising approximately 13% of the PDWSA, of which a portion will be disturbed by construction and mining. Existing mine regions of the Huntly Mine also occupy portions of the PDWSA.

5.5.4.7.2 Willowdale

The surface waters within and downstream of the Willowdale DE are used for the following social and economic uses:

- Cultural heritage
- Recreational purposes
- Public water supply, and
- Agricultural purposes.

5.5.4.7.2.1 Cultural Heritage

Registered Aboriginal cultural heritage sites are mapped along the Murray River, including the river itself. The cultural heritage values of the Murray River Aboriginal heritage site are presented under the Social Surroundings factor in Section 5.6.3.2.

5.5.4.7.2.2 Recreation

Recreation uses along the Murray River include camping, swimming and canoeing.

The Keats mine region of Willowdale DE overlies a small portion of the Murray River catchment. Downstream of the Willowdale DE, the Murray River runs through Lane Poole Reserve and is incorporated into several recreational facilities as a foreshore and for swimming and paddling. The majority of Lane Poole Reserve campsites and trails lie upstream of the confluence with Davis Brook and Swamp Oak Brook.

The Charlies Flat and Bobs Crossing day-use areas are downstream of the confluence of Swamp Oak Brook, and the Dwaarlindjirrap day-use area, Baden Powell campsite, and Nanga Bush Camp are downstream of the confluence with Davis Brook. The recreational facilities at Lane Poole Reserve are managed by DBCA (see Section 5.7.3).

5.5.4.7.2.3 Public Drinking Water and Agricultural Use

The Willowdale mine region intercepts the catchments of Harvey Dam, Stirling Dam, Logue Brook Dam and Sampson Brook Dam. Two of these dams, Stirling and Sampson Brook, are used for drinking water and their catchments comprise PDWSAs.

The Harvey Dam allows for releases into the Harvey River in sufficient quantities for irrigation during dry weather periods. Logue Brook Dam is used for recreational purposes.

Both the Logue Brook and Harvey Dams are downstream of the Stirling Dam and Stirling Dam catchment area.

5.5.4.7.2.4 Aquatic Ecosystems

Although aquatic fauna in surrounding areas of the NJF outside the Mine DE have been surveyed, populations within the Mine DEs have not been studied. As such this remains a data gap and there is very little information on extant aquatic species, their distribution, conservation status and the local hydro-ecological relationships.

In 2021, Water Research and Management reviewed the aquatic ecology of seasonal waterbodies within the greater mine region, which include:

- hyporheic zones known to support stygal species that are potentially short-range endemic species
- aquatic invertebrate species richness often similar between seasonal and perennial
- reaches of streams in the Jarrah Forest
- aquatic fauna communities typically comprise assemblages of species including those only found in seasonal waters and those that periodically disperse/recolonise from nearby refuges in perennial waters
- many aquatic invertebrates in south-west WA are found only in temporary waters, are adapted to drying and refilling cycles, and require a period of desiccation for further development.

Perennial aquatic habitat may be limited to isolated river pools and farm dams as well as perennial waters where present. A detailed survey of river pools and farm dams has not been completed within the Mine DE.

The Mine DEs lie upstream of perennial surface waters which are known or highly likely to support populations of aquatic fauna; this includes Serpentine Dam, South Dandalup Dam, North Dandalup and the Murray River.

The presence of dams is expected to have disrupted aquatic fauna migrations from downstream rivers. The Murray River remains un-dammed and has the potential to support migrations of aquatic fauna; however, the river has elevated salinity from its cleared agricultural upper catchment.

Streams within the Mine DE are presented in Figure 5-53 and Figure 5-54. Higher-order streams are associated with the major tributaries within the Mine DE and typically support a greater depth and width of aquatic habitat and a longer duration of stream flow.

The seasonal streamflow and seasonal river pools within the Mine DE have the potential to support transitory populations of aquatic species dispersing upstream from perennial waterways and reservoirs during winter and spring stream flows, as well as habitat for aquatic invertebrates.

Kennedy’s Pool and Mundalup Pool upstream of the Huntly / Del Park mine regions are potential perennial water bodies that provide refuges for aquatic fauna on the South Dandalup River during the summer and autumn. Farm dams, where present, may also provide refuges for aquatic fauna during summer and autumn.

5.5.4.7.2.5 Wetlands

The dataset of the Geomorphic Wetlands of the Swan Coastal Plain, sourced from DBCA, extends east beyond the SCP's boundaries and covers a portion of the Mine DE. Wetland management categories and objectives have been assigned to this area.

The Peel-Yalgorup Ramsar wetland system is a large system of shallow estuary and saline, brackish and freshwater lakes that host large numbers of waterbirds and vegetation. This wetland is 18 km west of Huntly DE and 36 km northwest of Willowdale DE and is considered the most important area for waterbirds and waders in Southwest Australia.

Along with river diversions, agricultural land use poses a key thread to the environmental values of the Peel-Yalgorup Ramsar site (Hale & Butcher, 2007). The Serpentine, Dandalup, Murray and Harvey Rivers all discharge into the Peel-Yalgorup system at some point, after traversing the SCP.

Conservation Category wetlands (CCW) are the highest priority wetlands, known for their significant ecological attributes and functions. These wetlands are considered to be extremely valuable, and any activities that could lead to their loss or degradation are deemed inappropriate (DBCA, 2025).

Resource Enhancement wetlands are priority wetlands that may have been partially modified but still support substantial ecological functions. Thet are considered to have the potential to be restored to the Conservation Category, and their protection is recommended through various mechanisms (DBCA, 2025).

CCWs and Resource Enhancement wetlands are mapped within small portions of Huntly DE (refer Figure 5-11 and Figure 5-12). CCWs appear to be confined to long, concentrated surface water drainage lines. There is one resource enhancement wetland identified within the Myara region.

The full extent of wetland systems across the Mine DEs has not been surveyed and remains a data gap. In the absence of a detailed assessment however, it is reasonable to assume that unmapped areas of the Darling Range are comparable to those that have been mapped. As such, it is considered likely that unmapped areas along surface water drainages within the Mine DE exhibit similar characteristics. The occurrence of Conservation category wetlands along these drainages should be assessed for the potential impact on the surface water regime of the wetlands.

There are no wetlands within the Mine DE mapped under the 'Directory of Important Wetlands in Australia – Western Australia' (Environment Australia, 2001).

5.5.5 Groundwater Systems

5.5.5.1 Regional Hydrogeology

The generalised hydrogeology of the Mine DEs has not been assessed in detail. Hydrogeological conditions are assumed to be analogous to adjacent catchments / studies areas, a summary of which is provided based largely on adjacent catchment conditions.

The Mine DEs lie within the Darling Plateau, an undulating lateritic regolith over Archaean granite with dolerite intrusions. This geology is detailed in Section 5.4.4.1 and supports the regional hydrogeology, comprising aquifers predominantly within weathered and fresh

Archaean basement rocks, as well as superficial aquifers within more recent sediments incised into the basement, coincident with existing and paleo-drainage lines.

Table 5-66 presents the main aquifer units that characterise the regional hydrogeology across the Darling Plateau, from surface level down to the basement.

Table 5-66: Main aquifer units of the Darling Plateau

Aquifer Unit	Description
Shallow weathered zone	Shallow gravely and sandy sediments, lateritic caprock and friable upper saprolite. The lateritic caprock and friable saprolite can contain economic bauxite and be subject to mining. Seasonal aquifer with significant storage, infiltration and flow capability.
Deep weathered zone	Lower saprolite layer. Aquifer of some storage potential, but limited bulk permeability, comprising clays. Clayey nature of this zone can be interspersed by macropore features developed along deep root systems which were subsequently filled with more clastic material.
Transition zone	Transition zone between fresh basement and saprolite, referred to as saprock, which typically has enhanced permeability
Transported sediments (alluvial)	In addition to the above, where drainage lines are sufficiently developed, and have eroded the basement material, sediments, typically alluvial, have accumulated in the lower lying areas. The permeability of the sediments is variably distributed and related to lithology, depth and degree of weathering.
Fractured bedrock	Permeability and yields are dependent on facture development and connectivity of fractures

Groundwater has been an active part of laterisation across the Darling Plateau, particularly in the development of the duricrust or caprock which lies above the weathered saprolite clays. Its development has been driven by groundwater flow and capillary action which led to the precipitation of iron minerals leached from the weathered bedrock. Caprock can also form in valley floors due to the accumulation of iron brought by groundwater flow and its precipitation due to evapotranspiration or exposure to the surface.

The caprock layer is discontinuous and of varying thickness, being found on slopes but generally being absent in valley floors, as well as where the basement rock outcrops. Of hydrological significance, root channels penetrate vertically via fissures and discontinuities in the caprock and deep into the saprolite clays are a consistent feature in the lateritic profiles. These channels create preferential flow paths which are understood to enable significant vertical fluxes from the shallow weathered zone into the deeper aquifers of weathered saprolite and saprock.

In addition to the aquifers presented in Table 5-66, aquifers are present in alluvial and colluvial sediments accumulated in drainage lines, where these are sufficiently developed and have eroded the regolith/basement. The permeability of the alluvial / colluvial sediments is variably distributed and related to lithology, depth and degree of weathering.

Regionally, groundwater levels within all aquifers appear to follow topography, such that groundwater level is highest in areas of highest topography and lowest in areas of lowest topography. Where groundwater levels intersect creeks drainages, groundwater discharges provide baseflow following winter rains (topped up aquifer storage and groundwater levels).

5.5.5.2 Local Hydrogeology

At the local scale, the aquifers are generally unconfined with flow directions emulating topography. As such groundwater elevations are highest in areas of highest topography and lowest in areas of lowest topography (e.g., valleys).

Measured depth to groundwater within the Huntly mine DE is variable, ranging from at surface (i.e., where discharging) to greater than 30 metres below ground level (m bgl). Shallow (<2m bgl) groundwater levels are generally observed in proximity to drainages whilst deep groundwater levels (>10 m bgl) are observed either away from mapped surface drainage features, along ridge lines or at the very top of first order drainage features.

Similar to Huntly, measured depth to groundwater within the Willowdale DE ranges from near surface (or artesian) to greater than 30 m bgl. The distribution of shallow groundwater (<2 m bgl) is mapped primarily along surface drainage features. Deep groundwater levels are also recorded along ridge lines or at the upper reach of first order drainage features.

5.5.5.2.1 Recharge and Discharge Processes

Recharge to groundwater systems occurs via the direct infiltration of rainfall. Duricrust, caprock layers and the underlying low permeability lateritic clays generally impede the vertical movement of infiltrate, promoting the occurrence of temporal perched / interflow, albeit with subordinate percolate downwards into the deeper aquifer, or taken up via transpiration.

Downward drainage of rainfall infiltrate into the deeper unconsolidated aquifer can be enhanced by root channels of well-established jarrah forest. These features form preferential flow paths allowing infiltrate to move more rapidly through the cemented layers and deeper clay zones of the laterite profile (Grigg & Kinal, 2020) (GHD, 2022b).

Macfarlane et al (2018) noted although jarrah forest may access deep groundwater owing to great tree rooting depths, use of deep groundwater is likely to be limited, and trees are likely to be largely reliant on soil water stored in the unsaturated zone above the water table. Groundwater use by jarrah is very likely to be facultative because there have been no reports of jarrah deaths in response to falling water tables in streamzones with recognition of northern jarrah forest water tables falling at average rates up to 0.5m/year. Deaths of trees have though been observed, with these associated with areas of shallow soil near rocky outcrops, high elevations and steep slopes.

Discharge also occurs where groundwater elevations intersect the base of the creek drainages providing baseflow contribution. Groundwater discharge to surface water is controlled largely by the landscapes' groundwater storage capacity, which is in turn controlled by regolith depth and groundwater levels (Advisian, 2024). Temporal changes to groundwater levels will thus vary groundwater contributions to creek flow and at times, can become the dominant proportion of baseflow (Grigg & Kinal, 2020), (GHD, 2022b).

Within the Huntly Mine DE, groundwater within the Myara and O'Neil mine regions is anticipated to discharge into the Serpentine River, the Big Brook River, Serpentine Dam and North Dandalup Dam, with all these catchment features either abutting the Mine DE or being particularly present within the Mine DE. Groundwater derived from within the Huntly and Del Park mine regions is anticipated to discharge primarily into the South Dandalup Dam which

is largely situated within the Mine DE. A small portion of the Mine DE will discharge westward into the Marrinup Brook catchment which drains westward into the Murray River.

Within the Willowdale Mine DE, groundwater derived from the Wills mine region is anticipated to primarily discharge to the Murray River, whereas groundwater derived from Keats and Tasman mine regions is expected to discharge westward into the Harvey River system, upstream of the Stirling Dam.

5.5.5.2.2 Groundwater Level Trends

A robust groundwater level dataset is available for the Huntly mine within and outside the Mine DE. An assessment of trends between 1990 and 2020, from the Alcoa groundwater bore network, indicates changes in groundwater have ranged from increases up to 1.5 m and declined in parts as much as 15 m (GHD, 2021c). The decline in groundwater levels is more broadly systemic and is likely linked to the long-term drying trend for which the south-west region of WA has experienced since the 1970s (WSP, 2024).

Groundwater level records from within the Willowdale DE are limited to 2022 onwards. Within this time period, groundwater levels are observed to fluctuate seasonally, generally within a 5 m range. Steady increases in groundwater levels are observed adjacent to mine areas which have become recently active.

5.5.5.2.3 Hydraulic Properties

Hydraulic conductivities across the Darling Plateau are varying with respect to the location tested, and the lithology/s encountered in the regolith or the valley alluvium.

Average hydraulic conductivity of the regolith transition zone is between about 0.3 and 0.6 m/day. Where present at or near the surface however, sands and gravels associated with interflow may have significantly higher hydraulic conductivities, particularly those on mid slopes and valley floors.

Saprolite clays, which overlie the transition zone, are inferred to be less permeable at less than 0.001 m/day. Basement bedrock primary porosity and storage (not tested) is expected to be significantly lower although possibly enhanced by secondary structural features (e.g., faulting), where present.

Aquifer storage (of the transition zone) is expected to range between 0.0037 and 0.1 (dimensionless), with an average value of about 0.01.

5.5.5.3 Surface Water-
5.5.5.4 Groundwater Interaction

Surface water and groundwater are hydraulically connected in streams, swamps and downstream reservoirs. Surface water is seasonally or at least intermittently connected to both the regional (or in some instances perched) water table and the interflow vadose zone.

This is supported by observations from streamflow monitoring across the greater Alcoa mining region and the Darling Plateau, which demonstrates a correlation and concurrence of streamflow with elevated groundwater levels.

Interflow and groundwater discharge are acknowledged as being the dominant streamflow generating processes, with direct surface run-off a lesser fraction of total flow (Croton & Reed, 2007). Indirect discharge of groundwater, particularly during high rainfall periods,

contributes to stream flow by amplifying other streamflow generating processes (i.e., surface runoff and throughflow) (Kinal & Stoneman, 2012).

Despite the lack of observational data within the Mine DEs, the nature of and processes involved in surface water and groundwater connectivity are considered similar / identical to other studied regions of the Darling Plateau.

5.5.5.4.1 Surface and Near Surface Flows

Surface water flows are in general, relatively short-lived events following winter rains, and ceasing to flow within two to three weeks following peak stream flow.

The short duration of surface water flow following rainfall suggests a contribution from catchment runoff and short-term storage, such as shallow subsurface flow, that top up the baseflow contribution from groundwater.

The near-surface flow occurs in variably saturated shallow subsurface where sufficient rainfall inputs can temporarily saturate the shallow permeable materials, where these lie above low permeability strata (e.g., saprolite clay). Due to the large heterogeneity of the weathered zone, this component of flow can often exfiltrate to the surface when encountering a barrier such as a basement outcrop or where the shallow subsurface zone pinches out.

The near-surface flows are conceptualised as a mosaic of intermittent aquifers, localised and largely non-contiguous, but able to support short term surface flows in streams when activated by winter rainfalls. The near-surface flow component is likely to merge with baseflow in lower slopes surrounding the streams where these sufficiently cut into the regional water table.

Given the short duration, streamflow carries the surface and near-surface flow contribution until it is exhausted, and streamflow becomes dependent solely on contribution from groundwater (i.e., baseflow). Historic monitoring across the Darling Plateau but outside of the Mine DEs indicates that winter rain leads to low salinity streamflow at the start of winter (i.e., dominated by surface and near-surface flow), then transitioning to relatively higher salinity that is more typical of groundwater (i.e., dominated by baseflow).

5.5.5.4.2 Groundwater Baseflows

Groundwater baseflow, or seepage, occurs at smaller rates over the winter and spring period, extending for weeks or months following winter and spring rains and when groundwater table levels are highest. Analysis of gauging data for streams adjacent to the Huntly DE indicates that baseflow can comprise approximately 40 to 80% of streamflow, depending on the location and the analytical method (GHD, 2023b).

Due to the shallow depth to groundwater in areas beneath the GDEs and wetlands, the regional groundwater continues to support the GDEs and wetlands during the summer months in absence of surface water flows. As long as groundwater within the topographical slopes surrounding the drainage lines or creeks does not considerably fall below the creek level (which would lead to hydraulic disconnection), or the flow gradient reduces such that the incoming flow is completely removed by riparian evapotranspiration, groundwater continues to exfiltrate to the creek or supporting sufficiently shallow water table in the riparian zone accessible for the support of vegetation communities.

Where groundwater levels are deeper, this attribute will limit GDEs to the groundwater table, which would also limit their lateral extent.

Where groundwater levels are deeper, surface flows are also likely to be reduced in magnitude, frequence and length, since less baseflow would be available to support streamflow. Given the long-term drying climate declining groundwater level trends, it is however possible that during the historical period before the last two decades the groundwater levels in across the Mine DEs were shallower and surface flows have been greater than observed in the dataset.

5.5.5.5 Groundwater Quality

The quality of groundwater is monitored within the Mine DEs, however these data have not been assessed for the purpose of the Proposal. Rather that groundwater quality data collected for the greater Alcoa project across the Darling Plateau (at Huntly Mine) has been used in this assessment to understand general groundwater quality conditions within the mined region and in areas where historical land use activities have been identical and catchment conditions considered analogous to those at Huntley and Willowdale.

Groundwater quality data indicate groundwater is fresh to brackish, generally less than 1,000 mg/L with average salinities less than 500 mg/L adjacent to the Huntly DE; salinity records in proximity to Willowdale DE were not available. Across the Darling Plateau, data indicates average groundwater salinity increases from west to east (WSP, 2024). At the Huntly Mine, an average of close to 200 mg/L in the western parts increases to an average of close to 400 mg/L in the eastern parts (based on 5 km spaced north-south windows) (GHD, 2021c). Spatial groundwater salinity trends at the Huntly mine appear to be relatively stable over the three decades of monitoring (1990 to 2020).

Regional data records suggest long-term salinity temporal trends in groundwater may be less attributed to the changing climate, than compared with water levels. Declining, stable and increasing salinity trends are observed at bores where predominantly declining water level trends are observed (GHD, 2021c).

Salt deposition from oceanic spray (transferred by rainfall) and dry fallout is largely stored in the deep weathered bedrock zone, with relatively little salt stored in the near surface horizons, including the shallow weathered sub-aquifer unit (Grigg & Kinal, 2020).

Dissolved metal concentrations in groundwater collected from Alcoa's monitoring bore network reflect the highly leached and now largely inert geological units in which these bores are screened and groundwater resides (GHD, 2022a). Concentrations of a select number of dissolved metals concentrations were observed (adjacent to Huntly DE) to generally exceed guideline criteria for drinking water (manganese), 95th percentile freshwater ecosystem health (arsenic, cadmium, chromium, copper, lead, nickel and zinc) at some locations.

Nitrogen and phosphorus concentrations are detected in groundwater sampled from the Alcoa groundwater monitoring bore network. Concentrations of ammonia, total nitrogen and total phosphorus in some bores exceeded adopted guideline criteria (ANZECC & ARMCANZ, 2000) for upland river ecosystems (GHD, 2022a).

Low concentrations of PFAS have been detected in some groundwater bores within Alcoa's mining areas. Detections have remained below the drinking water assessment criteria and

are not expected to influence environmental values (e.g., drinking water, ecological systems).

Minor detections of hydrocarbons, both total recoverable hydrocarbons (TPH) and PAH, have also been observed in groundwater samples collected from the Alcoa groundwater monitoring network. These concentrations are considered attributable to drilling activities (in particular the installation of groundwater monitoring bores) and/or related to short-term impacts from bushfires (GHD, 2022b), rather than being associated with the direct or diffuse release of chemicals associated with active mining works.

5.5.5.6 Groundwater Users

The Mine DE is situated within an unproclaimed groundwater management area where there are no licenced groundwater users; in stating this it is recognised that licences to take groundwater (and surface water) in unproclaimed groundwater resources are only required under certain circumstances, meaning unlicenced (and undocumented) groundwater users may exist within or close to the Mine DE.

Whilst the Darling Range is predominantly an undeveloped catchment, the potential for groundwater use remains where small pockets of (rural) development exist. In stating this however, it is expected Alcoa's activities are unlikely to have significant impact on any groundwater users given past mining activities have demonstrably resulted in a surplus of groundwater compared to pre-mining conditions (which results in groundwater mounding, refer to Section 5.5.7.5.1.3), albeit with no adverse impacts of this outcome known or expected on other groundwater users.

Groundwater contributes yields (baseflow) to surface waters including nearby streams, reservoirs and downstream rivers, which have beneficial uses as detailed in Section 5.5.4.2. Seasonal aquatic ecosystems are discussed in Section 5.5.4.7.2.4, with further reference to general aquatic fauna in Section 5.3.5, and Carters Freshwater Mussels in Section 5.3.5.1.1.

5.5.5.6.1 Groundwater Dependent Ecosystems

Potential groundwater-dependent ecosystems (GDEs) present within the Mine DE include:

- riparian, swamp and lower slope vegetation subject to seasonal inundation and/or waterlogging;
- seasonal aquatic ecosystems; and
- seasonally saturated sediments in valley floors (hyporheic zone).

Potential GDEs are mapped in Figure 5-15 and Figure 5-16 and detailed in Section 5.2.4.4. The potential for GDEs present is based on vegetation types (VTs) and key flora indicator species that prefer and occur on seasonally moister and wetter soils on the swamps, valley floors and lower slopes (Mattiske, 2021a) (Appendix 15), (Mattiske, 2021b)(Appendix 16). In summary, mapped VTs with A, AC, AD, CW, D, DA, E, PW, SW, and W dominant type vegetation may contain GDEs, which total 6,647 ha (16.3%) of the total Mine DE, including 6,386 ha (16.5%) of the Huntly DE and 261 ha (12%) of the Willowdale DE. Several VTs were either not mapped or not considered to represent GDEs and have the potential to be GDEs (such as VTs AW, C, CQ and SW-D) and remain a data gap.

As presented in Figure 5-57 and Figure 5-58, the majority of potential GDEs lie within the proposed Limited Disturbance Areas (LDAs) of the Mine DE.

There is a lack of groundwater monitoring data for the potential GDEs mapped within the Huntly and Willowdale Mine DE and there is potential for local variability in hydrogeological conditions between the Mine DE and areas previously studied. This includes the seasonal and inter-annual depth of the groundwater table within the surrounding weathered rocks, the presence of low permeability strata (e.g., deposited silt and clay) and the duration of saturation in the alluvial/colluvial sediments as the surrounding groundwater table recedes.

Variation (seasonal) in groundwater depths observed in monitoring data, suggest the groundwater table has the potential to seasonally recede below the level of streams and swamp sediments. This indicates that, in the absence of perched water on low permeability strata, stream and swamp sediments within the Mine DE may become unsaturated on a seasonal basis. Stream and swamp vegetation may therefore utilise soil moisture in the unsaturated sediments during the late summer or autumn, suggesting that groundwater-dependent vegetation if present comprises facultative rather than obligate phreatophytes.

Seasonal aquatic ecosystems are discussed in Section 5.3.5.

The alluvial/colluvial sediments that lie within streams and swamps are subject to seasonal saturation through surface and groundwater inflows, creating a hyporheic zone that may provide habitat for macroinvertebrates. The hyporheic zone can provide refuge for aquatic fauna that can burrow to avoid desiccation during dry periods and/or high flow events (Water Research and Management, 2021), including crustaceans, earthworms and insect larvae. Stygal amphipods have been recovered from the hyporheic zone of streams within the Huntly Mine region (though not assessed within the Mine DE), which may be potential SRE fauna (Water Research and Management, 2021).

5.5.6 Overview of Significant Environmental Values

Sensitive receptors relevant to those identified environmental values listed in the ESD are summarised in the following bullet points, whilst their locations in the Huntly and Willowdale DE regions are shown on Figure 5-51 and Figure 5-52.

- Rivers, creeks and tributaries including but not limited to:
  - the Murray, Serpentine, South Dandalup, North Dandalup, Harvey, Harris and Canning rivers
  - Wongong, Gooralong, Big and Drakes brooks, and
  - tributaries of the above.
- Lakes including:
  - Lake Brockman, Lake Navarino, Lake Moyanup, Lake Kabbamup, Yourdamung Lake, Lake Banksiadale, and
  - riparian areas and buffers associated with these lakes.
- Wetlands including:
  - conservation category wetlands
  - resource enhancement wetlands, and
  - valley floors and associated buffers.
- Unproclaimed groundwater and proclaimed surface water areas under the *Rights in Water and Irrigation Act 1914.*
- Public Drinking Water Source Areas, including but not limited to:
  - the Serpentine, Serpentine Pipehead, North Dandalup Pipehead, South Dandalup, Harvey and Stirling dam catchments
  - the Gooralong Brook, North Dandalup and Pinjarra Water Supply Catchment catchments, and
  - the Murray River Water Reserve.
- Waterbodies providing habitat for threatened, priority or conservation significant aquatic fauna.
- Dams and reservoirs, including but not limited to:
  - the Harvey, Serpentine, South Dandalup, North Dandalup and Stirling dams, and
  - other dams/reservoirs sited along major waterways and tributaries of the study area.

5.5.7 Potential Environmental Impacts

This ERD has been developed based on available information from Alcoa. A detailed impact assessment of the inland waters has not been undertaken by Alcoa for the Huntly or Willowdale DEs. As an alternative, this ERD utilises relevant assessments and studies from these adjacent areas to inform the qualitative impact assessment:

1. within the mining footprint and surrounds at the Huntly mine, and
2. at adjacent mines, including the South32 Worsley mine.

These studies (carried out both within adjacent and nearby catchments across the Darling Plateau) are considered analogous in both site settings, activities, environmental receptors and impacts, and therefore, considered suitable for providing an understanding of baseline and the potential environmental impacts for this assessment. These analogous studies are listed in Table 5-62.

5.5.7.1 Impact Assessment Methodology

The impact assessment method follows the source–pathway–receptor (SPR) linkage approach. The SPR objective, methodology and referenced report section is summarised in Table 5-67.

Table 5-67: Summary of SPR approach to inform the potential impacts inland water significant environment values

Assessment	Source	Pathway	Receptor
Objective	Identify the potential sources which may impact the inland waters environmental values (as listed in Section 5.5.7.2). For this ERD, this entails activities associated with Alcoa's mining operations.	Identify the potential environmental pathway from the source (i.e., mining activities) to the inland waters environmental values (as listed in Section 5.5.7.3).	Identify the inland waters environmental values (Section 5.5.7.4) potentially impacted by the identified source via the pathway.
Methodology	Review available Alcoa documents to inform potential sources.	Review available Alcoa documents and public studies (as listed in Table 5-62) to estimate the potential pathways. No additional modelling or field assessments were undertaken.	Review the locations of the Inland Waters environmental values against the source locations and potential pathways to estimate the likelihood and consequence of the impact to the receptor. No additional modelling or field assessments were undertaken.

5.5.7.2 Potential Sources which may Impact Inland Waters

The following activities of the Proposal may impact inland waters:

- clearing of native vegetation, including the stockpiling of soils for rehabilitation work
- mining of bauxite ore
- establishment of mine water controls, including those which alter natural surface water drainage regimes
- establishment of mine site infrastructure and working areas, including access and haulage roads
- movement, servicing and maintenance of heavy equipment and vehicles
- use of water for construction and mining activities
- disposal of wastes
- use and/or unintentional release of natural and manufactured products, including the application of fertilisers, herbicides and pesticides
- uncontrolled bush fires ignited due to mining, and

- closure and decommissioning activities.

5.5.7.3 Potential Pathways to Inland Waters

The following pathways have the potential to impact inland waters:

- overland flow during heavy rainfall and wet ground conditions
- discharge of surface water flows into stream or direct to inland waters
- transport along stream, discharging into inland waters, and
- groundwater recharge systems, both shallow and deep.

5.5.7.4 Summary of Potential Impacts to Inland Waters

The Proposal may result in the following potential environmental impacts to inland waters:

1. Changes to both the surface water and groundwater regimes because of Project operations, including changes in surface water and groundwater flows and downgradient receiving environments.
2. Increase in the rate and salinity of groundwater discharges to catchment surface water systems because of:
    - increased rainfall infiltration; and
    - decreased evapotranspiration in cleared and mined areas.
3. Increased sediment loads in surface water as a result of both mining and rehabilitation activities.
4. Contamination of surface water and/or groundwater resources following:
    - The use of water in Project operations;
    - The unintentional release of chemicals (such as hydrocarbons, PFAS, herbicides and pesticides etc) to ground or water; and/or
    - Mobilisation of existing contaminants from previous mining activities via surface water runoff and/or groundwater following vegetation clearance and/or soil disturbance.
5. Contamination of surface water and/or groundwater with PASS compounds as a result of soil and sediment disturbance, including removal, at waterway crossings.

The above listed potential impacts to inland waters are discussed further in Sections 5.5.7.5.1 to 5.5.7.5.5.

5.5.7.5 Overview of Mine Disturbance to Catchments

Table 5-68 presents indicative estimates of disturbance to surface water catchments due to the transition of the Mine into the mine regions designated within the Huntly DE (Myara, O'Neil, Del Park) and Willowdale DE (Tasman, Wills, and Keats). Estimates are based on the following:

- GIS mapping of mine disturbance to 2022;
- Disturbance proposed under the 2022–2026 (Alcoa, 2021) and 2023-2027 (Alcoa, 2023b) MMPs;

- Total 3,477 ha disturbance within PDWSAs for transition to Huntly and Willowdale DE regions, distributed to catchments based on the proportion of mine regions in each catchment; and
- Total 562.6 ha disturbance within unregulated catchments, distributed to catchments based on the proportion of mine regions in each catchment.

As presented, mine disturbance is expected to predominantly occur in the Huntly Mine DE, specifically within the Serpentine Dam catchment and to a lesser extent the North Dandalup, Serpentine Pipehead Dam, South Dandalup Dam, South Dandalup Pipehead Dam and Conjurunup Dam catchments. Within the Willowdale DE, mine disturbance is predominately within the Murray River catchment and to a lesser extent within the Stirling Dam and Samson Brook Dam catchment areas.

Table 5-68: Indicative Estimates of Mining Disturbance to Surface Water Catchments

Public Drinking Water Source Areas	Catchment Area (ha)	Open Area (ha)	Proportion of catchment (%)	Rehabilitation Area (ha)	Proportion of catchment (%)	Total Open and Rehab Areas (ha)	Proportion of catchment (%)	Proposed Disturbance (ha)	Proportion of catchment (%)
Huntly Mine Region									
Conjurunup Creek Pipehead Dam Catchment Area	3,921.7	39.0	1.0	0.0	0.0	39.0	1.0	17.9	0.5
North Dandalup Pipehead Dam Catchment Area	15,141.1	401.4	2.7	121.3	0.8	522.7	3.5	282.8	1.9
Serpentine Dam Catchment Area	66,160.9	2,800.8	4.2	1,561.8	2.4	4,362.6	6.6	3,264.0	4.9
Serpentine Pipehead Dam Catchment Area	2,881.3	72.6	2.5	14.7	0.5	87.3	3.0	21.1	0.7
South Dandalup Dam Catchment Area	30,804.5	8.5	0.03	0.0	0.0	8.5	0.03	17.5	0.1
South Dandalup Pipehead Dam Catchment Area	3,854.5	40.7	1.1	0.0	0.0	40.7	1.1	16.6	0.4
Total	**12,2764.0**	**3,363.0**	**2.7**	**1,697.8**	**1.4**	5,060.8	4.1	3,619.9	2.9
Willowdale Mine Region									
Samson Brook Catchment Area	7,451.7	3.8	0.0	0.4	0.0	4.2	0.1	0.0	0.0
Stirling Dam Catchment Area	25,366.6	110.2	0.4	62.8	0.2	173.1	0.7	10.2	0.0
Total	**32,818.3**	**114.0**	**0.3**	**63.2**	**0.2**	177.2	0.5	10.2	0.0
Grand Total PDWSA	**155,582.3**	**3,477.0**	**2.2**	**1,761.1**	**1.1**	**5,238.1**	**3.4**	**3,630.1**	**2.3**
Unregulated Catchment Areas									
Huntly Mine Region									
Dirk/Karnet	13,945.1	308.5	2.2	154.0	1.1	462.5	3.3	229.5	1.6
Marrinup Brook	7,759.5	23.4	0.3	0.0	0.0	23.4	0.3	0.0	0.0
Oakley	4,796.4	8.5	0.2	0.0	0.0	8.5	0.2	0.0	0.0
Total	**26,500.9**	**340.4**	**1.3**	**154.0**	**0.6**	494.4	1.9	229.5	0.9
Willowdale Mine Region									
Middle Murray	94,814.9	222.2	0.2	169.5	0.2	391.6	0.4	0.0	0.0
Total	**94,814.9**	**222.2**	**0.2**	**169.5**	**0.2**	391.6	0.4	0.0	0.0
Grand Total Unregulated	**121,315.9**	**562.6**	**0.5**	**323.5**	**0.3**	**886.1**	**0.7**	**3,859.6**	**3.2**

5.5.7.5.1 Potential Impact 1 – Changes to both Surface Water and Groundwater Regimes because of Project Operations, Including Changes in Surface Water and Groundwater Flows, and Downgradient Receiving Environments

Several activities associated with Alcoa's mine operations have the potential to change the local hydrological and hydrogeological regimes, and stream channel (fluvial) geomorphology.

5.5.7.5.1.1 Surface Water Regime

The clearing of vegetation is expected to alter hydrological flows reporting to nearby streams and reservoirs.

Changes to flow rates and volumes will occur due to the alteration of land cover and flow paths associated with vegetation clearing and development of mine facilities (pits, roads etc); different land covers will have different infiltration, evaporative and runoff properties, all of which will affect the rate and volume of surface water flows following rainfall.

Diversion of surface water runoff around mining areas and the collection ('capture') of stormwater within mine pits may also locally change the quantity of runoff reporting to streams and reservoirs.

Studies in the Huntly mine region comparing mined to largely unmined catchments indicate increased surface water runoff typically occurs in those areas being cleared and/or mined (GHD, 2023b). These studies also suggested minor reductions in surface water runoff may occur in those areas being rehabilitated, although this may not always be the case and is likely related to Leaf Area Index (LAI) rates in rehabilitation (Grigg & Hughes, 2018). However, rehabilitation activities are expected to increase infiltration and minimise surface water run-off, particularly through ripping.

Hydrological assessments specific to the Proposal has not been completed to understand the magnitude of increase in surface water flows to the PDWSAs and watercourses. However, the impact of the Proposal to the hydrological regime has been qualitatively estimated based on the size and location of the various activities and their areas in the Proposal, compared to the size of the catchment area in which they are located. The proportions of each relevant surface water catchment within the Mine DEs are presented in Table 5-63 and Table 5-64, whilst proposed mine disturbance and rehabilitation areas as a proportion of each catchment are presented in Table 5-68.

Proposed clearing estimates range from 0 to 4.2% for the individual catchment areas, with the proposed clearing within the Serpentine Dam catchment area the greatest, though still less than 5%.

Proposed rehabilitation area estimates range from 0 to 2.4% for the individual catchment areas, with the proposed rehabilitation area within the Serpentine Dam catchment area the greatest.

Mitigation controls developed and implemented by Alcoa (Section 5.5.8) aim to minimise mine-impacted runoff to inland water environmental values by designing adequate drainage controls; these are developed and presented in conceptual DCMPs designed to contain and infiltrate mine runoff surface waters, then further refined during the detailed design and review stages.

The Proposal is within the PDWSA catchments of Serpentine, North Dandalup, South Dandalup, Conjurunup Pipehead and Stirling dams. As such, some decrease in surface

water runoff to these PDWSAs is possible as Alcoa aim to contain and infiltrate mine runoff. The decrease is not expected to significantly impact any receptors given the catchment proportions of proposed areas to be cleared. Additionally, the Proposal areas to be cleared are small when compared to the overall size of the catchments, refer to Table 5-68, hence the overall risk to these dams of mine-impacted runoff associated with the Proposal is considered low, with total catchments impacts all below 3.4%.

Major rivers downstream of the Proposal areas (namely the Serpentine, Big Brook, South Dandalup, Murray and Harvey rivers) may temporarily experience slightly lower flows from overland runoff). This is not expected to significantly impact catchment-scale water fluxes as the Proposal areas are small when compared to the overall catchment areas reporting to the rivers (refer to Table 5-68), and the expected increase of groundwater discharge to these streams (as discussed in Section 5.5.7.5.1.3), hence the impact to these rivers also considered to be low.

Geomorphic wetlands located within the Myara region of the Huntly DE, are downstream of the proposed clearing, and may also receive a small increase in stream flows. This is not expected to be a significant impact. particularly due to likely occurrence within streamzone vegetation which has an associated Limited Disturbance Area.

Alcoa holds several surface water licences for its mining operations, namely:

- SWL63409, SWL153635, SWL83356, and SWL68893 for the Huntly Mine DE, with a total annual water entitlement of 0.6 GL (Alcoa, 2023b), and
- SWL61024 for the Willowdale Mine DE, which has an annual entitlement of 0.45 GL (Alcoa, 2023b).

These licences were issued by the DWER and valid until 2034, and are subject to terms, conditions, and restrictions regarding water use.

Alcoa's mining operations use approximately 1 GL of water per year, primarily for dust suppression on haul roads and conveyors ((Alcoa, 2023b). This volume is negligible when compared to total annual surface water flows in those catchments, with Alcoa's allocations unlikely to affect either surface water regimes, water-dependent ecosystems, other entitlements or water users. Additionally, the use of this water is not expected to result in any adverse environmental impacts, with ongoing monitoring to be carried out by Alcoa to demonstrate this.

5.5.7.5.1.2 Stream Channel Geomorphology

Changes in stream channel geomorphology may occur following changes in ground conditions which themselves may result in:

- New or additional erosion during surface water runoff events, followed by; and
- Subsequent deposition of sediment downstream in the catchment.

Rainfall on unvegetated or disturbed soils produces sediment as a combination of two primary modes, namely:

- Surface erosion; and
- Mass erosion.

Surface erosion occurs when rain-induced runoff passes over the soil surface and dislodges the loose particles that can be mobilised by the velocity of the running water. As this

continues, surface water flow paths begin to form sheet flow which has greater erosive power, which again concentrates flow into rivulets, ultimately forming rills and gullies. As a gully forms, the banks of the gully give way, generating the 'mass erosion' of sediment.

Potential consequences of erosion primarily relate to the quality of water in which terrestrial and aquatic flora and fauna may be negatively affected. Transported sediment from disturbed areas may also accumulate in downstream tributaries and impact environmental and/or social values.

No stream channel geomorphic assessments have been undertaken within the DEs to understand the magnitude of erosion and any potential changes in landform downstream of the Proposal. However, the potential impact downstream can be qualitatively estimated based the location of the Proposal relative to the overall catchment hydrology, current landcover, and slope (i.e., gradient) of downstream areas. Based on these considerations, localised changes to drainage patterns and runoff components are possible due to inherent changes in terrain morphology, including increased sedimentation and deposition in nearby waterways, including downstream catchments and PDWSAs. These though are expected to be localised and minor (GHD, 2021c) given Alcoa's erosion and sediment control measures (as discussed in Section 5.5.8) will be implemented to minimise erosion of cleared areas, further reducing the potential erosion.

The quantification of impacts to streamzones is not possible, given information available and variability of ephemeral streamzones. However, clearing for mining within streamzone vegetation (A and C dominant vegetation types as per Table 5-6) will not occur. Approximately 49 ha of streamzone vegetation may potentially be cleared as part of the Proposal, which represents 2% of streamzone vegetation within the Mine DEs (as detailed in Table 5-19).

With mitigation controls in place, only minor impact to existing stream channel geomorphic processes and patterns is expected to the following EVs downstream of the Proposal:

- The Serpentine, North Dandalup, South Dandalup, Conjurunup Pipehead and Stirling dams;
- The Serpentine, Big Brook, South Dandalup, Murray and Harvey rivers;
- Those wetlands located within the Myara region of the Huntly DE; and
- The Carter's Freshwater Mussel habitat located around Serpentine Dam.

Stabilisation activities (completed as part of the rehabilitation process) ultimately re-establish pre-mining hydrological processes, thereby decreasing surface runoff and reducing both:

- The occurrence of turbidity incidents; and
- The magnitude of any such incidents.

5.5.7.5.1.3 Groundwater Regime

Clearing of vegetation and removal of ore during mining is documented to cause an increase in groundwater recharge rates and a reduction in transpiration losses from the system water balance. This often results in increased groundwater elevations at and downgradient of these areas, which can:

- Result in the 'water logging' of soils, particularly downgradient of both cleared and mining areas; and
- Alter the hydrological regime to nearby GDEs and terrestrial vegetation habitats.

In response to bauxite mining, Grigg (2017) noted:

- Increases in streamflow rates were closely associated with changes in groundwater discharge areas and rates, particularly those close to and along valley floors;
- Changes in groundwater elevations were related to rainfall and LAI, with little to no difference in these factors between mine rehabilitation areas and unmined catchment areas;
- Peak increases in groundwater elevations during stripping and mining activities varied between:
    - 2.8 and 5.5 m beneath catchment lower slope and valley edge locations (i.e., at lower elevations in these catchments); and
    - 2.5 and 5.0 m beneath catchment mid-slopes; and
- Following rehabilitation, groundwater elevations ultimately returned to pre-mining levels or slightly below these elevations.

Trees and other vegetation communities at, and downgradient of cleared and open mining areas are expected to be most affected by mining-induced increases in groundwater elevations. Zones of poor tree health at Huntly are evident in areas with complete saturation of the soil profile (Grigg A. H., 2017), with *Eucalyptus marginata* known to have a low tolerance of complete root system inundation. Grigg (2017) but noted not all occurrences of poor tree health in areas of Alcoa's operations could be solely attributable to mining-induced changes in groundwater elevations, with the plant pathogen *Phytophthora cinnamomi* also seen as a contributing factor to their poor health and occasional dieback.

Advisian (2024) notes at other mining areas where shallow root systems of *Eucalyptus marginata* remain above the water table, these trees can survive and experience minimal health impacts. They do note though these trees may experience increased vulnerability to acute drought events and heatwaves which deplete shallow soil moisture.

Tolerance of waterlogging varies between plant species and vegetation types. Observations by Advisian (2024) suggest vegetation health may be maintained by even relatively thin and shallow unsaturated zone (tens of centimetres thick) overlying saturated layers, with tolerant species appearing to rapidly colonise areas of high groundwater tables.

Proposed clearing and rehabilitation activities is expected to directly impact approximately 13 ha of mapped CCW within the Mine DE, however site assessment will be undertaken to confirm CCW or REW extent to ensure avoidance or minimisation of impacts. No clearing for mining within CCWs or REWs will occur, however clearing for infrastructure may be required, therefore a Limited Disturbance Area will be placed on confirmed CCWs or REWs.

Indirect effects of localised increases of groundwater elevations on potential GDEs, wetlands (including CCW within the Mine DE) and the aquatic ecology of the streams, is expected to be most pronounced where groundwater level increases on top of natural variations are 'large' (e.g., 2 to 5 m), and increases in discharge occur. These could be locations which include GDEs and wetlands close to the mining footprint (e.g., less than 200 to 300 m), or where the mining footprint is large compared to the catchment area (GHD, 2021c). Minimal indirect impact to the groundwater receptors is anticipated. In stating this, DWER (2024) predicts future climate change will result in greater climate variability and longer dry spells or droughts, with higher evapotranspiration rates – combined with the possibility of reduced wet season rainfall – expected to result in reduced dry-season soil moisture contents.

Consequently, runoff and groundwater recharge are projected to decline, suggesting the magnitude of any future mining-induced increases of groundwater level increases may decline in the future (Department of Water and Environmental Regulation, 2024).

Small changes in groundwater levels and discharge can be expected where the mining footprint is:

(i) Relatively small within the catchment; and

(ii) Located some distance from the potential GDE and wetland receptors (e.g., greater than 500 m) (GHD, 2021c).

In such instances, such changes are considered unlikely to be of significance to vegetation communities.

In the context of catchment-scale hydrological responses, the effect of land clearing and mining is expected to be indistinguishable from the effect of other forest disturbances such as (other) timber harvesting operations or the clearing of land for pasture in line with those studies presented in (Grigg A. H., 2017).

The Proposal is within the PDWSA catchments of Serpentine, Serpentine Pipehead, North Dandalup, South Dandalup, South Dandalup Pipehead, Conjurunup Creek Pipehead, Samson Brook and Stirling Dams, whilst major rivers and tributaries within and downstream of the Proposal areas include the Serpentine, Big Brook, South Dandalup, Murray and Harvey rivers. Whilst these may temporarily experience slightly higher flows due to increased baseflows from groundwater inflows attributable to clearing and or mining in these areas, this is not expected to be a significant impact as the Proposal areas are small compared to the overall catchment reporting to the rivers (refer to Table 5-68).

Following mining, the mined landform will be re-shaped to mimic pre-mining conditions and stripped overburden and topsoils (which were stockpiled during stripping) reinstated. The gradual re-establishment of vegetation across the formerly mined areas and the associated return to pre-mining transpiration rates (in this case higher groundwater uptake than during land clearing and mining) is expected during rehabilitation, with (clearing and mining-induced) groundwater mounding predicted to dissipate, and groundwater elevations returning to, or close to, pre-mining conditions (Grigg A. H., 2017). Similarly, ponding may occur during and following rainfall events where local depressions are present in rehabilitated surfaces. These may promote areas of near-surface waterlogging and/or higher infiltration should re-establishing vegetation not fully intercept or transpire available water, but again are expected to be localised and not of significance.

5.5.7.5.1.4 Water Users

The Mine DEs are located primarily within the unproclaimed groundwater area east of the SWP. A very small portion of the Del Park mine region extends into the Murray, Pinjarra Comb – Fractured Rock West area. There are no registered groundwater licences within the Mine DEs, noting that there may not be a requirement to obtain a licence for groundwater extraction from the unproclaimed groundwater area and that unregistered groundwater use may exist in areas of rural development.

The Proposal does not include the active removal of groundwater to support Alcoa's planned operations, in particular as a 2 m groundwater separate distance between pit base and maximum groundwater level will be implemented. As such the Proposal is unlikely to impact

any registered or unregistered groundwater users near to or immediately down catchment of the Mine DEs. Historical mining activities demonstrate the impact of mining on the water balance results in a net surplus of groundwater (i.e., groundwater mounding), with no adverse impacts (i) known to have occurred to existing groundwater users' access or (quantitative) supply, nor (ii) expected. As there is no planned change to the mining process, there is no deviation from the current understanding of how the mining process impacts the overall catchment water balance and existing users.

There are various water users near Hunty and Willowdale DEs that could be impacted by changes to surface water and/or groundwater regimes. The above sections estimate minimal impact to inland water environmental values as a result of the Proposal. A qualitative public drinking water risk assessment (DWRA) completed as part of this ERD (Appendix 51) also estimated minor change to the PDWSAs as a result of change in surface water and groundwater regimes.

As described above, the Proposal is likely to result in only **minor** impacts from temporary increases in surface water flows, with these unlikely to prohibit the use of water for any of the following beneficial uses.

Huntly DE:

- Public water supply: Serpentine Dam, Serpentine Pipehead Dam, North and South Dandalup, Conjurunup Dam and South Dandalup Dam;
- Recreation and tourism: Serpentine Dam, Serpentine River downstream;
- Cultural heritage site: Serpentine River and South Dandalup River registered Aboriginal cultural heritage site;
- Agricultural site: use at the farm adjacent to Serpentine Main Dam; and
- Unregistered groundwater use.

Willowdale DE:

- Public water supply: Stirling Dam
- Recreational uses: camping, swimming and canoeing along Murray River downstream of Willowdale mining DE, including Logue Brook
- Cultural heritage sites: Murray River registered Aboriginal cultural heritage site, and
- Unregistered groundwater use.

5.5.7.5.2 Potential Impact 2 – Increase in the Rate and Salinity of Groundwater Discharges to Catchment Surface Water Systems

Modelling of predicted changes to groundwater elevations due of Alcoa's activities in the Huntly and Willowdale DE has not been undertaken, and the quantification of any impacts remains uncertain. In the absence of site-specific assessments however, the clearing of vegetation and removal of soil and bauxite ore are expected to both reduce evapotranspiration and increase the infiltration of rainfall in mine disturbed areas. This is expected to induce higher water tables beneath and downgradient of these areas (as described in Potential Impact 1), which can in turn:

- Result in higher groundwater discharges to waterways in actively-mined catchments;
- Result in more saline groundwater discharges to local waterways, including those which flow into public drinking water reservoirs; and

- Via changes in water geochemistry (salinity), impact nearby GDEs, wetlands and terrestrial vegetation habitats.

With regards to potential increases in rates of saline groundwater discharging to local waterways and accompanying changes in stream salinity, this is expected to be somewhat offset (i.e., buffered) by similar increased discharges of lower-salinity groundwater to these streams. This buffering effect is expected to result in a reduced observable change and 'dilute' the impact to the surface waterways.

5.5.7.5.2.1 Previous Studies of Mining Effects on Salinity

The potential for bauxite mining to result in stream salinity was recognized in the 1970s and led to the development of the Joint Intermediate Rainfall Zone Research Program (JIRZRP). Several experiments were conducted under the JIRZRP, including the Trial Mining Project (TMP) which involved the study of the effects of mining and rehabilitation during 2003 – 2011 in upper catchments of the Serpentine and Dandalup rivers. Findings of the TMP indicated an almost complete absence of response to mining in either streamflow or stream salinity (Croton J. N., 2011). It was concluded this lack of response was due to the decline in groundwater levels and that the groundwater rise from mining was insufficient to cause saline groundwater discharge into streams.

Similar findings were reported for other catchments in the Intermediate Rainfall Zone (IRZ) subject to forest thinning experiments over a comparable period (Kinal & Stoneman, 2011).

GHD (2023b) undertook a Hydrology and Water Quality Assessment for study areas that contained a small portion of the Huntly Proposal DE, albeit largely focusing on adjacent catchments at the Huntly Mine. A summary of the relevant outcomes is provided below.

Clearing of vegetation induces a groundwater level rise where transpiration occurring under the baseline condition transpiration is effectively removed. The potential for groundwater level rise commences during the pre-mining phase as the planned sites are cleared, stripped and prepped for mining.

Groundwater levels are expected to decline post-mining as rehabilitation re-establishes the Leaf Area Index, and ultimately return to pre-mining levels or thereabouts (Grigg A. H., 2017).

Increases of salt loads in the surface water streams may have the following consequences on relevant environmental values:

- Increased salinity of water stored within the public drinking water supply; and
- Changes to freshwater ecology.

Soil investigations in the 1980s identified a gradual increasing spatial trend in soil salt content between high rainfall areas (HRZ) and lower rainfall areas (LRZ) on the Darling Plateau. Low soil salt storage is expected in those soils in areas within and to the west of the HRZ (GHD, 2021c) which includes the Huntly and Willowdale DEs. As such, the risk of any notable (additional) mobilisation of salt in groundwater due to Alcoa's activities is expected to be low. This is demonstrated by groundwater salinity trends in the Myara North sub region of the Huntly mine which have been relatively stable over the three decades of monitoring (1990 to 2020).

Additionally, Dixon et. al. (2019) investigated the effects of mining and rehabilitation in the Serpentine Dam catchment using the LUCICAT catchment hydrology model. They modelled

a 'no-mining' scenario and two scenarios of mining at nine and 12% of the catchment, under two climate scenarios of average rainfall (914 mm/year) and low rainfall (841 mm/year). Model results are summarised in Table 5-69 and indicate streamflow salinity is expected to *decrease* during mining, then *increase* during rehabilitation. Their modelling also predicted an inverse trend in streamflow yield, an increase in streamflow during mining, and a decrease during rehabilitation. As such Dixon et. al. (2019) suggested mining may increase reservoir salinity by up to 3% compared to the no-mining case.

Table 5-69: Modelled effect of mining on streamflow salinity into Serpentine Dam (Dixon, Grigg, & Alam, 2019)

Scenario	Average salinity (mg/L) during mining (2011 – 2030)	Average salinity (mg/L) post mining (2031 – 2050)	Difference (mg/L) during mining (2011 – 2030)	Difference (mg/L) post-mining (2031 – 2050)
Not mined – average rainfall	166	155	Not assessed	Not assessed
Not mined – low rainfall	195	178	Not assessed	Not assessed
Mined 8 percent – average rainfall	163	160	-3.9	+4.8
Mined 8 percent – low rainfall	191	184	-4.7	+5.4
Mined 12 percent – average rainfall	163	158	-3.1	+3.8
Mined 12 percent – low rainfall	195	181	Nil	+2.6

5.5.7.5.2.2 Studies Conducted for the Proposal

GHD (2023b) undertook a Hydrology and Water Quality Assessment for the adjacent mine regions to the Proposal. It included groundwater modelling for the Myara North and Holyoake mine regions, a summary of which is provided below for the Serpentine and South Dandalup dams. In each instance, the predicted rise of groundwater levels associated with the clearing of vegetation and mining was considered to have the potential to mobilise salts naturally present in soils and groundwater in these catchments, which may then enter streams as groundwater-derived baseflow.

Potential changes to the salinity of streamflow entering the Serpentine and South Dandalup dams were estimated using (i) modelled changes in streamflow, and (ii) observed groundwater salinity. This was achieved by comparing modelled streamflow volumes and their proportional groundwater discharge component between mined and unmined cases, with modelled streamflows then converted to salt loads using observed salinity ranges.

5.5.7.5.2.3 Serpentine Dam

For the Myara North DE, GHD (2023b) noted salinity was predicted to:

- Decrease on average by 5 mg/L during mining; and
- Increased on average by 11 mg/L post-mining (when compared to the non-mining case).

When considering the impact of climate change, predicted average changes were 4 mg/L lower during mining, and on average 13 mg/L higher post-mining.

In both instances, the trend of salinity decreasing during mining and increasing post-mining was consistent with the findings of Dixon et. al. (2019).

Average annual salinity of groundwater discharge to surface waterways was estimated to range between 222 to 261 mg/L during mining, and 230 to 254 mg/L during rehabilitation. Accordingly, the modelling suggested the Proposal in the modelled areas ultimately had the potential to:

- Lower salinity concentrations by about 2% during mining; and
- Increase salinity concentrations by about 5% in the post-mining setting (when compared to the non-mining case).

These inflows were expected by GHD to 'fall within the threshold of freshwater quality'.

GHD (2023b) validated its predicted effects of mining on inflow salinity by noting salinity in the Serpentine Dam over the past 20 years typically varied between about 250 and 350 µS/cm, despite mine-clearing comprising approximately 10% of the catchment. It noted that there were no observable trends to suggest mining had impacted salinity in the Serpentine Dam despite mining activities being carried out in the O'Neil and McCoy mine regions (which lie within the IRZ), with salinity trends rather increasing during extended periods of low inflows and decreasing in response to higher inflows.

In light of the above, GHD concluded any changes in groundwater or surface water salinity attributable to the Proposal were unlikely to cause a significant impact to drinking water quality in the Serpentine Dam.

5.5.7.5.2.4 South Dandalup Dam

When compared to the non-mining case for the Holyoake DE, GHD (2023b) predicted average salinity increases of 8 mg/L may occur during mining, and changes of up to 17 mg/L may occur post-mining.

When considering the impact of climate change, average increases were predicted by GHD to be 5 mg/L during mining and 9 mg/L post-mining, with the lower salinity increase under the climate change scenario attributed to lower groundwater levels in response to reduced recharge, and thereby reduced groundwater discharge to nearby surface waterways.

Average annual salinity in groundwater inflows to nearby surface waterways was predicted by GHD to range between 100 and 130 mg/L during mining, and 105 to 163 mg/L post-mining. In both instances this water was considered to 'fall well within the threshold of freshwater quality'.

In light of the above, GHD considered the Proposal is unlikely to cause a significant impact to drinking water quality in the South Dandalup Dam due to changes in stream salinity.

5.5.7.5.2.5 Other Dams

No studies regarding potential impacts of mine-induced salinity changes on water geochemistry and quality in the South Dandalup Pipehead, Serpentine Dam Pipehead, Conjurunup Pipehead, North Dandalup and Stirling dams or Samson Brook are known.

Based on those studies carried out by GHD (2023b) for the Serpentine and South Dandalup dams, however, similar 'small scale' changes in salinity may occur in in response to mining in these catchment areas, albeit with these water bodies still capable of maintaining freshwater conditions. As such it is considered unlikely that the Proposal will cause or indirectly result in any significant impact to and public drinking water supplies in these catchments.

Based on a review of previous studies assessing potential impacts of mining in adjacent catchments, the Proposal is not expected to result in any significant changes to stream salinity. As such, freshwater conditions are expected to continue in all major rivers and their tributaries throughout the Huntly and Willowdale Mine DE, including the:

- Murray, Serpentine, South Dandalup, North Dandalup, Harvey, Harris and Canning rivers;
- Upper Wongong, Gooralong, Big and Drakes brooks; and
- Freshwater tributaries of the above.

5.5.7.5.2.6 Impact to freshwater aquatic ecosystems

Given groundwater is (generally) moderately fresh and, where monitored, does not appear to show any measurable increase in groundwater salinity, the effects of mining on groundwater salinity are expected to be negligible, including any subsequent impacts to GDEs, wetlands and other vegetation communities.

Stream macroinvertebrates monitored in both mined and un-impacted catchments at the Huntly Mine was undertaken as part of the JIRZRP TMP. Surveys were carried out in 2005, 2007, 2009, 2011, 2014, and 2019 (Water Research and Management, 2019) and included the sampling and comparative analysis of macroinvertebrates between sampling events as a potential indicator of mining-induced impacts to aquatic biodiversity. Analyses included univariate and multivariate analysis of species-level metrics including total taxa richness, EPT4 richness, functional feeding groups and Bray-Curtis similarity (Water Research and Management, 2019). These studies concluded there was no significant difference between macroinvertebrate communities in mined and un-mined catchments and noted that fauna observed was likely more dependent on natural habitat characteristics and localised anthropogenic disturbance at each site. In light of the above, the Carter's Freshwater Mussel habitat around Serpentine Dam is not expected to be adversely impacted as a result of any mine-induced increases in surface water salinity.

Based on the anticipated limited changes to stream salinity and the findings of stream monitoring at the Huntly Mine, vegetation clearance and mining is not expected to impact aquatic biodiversity as a result of any mine-induced increased in groundwater and/or streamflow salinity.

Additionally, following rehabilitation, the re-establishment of vegetation in previously cleared areas is expected to lower the elevation of the water table, similar to that during baseline conditions. This is not expected to further increase groundwater salinity or result in any long-term release of above-average concentrations of stored salts to groundwater, and therefore not expected to impact any GDEs, other vegetation communities, or public drinking water supplies.

5.5.7.5.3 Potential Impact 3 – Increased Sediment Loads in Surface Water as a Result of Both Mining and Rehabilitation Activities

As discussed in Potential Impact 1 (Section 5.5.7.5.1), changes in baseline landforms may locally affect stream channel geomorphology, and consequently potentially downslope and downstream sedimentation (both scour and deposition) processes.

A number of activities associated with Alcoa's operations have the potential to both directly and indirectly change sediment loads in nearby surface waterways. Direct impacts relate to those associated with the key stages of mine development and closure and include:

- Pre-mining land clearing: mostly through the clearing of vegetation, particularly those with deep root systems, the movement of heavy machinery, and the stockpiling of soils for later use;
- Mining: through the construction and use of surface water diversion drains around the perimeter of mine excavations (noting that sediment generated within the mine pits is not expected to be released to the environment); and
- Rehabilitation: from the placement of soils during post-mining landscaping and revegetation activities coupled with erosion of post-mining landforms.

Increases in turbidity in surface water runoff could be expected during each of these activities, with impacts highest during land clearing.

Potential indirect impacts relate to altered sedimentation patterns (channel erosion and scour dynamics) as a result of mining-induced changes in catchment water dynamics and are addressed as part of Potential Impact 1 (Section 5.5.7.5.1).

Potential impacts of increased surface water turbidity during and following rehabilitation is expected to be lower than that in active mining areas. Vegetation establishment and subsequent return to pre-mining transpiration levels is expected to provide long-term soil protection from erosion, whilst rehabilitation designs and stabilisation activities will maximise water infiltration and retention, thereby reducing sediment loads entering waterways (and the potential for turbidity incidents occurring).

With the ongoing establishment of ground cover and increasing leaf falls (which create sediment dams and allow the development of soil profiles), mobile sediment loads are also expected to decrease with time, ultimately returning to pre-impact levels (GHD, 2021c).

5.5.7.5.3.1 Increase in suspended sediment to drinking water reservoirs and dams

Previous assessments (GHD, 2021d) noted elevated levels of inorganic suspended sediments of up to 1 mg/L (equivalent to about 1-2 NTU) experienced in the Myara North and Holyoake mine areas were not expected to affect disinfection efficacy. Given the same land clearing and mining processes will be carried out by Alcoa in the Willowdale and Huntly DEs, similar sentiments regarding elevated suspended sediments and their impacts on PDWSAs, including its treatment, are expected in these areas.

Alcoa has developed a Water Resources Management Plan for its works to minimise any impacts to PDWSAs. A risk-based approach is undertaken within constrained areas, with additional details provided within FCAs. Multiple barriers are implemented to prevent impacts to downstream drinking water reservoirs.

A detailed sedimentation assessment is not available for the DEs of this Proposal. No information was available for assessing outcome of the recently instated 1 km reservoir setback, which commenced in Dec 2023. A qualitative impact assessment though has been undertaken for this ERD based on the distance of clearing to the environmental value, and portion of clearing compared to the overall catchment reporting to nearby rivers and reservoirs.

A qualitative public DWRA completed as part of this ERD (Appendix 51) estimated a maximum **moderate** impact to the overall drinking water reservoirs and dams water quality as a result of increase in suspended solids. Further discussion relevant to each water supply feature is presented in the following bullet points.

- Huntly DE:
    - Serpentine Dam: Clearing is proposed within the RPZ, with only infrastructure clearing occurring within proximity of the maximum water line of the dam. All mine pit clearing will occur more than 1 km of the maximum water line of the dam. With mitigation controls in place, **moderate** impact may occur from clearing within the RPZ as there are less barriers for the suspended sediments to settle (i.e., drop out of suspension) before reaching this dam.

      Clearing is also proposed approximately 15 km upstream of this dam, and it is expected that whilst larger suspended sediments mobilised from this clearing may settle before reaching this dam, some finer sediment may reach this dam.
    - Serpentine Dam Pipehead: Only minor areas of clearing for rehabilitation is proposed within the catchment; this will total 6.6% of the catchment. This will lower the risk of sediment mobilisation through rehabilitation activities, hence only **minor** impact may occur to surface water in this catchment following the adequate installation of drainage, erosion and sediment controls around cleared areas.
    - North Dandalup: Clearing is proposed within the RPZ. With mitigation controls in place, a **moderate** impact to surface water in this dam may occur as there is likely to be less barriers for suspended sediments to settle before it reaches this dam.

      Clearing is also proposed approximately 6.5 km further upstream of this dam, and it is expected that whilst larger suspended sediments mobilised from this clearing may settle before reaching this dam, some finer sediment may reach this dam.
    - South Dandalup: Small areas for clearing are proposed in the PDWSA, with most occurring in the RPZ. It total, 0.03% of this catchment will be cleared as part of this Proposal, with only **minor** impact considered possible following the application of adequate drainage, erosion and sediment controls around those areas to be cleared.
    - South Dandalup Pipehead: Small areas for clearing and rehabilitation are proposed in the PDWSA, albeit higher in the catchment. It total, 3% of this catchment will be cleared as part of this Proposal, with only **minor** impact on water quality in this catchment considered likely following the application of adequate drainage, erosion and sediment controls around cleared areas.
    - Conjurunup Pipehead: Small areas for clearing are proposed in the PDWSA, with some clearing occurring in the RPZ; this will total, 1% of this catchment. As such, only **minor** impact to water resources is considered likely to water resources in this

PDWSA following the application of adequate drainage, erosion and sediment controls around those areas to be cleared.

- Willowdale DE:
  - Stirling Dam: Clearing in the Wills region of the Willowdale DE is proposed approximately 20 km upstream of the dam. As such, an insignificant impact of this activity to water behind Stirling Dam is considered likely as any suspended sediment generated as a result of the Proposal expected to mostly settle before reaching this Dam.

5.5.7.5.3.2 Suspended sediment modelling in drinking water reservoirs and dams

GHD (2023b) modelled the relative differences between large winter and summer inflow events on reservoir and withdrawal turbidity levels, with these inflows represented by 10% and 1% AEP events. Likely turbidity concentrations were estimated for the Serpentine, South Dandalup and Pipehead PDWSAs, with sediment release events assumed to occur in combination with either moderate (30%) and high (75%) failure rates in mine sediment controls.

Hydrodynamic modelling indicated turbidity concentrations and sediment contents in the Serpentine Dam are likely to be sensitive to high level failures of mine sediment controls during storm events which have ten-year return periods or greater (i.e., a 10% AEP or higher). By contrast, the South Dandalup Dam had a lower sensitivity due to the relatively smaller proportion of the catchment subject to mining, whilst the Serpentine Pipehead Dam also had a lower sensitivity due to the hydrodynamic and dilution effects of the substantial IWSS inflows and withdrawals.

Results of the modelling were as follows:

- Increased concentrations of coarser suspended sediments (silt fractions) were of short duration due to the relatively rapid settling within reservoirs before reaching the offtake. Increased concentrations that occurred at the offtake were predominantly fine suspended sediments (clay fractions).
- For Serpentine Dam with moderate failure in mine sediment controls, suspended sediment increases of up to ~0.5 mg/L and ~0.2-0.3 mg/L were simulated for moderate failure in mine sediment controls for the summer and winter 1% AEP inflow events, respectively. The relatively higher increases for summer are due to the presence of thermal stratification and more limited mixing compared to winter.
- For Serpentine Dam with high failure of mine sediment controls, there was also limited change in suspended sediment between the non-mining and mining scenarios for either winter or summer 10% AEP events. Suspended sediment increases of up to ~1 mg/L and ~0.3-0.4 mg/L were simulated for high failure in mine sediment controls for the summer and winter 1% AEP inflow events, respectively.
- For South Dandalup Dam with moderate and high failure of mine sediment control, there was no material change in suspended sediment between the non-mining and mining scenarios for either winter or summer 10% or 1% AEP events.
- For Serpentine Pipehead Dam with moderate and high failure of mine sediment controls there was no material change in suspended sediment between the non-mining and mining scenarios for either winter or summer 10% or 1% AEP events.

When considering the above changes in suspended sediment, GHD (2023b) noted higher concentrations of inorganic suspended sediments of up to 1 mg/L (equivalent to about 1 to 2 NTU) were not expected to affect disinfection efficacy. It further noted where raw waters have turbidity concentrations of 20 NTU or more, these could still be effectively disinfected for chlorine-resistant viruses but may require longer contact with chlorine.

5.5.7.5.3.3 Increase in Suspended Sediment to Aquatic Ecology

The following potential ecological impacts may occur to the following rivers following the implementation of those mitigation controls described in Section 5.5.8.

- Huntly DE:
  - Serpentine River: **minor** potential impact possible given clearing is proposed less than 1 km from this river.
  - Big Brook and South Dandalup rivers: **minor** impact possible given the proposed area for clearing is small when compared to the remaining area of this catchment which drains to these rivers.
  - North Dandalup river: **no** potential impact is expected; clearing is not proposed upstream of this river.
- Willowdale DE:
  - Murray River and Harvey rivers: **minor** potential impact possible; proposed area for clearing is small compared to the overall catchment reporting to these rivers.

Wetlands (including CCW) are located downstream of proposed clearing areas in the Myara region of the Huntly DE. These may form through-flow and/or depositional zones for any mine-induced sediment loads in these waterways but only **minor potential** impact may eventuate following the application of applicable drainage, erosion and sediment controls at and around cleared areas.

Carter's Freshwater Mussel habitat is located around Serpentine Dam, including adjacent to that area to be cleared. Again, however, only **minimal** potential impact may occur to this habitat once (again) appropriate drainage, erosion and sediment controls have been put in place within and around cleared areas.

5.5.7.5.3.4 Wildfire Impacts to Water Quality

GHD (2023b) carried out a literature review of the impacts of bushfires within Western Australia on surface water quality. It included a review of the 2005 Perth Hills and 2016 Waroona-Yarloop fires which suggested the Serpentine, Pipehead, South Dandalup, and Wungong dam reservoirs may be susceptible to water quality impacts following bushfires. Major wildfire and heavy rainfall sequence in these catchments was found to result in higher likelihoods of widespread ash deposition, surface water runoff and accompanying erosion, all of which could generate substantial discharges of ash and sediment into catchments. Depending on the severity and location of fire and rainfall, it was considered there was a potential for discharges to exceed the attenuating capacity of the reservoir, resulting in elevated contaminant levels at the offtake which exceed the relevant drinking water quality criteria (GHD, 2023b).

GHD (2023b) noted there is a potential for major wildfire throughout the NJF, irrespective of Alcoa's activities. It notes the increased prevalence of wildfires in Western Australia over the

past two decades highlights this, which in part may be due to a reduction in prescribed burning since the 1990s, the reasons for which include:

- Climate change, in particular:
    - The expected increase in the duration for which vegetation is flammable; and
    - The likely greater accumulation of leaf litter (fuel accumulation) for fire events.
- Climate variability (e.g., increasing frequency of high fire risk days in which burning cannot be scheduled);
- Land-use changes and population growth (e.g., urban and rural air quality constraints, landowner objections); and
- Resource constraints.

Alcoa collaborates with DBCA in planning an annual prescribed burn program, and funds those burns conducted within and surrounding mining and rehabilitation areas. It uses a fire risk matrix based on fuel ages in rehabilitated areas and adjacent unmined forests to minimise impacts to the environment, including the potential for increased sediment loads in surface waterways.

5.5.7.5.4 Potential Impact 4 – Contamination of groundwater and/or Surface Water Due to Project-impacted Waters or Unintentional Release of Operational Water and/or Chemicals to the Environment

Both past and future mining-related activities may contaminate water resources within the DEs. Potential contaminants include fuel (diesel), oils and solvents, fertilisers, herbicides, pesticides, sewage and PFAS, all of which can be variably applied to and ‘stored’ in both the soils and water – including groundwater – in the DEs.

Diesel is the predominant hazardous material used at the Mine, with lesser amounts of hydraulic and lubricating oils also used. Minor quantities of other hazardous materials including solvents and adhesives are also used for vehicle and equipment maintenance, whilst herbicides, fertilisers and pesticides are also used.

Low traces of PFAS have been detected in previous mining areas. These are understood to be sourced from PFAS-containing fire suppressants previously used among Alcoa’s heavy vehicle mining fleet, and which have since been replaced with non-PFAS products.

Surface water runoff can mobilise contaminants directly downstream of the catchment when contaminants are adsorbed to surface soils. Pre-mining clearing and mining bauxite activities exposes the ground cover, with contaminants potentially mobilised downslope with suspended sediments in accompanying surface water runoff.

Pre-mining clearing and/or mining bauxite has the potential to raise groundwater levels, thereby further mobilising existing contaminants. As discussed in Potential Impact 1, catchment responses to land clearing and mining across the Darling Plateau include rising water tables following clearing, thereby potentially mobilising any soluble contaminants in these soils that were previously above the (pre-mining, i.e., lower) groundwater table.

5.5.7.5.4.1 Contamination of Surface Water and/or Groundwater as a result of Incorrect Storage and/or Accidental Release of Chemicals

Changes of surface water and/or groundwater geochemistry, including deterioration of quality and potential loss of beneficial uses of this water, may occur following the accidental

release of chemicals during site operations. In stating this however, it is expected large accidental spills can and will be quickly identified at the time of release, and Alcoa able to immediately implement appropriate mitigation and management protocols to contain and minimise potential impacts. It is recognised smaller spills and leaks may be missed but it is expected these would either be:

- Ultimately identified and appropriately managed; and/or
- Diluted with rainfall runoff and/or groundwater prior to any such contaminants reaching downstream drinking water reservoirs.

The Proposal is within the RPZ of the Serpentine, North Dandalup, South Dandalup and Conjurunup Pipehead dams. No information was available for assessing outcome of the recently instated 1 km reservoir setback, which commenced in Dec 2023. As such, contamination of these PDWSAs from accidental spills and/or leaks from site operations (storage / handling of hazardous materials and waste) is considered feasible, however in light of those considerations presented above, not expected to result in any significant impact, including the need to remove these PDWSAs from the potable water supply system.

In the event of a contaminant release on site, those surface waterways downstream of the release point, which include the Serpentine, Big Brook, South Dandalup, Murray and Harvey rivers, may be impacted, albeit temporarily. Potential impacts to GDEs and wetlands (including CCW) are also expected to be temporary.

The type and magnitude of the impact will depend on the compound released, it's behaviour in the environment (in particular whether it adsorbs to soil particles or is mobile in water), where it its released, and quantity released, however given Alcoa's past proven experience in (i) operating in these and similar settings, and (ii) mitigating and managing past incidents, any future accidental releases of chemicals in the DEs is not expected to significant impact the quality of water or its uses in these rivers.

In light of the above, potential impacts from contamination from Alcoa's proposed activities is considered minimal.

5.5.7.5.4.2 Impact to Drinking Water Sources

A qualitative public DWRA was carried out as part of this ERD. The DWRA is presented in Appendix 51 and assessed the potential impact of the following contaminants and incidents to the PDWSAs:

- Pathogenic microorganisms;
- Turbidity;
- Hazardous substances, including hydrocarbons and PFAS;
- Wildfires; and
- Long term erosion from rehabilitation areas, including final landforms.

Alcoa implements preventative risk management at the Mine, which incorporates multiple preventative mitigation measures to prevent hazards to downstream drinking water reservoirs from occurring or reduce them to acceptable levels. Multiple barriers are established to control hazards relating to pathogens, sediment discharge, hydrocarbons and other chemicals, which themselves are barriers to contaminant transport before raw water is removed at the offtakes and entering the Water Corporation's water treatment and distribution system.

A previous review of the existing barrier network at the Mine (GHD, 2023b) indicates that some barriers are likely to fail under certain conditions. When multiple failures occur, this may result in varying quantities of contaminants reaching the downstream reservoirs. Key conditions that can cause multiple-barrier failure include workforce behaviour in the case of discharge of pathogens, and major storm events during wet catchment conditions in the case of sediment and hydrocarbons.

Additional barriers and improvements to existing barriers are proposed to reduce the likelihood of barrier failure and potential for discharge of contaminants into reservoirs. The review details the proposed improvements, with key components as follows:

- Application of risk-based Mine drainage controls in all disturbed areas, in accordance with Alcoa Drainage Manual and Haul Road Sump Design Manual;
- Workforce education and monitoring relating to pathogen risk;
- Incident reporting and response (including waste bagging and removal) of pathogen discharge; and
- Rehabilitation of mine pits to be designed and executed to prevent overflow during a 1% AEP storm event of 24-hour duration.

Alcoa's Drainage Manual and Haul Road Sump Design Manual are working documents which are undertaking further review and improvements. Alcoa is conducting a detailed drainage management review that will incorporate learnings from historic and current drainage design, third party hydrological and engineering reviews and associated improvement plans. This will form a risk based mine drainage control tool that will be incorporated into the Manuals and executed.

5.5.7.5.4.3 Contamination of Surface Water and/or Groundwater as a result of On-site Project Water and/or Chemical Usage

Water is used on site for various purposes, most commonly dust suppression on haul roads and conveyors. It is largely sourced from local reservoirs and storm water run-off, with lesser amounts of treated wastewater also used where appropriate and approved to do so. As such water used on site, may contain some chemical compounds related to Alcoa's activities in these areas including:

- 'Heavy' hydrocarbons (such as oils, greases and diesel fuel) from heavy-equipment and vehicle use;
- 'Light' hydrocarbons (such as solvents and degreasers) associated with the maintenance of heavy-equipment, vehicles, and other plant;
- Herbicides and fertilisers used in rehabilitation activities; and
- Sewerage from accidental releases.

In stating the above, it is expected that concentrations of any such chemicals site water used in Alcoa's operations in the Huntly and Willowdale DEs will be minimal, with their impacts to the environment also coincidentally minimal.

Additionally, many of those chemicals used on site are expected to either:

(i) Degrade with time;

(ii) Adsorb to the soil, thereby minimising the long-term impacts of their unintentional release to the environment, including surface water and groundwater systems; and/or

(iii) Dilute along flow paths or in receiving environments.

In light of the above, Alcoa's use of project water in its activities is not expected to significantly impact any GDEs, wetlands (including CCW), other aquatic ecological systems or the quality of water in the nearby PDWSAs.

5.5.7.5.4.4 Mobilisation of Existing Contaminant attached to Soil due to the Release of Sediment-laden Runoff following Vegetation Clearance and/or Alteration of Surface Water Drainage Patterns

Some chemicals used in Alcoa's operations may adsorb to soil and remain relatively benign to water systems. Should these areas and chemical loadings though be disturbed by mining activities, this sediment may enter nearby water systems through direct or indirect pathways where any contaminants may then desorb from the soil, ultimately becoming mobile in surface water. This has the potential to deteriorate water quality and impacts to the receiving environments including GDEs and wetlands (including CCW), as well as water resources in nearby PDWSAs, with such contaminants expected to include:

- Oils, greases and diesel fuel from heavy-equipment and vehicle use;
- Solvents and degreasers associated with the servicing and maintenance of heavy-equipment, vehicles and other plant;
- PFAS from past fire-fighting activities; and
- To a lesser degree, herbicides and pesticides used in rehabilitation activities.

A qualitative public DWRA completed as part of this ERD (Appendix 51) estimated a maximum **high** residual impact may occur to that potable water within the drinking water reservoirs and dams as a result of an unspecified contaminant reaching the drinking water sources.

5.5.7.5.4.5 Hydrocarbons

Diesel is the only fuel used in site operations, and is predominantly used for haul trucks, excavators and other large earthmoving equipment. Other hydrocarbons such as hydraulic and lubricating oils, solvents and adhesives are also used for vehicle and equipment maintenance or water treatment, but these are secondary and considered minor when compared to diesel use.

The storage and handling of diesel creates a potential hazard for spillage of diesel that may enter nearby waterways, including PDWSAs. Haul trucks, some wheeled earthmoving equipment and light vehicles are refuelled at fuel bays located outside of the RPZs, whilst the planned major maintenance of haul trucks, light vehicles and some earthmoving equipment is undertaken at workshops.

Fuel bay and workshop buildings have roofs and sealed floors which are expected to capture any diesel spills or leaks during vehicle refuelling or maintenance. Diesel and oil storage tanks meet or exceed the minimum standards for the storage of C1 combustible liquids (as per the Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007), and as such are:

- Double-lined to minimise the potential for leaks; and
- Stored above ground to assist with the early detection and remediation of any leaks.

GHD (2023b) assessed the predicted impact of mining-related diesel spills within catchment areas. The assessment considered a worst-case scenario whereby 15,000 litres of diesel was discharged directly into a stream at each reservoir, with GHD predicting concentrations

at receiving locations allowing for river dilution, reservoir mixing and dispersion, and withdrawals from the dams. Peak diesel concentrations in the Serpentine and South Dandalup reservoirs were predicted to be less than 1 micrograms per litre (µg/L), whilst peak concentrations in the Serpentine Pipehead reservoir were predicted to be less than 5 µg/L. In both instances these concentrations were below that limit presented in the ADWG, and for the Serpentine Pipehead reservoir at the threshold for the aesthetic guideline.

Drinking water reservoirs and dams downstream of the proposed clearing (namely the Serpentine, Serpentine Pipehead, North Dandalup, South Dandalup, South Dandalup Pipehead, Conjurunup Pipehead, and Stirling dams) may be impacted in the event of a diesel spill within the PDWSA catchment. The qualitative DWRA assigned a **low** residual risk for hydrocarbons potentially contaminating PDWSA water quality, mobilised either via surface water or groundwater.

Conceptually, a large volume diesel spill (directly entering a waterway) may result in water quality impacts in the streamzone downstream of the spill as well as the upper reservoir prior to substantial mixing and attenuation. Localised impacts within the streamzone may impact aquatic fauna, GDEs, and wetlands (including CCW), as well as the condition and health of riparian vegetation. Additionally, impacts from any such spills occurring in the upper reservoir may affect aquatic fauna that reside in these waterbodies including native fish, freshwater crayfish and potentially populations of the Carter's Freshwater Mussel.

The majority of spills and leaks, particularly those from major incidents and involving large volumes, are expected to be identified quickly, and impacted soils excavated and appropriately disposed of off-site at licenced waste facilities.

Smaller spills and leaks may be missed, and these contaminants may locally impact groundwater and surface water. In stating this, however, smaller spills and leaks are expected to largely adsorb to soils beneath these spills (given both diesel and those oils used at site are somewhat hydrophobic, preferentially adsorbing to soils and organic matter as opposed to being soluble and mobile in water) and therefore considered unlikely to result in any notable impact to surface water or groundwater, including any microbiological communities in these systems.

5.5.7.5.4.6 Herbicides and Fertilisers

Herbicides are used by Alcoa for weed control during rehabilitation activities. These compounds however are of variable and often low solubilities and mobilisation rates in groundwater and surface water systems (what is commonly termed 'hydrophobic'), and often remain somewhat 'stationary' in those area where they are applied.

Fertiliser is also used by Alcoa in controlled quantities and in rehabilitation activities.

The inappropriate use, storage and/or disposal of herbicides and/or fertilisers can result in changes to ecological communities. These include the contamination of potable water sources, contamination and/or eutrophication of downstream surface water and groundwater receptors, and changes to downstream vegetation communities, including GDEs.

Drinking water reservoirs and dams downstream of those areas proposed to be cleared (namely the Serpentine Dam, Serpentine Dam Pipehead, North Dandalup, South Dandalup, South Dandalup Pipehead, Conjurunup Pipehead, Stirling Dam) may be impacted should any mobile concentrations of herbicides and/or fertilisers reach these water resources via

surface water or groundwater flow. The qualitative DWRA assigned a **low** potential residual risk for contamination to PDWSA water quality.

Wetlands (including CCW) located within the Myara region of the Huntly DE may be impacted by the use of herbicides and fertilisers in Alcoa's activities. In stating this, however, a **low** potential residual risk is expected given Alcoa's current and proposed mitigation strategies in place.

5.5.7.5.4.7 Pesticides

Pesticides may be used by Alcoa for feral animal control. These compounds though are often hydrophobic, meaning they preferentially bind to the soil rather than mobilise in surface water and groundwater systems.

The inappropriate use and storage and/or disposal of pesticides can result in changes to ecological communities. These include the contamination of potable water sources and contamination of downstream surface water and groundwater receptors, including GDEs and wetlands.

Drinking water reservoirs and dams downstream of proposed clearing areas (namely the Serpentine Dam, Serpentine Dam Pipehead, North Dandalup, South Dandalup, South Dandalup Pipehead, Conjurunup Pipehead, Stirling Dam) may be impacted should any mobile concentrations of pesticides reach these water resources via surface water or groundwater flow. The qualitative DWRA assigned a **low** residual risk for contamination to PDWSA water quality.

5.5.7.5.4.8 Pathogenic microorganisms

Sewage from site operations in both DEs is treated and then discharged to the environment via drip or sprinkler systems in designated areas.

Pathogens (such as *E. coli* or other faecal bacterium) and increased nutrients may enter waterways as a result of sewage overflow, subsurface leaching, sewage irrigation, and system breakdowns or leaks. The release of untreated sewage, particularly before or during a heavy rainfall event where the risk of dispersion is increased (GHD, 2023b), may present a risk to human health through:

- The direct contamination of drinking water; and/or
- Indirect impacts via changed ecological assemblages in the drinking water sources, including algal blooms detrimental to human health.

The Australian Drinking Water Guidelines state that the greatest risks to consumers of drinking water are pathogenic microorganisms (NHMRC, 2022).

Drinking water reservoirs and dams downstream of the proposed clearing (Serpentine Dam, Serpentine Dam Pipehead, North Dandalup, South Dandalup, South Dandalup Pipehead, Conjurunup Pipehead, Stirling Dam) may be impacted by pathogenic microorganisms due to vomiting or toileting within the PDWSA catchment. These microorganisms may be mobilised either via surface water or groundwater in these catchments, with the qualitative DWRA assigning a **moderate** potential residual risk to this occurrence.

Wetlands (including CCW) located within the Myara region of the Huntly DE, are downstream of the proposed mining activities. As such these wetlands may also be impacted by discharges from sewage leaks and spills in these catchments. **Minimal** residual

risk may eventuate within the Proposal DEs following the implementation of the appropriate mitigation strategies.

5.5.7.5.4.9 Per- and polyfluoroalkyl substances (PFAS)

Between 2013 and 2021 Alcoa used C6 aqueous film forming foams as a fire suppressant on its heavy vehicle mining fleet. This was found to contain low traces of PFAS and was replaced by Alcoa in December 2021 with approved fluorine-free foam fire suppressants across both the Huntly and Willowdale mines.

PFAS are water-soluble compounds which readily mobilise through the unsaturated zone. They are highly mobile in groundwater and surface water systems, and where present at notable concentrations in catchments are often detectable in stream flows.

Due to the absence of existing substantial soil and/or groundwater contamination in the Proposal DEs, any hydrological changes from construction and mining (i.e., the clearing of vegetation causing groundwater mounding and increased stream flows) are not expected to mobilise substantial quantities of PFAS into reservoirs. Accordingly, any indirect mobilisation of historic PFAS from catchments due to construction and mining is expected to pose a low potential risk to water quality.

The Myara reservoir is currently considered to be affected by minor PFAS concentrations. Detections are below the PFAS National Environmental Management Plan (NEMP) V2 95% Species Protection limit, however water from this reservoir is treated via a temporary PFAS treatment plant and must be confirmed as ‘non-detect’ for 28 PFAS species to ultra-trace levels prior to use on site.

Drinking water reservoirs and dams downstream of the proposed clearing (Serpentine Dam, Serpentine Dam Pipehead, North Dandalup, South Dandalup, South Dandalup Pipehead, Conjurunup Pipehead, Stirling Dam) may be impacted by PFAS traces mobilised either via surface water or groundwater. The qualitative DWRA assigned a residual **moderate** risk for PFAS contaminating PDWSA water quality.

Wetlands (including CCW) located within the Myara region of the Huntly DE, are downstream of the historic mining activities and may also receive PFAS traces with surface water runoff. **Minimal** residual risk is possible with mitigations in place.

5.5.7.5.4.10 Service Interruption of the Public Drinking Water Supply

The Proposal is considered unlikely to result in an exceedance of drinking water quality criteria at reservoir offtakes due to spills of hazardous materials, sewage treatment plant operation or release of sediment from mined areas.

There remains potential for large scale wildfires to occur in the PDWSAs that may result in drinking water quality becoming impacted for an extended duration. In such an event there is a potential requirement for the reservoir to be taken off-line, such as occurred for the Samson Brook Dam following the Waroona-Yarloop fire in 2016. However, the Proposal is not expected to increase the likelihood of severity of wildfires occurring in the mine regions, nor exacerbate the likelihood that this or other dams will need to be taken off-line due to wildfire impacts.

There remains potential for a major storm event (> 10% AEP or one in 10-year return interval) concurrent with a high level of failure in mine sediment controls to result in turbidity concentrations exceeding 1-2 NTU at the Serpentine Dam offtake. Such an event is unlikely

to cause an impact to treatment efficacy or public health but may dictate the reservoir being taken offline as a risk prevention measure.

Similarly, a large diesel spill in a reservoir is also unlikely to cause a significant impact to public health but may dictate the reservoir being taken offline. In stating this, modelling carried out by GHD (2023b) suggests such a catastrophic sediment release or diesel spill necessitating a shutdown of the Serpentine Dam or South Dandalup Dam reservoirs is unlikely to occur.

5.5.7.5.5 Potential Impact 5 – Contamination of Surface Water and/or Groundwater with PASS Compounds as a Result of Soil and Sediment Removal at Waterway Crossings

Disturbance of ASS, either actual or potential, at drainage crossings may impact surface water and groundwater through the resulting acidification of these soils and groundwater, coupled with the accompanying mobilisation of dissolved metals, metalloids and sulphate. This may alter water geochemistry which could have flow-on effects on:

- Water uses;
- The ecology of any nearby sensitive ecological receptors; and
- Environmental aesthetics, mostly through the precipitation of iron and growth of iron-reliant algal blooms.

ASS are described in Section 5.4.4.4, noting no investigations of PASS have been undertaken within the DEs.

ASS are generally formed and located below the water table, in particular in coastal and other low-lying areas (GoWA, 2015). Where in situ and undisturbed, including below the water table, they are benign. However, if these soils are exposed to air, those sulphide minerals in these soils can oxidise thereby generating and releasing sulfuric acid to water with consequential releases also of heavy metals, metalloids and sulphate to the environment.

Mapping undertaken by CSIRO (2011) suggests there is a 1 to 5% probability of PASS being present in soils within the DEs, albeit excluding those soils underlying the lakes. This mapping also indicates those soils underlying nearby PDWSA dams and catchments are classified with a ‘high’ (>70%) probability of ASS occurrence.

The Department of Primary Industries and Regional Development (DPIRD) risk map for soil surface acidification (DPIRD, 2023a) is consistent with that information shown in CSIRO (2011). It shows areas associated with inland waters (dams, swamps, rivers, tributaries and streams) have a 10 to 30% probability of acidic soils ($pH_{(Ca)}$ of <4.5) being present, with a decreasing probability with increasing distance away from these features.

CSIRO (2011) indicate most of the DE is considered to have a less than 3% risk of surface soil acidification. This though differs from those risk ratings for subsurface materials in DPIRD (2023b) which considers the majority of the DEs to have a greater than 70% risk of being or are presently acidic. Based on visual inspections of active mining areas in the Willowdale and Huntly DEs, those risk ratings of DPIRD (2023b) are considered very conservative.

Alcoa’s mining activities occur in shallow excavations above the water table, typically on hillslopes and other geomorphic areas of high vertical soil drainage (i.e., in areas where

waterlogging of soils does not occur or is infrequent). Mining involves the 'dry' excavation of ore from the near-surface horizon and does not require the dewatering or excavation of wet soils. As such, if PASS were to be present in cleared or mining areas they are not expected to be adversely impacted by Alcoa's activities.

The highest likelihood for the oxidation of ASS within the DE is expected to be associated with the disturbance of sediments and soils in low-lying areas including in swamps and along creeks. Oxidation of these soils may impact the pH of:

- Surface water bodies, including those which flow into PDWSA reservoirs; and
- Groundwater in the vicinity of impacted soils, particularly in valley floors where GDEs may exist.

There is insufficient information to assess the likelihood of and impact of any changes of soil and water conditions should any ASS in these areas be disturbed. In stating this, mining will not occur in low-lying areas including in swamps and along creeks, and only ancillary mine-related activities may be carried out in lower sections of the valleys and catchments including those for infrastructure crossings such as haul roads and conveyors. These activities may impact ASS if present; however, there is a lack of site-specific soil and groundwater data with which to confirm the presence and absence of potential or actual ASS in these areas, and what impacts their disturbance may have.

Where ASS soils may be present and disturbed, the size of mine activity (i.e., creek crossings) is expected to be limited. Impacts from mobilisation of ASS contaminants on disrupting aquatic ecology and reducing environmental aesthetics would likely be observable, small scale, localised and likely temporary in nature given short term construction periods. The risk would be **moderate**.

Buffer restrictions around PDWSA reservoirs would likely allow for some degree of contaminant dilution prior to waters entering the reservoirs, with this risk considered **low** and likely of insignificant consequence.

5.5.8 Mitigation

Alcoa operates the Huntly and Willowdale Mines through a mature environmental management system to international standards, and which undergoes continual improvement. Alcoa's environmental management of its Mine sites incorporates the mitigation hierarchy consistent with Western Australian guidance, which, in order of priority, is:

- Impact avoidance – avoiding the adverse environmental impact;
- Impact minimisation – limit the degree or magnitude of the adverse impact; and
- Rehabilitation – the process where disturbed land is returned to a stable, productive and self-sustaining condition, taking future land use into account. This process differs from the narrower definition of restoration by not aspiring to fully replace all of the original components of an ecosystem.

Alcoa's preventative risk management framework for mining involves multiple barriers to prevent and reduce hazards and the continual protection of inland water environmental values, including:

- Public drinking water supply (and other reservoir uses e.g., irrigation);

- Recreational values;
- Water dependent ecosystems (such as GDEs and wetlands, including CCW); and
- Maintaining the ecological integrity of the NJF.

The Proposal is a continuation of mining operations at Huntly and Willowdale mine areas. Alcoa has undertaken mining operations at the Huntly Mine since 1976[11] and the Willowdale Mine since 1984, including within the South Dandalup, North Dandalup, Serpentine and Wungong PDWSAs. To date, Alcoa's operations have not resulted in a substantial rise in salinity, release of sediment or spill of diesel that has required remedial actions in a reservoir or for a reservoir to be taken off-line. Alcoa will continue to employ current management practices to manage key risks associated with mining within the DEs.

Key mitigations include the following:

- Not undertaking clearing (excludes infrastructure, rehabilitation and monitoring activities) or mining within Limited Disturbance Areas (LDAs):
    - 1 km of the top water level of any water reservoir from 1 July 2024
    - from December 2023:
        - the Serpentine Pipehead Dam Catchment (constitutes a MAZ);
        - areas with an average pit slope greater than 16% within any RPZ as seen in Figure 5-55 and Figure 5-56; and
        - within 100 m buffer zone for mapped Stream Vegetation.
    - Confirmed Conservation Category Wetlands or Resource Enhancement Wetlands
- Not developing mine facilities, wastewater and sewage treatment plants inside the RPZ;
- Avoiding or minimising the discharge of any environmentally hazardous materials outside of containment infrastructure;
- Developing and implementing DCMPs for pits or haul roads within public drinking water catchments;
- Providing drainage control as-builts to ensure alignment with design intent;
- Prioritising rehabilitation within public drinking water catchments;
- Increasing rehabilitation areas completed each consecutive year, with a goal of achieving a minimum rehabilitation footprint of 3,159 ha between 2024 to 2027;
- Revising and implementing the Water Resources Management Plan (WRMP), to the extent practicable, as provided in Appendix 6;
- Undertaking compliance monitoring associated with the 2023–2027 MMP Ministerial Approval Conditions and associated incident reporting.

The relevant water mining avoidance and exclusion zones (listed above) implemented for the Huntly Mine DE and Willowdale Mine DE are shown on Figure 5-57 and Figure 5-58 respectively.

The Water Resources Management Plan (WRMP) (Appendix 6) is currently being implemented as part of existing operational practises and is expected to be revised to reflect the information, mitigations and outcomes provided in this ERD. Therefore, the ERD is considered to take precedence over the WRMP.

[11] Between 1972 and 1976, bauxite was supplied to the Refinery from the Del Park mine west of Huntly Mine.

Further detail on mitigation measures implemented under the mitigation hierarchy are described in the following sections.

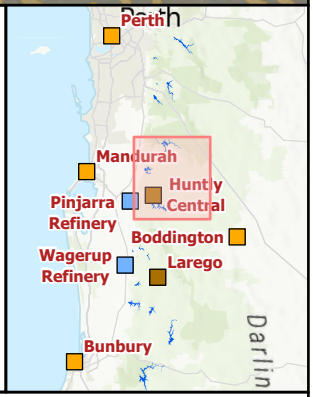


Legend

Mining Avoidance Zones
- Mining Avoidance Zones
- National Parks
- Conservation Parks

Limited Disturbance Areas
- Mapped & Derived Stream Vegetation 100m Buffer

- 1km Reservoir Top Water Level
- OCA1
- Huntly Mine DE
- Reservoirs
- Major Rivers
- Minor Rivers
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite Mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-57 Water Mining Avoidance & Limited Disturbance Areas - Huntly Mine DE

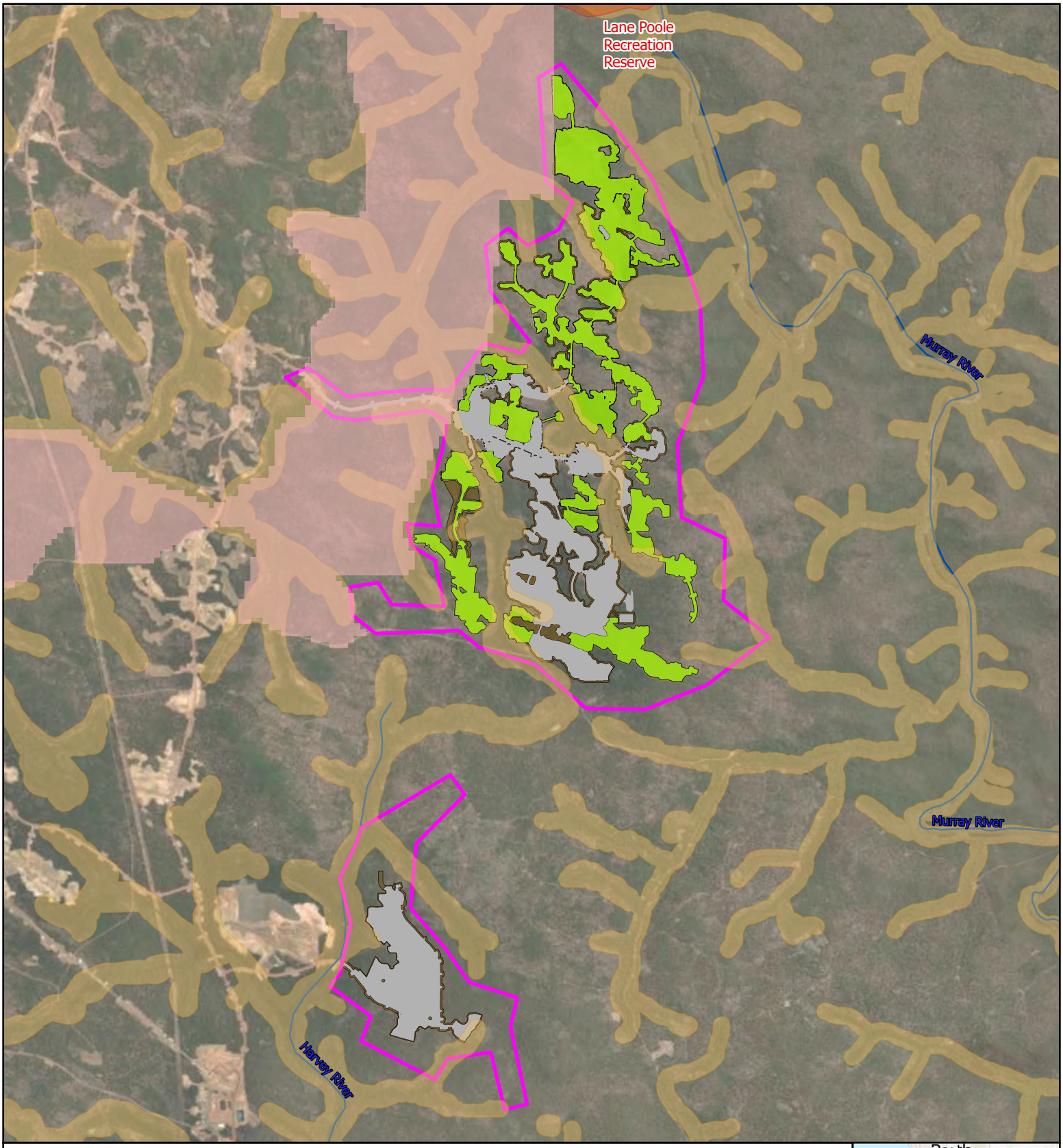
Kilometres
0 2 4 6 8 10 12

Scale: 1:175,000 at A4

Date Printed: 27/02/2025

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Alcoa



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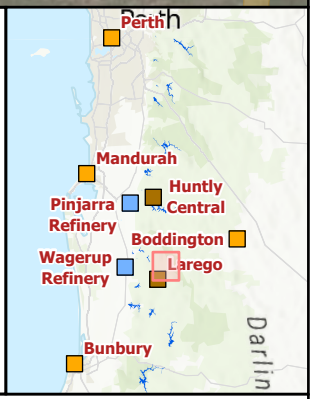
Mining Avoidance Zones

- Mining Avoidance Zones
- National Parks
- Conservation Parks

Limited Disturbance Areas

- Mapped & Derived Stream Vegetation 100m Buffer
- 1km Reservoir Top Water Level
- Willowdale Mine DE

- Major Rivers
- Proposed Disturbance Footprint
- Open Areas
- Proposed Rehabilitation Footprint



Bauxite Mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-58 Water Mining Avoidance & & Limited Disturbance Areas - Willowdale Mine DE

Kilometres

0 0.75 1.5 2.25 3 3.75 4.5

Scale: 1:60,000 at A4

Date Printed: 27/02/2025

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Alcoa

5.5.8.1 Avoidance

Alcoa's impact avoidance framework for the Proposal will protect the following key values and areas:

- Not undertaking clearing (excluding infrastructure, rehabilitation and monitoring activities) or mining within the following LDAs:
  - 1 km of the top water level of any water reservoir from 1 July 2024;
  - areas with an average pit slope greater than 16% within any RPZ from December 2023;
  - confirmed Conservation Category Wetlands and Resource Enhancement Wetlands; and
  - 100 m buffer zone around mapped Stream Vegetation.

  Additionally, no new mine pit clearing to occur within 1 km of the reservoir Top Water Level from December 2023.
- From December 2023, not undertaking any clearing for mining or exploration, and mining and exploration activities (excluding rehabilitation activities, and access) within the Serpentine Pipehead Catchment (considered a MAZ).
- Clearing within 2 km of Serpentine Dam top water level or within Serpentine Pipehead Catchment, must either be rehabilitated, stabilised, or have drainage controls in place within the first rehabilitation season available.
- Construction compounds and mine facilities, including sewage treatment plants and fuel farms, will be located outside of PDWSA reservoir protection zones.
- Alcoa will minimise the crossing of mapped swamp and streamzones as far as practicable.
- Fire-fighting aqueous film forming foams containing PFAS are now prohibited from coming to site.

Avoidance measures associated with Proposal potential impacts are detailed in Table 5-70. The relevant water relevant mining avoidance and exclusion zones (listed above) implemented for the Huntly Mine DE and Willowdale Mine DE are shown above on Figure 5-57 and Figure 5-58 respectively.

5.5.8.2 Minimise

The key minimisation measures associated with Proposal impacts include:

- Permit to Work in Close Proximity to Water Catchment Areas for activities near a reservoir is required;
- Bulk fuel tankers over 15,000 L will avoid main river channels;
- Servicing, maintenance and refuelling of vehicles and heavy equipment will occur in designated areas;
- Hydrocarbons and chemicals will be stored with proper containment;
- Hazardous materials will be stored as per regulations;
- Wastewater treatment plants will be maintained and monitored;
- Only PFAS-free firefighting foams will be used, all waste will be disposed of off-site, PFAS-affected water will be treated or disposed of at appropriately licenced facilities and stored in dedicated facilities;

- A 100 m buffer zone is maintained around streamzone Vegetation during fertiliser application for rehabilitation activities, fertiliser application is calculated per pit, herbicide application locations are recorded and submitted to the Water Corporation, and only approved chemicals are used within the PDWA;
- Rehabilitation design minimises potential for erosion and sediment movement;
- Rehabilitation schedule will prioritize areas based on current monitoring trends, such as water quality, groundwater levels, and other relevant factors;
- Minimise surface hydrology changes by managing surface water abstraction according to *Rights in Water and Irrigation* (RiWI) *Act 1914* licences and associated operating strategies;
- Monitoring and reviewing surface and groundwater upstream of reservoirs, as well as at impact and reference sites, involves several key activities:
    - Implement or revise the Catchment Scale Risk Assessment;
    - Implement or revise the DWRA;
    - Review Water Working Arrangements (between Alcoa, DWER, and Water Corporation);
    - Gather surface and groundwater monitoring baseline data where possible to identify potential mining activity impacts. Use reference data if baseline data is insufficient;
    - Maintain regular inspections for annual audit to track progress, address issues, and inform adaptive management for continuous improvement; and
    - Utilise the Ground Water Risk Assessment Framework provided by Water Corporation to guide groundwater bore installation in high-priority areas.
- Requirements of Water Quality Protection Note 10 (WQPN 10) Containment Spills – Emergency Response Plan (DWER, 2020). Ensure spill response equipment is available where appropriate.

Minimisation measures associated with potential impacts of the Proposal is detailed in Table 5-70.

5.5.8.3 Rehabilitation

Rehabilitation is a critical component to Alcoa's environmental management system and protects inland waters through ensuring stable and non-polluting landforms. Progressive rehabilitation and re-vegetation practices of disturbed land is an important strategy to ensure impact to Inland Waters are minimised as a result of the continuation of mining.

Alcoa's rehabilitation practices have performed for more than three decades against the completion criteria approved by DBCA to meet the objective of a self-sustaining jarrah forest ecosystem that meets multiple forest uses. The completion criteria have evolved in response to research and practice, with ongoing publication of research findings in the scientific literature.

As rehabilitation has been shown to decrease high turbidity event risk (DAA, 2023), Alcoa will seek to minimise open areas within the PDWSA, with a priority placed on proximity to the reservoir, through prioritised rehabilitation. An increase in rehabilitation area will be completed each consecutive year, to achieve a minimum of 3,159 ha between 2024 to 2027.

Alcoa's success in implementing and evolving its rehabilitation program provides confidence in our capacity to adapt as the objective for rehabilitation changes into the future. This may

include new State Government objectives for the NJF with the cessation of timber harvesting and introduction of the 2024-2033 Forestry Management Plan (FMP) and the potential requirement for enhanced resilience to future climate change. Alcoa remains committed to collaborating with DBCA and other agencies to ensure rehabilitation achieves outcomes that protect the inland waters values of the NJF.

5.5.8.4 Environmental Management Controls

Alcoa's risk-based management approach is presented in Plate 5-13 below. Alcoa considers that with the risk-based approach and management controls, which are described further in this section, clearing and mining can occur with minimal to moderate impacts to inland waters.

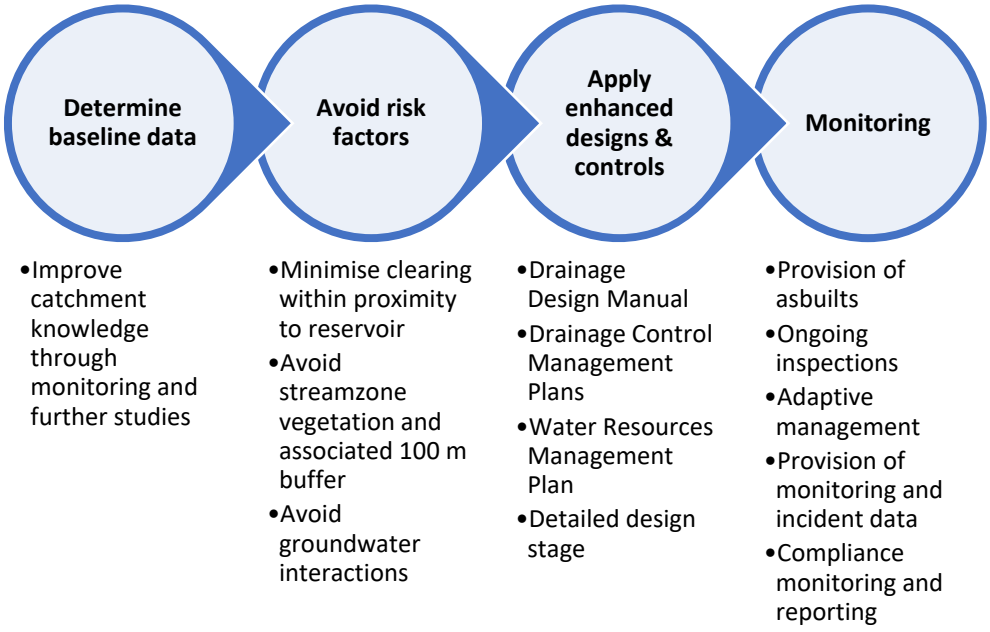


Plate 5-13: Risk based management approach key steps

5.5.8.4.1 Baseline Assessments

Alcoa has undertaken and continues to undertake research and assessments of the receiving environment (Section 5.5.3.1) which have been used to inform and develop mitigation strategies.

Development of baseline datasets, focusing on the collection of site-specific information (including mapping CCW extent within the Mine DE), is carried out to ensure adequate engineered controls are developed and in place to help further minimise impacts from catchment and sub-catchment activities. The following data is obtained to inform specific designs and incorporated into mine and haul road designs:

- Baseline surface water data;
- Known information on groundwater levels in the area; and
- Information from drilling programs regarding regolith depth.

Alcoa remains focused on opportunities to continue to improve understanding of catchment dynamics and impacts. As such, Alcoa will undertake further studies to confirm and refine drainage control effectiveness and improve ground and surface water knowledge.

5.5.8.4.2 Drainage Controls

The WA Mining and Haul Road Drainage Design Manual guides the design of drainage controls to manage catchment surface water runoff quality. This manual outlines Alcoa's approach to drainage management in relation to infiltration, surface runoff and groundwater with feedback and action, and is derived from risk-based or failure mode-based assessment relative to key factors of concern. It considers extensive research catchment and pit scale studies to manage catchment turbidity, and contains the Basis of Design information, design criteria and detailed design methodologies.

DCMPs are developed for individual pits and haul roads within public drinking water catchments as part of Forest Clearing Application (FCA) submissions. DCMPs provide an overview of conceptual drainage designs (Plate 5-14) and outcomes from the application of the Drainage Design Manual, including details of surface water storage and management, groundwater separation within pit development, operations and rehabilitation. The intent of the DCMP is to provide details of drainage control design, effectiveness, implementation and maintenance to minimise drainage events impacting downstream receptors including PDWSAs, wetlands and waterways.

A DCMP Summary Document provides an over-arching reference document to the individual pit and haul road DCMPs. The DCMP Summary Document outlines more specific details on operational practices as they relate to engineered drainage control design, implementation and effectiveness (see Appendix 57). It provides further information on drainage control design process and criteria, operational controls, detailed design stage, as-built reviews and inspections and groundwater investigations.

Detailed design of clearing, pits and haul roads and associated drainage controls is also undertaken, which takes into account clearing and development activities and site-specific activities.

Installation of drainage control structures occurs through the mining process. Four key reviews are undertaken as pits and haul roads are developed, namely:

- Ongoing active pit reviews;
- Active pit as-built reviews on a quarterly basis;
- As-built reviews of drainage protection slots (DPSs); and
- Haul roads as-builts inspections upon completion.

Inspections occur as required, to identify any maintenance or improvement requirements.

As-built reviews occur as required, to confirm that control installation has been to the prescribed design. If insufficient control capacity is identified, capacity is increased accordingly, or adaptive maintenance and improvement is undertaken.

Surface water abstractions from the South Dandalup Dam (Huntly Mine) and Samson Dam (Willowdale Mine) are rigorously managed through agreements and/or water abstraction licences and an operating strategy.

Hydrocarbons are stored in above ground tanks in accordance with the Dangerous Goods Regulations and relevant Australian Standards. Additionally, oily wastewater from the

workshops, fuel bays and vehicle wash down facilities is collected and treated to remove hydrocarbons and detergents.

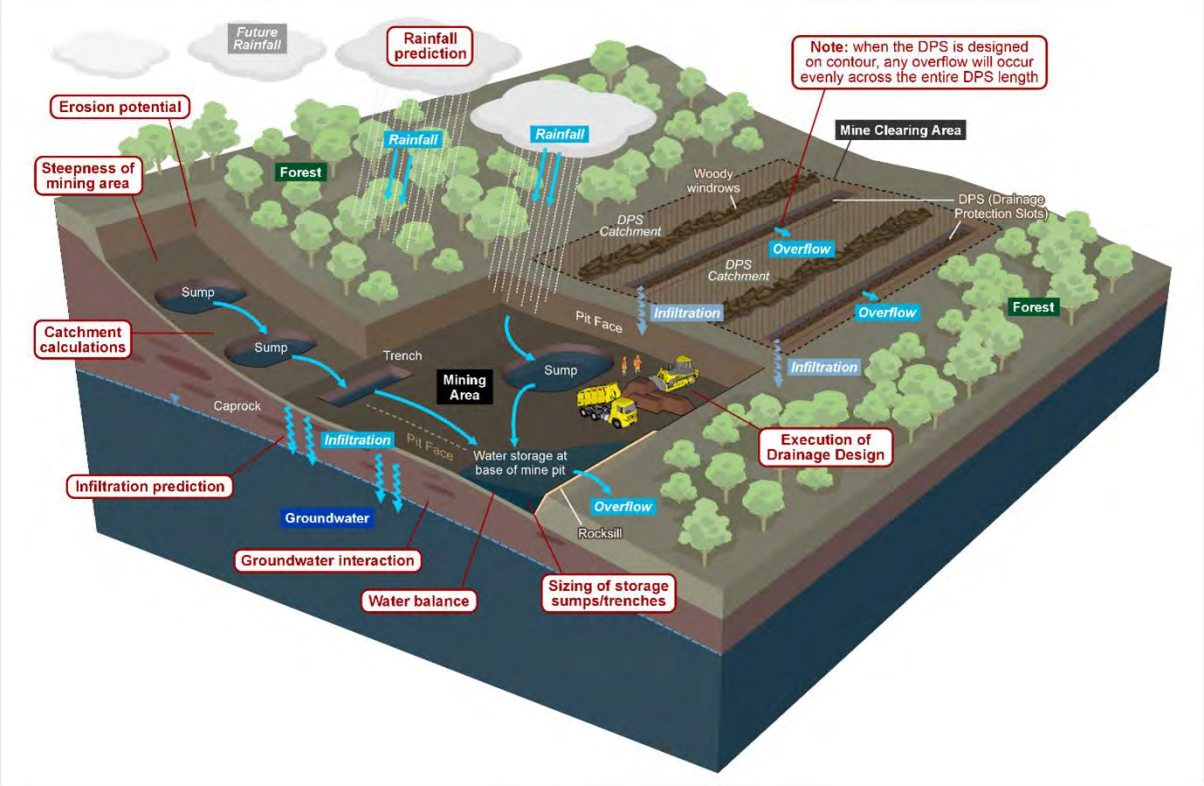


Plate 5-14: DCMP Conceptual Drainage Controls

5.5.8.4.3 Treated Water Reuse

At Huntly, treated water combines with stormwater collected for reuse for haul road watering, vehicle wash down and workshop hose down.

The Willowdale licence does not allow for reuse of treated water from the PFAS WTP at Arundel – rather it is discharged to the environment, outside of the water catchment.

Treated water reuse is authorised for the Larego WTP.

Water treated at the McCoy Dissolved Air Flotation (DAF) plant is released to a stormwater sump and either infiltrates to ground or is pumped to McCoy or Myara. This water is then further treated at the Huntly PFAS WTP, prior to discharge to pits or use as dust suppressant.

5.5.8.4.4 Remediation Activities

In January 2021, Alcoa's Huntly Bauxite Mine, McCoy, Myara, Willowdale Bauxite Mine, Arundel and Orion workshop areas, and their immediate surrounds, were classified by DWER as 'Possibly Contaminated – Investigation Required' under the Contaminated Sites Act 2003.

A contaminated sites assessment of both Huntly and Willowdale mine sites began in Q4 2020. A detailed site investigation has been completed and is scheduled for submission to the Contaminated Sites Branch by the end of 2024.

Alcoa has developed and implemented Interim PFAS Water Management Strategies for WA mining operations at Huntly and Willowdale. The key objective is to manage PFAS-affected water and to minimise impact to the drinking water catchment and the environment.

Huntly's interim management strategy focuses on the treatment of PFAS-affected water to non-detect levels for re-use on-site via a temporary water treatment plant which was constructed in November 2020. Validation sampling occurs at the PFAS water treatment plant via an autosampler for every 0.5 ML of throughput. This forms a composite sample for approximately 5 ML of water that is discharged to the clean water batching dams. All treated water is batched and confirmed to non-detect levels for all 28 ultra-trace PFAS suite species, as specified in Heads of EPAs Australia and New Zealand (2020) PFAS National Environmental Management Plan 2.0 prior to re-use for operational purposes.

Huntly's permanent solution has commenced under a capital project, and it is in the early design and options analysis stage. The solution will comprise of permanent PFAS-affected water treatment plants, solids handling and/or treatment, and associated infrastructure.

Alcoa has commenced construction of a permanent treatment solution at Willowdale which will be incorporated into the existing licenced wastewater treatment and discharge system.

5.5.8.4.5 Adaptive Management

Alcoa is also committed to further adaptive management and studies and will consult with ITAG on:

- Cumulative catchment scale risk assessments;
- Full mining cycle planning approaches;
- Risk assessment methodologies;
- Drainage Design Manual;
- Rehabilitation Design Manual; and
- A revised WRMP.

5.5.8.5 Monitoring

Monitoring is a key component to assessing and reviewing operational performance against baseline and threshold triggers. Alcoa applies a risk-based monitoring approach and incorporates surface water and groundwater monitoring programs across all mining phases and operation activities. Key components of the water monitoring programs are discussed in this section.

5.5.8.5.1 Surface Water and Stormwater Turbidity

Alcoa undertakes a range of physical and chemical monitoring and from this has identified turbidity as the primary indicator for performance. As such routine turbidity monitoring is used to assess the performance of mine stormwater management and to better understand catchment performance. Turbidity monitoring consists of:

- Compliance monitoring – monitoring points located immediately upstream of neighbours or public water supply storage reservoirs.

  Ongoing monitoring downstream of sensitive receptors is not warranted unless an impact at the receptor is detected. A period of monitoring is recommended to confirm impact negligible impact to the sensitive receptor.

- Local monitoring points – monitoring points are located upstream of compliance monitoring points, thereby providing an overview of any impacts of Alcoa's activities on surface water turbidity levels, including performance and impacts (if any) of its mine infrastructure.
- Visual checks – routine checks of drainage control structures to ensure runoff and turbidity are being controlled.
- Turbidity events – all turbidity events above the agreed reporting limits are investigated to (i) determine the root cause, and where possible, (ii) formulate corrective actions.
- Reviews – an annual review of the existing turbidity monitoring network is carried out to ensure as best as possible there is adequate coverage to detect, investigate and respond to potential runoff or turbidity events relating to mining activities.

Alcoa Mine operations hold three water abstraction licences issued under the RiWI Act. Licenses enable abstraction from South Dandalup Dam and Marrinup Brook with a minor proportion of the mine water demand also being met through harvested (in-pit) stormwater and recycled treated water. Monitoring of the abstracted water resource (for compliance and potential impacts, i.e., levels, flows and quality) is undertaken as required by water supply agreements and issued water abstraction licences.

As the mine operates in a water deficit, controlled off-site release is not anticipated, and significant impacts to hydrological regimes or water quality off-site (from mine activities) are therefore not expected. Monitoring of potential impacts from operational water usage such as via uncontrolled discharge pathways, are covered under monitoring for compliance and local monitoring points (described above), as well as monitoring for potential groundwater contamination. The surface water monitoring programme will be expanded to include monitoring and analysis of surface water flow.

5.5.8.5.2 Groundwater Monitoring

Alcoa has installed regional and local groundwater monitoring bores to facilitate groundwater investigations, typically for groundwater level monitoring but also for water quality assessment, with the aim of working towards providing at least two years of data ahead of mining in high Groundwater Risk Rated areas. Where two years of data is not available, at least one groundwater level is used to develop an estimated maximum groundwater level to inform pit designs.

Dewatering is not anticipated to be required to facilitate mining activities. As such no monitoring of groundwater elevations or geochemistry to assess any impacts of this activity will be undertaken.

Ongoing monitoring of bores (depth to groundwater and water quality) will be carried out. This will provide a good understanding of fluctuations in groundwater elevations and geochemistry due to seasonal variations in natural groundwater catchment dynamics and any influences from mining activities.

5.5.8.5.3 Compliance Monitoring

Compliance monitoring associated with 2023–2027 MMP Ministerial Approval Conditions and associated incident reporting occurs. Alcoa has a robust incident reporting and investigation process

which includes determination and implementation of corrective and preventative actions as required, and recording of actions in the Alcoa Incident Management System.

Table 5-70: Avoidance and minimisation of potential impacts to inland waters

PEI No and description	Industry standard, best practice and certainty of effectiveness
PEI 1 – Changes to both the surface water and groundwater regimes because of Project operations, including changes in surface water and groundwater flows and downgradient receiving environments.	**Industry standard, best practice and certainty of effectiveness**
Avoid	
• No clearing (excludes rehabilitation and monitoring activities) or mining within Serpentine Pipehead Dam Catchment (Alcoa, 2023b) from December 2023. Clearing within this zone must be rehabilitated, stabilised, or have drainage controls in place within the first available rehabilitation season. • No new mine pit clearing within: o 1 km of any reservoir Top Water Level from 1 July 2024 (Minister for State Development, 2023) & (Government of Western Australia, 2023); o Areas with an average slope greater than 16% within Reservoir Protection Zones (RPZs) from December 2023 (Minister for State Development, 2023); o 100 m buffer zone for mapped Stream Vegetation; o Confirmed Conservation Category Wetlands and Resource Enhancement Wetlands; and o OCA1 (Top Water Line 200 m). • Groundwater protection: Maintain a minimum clearance of 2 m between pit base and groundwater.	Established practice at Huntly & Willowdale Mine, moderate certainty
Minimise	
Evaluations of new mining areas to determine groundwater levels and interaction risks. Groundwater Level Assessments are utilised with incorporation of a 2 m buffer between pit shell in DCMPs, where required.	Established practice at Huntly & Willowdale Mine, moderate certainty
Monitoring as required under water supply agreement and water abstraction licences.	Established practice at Huntly & Willowdale Mine, high certainty
• Implementation of Drainage Design Manual and Rehabilitation Design Manual (under development). Mine surface water control designs (detailed in Drainage Design Manual) informed by hydrological studies (flow, infiltration diversion for mine planning storage purposes): o Drainage Protection Slots (DPSs), comprise shallow (~1.8 m) blasted or ripped ground, if required by risk rating; o Additional controls for steep slopes, shallow groundwater or large areas; o DPSs capture and infiltrate surface runoff within the blasted voids; and o In-pit sumps, pit faces and trenches (as per Drainage Design Manual). • Development and implementation of DCMPs for pits or haul roads within public drinking water catchments, which include: o Risk assessment for clearing and pit controls; o Clearing and pit catchment and control conceptual designs; and o Groundwater investigations with the intent to minimise groundwater interactions.	Established practice at Huntly & Willowdale Mine, moderate certainty
Site assessments undertaken to confirm extent of Conservation Category Wetlands and Resource Enhancement Wetlands. Confirmed occurrences will have Limited Disturbance Areas applied (no new mine pit clearing) and further mitigations to minimize indirect impacts will be investigated.	
Surface and groundwater monitoring program as per the WRMP, to the extent practicable. The surface water flow monitoring program will be expanded to identify and monitor any potential impacts to stream flow rates.	Proposed practice at Huntly & Willowdale Mine, high certainty
Rehabilitate	
Progressive rehabilitation of disturbed land, prioritising high risk areas, to minimise open areas.	Established practice at Huntly & Willowdale Mine, high certainty.
PEI 2 – Increase in the rate and salinity of groundwater discharge to catchment surface water systems because of increased rainfall infiltration, and decreased evapotranspiration in cleared and mined areas.	
Avoid	
• No clearing (excludes rehabilitation and monitoring activities) or mining within Serpentine Pipehead Dam Catchment (Alcoa, 2023b) from December 2023. Clearing within this zone must be rehabilitated, stabilized, or have drainage controls in place within the first available rehabilitation season. • No new mine pit clearing within: o 1 km of any reservoir Top Water Level from 1 July 2024 (Minister for State Development, 2023) & (Government of Western Australia, 2023); o Areas with an average slope greater than 16% within Reservoir Protection Zones (RPZs) from December 2023 (Minister for State Development, 2023); o Confirmed Conservation Category Wetlands and Resource Enhancement Wetlands; and o 100 m buffer zone for mapped Stream Vegetation. • Groundwater protection: Maintain a minimum clearance of 2 m between pit base and groundwater.	Established practice at Huntly & Willowdale Mine, moderate certainty
Evaluation of new mining areas to determine salinity risks.	Established practice at Huntly & Willowdale Mine, moderate certainty.
Rehabilitate	
Where salinity risk has been identified through previous data, rehabilitation will be completed as soon as practicable after mining has been completed.	Established practice at Huntly and Willowdale Mine, commencement timeframes may vary due to a range of factors, moderate certainty.

PEI No and description	Industry standard, best practice and certainty of effectiveness
Rehabilitation within the Mine Development Envelope will be undertaken as presented in section 5.5.2. Rehabilitation is prioritised within public drinking water catchments with an increase in rehabilitation area completed each consecutive year, to achieve a minimum of 3,159 ha between 2024 to 2027.	Established practice at Huntly and Willowdale Mine, high certainty.
Rehabilitation to prioritise elevated risk areas to minimise groundwater fluctuations and prevent salinity increase	Established practice at Huntly and Willowdale Mine, high certainty.
PEI 3 – Increased sediment loads in surface water as a result of both mining and rehabilitation activities.	
Avoid	
• No clearing (excludes rehabilitation and monitoring activities) or mining within Serpentine Pipehead Dam Catchment (Alcoa, 2023b) from December 2023. Clearing within this zone must be rehabilitated, stabilized, or have drainage controls in place within the first available rehabilitation season. • No new mine pit clearing within: o 1 km of any reservoir Top Water Level from 1 July 2024 (Minister for State Development, 2023) & (Government of Western Australia, 2023); o Areas with an average slope greater than 16% within Reservoir Protection Zones (RPZs) from December 2023 (Minister for State Development, 2023); o Confirmed Conservation Category Wetlands and Resource Enhancement Wetlands; and o 100 m buffer zone for mapped Stream Vegetation. • Groundwater protection: Maintain a minimum clearance of 2 m between pit base and groundwater.	Established practice at Huntly & Willowdale Mine, moderate certainty
Minimise	
Mine drainage to be designed and executed with minimum capacity of: • 1% AEP 24-hour rainfall event for mine pits; and • 1% AEP 72-hour rainfall event for haul roads.	Best practice, site constraints to execution may vary, moderate certainty
Implementation of Drainage Design Manual and Rehabilitation Design Manual (under development). Mine surface water control designs (detailed in Drainage Design Manual) informed by hydrological studies (flow, infiltration diversion for mine planning storage purposes): • Drainage Protection Slots (DPSs), comprise shallow (~1.8 m) blasted or ripped ground, if required by risk rating; • DPSs capture and infiltrate surface runoff within the blasted voids; • Additional controls for steep slopes, shallow groundwater or large areas; • In-pit sumps, pit faces and trenches (as per Drainage Design Manual); and • Application of risk-based Mine drainage controls in all disturbed areas, in accordance with Alcoa Drainage Management Manual.	Best practice, manuals under development, moderate certainty
Development and implementation of DCMPs for all pits and haul roads within public drinking water catchments. DCMPs to include: • Details regarding any known groundwater levels in close proximity to pits; • Pits Risk Ranking contents; • Drainage Control trigger assessments; • Additional controls for steep slopes, shallow groundwater or large areas; • Pit specific drainage control designs; • Conceptual development mining and rehabilitation schedule; and • Drainage protection shot design.	Established practice at Huntly and Willowdale mines. Best practice, high certainty.
Assess the suitability of planned or potential stream crossings locations for minimal impact principles, with designs to consider bank stability and erosion generation potential both during construction and operation.	Established practice at Huntly and Willowdale mines, program constraints may require construction in winter/spring, moderate certainty.
• If disturbance to mapped swamp and streamzones cannot be avoided, minimise disturbance within swamp and streamzones, as far as practicable; • Waterway crossings constructed as far as practicable during summer and autumn months; • Minimise disturbance and utilise existing cleared areas or areas that will be disturbed for future mining; • Clearing to preferentially occur outside of winter months; • Monitor for indications or early warnings of intense rainfall events using Alcoa's 'Red Alert Procedure'; this will allow mine personnel time to review the mine's drainage controls, 'winterisation', and state of readiness to cope with any approaching heavy rainfall events; • Carry out surface water and groundwater monitoring (to the extent practicable) as per the WRMP; and • Regular pit and clearing inspections and associated adaptive management.	Established practice at Huntly and Willowdale mines. Best practice, high certainty.
Rehabilitate	
• Progressive rehabilitation of disturbed land; • Prioritise rehabilitation within the Mine Development Envelope within any areas within public drinking water catchments; and • Rehabilitated mine areas to be designed to prevent surface water overflow during a 1% 24hr AEP event.	Established practice at Huntly and Willowdale Mine, high certainty.
PEI 4 – Contamination of groundwater and/or surface water due to Project-impacted waters or unintentional release of operational water and/or chemicals to the environment	

PEI No and description	Industry standard, best practice and certainty of effectiveness
Avoid	
• No clearing (excludes rehabilitation and monitoring activities) or mining within Serpentine Pipehead Dam Catchment (Alcoa, 2023b) from December 2023. Clearing within this zone must be rehabilitated, stabilised, or have drainage controls in place within the first available rehabilitation season; • No new mine pit clearing within: o 1 km of any reservoir Top Water Level from 1 July 2024 (Minister for State Development, 2023) & (Government of Western Australia, 2023); o Areas with an average slope greater than 16% within Reservoir Protection Zones (RPZs) from December 2023 (Minister for State Development, 2023); o 100 m buffer zone for mapped Stream Vegetation; o Confirmed Conservation Category Wetlands and Resource Enhancement Wetlands; and o Groundwater protection: Maintain a minimum clearance of 2 m between pit base and groundwater.	Established practice at Huntly & Willowdale Mine, moderate certainty.
Facilities with the potential to generate significant contamination of soils, surface water or groundwater, including workshops, fuel bays, wastewater systems and ablution facilities etc, will be located outside RPZs.	Established practice at Huntly & Willowdale Mine, high certainty.
Sewage treatment plants will be located: • Outside of designated RPZs; • Away from steep slopes; and • Away from streamzones.	Established practice at Huntly & Willowdale Mine, high certainty.
All construction and operational wastes (with the exception of treated sewage and oily water) will be transported off-site for recycling and/or disposal at licenced waste facilities.	Established practice at Huntly & Willowdale Mine, high certainty.
Sub-surface discharge of effluents or treated waters not permitted.	Established practice at Huntly & Willowdale Mine, high certainty.
Only approved chemicals utilised within the PDWA.	Established practice at Huntly & Willowdale Mine, high certainty.
Bulk fuel tankers >15,000 L will not cross the Serpentine River main channel.	Established practice at Huntly & Willowdale Mine, high certainty.
All anti-fire-fighting foams to be PFAS free.	Established practice at Huntly & Willowdale Mine, high certainty.
Minimise	
Implementation of Drainage Design Manual and Rehabilitation Design Manual (under development). Mine surface water control designs (detailed in Drainage Design Manual) informed by hydrological studies (flow, infiltration diversion for mine planning storage purposes): • Drainage Protection Slots (DPSs), comprise shallow (~1.8 m) blasted or ripped ground, if required by risk rating; • Additional controls for steep slopes, shallow groundwater or large areas; • DPSs capture and infiltrate surface runoff within the blasted voids; and • In-pit sumps, pit faces and trenches (as per Drainage Design Manual). Development and implementation of DCMPs for pits or haul roads within public drinking water catchments, which include: • Risk assessment for clearing and pit controls; • Assessment against the Groundwater Risk Assessment Framework (GWRAF); and • Groundwater investigations with the intent to minimise groundwater interactions.	Established practice at Huntly & Willowdale Mine, moderate certainty.
General • Minimise worker access in streamzones; • Worker training and awareness around hygiene practises within the RPZ; • Only approved chemicals utilised within the PDWA; • Storage of all hydrocarbons and chemicals will be undertaken within appropriately sized secondary containment in accordance with the Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 1997, as applicable to specific materials. Storage will consider the requirements of WQPN 56 – Tanks for fuel and chemical storage near sensitive water resources (DWER, 2018); • Hazardous materials and wastes will be stored at designated construction compounds or other storage facilities in accordance with the Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 1997, as applicable to specific materials; • Storage will consider the requirements of WQPN 56 – Tanks for fuel and chemical storage near sensitive water resources (DWER, 2018) and WQPN 65 – Toxic and hazardous substances (DWER, 2015); and • Wastes will be temporarily stored in designated containers and compounds prior to transport off-site for recycling or disposal at a licenced waste facility.	Established practices at Huntly & Willowdale Mine, high certainty.
PFAS • Only PFAS-free firefighting foams will be used; • Water supplies sourced from public water supply reservoirs are assumed do not exceed PFAS limits in ADWG (2011); • All waste will be disposed of off-site; • PFAS-affected water will be treated at the Myara PFAS Treatment Plant, Willowdale PFAS Treatment Plant or disposed of off-site at an appropriately licenced facility; and	Established practices at Huntly & Willowdale Mine, high certainty.

PEI No and description	Industry standard, best practice and certainty of effectiveness
• PFAS-affected water will be stored in dedicated storage facilities.	
Hydrocarbons • Hazardous materials and wastes will be stored at designated construction compounds or other storage facilities in accordance with Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 1997 as applicable to the specific materials; • Storage will take into consideration the requirements of WQPN 56 Tanks for fuel and chemical storage near sensitive water resources (DWER, 2018) and WQPN 65 Toxic and hazardous substances (DWER, 2015). This will include engineering and design control to be implemented at refuelling stations to minimise the influence and impact of any spills, including bunding and impermeable floors; • Haul trucks, heavy vehicles and light vehicles to be refuelled as far as practicable at designated refuelling stations and fuel bays, and re-fuelling undertaken in accordance with the re-fuelling procedure; • Stormwater runoff that may contain traces of hydrocarbons must be treated via a wastewater treatment system; • Vehicle refuelling will occur in designated fuel bays, as far as practicable; • Mobile fuel tankers that service heavy equipment in the field will be limited to 15 m^3 capacity with re-fuelling undertaken in accordance with the re-fuelling procedure; and • Planned major servicing and maintenance of Alcoa vehicles and heavy equipment will occur within designated workshops at mine facilities, as far as practicable.	Industry standard, high certainty. Established practice at Huntly Mine.
Spill Response • All spills or leaks to be reported and remediated as soon as practicable, in accordance with Alcoa procedures; • Operations have an emergency response plan that includes the requirements of WQPN 10 Containment spills – emergency response plan (DWER, 2020); • Spill response equipment will be maintained at the designated construction compound during construction or mine facilities during operations in accordance with the Huntly Mine Emergency Response Plan. Staff will be trained in spill response and clean up to enable effective and efficient clean-up of any spills which may occur; • Inspection of spill locations after clean-up is completed to ensure all contaminated soil is removed and managed accordingly; and • Incident reporting and investigation will be conducted in accordance with Alcoa's procedures to reduce the likelihood of similar incidents occurring.	Industry standard, high certainty.
Fertilisers and herbicides • Buffer zones to be implemented around effluent land irrigation area, with irrigation consisting of drip and small sprinkler dispersion to surface; • Fertiliser program (measured fertiliser application, concentration and mix approved by DBCA) execution on non-rain days/dry part of year- during optimal time of year for uptake of nutrients by plants (Spring); • Fertiliser maps produced for the contractor – Overview Map, Individual Helipad Maps – showing all pits to be fertilised from the one helipad location, and Individual map – where greater detail for specific pits is required; • GIS coordinated adhered to for buffer zone maintenance via flight logs; • Audit of fertiliser use volumes to be carried out to cross check rates of fertiliser applied per pit; and • Herbicide application locations recorded and submitted to Water Corporation annually.	Established practice at Huntly & Willowdale Mine, high certainty.
Pathogens and sewage • Wastewater treatment plants and associated sump networks constructed and engineered with applicable design standards; • Where practicable, personnel should use designated ablution block facilities, if this is not possible then biological waste must be bagged and disposed of at a designated disposal location outside of the RPZ; • A Permit to Work in Close Proximity to Water Catchment Areas will be sought where work activities are carried out near a reservoir; • Fit for work policy includes restriction to RPZ for personnel with gastrointestinal symptoms. Worker training and awareness around hygiene practises within the RPZ; and • Induction packages – all people working in Project areas will be made aware of the relevant RPZ access requirements and controls to prevent potential impacts on public health.	Established practice at Huntly & Willowdale Mine, high certainty.
Treated wastewater management Adoption of active water management and planning including: • Adoption of DWER licence conditions, in particular those documenting the required quality of treated water prior to its disposal; • Sumps designed and constructed as per DDM; • Regular sump inspections; • Maintaining freeboard in treated water sumps to prevent overflow events; • Routine scheduling and performance of water infrastructure inspections and maintenance; • Calibration of water meters annually for the accurate measurement and metering of discharge volumes; and • Red alert procedure as an early warning system of forecast for intense rainfall and mine readiness to cope with the heavy rainfall.	Established practice at Huntly & Willowdale Mine, high certainty.
Inspections and Monitoring • Implementation of surface water and groundwater monitoring program as per the WRMP to the extent practicable; and • Regular clearing and inspection of active pits and implementation of associated adaptive management as necessary.	Established practice at Huntly & Willowdale Mine, high certainty.

PEI No and description	Industry standard, best practice and certainty of effectiveness
Reporting Incident reporting and response of all unplanned and accidental waste discharges in accordance with Alcoa procedures.	Established practice at Huntly & Willowdale Mine, high certainty.
Rehabilitate	
Rehabilitation within the Mine Development Envelope will be undertaken, with any areas within public drinking water catchments prioritised.	Established practice at Huntly and Willowdale Mine, high certainty.
Rehabilitation within the Mine Development Envelope will be undertaken as presented in Section 6.1. Rehabilitation is prioritised within public drinking water catchments with an increase in rehabilitation area completed each consecutive year, to achieve a minimum of 3,159 ha between 2024 to 2027.	Established practice at Huntly and Willowdale Mine, high certainty.
Contaminated areas will be identified at closure and remediated in accordance with the *Contaminated Sites Act 2003.*	Industry standard, high certainty.
All spills or leaks will be reported and remediated as soon as practicable, in accordance with Alcoa procedures. Incident reporting and investigation will be conducted in accordance with Alcoa's procedures to reduce the likelihood of similar incidents occurring.	Established practice at Huntly & Willowdale Mine, high certainty.
Contamination of surface water or groundwater with PASS compounds as a result of soil and sediment removal at waterway crossings.	
Avoid	
No clearing (excludes infrastructure, rehabilitation and monitoring activities) or mining within 100 m buffer zone for mapped stream vegetation.	Established practice at Huntly and Willowdale Mine, high certainty.
Minimise	
Haul roads, conveyors, and other infrastructure planned to limit crossing of mapped swamp and streamzones, to the minimum required for safe mining, as far as practicable. If disturbance to mapped swamp and streamzones cannot be avoided, disturbance of these areas will be minimised as far as practicable.	Established practice at Huntly Mine, high certainty.
Waterway crossings constructed as far as practicable during summer and autumn months (i.e., during drier seasons and lower baseflows).	Established practice at Huntly and Willowdale Mine, program constraints may require construction in winter/spring, moderate certainty.
Application of risk-based mine drainage controls in all disturbed areas, in accordance with Alcoa Drainage Management Manual.	Best practice, manuals under development, moderate certainty.
Rehabilitate	
Rehabilitation within the Mine Development Envelope will be undertaken as presented in Section 6.1. Rehabilitation is prioritised within public drinking water catchments with an increase in rehabilitation area completed each consecutive year, to achieve a minimum of 3,159 ha between 2024 to 2027.	Established practice at Huntly and Willowdale Mine, high certainty.

5.5.9 Assessment and Significance of Residual Impacts

Table 5-71 presents an assessment of residual impacts to inland waters and their significance for the Huntly and Willowdale DEs, respectively. As noted in these tables, the Proposal is unlikely to cause significant residual impacts to inland waters.

Alcoa implements preventative risk management involving multiple barriers to prevent and reduce hazards to drinking water reservoirs and has proposed additional barriers to further avoid and minimise hazards. These include:

- avoidance of mining within 1 km of the top water levels of Serpentine Dam, North Dandalup Dam and South Dandalup Dam
- design of rehabilitated pits to contain major storm runoff, and
- avoidance of PFAS in fire-fighting foams and water supplies.

The effectiveness of rehabilitation, including resilience during drought and heat waves, has been demonstrated through long-term research and monitoring, and is at a high level of confidence.

Alcoa has operated in the NJF for over five decades including substantial operations within the South Dandalup, North Dandalup, Serpentine, Samson Brook, Stirling, and Wungong PDWSAs. To date there has not been a substantial rise in salinity, a catastrophic sediment release or a catastrophic diesel spill from Alcoa's operations that has required remedial actions in a reservoir or for a reservoir to be taken off-line.

5.5.10 Environmental Outcomes

Table 5-72 presents proposed environmental outcomes with respect to inland waters. Environmental outcomes are supported by environmental management objectives as detailed in the Water Resources Management Plan (WRMP) as included in Appendix 6. The proposed environmental outcomes:

- reflect specific and measurable environmental states
- have a clear boundary, size, extent, or limit, and
- are consistent with the EPA's objective to maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.

Table 5-72 identifies where another statutory decision-making process can mitigate the potential environmental impacts of the Proposal on the environment to be consistent with the EPA's factor objective.

Table 5-71: Residual impacts to inland waters

Potential environmental impact (PEI)	Residual impact	Likelihood of significant impact
PEI 1 Changes to both surface water and groundwater regimes because of Project operations, including changes in surface water and groundwater flows, and downgradient receiving environments.	**Surface Water** • The Proposal has the potential to result in temporary groundwater mounding (as a result of increases in groundwater recharge rates resulting in higher groundwater levels) which may increase groundwater discharge (i.e., baseflow) to surface waters. • The Proposal has the potential to temporarily alter runoff flow volumes and rates due to alteration of land cover and flow paths and capture of site stormwater. • Increases in surface water flows are predicted to be both temporary and small given the size of mining operations and limited duration included under the Proposal. • Following rehabilitation groundwater elevations and surface water flows are expected to return to near pre-mining conditions, albeit with some variation and long-term decreases owing to future climate change. • Mitigation controls aim to minimise (and buffer) runoff by designing adequate drainage controls (such as DCMPs). • Mine rehabilitation is expected to eventually remove groundwater 'mounds' beneath cleared and mined areas and return groundwater discharge rates and surface water flow regimes to near pre-mining conditions. • Changes to surface waters flows may occur but are not expected to result in the loss of any significant beneficial uses at downstream receptors such as recreation, cultural heritage amenity, drinking water (quantity). • The Huntly DE is within or upstream of Public Drinking Water Supply Dam catchments. The dams regulate flows along the Serpentine River and Dandalup River, which discharge into the Peel-Yolgurup Ramsar site. Changes to surface water flows due to mining are expected to be insignificant in consequence on catchment hydrology downstream from dams. • Willowdale DE is upstream of The Stirling and Samson Brook Public Drinking Water Supply Dams which regulate flows along the Harvey River. A very small proportion of the Proposal is situated within the Murray River catchment which is a wild river. Both the Harvey and Murray Rivers discharge to the Peel-Yolgurup Ramsar site. Changes to surface water flows due to mining will be insignificant in consequence downstream from dams. The portion of Murray River catchment impacted is minor and likely of negligible consequence.	Unlikely
	• Streamforms specifically designed to minimise sediment impacts.	Unlikely

Potential environmental impact (PEI)	Residual impact	Likelihood of significant impact
	Groundwater • The Proposal has the potential to result in the temporary mounding of groundwater which may: (i) result in the water logging of soils, and/or (ii) alter groundwater flux to environments receiving / accessing groundwater. • Rehabilitation will include the reinstatement of stripped overburden and topsoils and re-shaping of landforms to mimic pre-mining conditions. The accompanying gradual re-establishment of vegetation across formerly mined areas and the associated increase in water uptake by this vegetation is expected to result in groundwater mounds dissipating and groundwater elevations ultimately returning to or near pre-mining conditions. • Mining remains above the water table at all times. • Monitoring of groundwater and ecology will be carried out to determine if any highly sensitive areas are being impacted by mining activities, and help in the implementation of appropriate mitigation and management strategies if necessary. • Changes to groundwater are expected to be temporary and generally within historical climatic changes before returning to pre-mining conditions. The changes to groundwater are therefore conditioned to have an insignificant impact to terrestrial and ecology.	Unlikely
PEI 2 Increases in stream salinity as a result of mining-induced saline groundwater discharge.	• The Proposal has the potential to indirectly increase stream salinity through an increase in saline groundwater discharge into waterways. • Rehabilitation prioritises the re-establishment of vegetation and trees in previously cleared mining areas, thereby lowering the water table to baseline elevations or thereabouts. • Rehabilitation practices aim to reverse any potential stream salinity changes to pre mining conditions. Any realised impacts are likely to be temporary. • Rehabilitation will be prioritised in areas at risk of groundwater mounding and/or new mining-induced groundwater discharges at the surface. • Vegetation clearance and mining is not expected to impact aquatic biodiversity as a result of any mine-induced increased in groundwater and/or streamflow salinity. • Increased stream salinity has the potential to result in small changes to the salinity of inflows to public drinking water supply reservoirs. This though is expected to be in-part offset (i.e., buffered) by similar increased discharges of lower-salinity groundwater to these streams, hence any such changes are expected to be small and surface waters still of freshwater quality.	Unlikely

Potential environmental impact (PEI)	Residual impact	Likelihood of significant impact
PEI 3 Increased sediment loads in surface water as a result of both mining and rehabilitation activities.	• A number of activities associated with Alcoa's operations have the potential to both directly and indirectly change sediment loads in nearby surface waterways. • Mine rehabilitation vegetation is expected to be sustained over the long term with resilience to climate change comparable to that of un-mined Jarrah Forest. • Mine rehabilitation is expected to provide long term protection of soils from erosion and associated sediment discharge to streams and reservoirs. • A major storm event concurrent with a catastrophic level of failure in mine sediment controls may result in temporary higher turbidity levels in the water supply reservoirs and dams. Such an event is unlikely to cause an impact to treatment efficacy or public health but may dictate the reservoir being taken offline until turbidity levels return to within limits, as a risk prevention measure. • Catastrophic sediment release events that result in the shutdown of a PDWS have not occurred to date at any of the Alcoa operational areas (Huntly Mine, the Willowdale Mine or other Alcoa operations). As such the likelihood of such an event occurring in the future is considered unlikely given Alcoa's demonstrated past work practices.	Low likelihood at Serpentine Dam. Unlikely at other PDWSAs.
PEI 4 Contamination of groundwater and/or surface water due to Project-impacted waters or unintentional release of operational water and/or chemicals to the environment.	**Sediment and contaminated sediment** • Mobilisation of sediment and any attached contaminants may occur following vegetation clearance and/or alteration of surface water drainage patterns. This sediment may reach nearby surface waterways where it may both physically and (if contaminated) chemically impact waters, including that in reservoirs. • Alcoa implements preventative risk management at both Huntly and Willowdale mines, which incorporates multiple barriers to prevent hazards to downstream drinking water reservoirs from occurring or reduce them to acceptable levels. These barriers act to prevent and minimise the discharge of sediment (as well as other contaminants such as pathogens, hydrocarbons, pesticides and herbicides) into downstream reservoirs, which are themselves barriers to contaminant transport prior to raw water being removed at the offtakes and entering the Water Corporation's water treatment and distribution system. • Individual barriers may fail under certain conditions and the failure of multiple barriers may result in varying quantities of contaminants reaching downstream reservoirs. • Additional and improved barriers are proposed to reduce: (i) the likelihood of barrier failure, and (ii) potential for discharge of contaminants into reservoirs.	Unlikely

Potential environmental impact (PEI)	Residual impact	Likelihood of significant impact
	Pathogenic microorganisms • Source vulnerability assessment concluded that microbial risks because of human settlement and stock animal aligned with category 1 source waters for the PDWSAs. This is consistent with the current treatment applied at the source water. • Quantitative microbial risk assessment indicates a sewage treatment plant at the proposed mine facilities has a potential to generate cryptosporidium dosages at reservoir offtakes, albeit at levels well within health risk thresholds. • Direct faecal deposition within the Serpentine Dam PDWSA has potential to result in exceedance of health risk thresholds. • Additional preventative measures will be implemented for all PDWSAs to reduce the risk of direct faecal deposition, including workforce inductions on pathogen risk and procedures. • Additional and improved barriers are proposed to reduce: (i) the likelihood of barrier failure, and (ii) potential for discharge of contaminants into reservoirs. Improved barriers will include workforce inductions regarding pathogen risks and procedures.	Unlikely
	Pesticides, herbicides and fertilisers • Pesticides and herbicides will be used during Proposal activities, however, will only be used in demarcated Proposal areas and applied at appropriate ('controlled') rates. • Pesticides and herbicide compounds often have low solubilities and mobilisation rates in groundwater and surface water systems and often remain somewhat 'stationary' in those areas where they are applied. As such they are not expected to enter nearby streams and/or PDWSAs at concentrations which may result in any significant impact to sensitive aquatic ecological habitats, including wetlands or GDEs, or interrupt water supplies from PDWSAs. The qualitative DWRA assigned a low residual risk for contamination to PDWSA water quality. • Application of fertiliser will occur in accordance with the Fertiliser Program (which details measured fertiliser application rates, concentrations and mixes approved by DBCA). • Fertiliser maps will be produced by Alcoa for use by contractors. These will include as necessary: • overview map • individual helipad maps – showing all pits to be fertilised from the one helipad location, and • individual maps – should greater detail be required.	Unlikely

Potential environmental impact (PEI)	Residual impact	Likelihood of significant impact
	• Application of fertilisers will only occur on dry (no-rain) days and during the drier months of year, including during Spring which is the optimal time of year for uptake of nutrients by plants. • Alcoa will carry out audits of fertiliser application rates to cross-check the amount of fertiliser applied. • Additional and improved barriers will be adopted if needed to reduce: (i) the likelihood of barrier failure, and (ii) potential for the discharge of herbicide, pesticide and/or fertiliser residues (including pathogens) into reservoirs.	
	Wildfires • The Proposal is expected to enable DBCA's prescribed burning program to be effectively implemented, as has been demonstrated with coordinated and planned burns at the Huntly Mine to date. • The Proposal is expected to maintain and support the State Government's program to limit fuel accumulation in the NJF, thereby reducing the likelihood of large wildfires occurring in mine regions that could impact water quality.	Unlikely
	Hydrocarbons • Direct discharge of 15 m^3 of diesel to a stream is unlikely to result in reservoir offtake water quality (contamination issues) that exceeds drinking water health criteria. However, a worst-case diesel spill to a stream may result in offtake water quality that exceeds the threshold for taste and odour. • Storage and handling of fuels, oil and other hazardous materials and wastes will predominantly occur at the mine facilities, outside of designated RPZs and with established barriers to contaminant discharge and transport. • Small diesel or oil spills that escape detection and remediation are unlikely to result in substantial migration of contaminants that reach streams and can be transported into reservoirs. • Seepage of spills into groundwater is expected to increase time for natural attenuation of these contaminants to occur. Accordingly, the storage and handling of hazardous materials is expected to pose a low risk to water quality. • Should a large diesel spill occur within a PDWSA catchment and enter a reservoir, it is unlikely to cause an impact to public health. It may though dictate the reservoir being taken offline. In stating this however, Alcoa's operations at the Mine have not yet resulted in such catastrophic sediment releases or diesel spill events that have required a shutdown of a PDWS, and the potential likelihood of a future catastrophic event is considered unlikely to occur.	Unlikely

Potential environmental impact (PEI)	Residual impact	Likelihood of significant impact
	PFAS • Alcoa has committed to using PFAS-free fire-fighting foams at all of its operations. • All water supplies for construction and operations in the Huntly and Willowdale DEs will be: (i) sourced from public drinking water sources and/or other licenced surface water abstraction locations (ii) include stormwater captured on site, or (iii) be obtained from licenced onsite water treatment facilities where approved for reuse on the Mine. As such water used in site operations is expected to be (or largely be) PFAS 'free'. • Existing land uses within the Huntly and Willowdale mine regions do not suggest or indicate the presence of substantial PFAS contamination. Further baseline monitoring program is required to substantiate this within the DEs, however the potential for indirect mobilisation of historic PFAS from catchments due to construction and mining is expected to pose a low risk to water quality.	Unlikely
	Generated waste (refuse and sewerage) • All construction and operational solid wastes will be disposed off-site at licenced waste facilities. As such these expected to pose a low risk to surface water and groundwater quality. • Treated wastewater from the McCoy (Huntly) and Larego (Willowdale) wastewater treatment plants must achieve the required water quality standards identified in Part V licences L6210/1991/10 and L6465/1989/10 respectively, prior to its release. • On-site sewage treatment and disposal is addressed under pathogenic microorganisms (see above).	Unlikely
PEI 5 Contamination of surface water and/or groundwater with PASS compounds because of soil and sediment removal at waterway crossings.	• The Proposal has the potential to disturb ASS (either actual or potential) resulting in the acidification of soils and groundwater, and the elevated release of heavy metals, metalloids and sulphate into water. This may result impact nearby sensitive aquatic ecological habitats, and interrupt or directly impact other beneficial uses and environmental values. • Where ASS soils are present, the size of any mine-related activity will be minimised (i.e., creek crossings), if not avoided. • Impacts from the mobilisation of any ASS contaminants on disrupting aquatic ecology and reducing environmental aesthetics is expected to be localised and temporary and may not have long-lasting impacts in any nearby sensitive ecological habitats, environmental values and/or PDWSA reservoirs. • The adoption of buffer restrictions around PDWSA reservoirs is expected to allow for some degree of contaminant dilution prior to any ASS-impacted waters entering PDWSAs. • Ongoing monitoring around key risk areas and of water quality downstream of mine active areas will be carried out as an early warning indicator for the presence of impacts.	Unlikely

Table 5-72: Proposed Environmental Outcomes – Inland Waters

Potential environmental impact	Receptor	Environmental outcome	Other statutory approval that will assure outcome	Monitoring of outcomes
PEI 1 Changes to both surface water and groundwater regimes because of Project operations, including changes in surface water and groundwater flows, and downgradient receiving environments.	• Surface water beneficial use (recreation, cultural heritage, agricultural use and public drinking water). • Aquatic ecology. • Public drinking water supply. • Groundwater receiving environments such as GDEs, wetlands, creeks and rivers).	No Proposal-related turbidity levels exceeding criteria defined in WRMP within public drinking water reservoir or Murrary River.	• Environmental licence under Part V of EP Act • Assessment and approval of the MMP and subsequent FCAs include consultation with key regulatory agencies.	• Surface water quantity and quality monitoring along identified receptors, downstream of active mining areas. • Incident records. • Water quality monitoring campaign following discharge incident. • Monitoring and reporting of rehabilitation extent and performance against completion criteria. • Assess and review water quality and quantity monitoring against baseline and performance triggers. • Annual reporting of reservoir operation.
		No clearing for mining of ore within 100m of mapped stream zone vegetation.		
		No disturbance or adverse impacts to more than 49 ha of streamzone vegetation and only for the purposes of construction and operation of haul roads, services roads, transport corridors, mine water supply and other infrastructure.		
		No clearing within 1km of reservoir top water level (except for rehabilitation, monitoring and infrastructure purposes)		
		No clearing within areas of average >16% slope within the RPZ (except for rehabilitation, monitoring and infrastructure purposes)		
		No mining within 1km of reservoir top water level from 1 July 2024		
		No clearing within Confirmed Conservation Category Wetlands and Resource Enhancement Wetlands (except for rehabilitation, monitoring and infrastructure purposes)		

Potential environmental impact	Receptor	Environmental outcome	Other statutory approval that will assure outcome	Monitoring of outcomes
		Ensure the Water Resources Management Plan, once endorsed by Minister for State Development, is implemented		
PEI 2 Increase in the rate and salinity of groundwater discharges to catchment surface water systems	• Surface water beneficial use (recreation, cultural heritage, agricultural use and public drinking water). • Aquatic ecology. • Public drinking water supply. • Groundwater receiving environments such as GDEs, wetlands, creeks and rivers).	No Proposal-related salinity levels exceeding criteria defined in WRMP within public drinking water reservoir or Marrinup Brook.	N/A	• Annual monitoring and reporting of rehabilitation extent and performance against completion criteria. • Surface water and groundwater quality monitoring and assessment against baseline and performance triggers. • Annual reporting of reservoir operation.
PEI 3 Increased sediment loads in surface water because of both mining and rehabilitation activities.	• Aquatic ecology (including the Peel-Yalgorup System *Ramsar* site). • Public Health. • Public Drinking Water Supply.	Ensure rehabilitation commences within RPZ within 12 months following activity completion	-	• Annual monitoring and reporting of rehabilitation extent and performance against completion criteria • Surface water quality monitoring along identified receptors, downstream of active mining areas • Incident records. • Water quality monitoring campaign following discharge incident. • Annual reporting of reservoir operation

Potential environmental impact	Receptor	Environmental outcome	Other statutory approval that will assure outcome	Monitoring of outcomes
				• Review and reporting on water quality monitoring against baseline and performance triggers
PEI 4 Contamination of groundwater and/or surface water due to Project-impacted waters or unintentional release of operational water and/or chemicals to the environment	• Surface water beneficial use (recreation, cultural heritage, agricultural use and public drinking water). • Aquatic ecology. • Public drinking water supply. • Groundwater receiving environments such as GDEs, wetlands, creeks and rivers).	No construction or operational waste disposal areas located within the Mine Development Envelope, with the exception of mine facilities treated sewage effluent irrigation area. No Proposal-related water contamination exceeding ecological or health guideline criteria (defined in WRMP) within public drinking water reservoir or Murrary River.	Environmental licence under Part V of EP Act *Contaminated Sites Act 2003*	• Monthly review of mine fleet movements in RPZ. • Annual reporting of waste disposal. • Detailed site investigation, remediation action plan and validation report upon facilities decommissioning. • Annual reporting of reservoir operation. • Baseline and operational water quality monitoring of contaminants of potential concern • Review of monitoring against baseline and performance triggers.
PEI 5 Contamination of surface water and/or groundwater with PASS compounds because of soil and sediment removal at waterway crossings	• Surface water beneficial use (recreation, cultural heritage, agricultural use). • Aquatic ecology. • Groundwater receiving environments such as GDEs, wetlands, creeks and rivers).	PASS study is undertaken for any PASS areas and if required, Management Plans developed.	*Contaminated Sites Act 2003*	• Monitoring and annual reporting of soil and water conditions downstream of mine activity areas in PASS risk areas (deemed moderate or above)

5.6 Key Environmental Factor – Social Surroundings (Heritage)

5.6.1 EPA Objective

The objective of the environmental factor 'social surroundings' is:

To protect social surroundings from significant harm.

For the purposes of EIA, the EPA (EPA, 2023a) defines social surroundings as it is presented in the EP Act: 'In the case of humans, the reference to social surroundings in the definition of environment in subsection (1), is a reference to aesthetic, cultural, economic and social surroundings to the extent that those surroundings directly affect or are affected by physical or biological surroundings.'

This section describes the cultural surroundings with respect to Aboriginal and European heritage, while Section 12 describes the economic, social and aesthetic surroundings with respect to amenity.

5.6.2 Relevant Policy and Guidance

EPA policy and guidance:

- Environmental Factor Guideline – Social Surroundings (EPA, 2023a);
- Technical Guidance, Environmental impact assessment of Social Surroundings – Aboriginal cultural heritage (EPA, 2023c);
- Instructions on how to prepare an Environmental Review Document (EPA, 2024c); and
- Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans (EPA, 2024b).

5.6.2.1 Other Policy and Guidance

- *Aboriginal Heritage Act 1972* (WA) (AH Act) (GoWA, 2023);
- *Heritage Act 2018* (WA) (GoWA, 2024b);
- *Environment Protection and Biodiversity Conservation Act 1999 (Cth)* (EPBC Act) (DCCEEW, 2023d);
- *Engaging with First Nations People and Communities on Assessments and Approvals under Environment Protection and Biodiversity Conservation Act 1999* (interim guidance) (DCCEEW, 2023e);
- *Aboriginal Heritage Act 1972 Guidelines (Version 1.0)* (DPLH, 2023); and
- *The Burra Charter (Australia ICOMOS Charter for Places of Cultural Significance)* (ICOMOS, 2013).

Alcoa has applied the Environmental Factor Guideline – Social Surroundings to the activities described within the Proposal and has taken steps to identify areas of aesthetic, cultural, economic and/or social values which may be impacted. The management measures outlined in Section 5.6.5 are implemented to avoid or minimise impacts to these values.

5.6.3 Receiving Environment

5.6.3.1 Aboriginal Engagement

The Huntly and Willowdale DEs are located within the southwest Native Title Settlement region. This Settlement is one of the most comprehensive Native Title agreements negotiated in Australian history and involves around 30,000 Noongar people and covers approximately 200,000 square kilometres of the southwest region of Western Australia.

As part of the Settlement, the Western Australian Government formally recognised that the Noongar people are the Traditional Owners of Noongar *Boodja* (Noongar land) and have cultural responsibilities and rights in relation to the land in an Act of Parliament (*the Noongar Recognition Act (WA) 2016*). Noongar groups surrendered their Native Title (thus finalising all current and preventing future Native Title claims) in consideration of this Statutory recognition.

The remainder of the settlement is contained in six Indigenous Land Use Agreements (ILUAs) that create trusts to hold both financial and other benefits for Noongar People, including a land estate, create co-management opportunities for conservation reserves and establish regional corporations to manage Noongar People's rights and obligations under the ILUAs. The Settlement ILUAs commenced operation on 25 February 2021.

The Huntly and Willowdale DEs are located within the Gnaala Karla Booja ILUA area, which encompasses the lands of the *Binjareb/Pinjarup*, *Wilman* and *Ganeang* Noongar language or dialectical groups. The ILUA established the Gnaala Karla Booja Aboriginal Corporation (GKB AC) as the entity through which the rights and benefits conferred under the Settlement are managed for the benefit of Noongar People in this region. Alcoa is committed to regular and ongoing engagement with GKB AC in relation to Alcoa's existing operations and proposed future activities within the Corporation's area of responsibility.

Since the appointment of GKB AC's inaugural Chief Executive Officer in March 2023, Alcoa has engaged with the corporation regarding mining operations and proposed mining approvals. This has included engagements involving the GKB AC Board of Directors, Cultural Advice Committee and Executive leadership team and senior Alcoa leadership, operations, environment and cultural heritage teams. Significant engagements have consisted of:

- Meeting with GKB AC board of Directors on 4 March 2023 regarding ongoing engagement relating to ongoing operations and future approvals.
- Meeting with GKB AC Cultural Advice Committee on 5 July 2023 regarding mining approval process (in particular, Alcoa's Mining Management Plan processes).
- Meeting with GKB AC Executive Leadership Team on 4 August 2023 regarding Mining Management Plan approval process and cultural heritage management processes.
- Meetings with GKB AC Executive Leadership Team on 6 March, 23 April and 30 July 2024.
- Approvals framework workshops with senior GKB AC staff and external consultants on 24 May and 15 August 2024.

A series of workshops and other engagements with GKB AC staff and the Corporation's governance groups is planned for the remainder of 2024 and into 2025 on:

- Finalising the overarching Cultural Heritage Management Framework for Alcoa's mining operations developed cooperatively between GKB AC and Alcoa (currently planned for November and December 2024);
- Touring Alcoa's operational areas to gain a greater understanding of activities, cultural heritage performance and rehabilitation outcomes (potential dates in December 2024 being explored); and
- Exploring Key Environmental Factors related to Alcoa's mining operations (including Part IV and Part V approvals); currently planned to run from December 2024 to February 2025.

5.6.3.2 Baseline Studies

A search of the Aboriginal Cultural Heritage Survey Areas spatial layer administered by DPLH (2025) shows that the complete footprint of the mine DEs has been covered by historical Aboriginal Cultural Heritage Surveys, with a total of 34 reports lodged with DPLH. It is acknowledged many of these reports are desktops and have been completed for activities or purposes unrelated to this assessment. A summary of the key social surroundings (heritage) studies that have been undertaken in relation to the Proposal is presented in Table 5-73 below.

DPLH maintains a record of Aboriginal Cultural Heritage sites or places that are recorded during surveys and reported to DPLH. Alcoa consults with Gnaala Karla Booja Aboriginal Corporation prior to the disclosure of Aboriginal Cultural Heritage sites or places to DPLH. All Aboriginal heritage places that Gnaala Karla Booja Aboriginal Corporation has agreed to report have been reported. Alcoa continues to consult with the Corporation regarding ongoing reporting of Aboriginal Heritage survey results. Aboriginal Cultural Heritage values identified through survey work are summarised in the following sections, noting some information remains confidential and as such has not been reported.

Table 5-73: Baseline Studies for Social Surroundings (Heritage)

Year	Author	Study name
2003	Archae-Aus Pty Ltd	Preliminary Advice of an Aboriginal archaeological assessment of sample survey areas Three and Four, Mccoy mining region
2005	Archae-Aus Pty Ltd.	The report of an Indigenous archaeological assessment – Larego mining envelope, near Willowdale, South-Western Australia
2006	Archae-Aus Pty Ltd.	The report of an Aboriginal archaeological assessment of the McCoy and Orion mining regions, Huntly and Willowdale mines, near Dwellingup, South-Western Australia
2008	Archae-Aus Pty Ltd.	The report of an Aboriginal archaeological assessment of the Myara region, near McCoy mine, Karnet, South-Western Australia
2009	Archae-Aus Pty Ltd	The report of an Aboriginal archaeological assessment of the O'Neill region, near McCoy mine, Karnet, South-Western Australia
2010	Archae-Aus Pty Ltd.	Preliminary Advice of five creek crossings in the O'Neil and Myara regions, Dwellingup.
2011	Archae-Aus Pty Ltd	Preliminary Advice of an Indigenous archaeological assessment of water monitoring targets in the Huntly mining area

Year	Author	Study name
2012	Archae-Aus Pty Ltd	Archaeological assessment of a water monitoring target in the Huntly mining area
2012	Archae-Aus Pty Ltd	Preliminary Advice – Indigenous archaeological heritage Assessment of Pisolite and Gabbro creek crossings within the Myara mining area
2018	Archae-Aus Pty Ltd.	A report of an archaeological assessment of the Myara mine additional area project area, near serpentine, Western Australia.
2020	Archae-Aus Pty Ltd	A report on an Aboriginal archaeological sample survey of the Larego project area near Willowdale, Western Australia
2021a	Archae-Aus Pty Ltd.	Alcoa of Australia limited: Pinjarra alumina refinery revised proposal aboriginal archaeological heritage report, Myara north and Holyoake.
2021b	Archae-Aus Pty Ltd.	Pinjarra Alumina Refinery Revised Proposal Historical Archaeological Assessment – Holyoake, Myara North and Pinjarra Alumina Refinery
2022	Archae-Aus Pty Ltd.	Report on an archaeological and ethnographic site avoidance assessment of the proposed O'Neil mine east area, Dwellingup, Western Australia
2024	Archae-Aus Pty Ltd	Preliminary Advice on an Archaeological Site Avoidance Aboriginal Cultural Heritage Survey within the Thorpe Mine Region, WA
2024	Aboriginal Land Services	Site avoidance archaeological and ethnographic survey – Larego
2024	Archae-Aus Pty Ltd	Preliminary Advice on an archaeological site avoidance Aboriginal cultural heritage survey within the Thorpe mine region, Western Australia Trips 16 – 18

5.6.3.3 Knowledge and Survey Gaps

The Pinjarra Alumina Refinery Revised Proposal (Assessment 2253) addresses additional Social Surrounding (Heritage) within Section 11. While Assessment 2253 covers different clearing areas than this Proposal and does not include Willowdale, the cumulative impact information for surrounding mines is considered relevant and should be considered. Given the timeframe of this Proposal, the information from Assessment 2253 has been reviewed and extrapolated to address knowledge and survey gaps within the current Proposal.

5.6.3.4 Aboriginal Heritage – Archaeological

The DPLH dataset contains places within Western Australia that have been reported to the Registrar of Aboriginal Sites as possible Aboriginal sites as defined by the *AH Act* and includes the following categories:

- Registered Sites – places assessed by the Aboriginal Cultural Heritage Council (ACHC) as meeting the criteria set out in Sections 5 and 39 of the *AH Act.*
- Lodged Places – places that are yet to be formally assessed by the Aboriginal Cultural Material Committee (ACMC) against the criteria set out in Sections 5 and 39 of the *AH Act.*
- Stored Data – places the ACMC has assessed to which the *AH Act* does not apply (noting that additional information might come to light that could trigger reassessment).

Under the DPLH registers, Aboriginal Heritage Places include both archaeological and ethnographic sites. Archaeological sites preserve evidence of past activities by Aboriginal groups or people, such as artefacts and quarries, and are described in this section. Ethnographic sites are places known to Traditional Owners as part of their cultural traditions

and typically have mythological or ceremonial meaning. Ethnographic sites are described in Table 5-74 below.

Spatial analysis was conducted to identify recorded Aboriginal heritage within 5 km of the Mine DEs, using the DPLH-099 Aboriginal Heritage Registered Places and DPLH-100 Aboriginal Heritage Lodged Places datasets.

Table 5-74 presents the Aboriginal Heritage Places on both these public registers within 5 km of the Huntly Mine DE.

Table 5-74: Registered and Lodged Aboriginal Heritage Places within 5 km of the Huntly Mine DE

Place ID	Place Name	Status	Place type
Huntly Mine DE			
3582	SERPENTINE RIVER	Registered	Ritual / Ceremonial; Creation / Dreaming Narrative
3950	KRONIN BROOK 2	Registered	Artefacts / Scatter
3951	KRONIN BROOK 3	Registered	Artefacts / Scatter
3952	KRONIN BROOK 4	Registered	Artefacts / Scatter
27937	Dandalup River	Registered	Creation / Dreaming Narrative; Hunting Place; Landscape / Seascape Feature; Plant Resource; Water Source
3687	WURDAATJI CAVE	Lodged	Creation / Dreaming Narrative
23011	Dwellingup Artefact Scatter (S04-12)	Lodged	Artefacts / Scatter
23012	Dwellingup Artefact Scatter (S04-13)	Lodged	Artefacts / Scatter
28330	MY08-02	Lodged	Artefacts / Scatter
28331	MY08-03	Lodged	Artefacts / Scatter
28332	MY08-04	Lodged	Artefacts / Scatter
28336	MY08-08	Lodged	Artefacts / Scatter
28340	MY08-12	Lodged	Artefacts / Scatter
28341	MY08-13	Lodged	Artefacts / Scatter
28342	MY08-14	Lodged	Artefacts / Scatter
28343	MY08-15	Lodged	Artefacts / Scatter
28344	MY08-16	Lodged	Artefacts / Scatter
28345	MY08-17	Lodged	Artefacts / Scatter
28346	MY08-18	Lodged	Artefacts / Scatter
28347	MY08-19	Lodged	Artefacts / Scatter
28348	MY08-20	Lodged	Artefacts / Scatter; Historical
28349	MY08-21	Lodged	Artefacts / Scatter
28350	MY08-22	Lodged	Artefacts / Scatter
28351	MY08-23	Lodged	Artefacts / Scatter
28352	MY08-24	Lodged	Artefacts / Scatter
28353	MY08-25	Lodged	Artefacts / Scatter
28354	MY08-26	Lodged	Artefacts / Scatter

Place ID	Place Name	Status	Place type
28355	MY08-27	Lodged	Artefacts / Scatter
28356	MY08-28	Lodged	Artefacts / Scatter
28357	MY08-29	Lodged	Artefacts / Scatter; Historical
28358	MY08-30	Lodged	Artefacts / Scatter
28359	MY08-31	Lodged	Artefacts / Scatter
28360	MY08-32	Lodged	Artefacts / Scatter
28361	MY08-33	Lodged	Artefacts / Scatter
28362	MY08-34	Lodged	Artefacts / Scatter
28363	MY08-35	Lodged	Artefacts / Scatter
28364	MY08-36	Lodged	Artefacts / Scatter
28365	MY08-37	Lodged	Artefacts / Scatter
28366	MY08-38	Lodged	Artefacts / Scatter; Grinding areas / Grooves
28367	MY08-39	Lodged	Artefacts / Scatter
28368	MY08-40	Lodged	Artefacts / Scatter; Traditional Structure
28369	MY08-41	Lodged	Artefacts / Scatter
28370	MY08-42	Lodged	Artefacts / Scatter; Grinding areas / Grooves
28371	MY08-43	Lodged	Artefacts / Scatter
28372	CN508-01	Lodged	Artefacts / Scatter
40489	AO22-042	Lodged	Artefacts / Scatter
40502	AO22-045	Lodged	Artefacts / Scatter
40526	MY08-35	Lodged	Artefacts / Scatter
40527	ME16-005	Lodged	Artefacts / Scatter
40528	MY08-43	Lodged	Artefacts / Scatter
40535	ON09-07	Lodged	Artefacts / Scatter
40556	ON09-04	Lodged	Artefacts / Scatter
40557	AO22-043	Lodged	Artefacts / Scatter
40653	AO22-009	Lodged	Artefacts / Scatter
40668	AO22-014	Lodged	Artefacts / Scatter
Huntly Mine DE – within 5 km buffer			
3546	MICHAEL'S CAMP.	Registered	Camp
3582	SERPENTINE RIVER	Registered	Ritual / Ceremonial; Creation / Dreaming Narrative
3946	N DANDALUP RIVER 2	Registered	Artefacts / Scatter
3947	N DANDALUP RIVER 3	Registered	Artefacts / Scatter
3948	N DANDALUP RIVER 4	Registered	Artefacts / Scatter
3949	KRONIN BROOK 1	Registered	Artefacts / Scatter
3950	KRONIN BROOK 2	Registered	Artefacts / Scatter
3951	KRONIN BROOK 3	Registered	Artefacts / Scatter
3952	KRONIN BROOK 4	Registered	Artefacts / Scatter

Place ID	Place Name	Status	Place type
3953	N DANDALUP RIVER 5	Registered	Artefacts / Scatter
4115	ADELAIDE RD EAST, PINJARRA	Registered	Artefacts / Scatter
4331	GAS PIPELINE 90	Registered	Artefacts / Scatter
15853	PINJARRA WILLIAMS ROAD 01	Registered	Engraving
15854	PINJARRA WILLIAMS ROAD 02	Registered	Plant Resource
15855	PINJARRA WILLIAMS ROAD 03	Registered	Hunting Place
15856	PINJARRA WILLIAMS ROAD 04	Registered	Other
27937	Dandalup River	Registered	Creation / Dreaming Narrative; Hunting Place; Landscape / Seascape Feature; Plant Resource; Water Source
32060	RSA10AS02	Registered	Artefacts / Scatter
38647	Yam Farm Serpentine National Park	Registered	Ritual / Ceremonial
3563	JARRAHDALE	Lodged	Artefacts / Scatter; Quarry
3594	MUNDUP.	Lodged	Camp; Plant Resource
3687	WURDAATJI CAVE	Lodged	Creation / Dreaming Narrative
4114	ADELAIDE/ALCOA RDS, PINJARRA	Lodged	Artefacts / Scatter
15720	ALCOA 01	Lodged	Artefacts / Scatter
18749	HEA01	Registered	Artefacts / Scatter
19263	Jarrahdale Camping Ground 1	Lodged	Artefacts / Scatter; Camp; Meeting Place; Water Source
19264	Jarrahdale camping ground 2	Lodged	Artefacts / Scatter
19801	PJ-A02 ARTEFACT SCATTER	Lodged	Artefacts / Scatter
19803	SCOT-A-01	Lodged	Artefacts / Scatter; Quarry
19804	SCOT-A-02	Lodged	Artefacts / Scatter
19805	S01/05	Lodged	Artefacts / Scatter
19806	S01/06	Lodged	Artefacts / Scatter
19807	S01/07	Lodged	Artefacts / Scatter
19808	S01/08	Lodged	Artefacts / Scatter
19823	S01/01 Artefact Scatter	Lodged	Artefacts / Scatter
19824	S01/02 Artefact Scatter	Lodged	Artefacts / Scatter
19825	S01/03 Artefact Scatter	Lodged	Artefacts / Scatter
19827	S00/01 Artefact Scatter	Lodged	Artefacts / Scatter
19828	S00/02 Artefact Scatter	Lodged	Artefacts / Scatter
19829	S00/03 Possible Artefact Scatter	Lodged	Artefacts / Scatter
21263	S02/04 Artefact Scatter	Lodged	Artefacts / Scatter
21264	McCoy & Huntly Mine Isolated FInds	Lodged	Other
22992	Dwellingup Artefact Scatter (S03-01)	Lodged	Artefacts / Scatter
22993	Dwellingup Artefact Scatter (S03-02)	Lodged	Artefacts / Scatter

Place ID	Place Name	Status	Place type
22994	Dwellingup Scarred Tree (S03-03)	Lodged	Burial; Modified Tree
22995	Dwellingup Scarred Tree (S03-04)	Lodged	Burial; Modified Tree
22996	Dwellingup Artefact Scatter (S03-05)	Lodged	Artefacts / Scatter
22997	Dwellingup Artefact Scatter (S03-06)	Lodged	Artefacts / Scatter
23000	Dwellingup Artefact Scatter (S04-01)	Lodged	Artefacts / Scatter
23001	Dwellingup Artefact Scatter (S04-02)	Lodged	Artefacts / Scatter
23002	Dwellingup Artefact Scatter (S04-03)	Lodged	Artefacts / Scatter
23003	Dwellingup Artefact Scatter (S04-04)	Lodged	Artefacts / Scatter
23004	Dwellingup Artefact Scatter (S04-05)	Lodged	Artefacts / Scatter
23005	Dwellingup Artefact Scatter (S04-06)	Lodged	Artefacts / Scatter
23006	Dwellingup Artefact Scatter (S04-07)	Lodged	Artefacts / Scatter
23007	Dwellingup Artefact Scatter (S04-08)	Lodged	Artefacts / Scatter
23008	Dwellingup Artefact Scatter (S04-09)	Lodged	Artefacts / Scatter
23009	Dwellingup Artefact Scatter (S04-10)	Lodged	Artefacts / Scatter
23010	Dwellingup Artefact Scatter (S04-11)	Lodged	Artefacts / Scatter
23011	Dwellingup Artefact Scatter (S04-12)	Lodged	Artefacts / Scatter
23012	Dwellingup Artefact Scatter (S04-13)	Lodged	Artefacts / Scatter
23013	Dwellingup Artefact Scatter (S04-14)	Lodged	Artefacts / Scatter
23014	Dwellingup Artefact Scatter (S04-15)	Lodged	Artefacts / Scatter
23015	Dwellingup Artefact Scatter (S04-16)	Lodged	Artefacts / Scatter
23016	Dwellingup Artefact Scatter (S04-17)	Lodged	Artefacts / Scatter
23017	Dwellingup Artefact Scatter (S04-18)	Lodged	Artefacts / Scatter
23018	Dwellingup Artefact Scatter (S04-19)	Lodged	Artefacts / Scatter
23019	Dwellingup Artefact Scatter (S04-20)	Lodged	Artefacts / Scatter
23020	Dwellingup Artefact Scatter (S04-21)	Lodged	Artefacts / Scatter

Place ID	Place Name	Status	Place type
23021	Dwellingup Artefact Scatter (S04-22)	Lodged	Artefacts / Scatter
23022	Dwellingup Artefact Scatter (S04-23)	Lodged	Artefacts / Scatter
23023	Dwellingup Artefact Scatter (S04-24)	Lodged	Artefacts / Scatter
23451	Oakley Plantation 1	Lodged	Artefacts / Scatter
23456	Oakley Plantation 2	Lodged	Artefacts / Scatter
26171	KEY08-01	Lodged	Modified Tree; Other
26172	KEY08-02	Lodged	Modified Tree; Other
28329	MY08-01	Lodged	Artefacts / Scatter
28330	MY08-02	Lodged	Artefacts / Scatter
28331	MY08-03	Lodged	Artefacts / Scatter
28332	MY08-04	Lodged	Artefacts / Scatter
28333	MY08-05	Lodged	Artefacts / Scatter
28334	MY08-06	Lodged	Artefacts / Scatter
28335	MY08-07	Lodged	Artefacts / Scatter
28336	MY08-08	Lodged	Artefacts / Scatter
28337	MY08-09	Lodged	Artefacts / Scatter
28338	MY08-10	Lodged	Artefacts / Scatter
28340	MY08-12	Lodged	Artefacts / Scatter
28341	MY08-13	Lodged	Artefacts / Scatter
28342	MY08-14	Lodged	Artefacts / Scatter
28343	MY08-15	Lodged	Artefacts / Scatter
28344	MY08-16	Lodged	Artefacts / Scatter
28345	MY08-17	Lodged	Artefacts / Scatter
28346	MY08-18	Lodged	Artefacts / Scatter
28347	MY08-19	Lodged	Artefacts / Scatter
28348	MY08-20	Lodged	Artefacts / Scatter; Historical
28349	MY08-21	Lodged	Artefacts / Scatter
28350	MY08-22	Lodged	Artefacts / Scatter
28351	MY08-23	Lodged	Artefacts / Scatter
28352	MY08-24	Lodged	Artefacts / Scatter
28353	MY08-25	Lodged	Artefacts / Scatter
28354	MY08-26	Lodged	Artefacts / Scatter
28355	MY08-27	Lodged	Artefacts / Scatter
28356	MY08-28	Lodged	Artefacts / Scatter
28357	MY08-29	Lodged	Artefacts / Scatter; Historical
28358	MY08-30	Lodged	Artefacts / Scatter
28359	MY08-31	Lodged	Artefacts / Scatter
28360	MY08-32	Lodged	Artefacts / Scatter
28361	MY08-33	Lodged	Artefacts / Scatter

Place ID	Place Name	Status	Place type
28362	MY08-34	Lodged	Artefacts / Scatter
28363	MY08-35	Lodged	Artefacts / Scatter
28364	MY08-36	Lodged	Artefacts / Scatter
28365	MY08-37	Lodged	Artefacts / Scatter
28366	MY08-38	Lodged	Artefacts / Scatter; Grinding areas / Grooves
28367	MY08-39	Lodged	Artefacts / Scatter
28368	MY08-40	Lodged	Artefacts / Scatter; Traditional Structure
28369	MY08-41	Lodged	Artefacts / Scatter
28370	MY08-42	Lodged	Artefacts / Scatter; Grinding areas / Grooves
28372	CN508-01	Lodged	Artefacts / Scatter
28374	MY08 – Isolated Artefacts	Lodged	Other
29544	SP10-01	Lodged	Artefacts / Scatter
30612	Pinjarra Williams Road Stone Structure	Lodged	Traditional Structure
30635	Pinjarra Williams Road Scarred Tree 1	Lodged	Modified Tree
30636	Pinjarra Williams Road Scarred Tree 2	Lodged	Modified Tree
38897	MB20-01	Lodged	Artefacts / Scatter
38900	MB20-02 is the site number given to the place. No other name was recorded for the place, however it	Lodged	Artefacts / Scatter
40489	AO22-042	Lodged	Artefacts / Scatter
40502	AO22-045	Lodged	Artefacts / Scatter
40526	MY08-35	Lodged	Artefacts / Scatter
40527	ME16-005	Lodged	Artefacts / Scatter
40535	ON09-07	Lodged	Artefacts / Scatter
40543	JS16-004	Lodged	Artefacts / Scatter
40544	JS16-003	Lodged	Artefacts / Scatter
40556	ON09-04	Lodged	Artefacts / Scatter
40557	AO22-043	Lodged	Artefacts / Scatter
40649	AO22-001	Lodged	Artefacts / Scatter
40650	AO22-002	Lodged	Artefacts / Scatter; Grinding areas / Grooves; Traditional Structure; Water Source
40651	AO22-003	Lodged	Artefacts / Scatter
40652	AO22-008	Lodged	Artefacts / Scatter
40653	AO22-009	Lodged	Artefacts / Scatter
40668	AO22-014	Lodged	Artefacts / Scatter
40790	JS16-001	Lodged	Artefacts / Scatter
40791	JS16-002	Lodged	Artefacts / Scatter

Table 5-75 presents the Aboriginal Heritage Places within 5 km of the Willowdale Mine DE.

Table 5-75: Registered and Lodged Aboriginal Heritage Places within 5 km of the Willowdale Mine DE

Place ID	Place Name	Status	Place type
Willowdale Mine DE			
24688	S05-15	Lodged	Artefacts / Scatter
24689	S05-16	Lodged	Artefacts / Scatter; Historical
Willowdale – within 5 km buffer			
3537	Murray River	Registered	Creation / Dreaming Narrative
5290	Corridor Site 03	Registered	Artefacts / Scatter
24680	S05-07	Lodged	Artefacts / Scatter
24684	S05-11	Lodged	Artefacts / Scatter
24685	S05-12	Lodged	Artefacts / Scatter
24686	S05-13	Lodged	Artefacts / Scatter
24687	S05-14	Lodged	Artefacts / Scatter
24688	S05-15	Lodged	Artefacts / Scatter
24689	S05-16	Lodged	Artefacts / Scatter; Historical
28371	MY08-43	Lodged	Artefacts / Scatter
39727	'Harvey River' (named "Koritjuka Bilya" as reported by Lesley Ugle on 2 Feb 2023; on public notice.	Lodged	Camp; Ritual / Ceremonial; Creation / Dreaming Narrative; Hunting Place; Landscape / Seascape Feature; Water Source
40528	MY08-43	Lodged	Artefacts / Scatter
40530	LA20-02	Lodged	Artefacts / Scatter

5.6.3.5 Aboriginal Heritage – Ethnographic

Spatial analysis of the DPLH-099 Aboriginal heritage registered and DPLH-100 Aboriginal heritage lodged datasets indicates that there are three ethnographic sites within the Huntly Mine DE, two are water courses which extend inside and outside the DE area and one is a cave (Table 5-76).

There are no additional ethnographic sites registered or lodged within the Willowdale Mine DE and two ethnographic sites in a 5 km buffer surrounding Willowdale Mine DE, both are water courses (Table 5-77). In addition to these registered or lodged ethnographic sites Alcoa has six additional Aboriginal heritage places of ethnographic significance on its internal heritage sites database within 5 km of the Willowdale Mine DE.

Alcoa recognises other Aboriginal heritage places not classified as ethnographic are also culturally important to Aboriginal people.

Table 5-76: Aboriginal Ethnographic Sites within 5 km of Huntly Mine

Place ID	Place Name	Status	Type
Within Huntly Mine DE			
27937	Dandalup River	Registered	Creation, Dreamtime Narrative
3582	Serpentine River	Registered	Creation, Dreamtime Narrative
3687	Wurdaatji Cave	Lodged	Creation, Dreamtime Narrative

Table 5-77: Aboriginal ethnographic sites within 5 km of Willowdale Mine

Place ID	Place Name	Status	Type	Site Location
Outside of Willowdale Mine DE but within 5 km				
3537	Murray River	Registered	Creation / Dreaming Narrative	Not included
39727	'Harvey River' (named "Koritjuka Bilya" as reported by Lesley Ugle on 2 Feb 2023; on public notice.	Lodged	Camp; Ritual / Ceremonial; Creation / Dreaming Narrative; Hunting Place; Landscape / Seascape Feature; Water Source	Not included
Not included in DPLH 099 or 100 search areas				
NA	LS23-004	Unknown	Not included	Larego South
NA	LS23-005	Unknown	Ethno-botanical	Larego South
NA	LS23-006	Unknown	Ethno-botanical	Larego South
NA	LS23-007	Unknown	Ethnographic	Larego South
NA	Hoffman Mill Campground	Unknown	Natural Feature, Water Source	Larego South
NA	LS24-038	Unknown	Natural Feature, Gnamma Hole, Water Source, Mythological	Larego South

5.6.3.6 Additional Aboriginal Heritage Places

Alcoa's cultural heritage management system includes additional cultural heritage places identified in the Mine DEs which may have not been lodged or registered with DPLH. Alcoa has reported all Aboriginal heritage places that Gnaala Karla Booja Aboriginal Corporation has agreed should be reported and are continuing to consult with the Corporation regarding ongoing reporting of Aboriginal Heritage survey results. Cultural heritage places in which the corporation has provided consent to include are included on Figure 5-59 and Figure 5-60, and listed in Table 5-78 and Table 5-79 overleaf. Alcoa will continue to avoid impacts to all Aboriginal heritage places, unless they have been subject to Section 18 Consent or are assessed as not meeting criteria as an Aboriginal heritage place under the AH Act.

Table 5-78: Aboriginal Heritage Places within 5 km of Huntly not Registered or Lodged with DPLH

Place ID	Place Name	Status	Type	Site Location
Within Huntly Mine DE				
NA	AO22-004	Not provided	Artefact Scatter	O'Neil East
NA	AO22-004-SI	Not provided	Information not provided	O'Neil East
NA	AO22-005	Not provided	Artefact Scatter	O'Neil East
NA	AO22-006	Not provided	Artefact Scatter, Reduction Area	O'Neil East
NA	AO22-006-SI	Not provided	Information not provided	O'Neil East
NA	AO22-007	Not provided	Artefact Scatter, Reduction Area	O'Neil East
NA	AO22-007-SI	Not provided	Information not provided	O'Neil East
NA	AO22-009 SI	Not provided	Artefact Scatter	O'Neil East
NA	AO22-010	Not provided	Artefact Scatter	O'Neil East
NA	AO22-011	Not provided	Other – Sharpening Stone	O'Neil East
NA	AO22-011	Not provided	Sharpening Stone	O'Neil East
NA	AO22-012	Not provided	Artefact Scatter	O'Neil East
NA	AO22-012-SI	Not provided	Artefact Scatter	O'Neil East
NA	AO22-013	Not provided	Artefact Scatter	O'Neil East
NA	AO22-015	Not provided	Artefact Scatter	O'Neil East
NA	AO22-015	Not provided	Artefact /scatter	O'Neil East
NA	AO22-016	Not provided	Artefact Scatter	O'Neil East
NA	AO22-016	Not provided	Artefact Scatter	O'Neil East
NA	AO22-017	Not provided	Artefact Scatter	O'Neil East
NA	AO22-017-SI	Not provided	Artefact Scatter	O'Neil East
NA	AO22-018	Not provided	Artefact Scatter / Reduction Area	O'Neil East
NA	AO22-018-SI	Not provided	Artefact Scatter / Reduction Area	O'Neil East
NA	AO22-019	Not provided	Artefact Scatter	O'Neil East
NA	AO22-019-SI	Not provided	Artefact Scatter	O'Neil East
NA	AO22-020	Not provided	Artefact Scatter	O'Neil East
NA	AO22-020-SI	Not provided	Artefact Scatter	O'Neil East
NA	AO22-021	Not provided	Artefact Scatter	O'Neil East
NA	AO22-021-SI	Not provided	Artefact Scatter	O'Neil East
NA	AO22-022	Not provided	Artefact Scatter	O'Neil East
NA	AO22-022-SI	Not provided	Artefact Scatter	O'Neil East
NA	AO22-023	Not provided	Artefact Scatter	O'Neil East
NA	AO22-024	Not provided	Artefact Scatter	O'Neil East
NA	AO22-025	Not provided	Artefact / Grinding	O'Neil East
NA	AO22-026	Not provided	Artefact Scatter	O'Neil East
NA	AO22-027	Not provided	Artefact Scatter / Ceremonial	O'Neil East

Place ID	Place Name	Status	Type	Site Location
NA	AO22-028	Not provided	Artefact Scatter	O'Neil East
NA	AO22-028	Not provided	Artefact Scatter	O'Neil East
NA	AO22-029	Not provided	Artefact Scatter	O'Neil East
NA	AO22-030	Not provided	Artefact Scatter	O'Neil East
NA	AO22-030	Not provided	Artefact Scatter	O'Neil and O'Neil East
NA	AO22-032	Not provided	Artefact Scatter	O'Neil East
NA	AO22-032-SI	Not provided	Information not provided	O'Neil East
NA	AO22-033	Not provided	Artefact Scatter	O'Neil East
NA	AO22-033 SI	Not provided	Artefact Scatter	O'Neil East
NA	AO22-034	Not provided	Scarred Tree	O'Neil East
NA	AO22-035	Not provided	Scarred Tree	O'Neil East
NA	AO22-036	Not provided	Scarred Tree	O'Neil East
NA	AO22-036-SI	Not provided	Information not provided	O'Neil East
NA	AO22-037	Not provided	Artefact Scatter	O'Neil East
NA	AO22-037-SI	Not provided	Artefact Scatter	O'Neil East
NA	AO22-038	Not provided	Scarred Tree	O'Neil East
NA	AO22-039	Not provided	Artefact Scatter	O'Neil East
NA	AO22-039-SI	Not provided	Information not provided	O'Neil East
NA	AO22-040	Not provided	Artefact Scatter	O'Neil East
NA	AO22-040	Not provided	Artefact Scatter	O'Neil East
NA	AO22-041	Not provided	Artefact Scatter	O'Neil East
NA	AO22-041	Not provided	Artefact Scatter	O'Neil East
NA	AO22-042-SI	Not provided	Artefact Scatter	O'Neil East
NA	AO22-044	Not provided	Artefact Scatter	O'Neil East
NA	AO22-044-SI	Not provided	Information not provided	O'Neil East
NA	AO22-045-SI	Not provided	Artefact Scatter	O'Neil East
NA	AO22-046	Not provided	Artefact Scatter	O'Neil East
NA	AO22-046-SI	Not provided	Artefact Scatter	O'Neil East
NA	AO22-048	Not provided	Corroboree Ground	O'Neil East
NA	AO22-048 SI	Not provided	Corroboree Ground, Modified Tree, Artefact Scatter, Grinding, Cermonial	O'Neil East
NA	CN508-01-SI	Not provided	Information not provided	Myara
NA	ME16-003	Not provided	Artefact Scatter	Huntly
NA	ME16-003-SI	Not provided	Information not provided	Myara
NA	ME16-004	Not provided	Artefact Scatter	Huntly
NA	ME16-005-SI	Not provided	Information not provided	Myara
NA	ME16-006	Not provided	Artefact Scatter	Huntly
NA	ME16-007	Not provided	Artefact Scatter	Huntly
NA	ME16-007-SI	Not provided	Information not provided	Myara
NA	ME16-008	Not provided	Artefact Scatter	Huntly

Place ID	Place Name	Status	Type	Site Location
NA	ME16-008-SI	Not provided	Information not provided	Myara
NA	MY08-12	Not provided	Artefact Scatter	Huntly
NA	MY08-17-SI	Not provided	Information not provided	Myara
NA	MY08-28-SI	Not provided	Information not provided	Myara
NA	MY08-31-SI	Not provided	Information not provided	Myara
NA	MY08-33-SI	Not provided	Artefact Scatter	Myara
NA	MY08-35-SI	Not provided	Information not provided	Myara
NA	MY08-38-SI	Not provided	Information not provided	Myara
NA	MY08-42-SI	Not provided	Artefact Scatter, Grinding	Huntly
NA	MY08-43-SI	Not provided	Artefact Scatter	Myara
NA	MY18-002	Not provided	Artefact scatter	
NA	MY18-004	Not provided	Artefact scatter	
NA	MY18-006	Not provided	Artefact scatter, Quarry	
NA	MY18-007	Not provided	Artefact scatter	
NA	MY18-010	Not provided	Artefact scatter	
NA	MY18-011	Not provided	Artefact scatter	
NA	ON07-06 SI	Not provided	Artefact Scatter	O'Neil
NA	ON09-01	Not provided	Artefact Scatter	Huntly
NA	ON09-01 SI	Not provided	Artefact Scatter	O'Neil
NA	ON09-02	Not provided	Artefact Scatter	Huntly
NA	ON09-02	Not provided	Artefact Scatter	O'Neil
NA	ON09-02-SI	Not provided	Artefact Scatter	O'Neil
NA	ON09-03	Not provided	Artefact Scatter	Huntly
NA	ON09-03	Not provided	Artefact Scatter	O'Neil
NA	ON09-04	Not provided	Artefact Scatter, Reduction Area	O'Neil
NA	ON09-05	Not provided	Artefact Scatter	Huntly
NA	ON09-06	Not provided	Artefact Scatter	Huntly
NA	ON09-07 SI	Not provided	Artefact Scatter	O'Neil
NA	S04/11-SI	Not provided	Artefact Scatter	
NA	S04/12-SI	Not provided	Artefact Scatter	
NA	S04-12-SI	Not provided	Information not provided	O'Neil East
NA	S04-13-SI	Not provided	Information not provided	O'Neil East
NA	TH24-001	Not provided	Artefact Scatter	Huntly
NA	TH24-002	Not provided	Artefact Scatter	Huntly
NA	TH24-003	Not provided	Artefact Scatter	Huntly
NA	TH24-004	Not provided	Artefact Scatter	Huntly
NA	TH24-005	Not provided	Artefact Scatter	Huntly
NA	TH24-006	Not provided	Artefact Scatter	Huntly
NA	TH24-007	Not provided	Artefact Scatter	Huntly
NA	TH24-008	Not provided	Artefact Scatter, Scar Tree	Huntly

Place ID	Place Name	Status	Type	Site Location
NA	TH24-009	Not provided	Artefact Scatter	Huntly
NA	TH24-010	Not provided	Artefact Scatter, Scar Tree	Huntly
NA	TH24-012	Not provided	Artefact Scatter	Huntly
NA	TH24-013	Not provided	Artefact Scatter, Ethnographic	Huntly
NA	TH24-014	Not provided	Artefact Scatter, Ethnographic	Huntly
Outside of Huntly Mine De but within 5 km				
NA	S03/07	Not provided	Artefact Scatter	Huntly
NA	S03/08	Not provided	Artefact Scatter	Huntly
NA	S02/02	Not provided	Artefact Scatter	Huntly
23008	S04/09	Not provided	Artefact Scatter	Huntly
23001	S04/14	Not provided	Artefact Scatter	Huntly
NA	S99/01	Not provided	Artefact Scatter	Huntly
23014	S00/02	Not provided	Reduction Area	Huntly
NA	S99/02	Not provided	Scarred Tree	Huntly
NA	S01/6B	Not provided	Artefact scatter	Huntly
NA	S01/6C	Not provided	Artefact scatter	Huntly
NA	S01/6A	Not provided	Artefact scatter	Huntly
NA	S02/03	Not provided	Artefact scatter	Huntly
NA	S02/01	Not provided	Artefact scatter	Huntly
NA	S01/01B	Not provided	Artefact scatter	Huntly
NA	HO13-04	Not provided	Artefact Scatter	Huntly
NA	JS14-06 (DAA 3563)	Not provided	Artefact Scatter, Reduction Area, Structure, Water Source	Huntly
NA	TS15-01	Not provided	Artefact Scatter	Huntly
NA	JS14-02	Not provided	Artefact Scatter	Huntly
NA	JS14-03	Not provided	AS,RA, WS, S	Huntly
NA	JS14-01	Not provided	Artefact Scatter	Huntly
NA	JS14-04	Not provided	Artefact Scatter	Huntly
NA	JS14-05	Not provided	Artefact Scatter	Huntly
NA	ME16-002	Not provided	Artefact Scatter	Huntly
NA	ME16-001	Not provided	Artefact Scatter	Huntly
NA	JS17-004	Not provided	Artefact Scatter	Huntly
NA	JS17-006	Not provided	Artefact Scatter	Huntly
NA	MY18-012	Not provided	Artefact Scatter	Huntly
NA	MY18-013	Not provided	Cultural Landscape	Huntly
NA	MY18-009	Not provided	Artefact Scatter	Huntly
NA	MY18-008	Not provided	Potential Roack Art	Huntly
NA	MY18-014	Not provided	Stone Structure (Lizard Trap)	Huntly
NA	MY18-001	Not provided	Artefact Scatter	Huntly

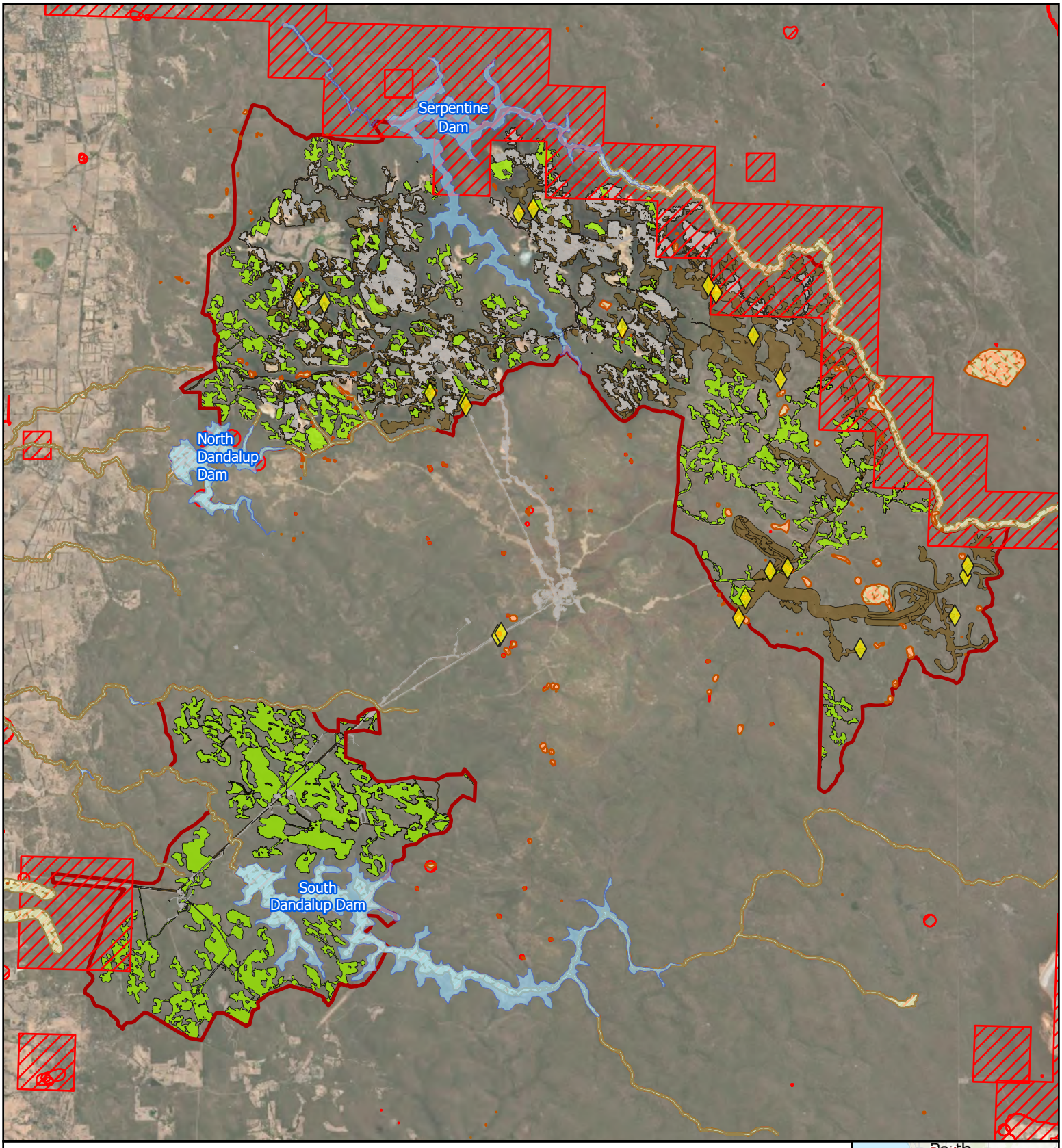
Place ID	Place Name	Status	Type	Site Location
NA	MY18-003	Not provided	Artefact Scatter	Huntly
NA	MY18-005	Not provided	Artefact Scatter	Huntly
NA	A18WM1a	Not provided	Artefact Scatter	Huntly
NA	AO22-001	Not provided	Artefact Scatter	O'Neil East
NA	AO22-047	Not provided	Artefact Scatter	O'Neil East
NA	AO22-002	Not provided	Artefact Scatter	O'Neil East
NA	BP22-006	Not provided	Artefact Scatter	Pinjarra Refinery
NA	BP22-004	Not provided	Reduction Area	Pinjarra Refinery
NA	BP22-003	Not provided	Preliminary Boundary	Pinjarra Refinery
NA	BP22-005	Not provided	Preliminary Boundary	Pinjarra Refinery
NA	BP22-002	Not provided	Artefact Scatter	Pinjarra Refinery
NA	BP22-001	Not provided	Artefact Scatter	Pinjarra Refinery
NA	Oakley Brook-CL001	Not provided	Artefact Scatter – At request of TOs	Pinjarra Refinery
NA	ALCOA-A01	Not provided	Ceremonial – At request of TOs	Pinjarra Refinery
NA	Potential Rock Art	Not provided	Artefact Scatter	Pinjarra Refinery
NA	JS16-010	Not provided	Artefact Scatter	Huntly
NA	JS16-006	Not provided	Artefact Scatter, Reduction Area, Scar Tree	Huntly
NA	JS16-008	Not provided	Artefact Scatter	Huntly
NA	JS16-007	Not provided	Artefact Scatter	Huntly
NA	JS16-009	Not provided	Artefact Scatter	Huntly
NA	JS16-005	Not provided	Artefact Scatter	Huntly
NA	JS16-001	Not provided	Artefact Scatter	Huntly
NA		Not provided	Modified Tree	O'Neil East
NA	AO22-008 SI	Not provided	Modified tree	O'Neil East
NA	AO22-047 SI	Not provided	Artefact Scatter	O'Neil East
NA	MC24-001	Not provided	Information not provided	McCoy
NA	MC24-002	Not provided	Information not provided	McCoy
NA	S04-08	Not provided	Information not provided	McCoy
NA	S03/06-SI	Not provided	Information not provided	Huntly
NA	S04/02-SI	Not provided	Information not provided	Huntly
NA	S04/01-SI	Not provided	Information not provided	Huntly
NA	S04/05-SI	Not provided	Information not provided	Huntly
NA	S04/06-SI	Not provided	Information not provided	Huntly
NA	S00/02-SI	Not provided	Information not provided	Huntly

Place ID	Place Name	Status	Type	Site Location
NA	S04/21-SI	Not provided	Information not provided	Huntly
NA	AO22-003-SI	Not provided	Information not provided	O'Neil East
NA	S03/01-SI	Not provided	Information not provided	McCoy
NA	MC24-006-SI	Not provided	Information not provided	O'Neil East
NA	S04/04-SI	Not provided	Information not provided	McCoy
NA	ON-HRZ-001-SI	Not provided	Information not provided	O'Neil East
NA	S03/05-SI	Not provided	Information not provided	Huntly
NA	S04/09 SI	Not provided	Information not provided	McCoy
NA	S04/10C SI	Not provided	Information not provided	McCoy
NA	S04/10B SI	Not provided	Information not provided	McCoy
NA	S04/04-SI	Not provided	Information not provided	McCoy

Table 5-79: Aboriginal heritage places within 5 km of the Willowdale Mine DE not registered or lodged with DPLH

Place ID	Place Name	Status	Type	Site Location
Outside of Willowdale Mine DE but within 5 km				
NA	LA18-001	Not provided	Artefact Scatter	Willowdale
NA	LA18-002	Not provided	Artefact Scatter	Willowdale
NA	LA18-004	Not provided	Artefact Scatter	Willowdale
NA	LA18-003	Not provided	Artefact Scatter	Willowdale
NA	LA20-03	Not provided	Artefact Scatter	Willowdale
NA	LA20-04	Not provided	Artefact Scatter	Willowdale
NA	LA20-05	Not provided	Artefact Scatter	Willowdale
NA	LA20-01	Not provided	Artefact Scatter	Willowdale
NA	LA20-07	Not provided	Artefact Scatter	Willowdale
NA	LA20-06	Not provided	Artefact Scatter	Willowdale
NA	S05 – 11	Not provided	Reduction Area	Willowdale
NA	LA18-004-SI	Not provided	Information not provided	Larego
NA	LA18-003	Not provided	Artefact Scatter	Willowdale
NA	LA20-002-SI	Not provided	Information not provided	Larego
NA	LA20-001-SI	Not provided	Information not provided	Larego
NA	S05-07-SI	Not provided	Information not provided	Larego
NA	S05-14-SI	Not provided	Information not provided	Larego
NA	S05-11-SI	Not provided	Information not provided	Larego
NA	S05-12-SI	Not provided	Information not provided	Larego
NA	LA18-002-SI	Not provided	Information not provided	Larego
NA	LS23-004	Not provided	Grinding	Larego South
NA	Hoffman Mill Campground	Not provided	Historical	Larego South

Place ID	Place Name	Status	Type	Site Location
NA	LS23-030	Not provided	Culturally Modified Tree	Larego South
NA	LS24-039	Not provided	Culturally Modified Tree	Larego South
NA	Not provided	Not provided	Isolated Artefact(s)	Larego South
NA	Not provided	Not provided	Isolated Artefact(s)	Larego South
NA	Not provided	Not provided	Isolated Artefact(s)	Larego South
NA	Not provided	Not provided	Isolated Artefact(s)	Larego South
NA	Not provided	Not provided	Isolated Artefact(s)	Larego South
NA	Not provided	Not provided	Isolated Artefact(s)	Larego South
NA	Not provided	Not provided	Isolated Artefact(s)	Larego South
NA	Not provided	Not provided	Isolated Artefact(s)	Larego South
NA	Not provided	Not provided	Isolated Artefact(s)	Larego South
NA	Not provided	Not provided	Isolated Artefact(s)	Larego South
NA	Not provided	Not provided	Isolated Artefact(s)	Larego South
NA	Not provided	Not provided	Isolated Artefact(s)	Larego South
NA	Not provided	Not provided	Isolated Artefact(s)	Larego South
NA	Not provided	Not provided	Isolated Artefact(s)	Larego South
NA	Not provided	Not provided	Isolated Artefact(s)	Larego South
16734	Coff's Creek 2d	Historic	Artefacts/Scatter	Not Recorded
16737	Coff's Creek 2f	Historic	Artefacts/Scatter	Not Recorded
16746	Orion Road 2	Historic	Artefacts/Scatter	Not Recorded
16732	Coff's Creek 2a	Historic	Artefacts/Scatter	Not Recorded
16729	Coff's Creek 1b	Historic	Artefacts/Scatter	Not Recorded
16735	Coff's Creek 2e	Historic	Artefacts/Scatter	Not Recorded
16736	Coff's Creek 2b	Historic	Artefacts/Scatter	Not Recorded
16730	Coff's Creek 1c	Historic	Artefacts/Scatter	Not Recorded

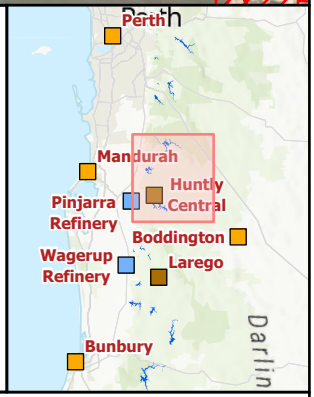


Legend

- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Huntly Mine DE
- Reservoirs
- Site Avoidance Surveys

Alcoa Aboriginal Heritage

- Cultural Landscape
- Alcoa Aboriginal Heritage Sites
- Alcoa Aboriginal Heritage Sites 10m Buffer
- Government Aboriginal Heritage Sites



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-59 Huntly Mine DE - Aboriginal Heritage Sites

Kilometres

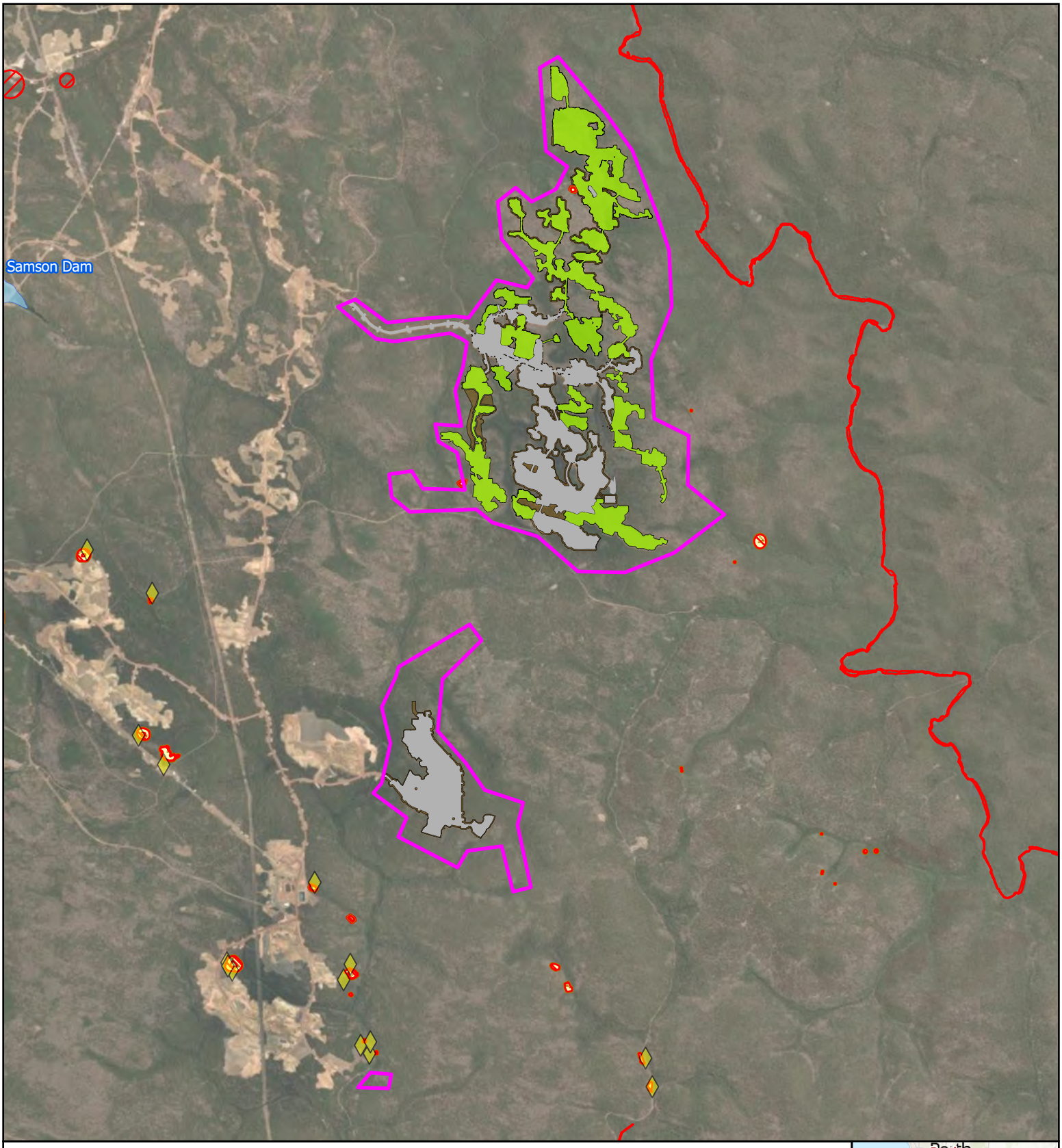
10 15 20 25 30

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Date Printed: 27/02/2025

Alcoa



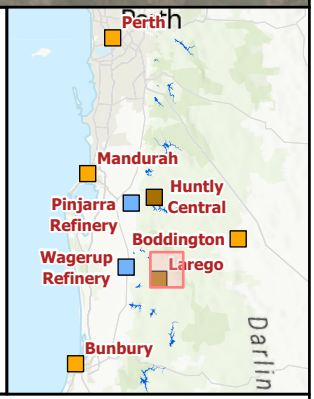
Legend

- Willowdale Mine DE
- Reservoirs
- Site Avoidance Surveys

Alcoa Aboriginal Heritage

- Alcoa Aboriginal Heritage Sites
- Alcoa Aboriginal Heritage Sites 10m Buffer
- Government Aboriginal Heritage Sites

- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-60 Willowdale Mine DE - Aboriginal Heritage Sites

Kilometres

0 0.75 1.5 2.25 3 3.75 4.5

Scale: 1:75,060 at A4

Date Printed: 27/02/2025

N

Alcoa

5.6.3.7 Aboriginal Cultural Values Associated with Physical or Biological Surroundings

As part of the process to develop the comprehensive Cultural Heritage Management Framework for ML1SA, Alcoa has engaged with senior Traditional Owners, through the GKB AC Cultural Advice Committee, on the broader cultural values of the Northern Jarrah Forest.

As detailed in this Framework, from a Noongar perspective, the predominant western view of 'cultural heritage' is narrow and static. Noongar people experience their cultural heritage as living and dynamic, continuing today, as it has been for millennia. The physical cultural heritage places across Noongar Booja are not just comprised of objects with archaeological interest, but also exist within a broader living cultural landscape, connecting Noongar people to their ancestors, to lore, to *kaartijin* (knowledge), and to deep-time cultural heritage.

Bilya (rivers) often mark tribal boundaries and *biddis* (paths) often follow them. The rivers themselves are sacred, created by the great ancestral being, the waugul/wagyul/waakal[12], and are all interconnected. For example, the *Waangaamaap Bilya* (Serpentine River) is connected to *Djarlgarro Beelier* (Canning River) which is connected to *Derbal Yerrigan* (Swan River). The *wagyul* continues to rest in these places, which means they should be approached in a culturally safe and respectful way.

To Noongar people, the *kura* (past) and *yey* (present) are connected spiritually, physically, and emotionally through and to Country, ancestors, customs, and obligations under the lore and kaartijin. This all-encompassing *kundaam* (belief system) is fundamental to Noongar identity. Within this worldview, the maintenance of a healthy country, significant places, and objects and healthy waters are central to maintaining a healthy cultural landscape.

More specific consultation with Traditional Owners during heritage surveys regarding the Proposal drew out the following information on cultural values of the biophysical environment. This included key components relating to inland waters, the negative effects of inappropriate fire regimes, introduction of feral animals, weeds, and environmental pathogens on forest health and access to country.

1. Inland Waters:

    - Waterways have cultural, social, spiritual, aesthetic, and economic value to Noongar people. Freshwater springs are of cultural and spiritual significance based on association with the Waugal. Waterways were formerly a primary source of food and resources for Noongar people; however, water quality and aquatic fauna have declined within the lifetime of the consulted representatives.
    - Noongar life formerly revolved around rivers and waterways, with people traditionally camping along waterways. Fishing activity has notably declined within the lifetime of the consulted representatives. Deteriorating water quality is considered to have led to a reduction in bush tucker and medicine trees, decreases in native fauna and poisoning of cultural food, particularly freshwater marron. Marron represented a staple in Noongar diet and cultural practice.

[2]As an orally transmitted language, many different spellings exist for Noongar words.

2. Forest Health:

    - In addition to the rivers, Noongar people traditionally relied on the forest for resources, the availability of which has also been observed to have declined. Whilst the historical timber industry activity within the forest has contributed, more recent declines in fire-sensitive plants are attributed by Noongar people to the use of controlled (hot) burns and the spread of weeds and *Phytophthora* dieback causing changes to forest composition. In addition, deliberately introduced feral animals such as wild pigs are damaging sensitive ecological communities and out-competing native animals. There is a desire to restore the forest by controlling the threats and reintroducing traditional (cooler) burning regimes.

3. Access to country:

    - Cultural practices such as hunting, fishing, and native flora gathering for food and medicines are ways to maintain connections to cultural practices as well as to maintain spiritual and physical health. Maintaining these cultural practices relies heavily on access to traditional lands.
    - Maintaining cultural values relies on the ability to conduct traditional cultural practices on country. 'Going out bush' is a practice which includes hunting, fishing, and foraging for food. This includes kangaroo hunting, marron fishing and collecting bush tucker and medicines. Being on country represented an important way of regenerating relationships between elements of the cultural landscape from the past, present and future. There has been a loss of spontaneous access to country over time. This has restricted knowledge transfer to younger generations, particularly in practical learning due to reduced spatial and cultural contexts.

5.6.3.8 European Heritage

5.6.3.8.1 Historical Overview

The Huntly and Willowdale Mine DEs contain and are in proximity to European heritage places and objects associated with the historic timber industry centred on Jarrahdale and Dwellingup.

Logging commenced at 'Jarrahdale Station' in the 1870s with No. 1 Mill being constructed on the banks of Gooralong Brook and a railway linking Jarrahdale to Rockingham (Archae-Aus, 2021). No. 3 Mill, also known as the 39 Mile Mill, was established in the 1880s on the banks of 39 Mile Brook, while the Board Mill was established to the southeast of Jarrahdale in 1907 (Archae-Aus, 2021). Eighteen timber mills were constructed near Jarrahdale over a period 120 years, many of which were destroyed by fire and rebuilt (Jarrahdale Heritage Society, 2024). Mills and timber railways were also often dismantled and rebuilt at other locations as logging coups were exhausted of useable timber (Archae-Aus, 2021). This reuse of facilities and materials has had a profound impact on the extent to which there are physical remains of this industry surviving in the Jarrah Forest from this historical period. The last timber mill at Jarrahdale was closed in 1997.

Dwellingup was established in 1910 as a terminus for the Pinjarra-Marrinup Railway with the No. 1 State Mill constructed in the same year. Other mills were established at the hamlets of Holyoake (located about 2 km east of Dwellingup), Banksiadale, and Amphion as well as the Plavin and PWD mills near Amphion. Charles Plavin operated a private mill from 1918. The

Pinjarra-Boddington (Hotham Valley) railway was an important transport link and Inglehope was established as a railway siding to support operations.

The timber industry created several hamlets in addition to the larger towns of Jarrahdale and Dwellingup but all hamlets have been abandoned over time. The hamlet of Big Brook and two former mills were inundated by the construction of the Serpentine Dam in 1971, whilst the hamlets of Holyoake and Nanga Brook were destroyed by the Dwellingup fire of 1961.

Early timber hauling was by horse or bullock teams that hauled to log landings for loading onto locomotives and transport to mills for processing. A network of rail lines extended from Jarrahdale and Dwellingup towns through the forest. Water wells were an important feature of the timber industry, supplying water for workers, livestock, and eventually steam locomotives.

Another feature of the early exploration and timber industry were ‘shield trees’ that were used from the 1830s to the mid-20th century as a location reference system. The trees are currently common throughout the forests of the southwest region (Archae-Aus, 2021).

Apart from the timber industry another notable event was the development of Prisoner of War (POW) camps in the 1940s during World War II, including a POW camp near Jarrahdale No. 3 Mill, and the Marrinup POW camp near Dwellingup.

5.6.3.8.2 Contemporary use of Historical Features

The historical features of Jarrahdale and Dwellingup are expected to form a component of the sense of place for residents and visitors as some features are associated with recreation and tourism. These include the POW Camp near Jarrahdale, the Hotham Valley Tourist Railway, and contemporary use of shield trees for orienteering. The historical values of Jarrahdale and Dwellingup are promoted by local government and organisations such as the Jarrahdale Historical Society and Hotham Valley Railway. An assessment of the recreational and tourism values of Jarrahdale and Dwellingup is presented under the Social Surroundings (Amenity) factor in Section 5.7.

5.6.3.8.3 Registered Places

No World Heritage Sites or Commonwealth Heritage Sites occur within 5 km of the Mine DE. Spatial analysis was undertaken to identify State Register sites within 5 km of the Mine DEs, using the DPLH-006 (Heritage Council WA – State Register) dataset (Department of Planning, Lands and Heritage, 2021).

There is one place on the State Heritage Register within the Huntly mine DE:

- The Marrinup Prisoner of War Camp which is in the Del Park region of Huntly

There is one place on the State Heritage Register within 5 kilometres of the Huntly mine DE:

- Spencer’s Cottage

There are no places on the State Heritage Register within the Willowdale mine DE or within 5 km.

Spatial analysis was undertaken to identify local heritage sites recorded within 5 km of the Huntly and Willowdale mine DEs, using the DPLH-008 (Heritage Council WA – Local Heritage Survey) dataset. The local heritage sites are presented in Table 5-80 and in Figure 5-61.

The analysis indicates that there are two local heritage sites recorded within the Huntly mine DE:

- Serpentine Dam
- The Marrinup Prisoner of War Camp (also included in the State Register)

There are 26 additional places on the local heritage register within 5 km of the Huntly Mine DE (see Table 5-80 overleaf). None of these places are under threat of impact through the Proposal.

There are no local heritage sites recorded within the Willowdale Mine DE, nor are there any local heritage sites within 5 km of the Willowdale Mine DE.

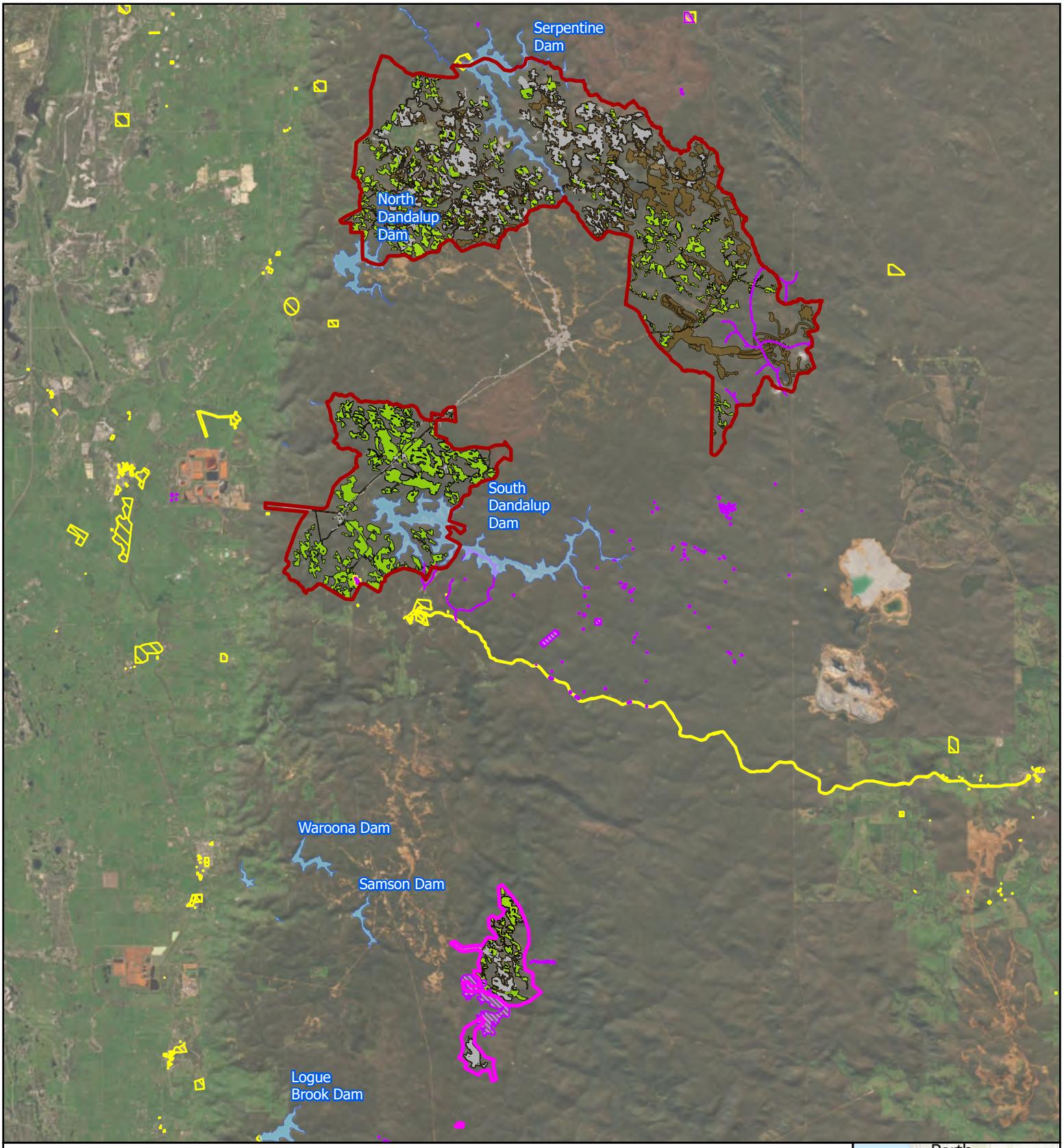
Table 5-80: Local Heritage Survey (DPLH-008) identified heritage listings within 5 km of the Mine DE

Place ID	Place Name	Location	Significance
Within Huntly Mine DE			
4174	Serpentine Dam	Serpentine	Category 3. Conservation Encouraged Significant as an individual building within the Municipality. One of the largest water storage facilities supporting the Perth population, allowing for the rapid industrial growth in the 1950's in Kwinana
3103	Marrinup Prisoner of War Camp	Forest Block No 23, Marrinup	Category A. Essential to the heritage of the locality. Rare or outstanding example. Marrinup POW Camp is the only example of a permanent specialised WWII camp constructed in Western Australia. There has been minimal development of the site for the archaeological record is still intact. Marrinup POW Camp is significant as evidence of the impact of WWII on Western Australia, Marrinup POW Camp is associated with the hundreds of men, from both the German and Italian communities, who were prisoners there.
Within 5 km of Huntly Mine DE			
3302	Spencer's Cottage	Lot 79 Falls Rd, Serpentine	Category 1A. Conservation Essential: A place which may meet the criteria for inclusion on the State Register of Heritage Places, of state or national value. Marrinup POW Camp is the only example of a permanent specialised WWII camp constructed in Western Australia. There has been minimal development of the site for the archaeological record is still intact. Marrinup POW Camp is significant as evidence of the impact of WWII on Western Australia, Marrinup POW Camp is associated with the hundreds of men, from both the German and Italian communities, who were prisoners there.
7052	Water Well	53 Mile peg Albany Hwy, Wandering	Category 3. Retain and conserve if possible. The place has historic value as a reminder of the importance, to early settlers, of regular water supplies along well travelled routes.
7196	Bodhinyana Buddhist Monastery	216 Kingsbury Dr, Serpentine	Category 3. Conservation Encouraged Significant as an individual building within the Municipality. The Bodhinyana Buddhist Monastery is the only monastery of its kind and tradition in Australia, where Buddhism is taught and practiced according to the correct principles of its ancient charter. It continues to maintain an active and influential patronage in Thailand.
8486	Italian Prisoner of War Camp	Balmoral Rd, Jarrahdale	Category 2. Conservation Highly Recommended. Of very considerable value to the Municipality. The site of the former POW camp has historic and social significance as a reminder of the Second World War and how it impinged on the townsite of Jarrahdale and the region. It is also included in the Jarrahdale Guided Walks and so has become an important tourist asset to the town.

Place ID	Place Name	Location	Significance
8494	Keysbrook Farmhouse	South Western Hwy, Keysbrook	Category 2. Conservation highly recommended. Of very considerable value to the Municipality. Keysbrook has some social, historic, and aesthetic value being an early example of a homestead cottage in the Keysbrook district and from its association with the Key and Tonkin family.
8495	Old Bolinda Vale Farmhouse	South Western Hwy, Keysbrook	Category 2. Conservation highly recommended. Of very considerable value to the Municipality. Historic and scientific significance for the use of superphosphate for pasture improvement, and the development of a large dairy farm, The Kentish family have made a significant contribution to the Serpentine community.
9095	Goldmine Hill	Whittakers Rd, North Dandalup	Category B. Very important to the heritage of the locality. Goldmine Hill has the archaeological potential to reveal information about late 19th century gold mining techniques. Goldmine Hill has the potential, if appropriately interpreted, to inform visitors about a key aspect of North Dandalup's and the State's history.
27288	Serpentine Town Dam	Hart Road, Serpentine	Category 3. Conservation encouraged. Significant as an individual building within the Municipality.
23897	North Dandalup Primary School	Lot 1848 Hines Rd, North Dandalup	Category C. Contributes to the heritage of the locality. North Dandalup Primary School has been associated with the provision of education to children in the area since 1900. North Dandalup Primary School has social significance for former pupils, parents, and staff.
23900	Oakley Brook Dam	Scarp Rd, Oakkley	Category D. Contributes to the heritage of the locality. Oakley Brook Dam is associated with the railway line and station and reflects the importance of rail transport in the history of Pinjarra. Oakley Brook Dam has historic significance as a unique part of a system to provide fresh water to Pinjarra.
23957	Whittaker's Mill	Lot 1367 Whittaker's Rd, Whittaker	Category D. Contributes to the heritage of the locality. Whittaker's Mill was the headquarters of Whittaker Bros, a significant timber producer whose output is linked to the development of Western Australia throughout the 20th Century. Whittaker's Mill has archaeological potential to reveal additional information regarding timber production in the first half of the 20th Century.
3105	Nursing Post Gates-Dwellingup	Banksiadale rd, Dwellingup	Category C. Contributes to the heritage of the locality. Memorial Gates forms a simple local landmark, identifying the location of a hospital. Memorial Gates has historic significance as a memorial for those who served in World Wars I and II. Memorial Gates has historic and architectural significance as a remnant of the original hospital.

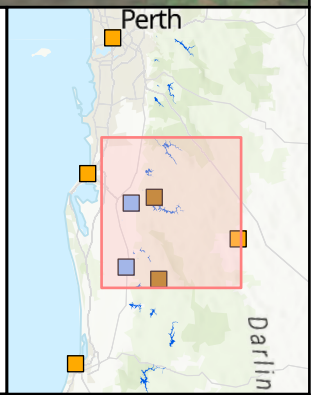
Place ID	Place Name	Location	Significance
3106	Dwellingup Hotel	9 Marrinup St, Dwellingup	Category A. Essential to the heritage of the locality. Rare or outstanding example. Dwellingup Hotel is a prominent building in the town, and a landmark for more than a century. Dwellingup Hotel has been a significant social centre for the town for a century. Dwellingup Hotel is one of the oldest buildings in Dwellingup, the majority of other places having been destroyed in the 1961 fire. Dwellingup Hotel is rare as a previously State-run hotel.
3107	Returned and Services League (RSL) Hall	39 McLarty St, Dwellingup	Category B. Very important to the heritage of the locality. RSL Hall is a typical timber and iron building of the type used as rural schools in the early 20th century and is still readable as such on the exterior. RSL Hall is one of the oldest buildings in Dwellingup. RSL Hall is associated with the provision of education to the children of timber workers.
9014	Marrinup Townsite (Ruins)	End of Grey Rd, Marrinup	Category B. Very important to the heritage of the locality. Marrinup Townsite (ruins) has significance as the historical site of a mill town, which were once central to the economy of the Dwellingup area.
9093	Precinct Dwellings	Newtown St, Dwellingup	No information
16759	Marginata Crescent Precinct, Dwellingup	Marginata Cres, Dwellingup	Category B. Very important to the heritage of the locality. The precinct is important as a rare, substantial, cohesive, and intact group of government-designed early twentieth century timber workers' cottages, which were relocated in 1964 to an area laid out according to the Garden City principles in the 1950s.
17635	Railway Line Precinct – Boddington to Dwellingup	Boddington to Dwellingup	Category C. Conservation of the place is highly desirable. The construction of the railway through Boddington prompted Boddington as the focal point for development, instead of Marradong and Hotham River.
23671	Boarding House (fmr)	Location Rd, Dwellingup	Category C. Contributes to the heritage of the locality. Boarding House (fmr) is associated with the timber industry around Dwellingup, including Bunnings and, more recently, the School of Wood. Boarding House (fmr) is a good representative example of a forestry cottage constructed for use as a Mill Manager's residence.
23846	St Mark's Church	20 Church St, Dwellingup	Category C. Contributes to the heritage of the locality. St Mark's Church is a simple weatherboard and iron building erected as a place of worship and which has some detailing, such as the porch and windows, which reveal its original intention. St Mark's Church is associated with the provision of places of worship in mill towns. St Mark's Church has social significance for those who have worshipped there.

Place ID	Place Name	Location	Significance
23854	Dwellingup Nursing Post	2510 Del Park Rd, Dwellingup	Category B. Very important to the heritage of the locality. Dwellingup Nursing Post is a typical weatherboard and iron building erected for health services and is a survivor the 1961 fire which destroyed the adjacent hospital. Dwellingup Nursing Post has been associated with the provision of medical services in the area from 1923 to the 1990s.
23864	CWA Hall, Dwellingup	23 Newton St, Dwellingup	Category D. Contributes to the heritage of the locality. Despite alterations, Country Women's Association Hall (CWA Hall), Dwellingup is a simple weatherboard and iron building, and still readable as the school it originally was. CWA Hall, Dwellingup has historic significance as the former Huntly School House, now converted to act as a CWA Hall.
23941	Phillipson's House	203 Holyoake Rd, Dwellingup	Category B. Very important to the heritage of the locality. Phillipson's House is a fine and intact example of a timber worker's cottage which retains an authentic façade to the street. Phillipson's House is a rare remaining residence from Holyoake.
23954	Holyoake Swimming Hole	Holyoake Rd, Dwellingup	Category D. Contributes to the heritage of the locality. Holyoake Swimming Hole has historic significance as a recreation site for the residents of the mill town.
23960	Dwellingup Mill	44 Banksiadale Rd, Dwellingup	Category C. Contributes to the heritage of the locality. Holyoake Swimming Hole has historic significance as a recreation site for the residents of the mill town.
24377	Marginata Crescent Heritage Area	Dwellingup	Category B. Very important to the heritage of the locality. Marginata Crescent Heritage Area has very high aesthetic value as a precinct of weatherboard cottages, all constructed in a similar era, although with different external appearances. Marginata Crescent Heritage Area is associated with the timber industry in the Dwellingup area and associated with the Dwellingup fire in 1961, as the residences were some of the few structures to survive following the event.



Legend

- Huntly Mine DE
- Willowdale Mine DE
- Reservoirs
- Alcoa European Heritage Sites
- Alcoa European Heritage Sites 10m Buffer
- Government European Heritage Sites
- Government European Heritage Sites 10m Buffer
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-61 European Heritage - Huntly and Willowdale Mine DEs

Kilometres

0 4 8 12 16 20 24

N

Scale: 1:320,000 at A4

Date Printed: 27/02/2025

Alcoa

5.6.4 Potential Environmental Impacts

The following Proposal activities have the potential to impact social surroundings (heritage):

- Clearing of native vegetation.
- Operations, mining, refining, and operational activities.
- Physical presence of infrastructure.
- Rehabilitation activities.

The Proposal activities may result in the following potential impacts to social surroundings (heritage):

- Disturbance (direct or indirect) to Aboriginal heritage sites and intangible cultural heritage.
- Disturbance (direct or indirect) to European heritage sites.

As discussed above, Aboriginal cultural values extend beyond tangible heritage sites and can included impacts to environment, damage to the health of waterways and restriction of access to country for cultural activities.

5.6.4.1 Disturbance to Aboriginal Heritage Sites and Cultural Values

There is the potential for direct and indirect impacts to archaeological and ethnographic Aboriginal heritage sites as a result of construction and operation within the Mine DEs. Direct impacts can occur to archaeological and ethnographic sites from physical disturbance such as earthworks and construction of structures.

Archaeological sites are physical remnants of past activities and can be subject to indirect impacts, such as stormwater runoff, erosion, and sediment from nearby construction areas.

Ethnographic sites have mythological or ceremonial value and may be affected by impacts specific to the site values, such as impacts to landscape character or to hydrological processes (in the case of rivers), along with indirect impacts to physical site elements (e.g., runoff, erosion and sedimentation).

Furthermore, there is the potential for impact to intangible cultural heritage such as the ability for GKB AC to continue to carry out cultural practices in areas that become restricted by mining activities.

5.6.4.2 Aboriginal Sites within the Mine DEs

Construction and mining may potentially impact the archaeological sites recorded within the Mine DEs. Impacts may occur through direct disturbance or indirect impacts if the sites lie downslope and close to clearing areas. The archaeological sites recorded within the Mine DEs are typically located close to waterways and are, therefore, unlikely to be directly impacted by mining given that mine pits will not be formed in streamzone vegetation. However, they may be directly impacted by infrastructure crossings and may be indirectly impacted by stormwater runoff or sediment discharges from mine pits or haul roads upslope.

The following DPLH Heritage Places and Alcoa Heritage Sites have been identified as being within 100 m of the Proposed Disturbance Footprint:

- Huntly – 177 individual Aboriginal cultural heritage sites consisting of artefact scatters, scarred trees and quarries;
- Huntly – five registered sites, one historic site, and fifty-four lodged places;
- Willowdale – two Heritage sites which are artefact scatters; and
- Willowdale – two Lodged Places which are artefact scatters.

All Aboriginal cultural heritage places identified will be avoided apart from waterways crossings and the installation of the turbidity monitors as detailed below.

The Proposed Disturbance Footprint intersects one registered Aboriginal cultural heritage site, the Serpentine River (DPLH 3582). The Serpentine River is listed on the AHIS as having a 'closed' status resulting in its boundary being dithered to a series of 1 km boxes. Previous ethnographic consultation undertaken by Alcoa with Gnaala Karla Booja Traditional Owners has identified that the ethnographic site boundary relates to a 100 m buffer around the Serpentine River. This 100 m buffer resulting from the ethnographic consultation has been incorporated into Alcoa's GIS and is used to inform mine planning.

Mining activities are located outside the ethnographic boundary for the Serpentine River; however, the Proposed Disturbance Footprint currently references the installation of water quality turbidity monitors within the Serpentine River. Alcoa has engaged with GKB AC and DPLH to ensure appropriate approvals are in place, wherever required, prior to the turbidity monitors being installed.

5.6.4.3 Aboriginal Heritage Sites outside the Mine DEs

Aboriginal heritage sites that lie outside the Mine DEs will not be subject to direct impacts from the Proposal. These may potentially be subject to indirect impacts if they occur close to and downslope of construction or mining.

Alcoa has in place a system of controls to prevent indirect impacts on areas outside of mine envelopes, including:

1. A system of standard buffers and exclusion zones around sensitive environmental zones (such as streamlines and granite outcrops) and cultural heritage places that control activities within close proximity to these places;
2. Drainage and sediment management structures on all haul roads and within mine pits ensure that cultural heritage places are not affected by surface water or uncontrolled sediment flows; and
3. Demarcation of work areas to prevent accidental entry into unapproved areas.

5.6.4.4 Aboriginal Cultural Values Associated with Physical or Biological Surroundings

'Inland waters' is a key component of Aboriginal cultural values, with Noongar life traditionally revolving around waterways and the associated food resources and social and aesthetic values (Section 5.5.3). Agriculture has resulted in widespread impacts to the water quality of waterways in the NJF subregion and SCP, including salinisation of the Murray River (Section 5.5.4.3.2.1). Water supply reservoirs along the Darling Scarp have disrupted aquatic fauna migration and substantially reduced flow in the Serpentine and

Dandalup Rivers downstream (Section 5.5.4.3.1.1). Climate change has resulted in a decline in river flows since the 1970s (see Section 5.2.4.10). The historic impact to hydrological regimes and water quality, as well as introduced aquatic fauna and weed invasion, is expected to have substantially impacted on the quality of aquatic and riparian ecosystems and the associated Aboriginal cultural values.

As summarised in Section 5.5.9, the Proposal is unlikely to cause significant residual impacts to Inland Waters, including hydrological regimes or water quality. As detailed in Section 5.5.9, the Proposal is expected to result in limited changes to stream salinity and freshwater conditions are expected to be maintained in major tributaries throughout the Mine DE. As detailed in Section 0, mine rehabilitation is expected to provide long-term protection of soils from erosion and associated sediment discharge to streams and reservoirs.

Alcoa implements preventative risk management involving multiple barriers to prevent and reduce hazards to drinking water reservoirs and has proposed additional barriers to further avoid and minimise hazards. Alcoa has operated in the NJF for over five decades including substantial operations within drinking water catchments. To date there has not been a substantial rise in salinity, a catastrophic sediment release or a catastrophic diesel spill from Alcoa's operations that has required remedial actions in a reservoir or for a reservoir to be taken off-line.

Regarding forest health, and the associated cultural value of natural resources, Alcoa has comprehensive controls in place to prevent the spread of *Phytophthora* dieback and weeds and controls both these and feral animals throughout its operations. As a result, further impacts to tangible and intangible Noongar cultural heritage values in the forest from these threats would be limited.

Access to country is another key component of Aboriginal cultural values, supporting Noongar spiritual and physical health and enabling transfer of Aboriginal cultural knowledge. Access to country has historically been restricted through agricultural, urban, and rural residential development of the NJF and SCP subregions, with Noongar people displaced or forcibly removed from their traditional lands. Access to country has been available within publicly accessible State Forest, National Parks and recreational reserves in the NJF and SCP subregions. The Huntly and Willowdale Mine DEs have restricted public access to State Forest as mine regions have been progressively opened, and pending closure and handback of mine regions to State Government.

As presented in Section 5.7.4, the Proposal will contribute to cumulative restrictions to public access to State Forest. The restriction to public access will continue until mine regions are sufficiently rehabilitated and the mine lease relinquished, at which point the areas will revert to State Forest. To partially address the restriction on access to the forest by Noongar people, Alcoa intends to enter into a formal access protocol with GKB AC. In addition, Alcoa is working to facilitate the involvement of Traditional Owners in cultural monitoring and environmental assessment activities across its current and future development areas. However, for operational safety reasons, some access restrictions will remain in place until rehabilitated land is handed back.

Noongar aspirations to reintroduce cultural burning practices to the forest are understood but this is beyond Alcoa's responsibility.

5.6.4.5 Disturbance to European Heritage Sites

European heritage sites comprise the physical remnants of the former timber industry near Jarrahdale and Dwellingup, the Serpentine Dam, as well as former POW camps. The sites are devoid of intact buildings or structures, however, there are other physical remains including the dam, footings, pits, logs, and other materials.

Direct impacts could occur to these heritage sites from physical disturbance such as earthworks and construction of structures. The heritage sites could also be subject to indirect impacts due to stormwater runoff, erosion, and sediment from nearby construction areas. Due to the lack of intact buildings or structures, the sites are not expected to be susceptible to dilapidation from vibration or dust.

5.6.4.5.1 Registered Places

The identified local European heritage sites are not within proximity to the Proposed Disturbance Footprint. The sites have been avoided and will not be impacted by the Proposed Disturbance Footprint.

5.6.4.5.2 Other European Sites

Additional European heritage surveys are underway with the Mine DEs and a management plan is being finalised, where required.

5.6.5 Mitigation

Alcoa is experienced in avoiding and managing impacts to social surroundings in the Huntly and Willowdale regions having operated mining in the region since 1976. Alcoa's environmental management of the mining and refining operations in the region incorporates the mitigation hierarchy consistent with Western Australian regulatory guidance, which is in order of priority:

1. Impact avoidance
2. Impact minimisation
3. Rehabilitation.

Alcoa avoids direct and indirect impacts to places of Aboriginal cultural heritage to the greatest extent practicable as a guiding principle, and historically has modified mine infrastructure and pits to exclude heritage places. To date, Alcoa has sought statutory approvals under the *Aboriginal Heritage Act 1972* to cross the various culturally important rivers that bisect its operations as these impacts are unavoidable. Alcoa is committed to consultation with GKB AC prior to lodging any Notices under Section 18 of the *Aboriginal Heritage Act 1972* to facilitate these crossings.

Alcoa has a program of additional ongoing consultation and engagement with GKB AC regarding cultural heritage matters to support the above approach. This includes ongoing heritage surveys for activities that may impact on waterways (whether Registered Aboriginal sites or not) and the engagement of cultural monitors for certain ground disturbing activities (not limited to instances where this is recommended in heritage survey reports). Further, Alcoa is developing a Cultural Heritage Management Framework in collaboration with GKB AC under which will sit CHMPs dealing with specific mine regions or heritage places, where required.

Mitigation measures associated with social surroundings (heritage) impacts are detailed in Table 5-81. As presented, the mitigation measures are typically established practice or best practice and have a high certainty of effectiveness. Mitigation measures with a moderate certainty of effectiveness relate to timing of survey requirements, avoidance of some heritage sites, development of best practice Aboriginal Cultural Heritage Management Plans (CHMPs), European Heritage Management Plans (EHMPs) and workforce inductions.

5.6.5.1 Protection of Key Values and Areas

In planning the Proposal, Alcoa has committed to the protection of key values and areas identified by environmental studies and stakeholder consultation. Alcoa has carefully considered the heritage values identified in the Mine DEs, including the Serpentine River mythological site, archaeological sites, and European heritage sites of local significance.

Alcoa undertook a comprehensive review of the identified heritage values against mining requirements to develop achievable Limited Disturbance Areas (LDAs) and mining avoidance zones (MAZ), which involved collaboration between mine planning, engineering, environment heritage, and communities teams. The LDZ and MAZ will protect key heritage values and areas.

Alcoa's impact avoidance framework includes additional protection measures to avoid key values and areas where practicable. This approach provides protection to environmental values that are not covered by LDAs and MAZs. While these measures cannot be mapped over specific avoidance zones, they are expected to provide a high level of protection to key environmental values in the Mine DE. The other avoidance measures include avoidance of registered and recorded Aboriginal heritage sites, as far as practicable. The following applies:

- For all heritage values to be protected "as far as practicable", where disturbance is proposed to occur to the values, Alcoa will investigate alternatives to avoid disturbance, such as alternative infrastructure routes or locations.
- Where avoidance of European heritage values is not practicable, Alcoa will document the findings and determine appropriate mitigation of impacts. If the places to be impacted are either entered on the relevant Register or have such significance that they could be registered, Alcoa will engage with the relevant stakeholders and statutory authority.
- Where direct impacts of known Aboriginal heritage sites cannot be avoided, Alcoa will consult with the relevant Traditional Owners through GKB AC prior to seeking Ministerial Consent under section 18 of the *Aboriginal Heritage Act 1972* or consent under Regulation 7 and 10 of the Aboriginal Heritage Regulations. Agreed mitigation actions will be documented in a Cultural Heritage Management Plan related to the activities to be approved or prepared specifically to support the approval application.

Table 5-81: Avoidance and Minimisation of Potential Impacts to Social Surroundings (Heritage)

Potential Impacts and Mitigations	Industry standard, best practice and certainty of effectiveness
Disturbance to Aboriginal Heritage sites and cultural values – the Mine DEs	
Prior to any ground disturbing activities, Alcoa provides an activity notice as per the Noongar Standard Heritage Agreement (NSHA). Where it is agreed that culture heritage surveys are required, Alcoa will undertake archaeological and ethnographic Aboriginal heritage surveys in consultation with nominated Aboriginal representations in accordance with the NSHA.	Best practice, moderate certainty
Avoid	
Heritage survey results will be used to inform mine planning and infrastructure design, where possible. Direct and indirect impacts will be avoided to the greatest extent practicable.	Best practice, moderate certainty
Provision of Mining Avoidance Zones (MAZs), whereby no clearing activities for mining or infrastructure will occur: • Registered Aboriginal heritage sites (buffered 10 m). • Aboriginal heritage sites identified during surveys (buffered 10 m)	Existing practice, high certainty
Avoid direct impacts to the Local Heritage Survey Places Serpentine Dam Place ID 4174 and Marrinup Prisoner of War Camp Place ID 3103.	Best practice, high certainty
Minimise	
Where direct impacts of known Aboriginal heritage sites cannot be avoided, Alcoa will seek the free, prior and informed consent of Traditional Owners, document that consent and any mitigating actions agreed with Traditional Owners and seek Ministerial Consent under section 18 of the *Aboriginal Heritage Act 1972*.	Best practice, high certainty
An Aboriginal Cultural Heritage Management Plan (CHMP) will be developed for the Mine DEs, to guide management of Aboriginal heritage during construction and operations. The CHMP will be developed collaboratively with Traditional Owners and their representative body, GKB AC.	Best practice, high certainty
Prior to any ground disturbing activities, Alcoa provides an activity notice as per the Noongar Standard Heritage Agreement (NSHA). Where it is agreed that culture heritage surveys are required, Alcoa will undertake archaeological and ethnographic Aboriginal heritage surveys in consultation with nominated Aboriginal representations in accordance with the NSHA	Existing practice, high certainty
In certain cases, targeted CHMPs will be developed where ground disturbing activities have the potential to impact significant cultural heritage.	Best practice, high certainty
CHMPs will include consideration of stormwater, erosion, and sediment management to prevent indirect impacts to Aboriginal heritage during construction and operations. Refer to stormwater, erosion, and sediment management in Inland Waters chapter (Section 5.5.8).	Best practice, high certainty
Aboriginal cultural heritage sites located with 100 m of proposed clearing boundaries will have site specific CHMPs developed which may include the following additional controls: • Detailed site identification level heritage assessments to confirm boundaries and establish appropriate buffer distances from development activities • Heritage demarcation such as fencing and signage • Work exclusion zones • Inclusion of heritage in applicable safety toolbox discussions and job hazard assessments • Heritage awareness inductions of personnel and contractors • GBK AC monitors present during agreed development activities	Best practice, high certainty
Heritage and Cultural Awareness – contractors and employees working at both Huntly and Willowdale mines will be provided with cultural and heritage awareness training to ensure that they are aware of heritage management requirements.	Best practice, moderate certainty
Disturbance to European heritage sites – Huntly Mine	
Avoid	
Other European heritage sites and features identified by Archae-Aus (2021), including shield trees recorded by DBCA within the Mine DEs, will be avoided where practicable.	Best practice, moderate certainty
Provision of Mining Avoidance Zones (MAZs), whereby no clearing activities for mining or infrastructure will occur: • European heritage sites (buffered 10 m).	Existing practice, high certainty
Minimise	
Where avoidance is not practicable to European heritage sites and features, and shield trees, disturbance will be managed in accordance with a European Heritage Management Plan (EHMP) developed collaboratively with key stakeholders.	Best practice plan to be prepared, moderate certainty
The EHMP will include stormwater, erosion, and sediment management to prevent indirect impacts to European heritage during construction and operations. Refer to stormwater, erosion, and sediment management in Inland Waters chapter (Section 5.5.8).	Best practice, high certainty

5.6.6 Assessment and Significance of Residual Impacts

The assessment of residual impact to Aboriginal heritage sites is pending the completion of further Aboriginal heritage surveys within the Mine DEs. Based on the findings of surveys and consultation, Alcoa will seek to implement avoidance, minimisation, and management measures (as outlined in Section 5.6.5) such that there are no significant residual impacts to Aboriginal heritage. Any disturbance to Aboriginal heritage sites will be in accordance with consent under Section 18 of the *AH Act*.

No State Heritage Register sites and no Local Heritage Survey Places will be subject to physical disturbance. Alcoa will implement impact avoidance and management measures to protect other European heritage sites and features within the Mine DE and no significant residual impacts to European heritage are likely to occur.

The Proposal is not expected to cause cumulative impacts to Aboriginal cultural values associated with Inland Waters.

The long-term restriction to public access and informal use over large areas of State Forest is expected to restrict access to country for Noongar people, causing an impact to associated Aboriginal cultural values. Alcoa will engage with Traditional Owners as part of the CHMP development for the Proposal to develop practicable arrangements for access to country that also meet statutory requirements for public safety in mine areas.

5.6.7 Environmental Outcomes

Table 5-82 presents proposed environmental outcomes with respect to social surroundings (heritage). The proposed environmental outcomes:

- Reflect specific and measurable environmental states
- Have a clear boundary, size, extent, or limit
- Are consistent with the EPA's objective to protect social surroundings from significant harm.

Table 5-82 identifies where another statutory decision-making process can mitigate the potential environmental impacts of the Proposal on the environment to be consistent with the EPA's factor objective. As presented, management under the *AH Act* is expected to regulate outcomes relating to Aboriginal heritage.

Table 5-82: Proposed environmental outcomes – social surroundings (heritage)

Potential environmental impact	Environmental outcome	Other statutory approval that will assure outcome	Monitoring of outcomes
Disturbance to Aboriginal Heritage sites and cultural values	Aboriginal cultural heritage sites maintained in accordance with the consent and recommendations of Traditional Owners.	Section 18 consent under *AH Act*	Section 18 consent under *AH Act*
	Ensure all Aboriginal heritage for all areas proposed to be cleared or indirectly impacted by		

Potential environmental impact	Environmental outcome	Other statutory approval that will assure outcome	Monitoring of outcomes
	the proposal are identified in consultation with the GKB AC.		
Disturbance to European heritage sites	No direct impacts (excluding monitoring and management activities) in defined Mining Avoidance Zones	Assessment and approval of the MMP and subsequent FCAs include consultation with key regulatory agencies.	Annual reporting of clearing extent
	No direct impact to DPLH mapped Local Heritage Survey Places		

5.7 Key Environmental Factor – Social Surroundings (Amenity)

This section aims to address Tasks 24–27 as outlined in the ESD, focusing on Social Surroundings (Amenity) within the Huntly and Willowdale 2022 to 2026 and 2023 to 2027 assessment areas with an emphasis on:

- Characterising and describing the key significant amenity values, including visual/aesthetic and social/intrinsic and natural or historical heritage values within and adjacent to the Proposal areas and any sensitive receptors that may be significantly impacted as a result of the Proposal;
- Clarify the potential impacts (direct and indirect) as a result of construction and operational elements of the Proposal on important key significant amenity values;
- Describing how significant impacts to the identified significant amenity key values from the modification of physical and biological surroundings will be avoided and/or mitigated consistent with recognised methodologies and guidance and determine consultation and mitigation for those values; and
- Describing and justifying measures to avoid, mitigate, and manage significant impacts to nearby sensitive receptors from potential noise, light, dust, and odour emissions and detail the likely environmental outcomes.

5.7.1 EPA Objective

The EPA's environmental objective of the Key Environmental Factor 'Social Surroundings' is:

"To protect social surroundings from significant harm".

For the purposes of EIA, the EPA (2023a) defines social surroundings as it is presented in the EP Act: "*In the case of humans, the reference to social surroundings in the definition of environment … is a reference to aesthetic, cultural, economic and other social surroundings to the extent to which they directly affect or are affected by physical or biological surroundings*".

5.7.2 Relevant Policy and Guidance

5.7.2.1 EPA Policy and Guidance

- Environmental Factor Guideline – Social Surroundings (EPA, 2023a);
- Instructions on how to prepare an Environmental Review Document (EPA, 2024c);
- Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans (EPA, 2024b);
- Guidance for the Assessment of Environmental Factors (in accordance with the Environmental Protection Act 1986): Separation Distances between Industrial and Sensitive Land Uses (EPA, 2005); and
- Environmental Protection (Kwinana) (Atmospheric Waste) Policy 1999 (EPA, 1999).

5.7.2.2 Other Policy and Guidance

- Environmental Protection (Noise) Regulations 1997 (GoWA, 2024a);
- Visual Landscape Planning in Western Australia: A manual for evaluation, assessment, siting and design (Western Australian Planning Commission, 2007);
- Guidelines for Landscape and Visual Impact Assessment, 3rd Edition (Landscape Institute and Institute of Environmental Management & Assessment, 2013);
- National Environment Protection (Ambient Air Quality) Measure 1998 (NEPC, 2021); and
- Statutory Guidelines for Mine Closure Plans (DMIRS, 2023).

5.7.3 Receiving Environment

5.7.3.1 Baseline Studies

Alcoa has completed several social surroundings studies related to amenity (Table 5-83). These include assessment of visual impacts, noise and dust. All studies have been undertaken in accordance with recognised guidance material applicable to the subject matter within WA, or other states and territories where guidance is insufficient in WA.

Table 5-83: Baseline Studies for Social Surroundings (Amenity)

Study name	Relevant Proposal components	Appendix
Landscape and Visual Amenity		
Landscape and Visual Impact Assessment Huntly Mine – Myara Mine Region (GHD, 2025a)	Predicted visual impact for Myara mine area (northwest portion of Huntly Mine DE).	Appendix 58
Landscape and Visual Impact Assessment Willowdale Mine, Larego Mine Region (GHD, 2025e)	Predicted visual impact for Willowdale Mine DE.	Appendix 59
Holyoake Mine Development – O'Neil East Landscape and Visual Impact Assessment (GHD, 2023c)	Predicted visual impact for O'Neil East mine area (northeast portion of Huntly Mine DE).	Appendix 60
Alcoa Holyoake Environmental Assessment – Landscape and Visual Impact Assessment – Holyoake East (GHD, 2023d)	Contextual information only.	-

Study name	Relevant Proposal components	Appendix
Noise		
O'Neil Mine Noise Impact Assessment (GHD, 2024f)	Predicted noise generation for the O'Neil mine area (eastern portion of Huntly Mine DE).	Appendix 61
Willowdale Mine Larego Region Noise Impact Assessment (GHD, 2024g)	Predicted noise generation for the Larego mine area (exceeds Willowdale Mine DE).	Appendix 62
Myara Mine Region Noise Impact Assessment (GHD, 2024h)	Predicted noise generation for the Myara mine area (northwest portion of Huntly Mine DE).	Appendix 63
Alcoa Holyoake Environmental Assessments O'Neil Baseline Noise Monitoring (GHD, 2024i)	Baseline Noise levels for O'Neil mining area (northeast portion of Huntly Mine DE).	Appendix 64
Pinjarra Alumina Refinery Revised Proposal – Noise Assessment for Huntly Mine (Myara North and Holyoake) (Wood, 2023)	Establishes baseline noise levels for Huntly Mine DE by using common noise sensitive receptions from Myara North min area.	Appendix 65
Dust and Air Emissions		
Alcoa O'Neil Region Air Quality Impact Assessment (GHD, 2024j)	Predicted dust generation for the O'Neil mine area (eastern portion of Huntly Mine DE).	Appendix 66
Myara Mine Region Air Quality Impact Assessment (GHD, 2025k)	Predicted dust generation for the Myara mine area (northwest portion of Huntly Mine DE).	Appendix 64
Larego Mine Region Air Quality Impact Assessment (GHD, 2025l)	Predicted dust generation for the Larego mine area (exceeds Willowdale Mine DE).	Appendix 68

No formal assessments have been undertaken to identify potential economic, light, odour, or traffic social impacts relating to the Proposal. Potential impacts derived from these factors are considered negligible and consistent with existing operations and activities, and therefore existing site knowledge and social amenity interactions have been considered.

5.7.3.2 Knowledge and Survey Gaps

Social impact assessments have been completed which cover the Proposal, however it is acknowledged that the noise modelling (GHD, 2024g and GHD, 2024h) may include some underestimation of noise emission levels and parameters. The noise models are under refinement and Section 5.7.5 has further information on Mining Sensitivity Zones and the associated criteria and recommended buffers to detail how mitigations will ensure acceptable impacts are achieved.

The Pinjarra Alumina Refinery Revised Proposal (Assessment 2253) addresses additional Social Impacts (Amenity) within Section 12. While Assessment 2253 covers different clearing areas than this Proposal and does not include Willowdale, the cumulative impact information for surrounding mines is considered relevant and should be considered. Given the timeframe of this Proposal, the information from Assessment 2253 has been reviewed and extrapolated to address knowledge and survey gaps within the current Proposal.

5.7.3.3 Aesthetic, Social, and Economic Surroundings

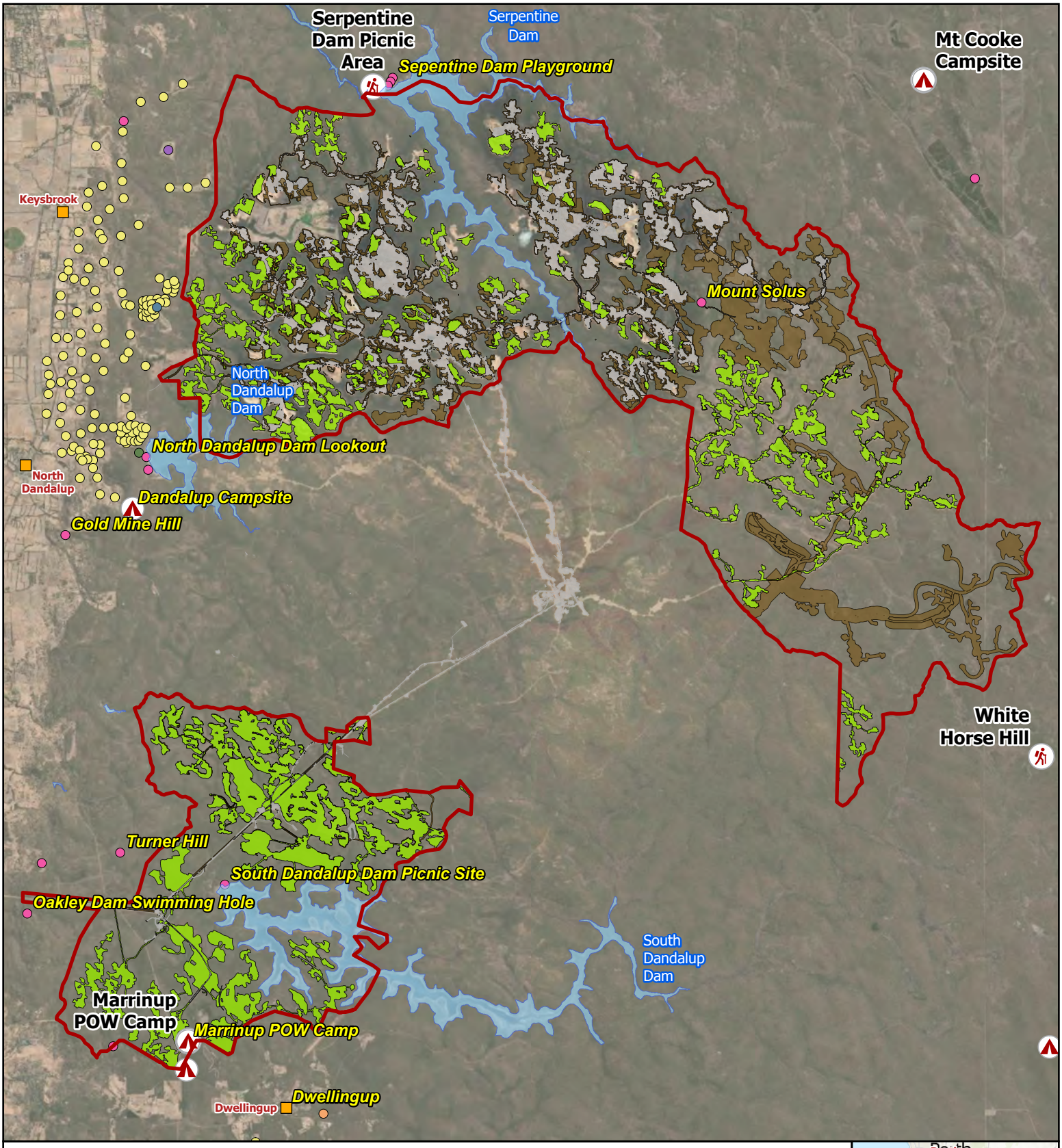
The aesthetic, social, and economic surroundings relate to the land use and landscape values of the Proposal. The land use in this area is predominantly associated with recreational and conservation values of the NJF, incorporating the Serpentine National Park, Dwellingup, Jarrahdale, and Marrinup State Forests and Lane Poole Reserve. The Huntly Mine DE encompasses Serpentine (including Serpentine Pipehead), North Dandalup, and South Dandalup Dams. Each of these dams provides vital storage capacity for Perth's drinking water supply. While the Larego Mine region, not included in this Proposal, encompasses the Logue Brook Dam the Willowdale Mine DE (particularly the Tasman region) is located ~9.5 km east of the Logue Brook Dam. The natural surroundings support ecotourism in the region with several trails and campgrounds housed within NJF and in close proximity to the Mine DEs.

The closest towns to the area lie to the western sides of the Mine DEs. Huntly is bounded to the north-west by Jarrahdale and Serpentine, west by Pinjarra and to the south by Dwellingup, noting a number of smaller towns and rural properties lie between each. The Willowdale Mine DE is much smaller and more centralised within the forest area. The closest town is Waroona, situated to the north-west approximately 13 km away. These towns lie within the Shires of Serpentine Jarrahdale (population 32,173 in 2021), Murray (population 18,068 in 2021) and Waroona (4,234 in 2021) (Australian Bureau of Statistics, 2021) which share future visions of balancing sustainable growth and diverse opportunities with the natural beauty and distinctive lifestyle offered by these locations. Much of this area was established to support the historic timber industry. The forested surrounds of the towns create a distinctive character from that of other towns in the NJF that have more rural or industrial development (e.g., Boddington to the east and Collie to the south). The land uses surrounding the Huntly and Willowdale Mine DEs are shown in Figure 1-6 and Figure 1-7 respectively.

The forested land within and surrounding the Mine DEs have been subject to past timber harvesting with small pockets of old growth forest remaining. Large-scale commercial timber harvesting ceased on 1 January 2024 under the 2024-2033 FMP and WA Labour Government commitments, with logging of native forests limited to maintenance of forest health and areas approved for mining clearing (EPA, 2023g).

The townsites, surrounding rural properties and network of recreational trails and facilities represent receptors sensitive to potential amenity impacts associated with the Mine DEs. Receptors associated with night-time occupation, including residences and recreational campsites, have a higher sensitivity particularly with respect to noise levels. Sensitive receptors for the Huntly and Willowdale mines are shown in Figure 5-62 and Figure 5-63 respectively.

The extensive forested landscape, diverse recreation and tourism offerings and historic timber industry contribute to the sense of place for residents and visitors. Distinctive landscapes and formal recreational trails and facilities entwine with 'off the beaten track' experiences of informal trails in the wider State Forest. It is expected that the sense of place will vary depending on individuals, with some residents seeking the peace and quiet of a forested setting and others encouraging visitors and a degree of economic and social activity.

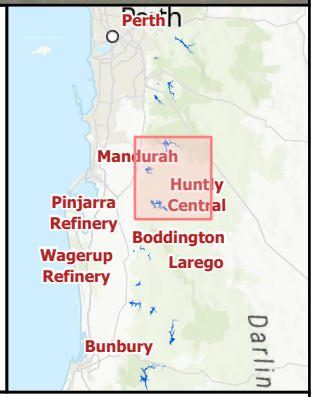


Legend

- Huntly Mine DE
- Reservoirs
- Recreational Sites
- Open Areas
- Campsites
- Proposed Disturbance Footprint
- Rehabilitation Footprint

Places

- City/Town



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-62 Huntly Mine DE - Sensitive Receptors

Kilometres

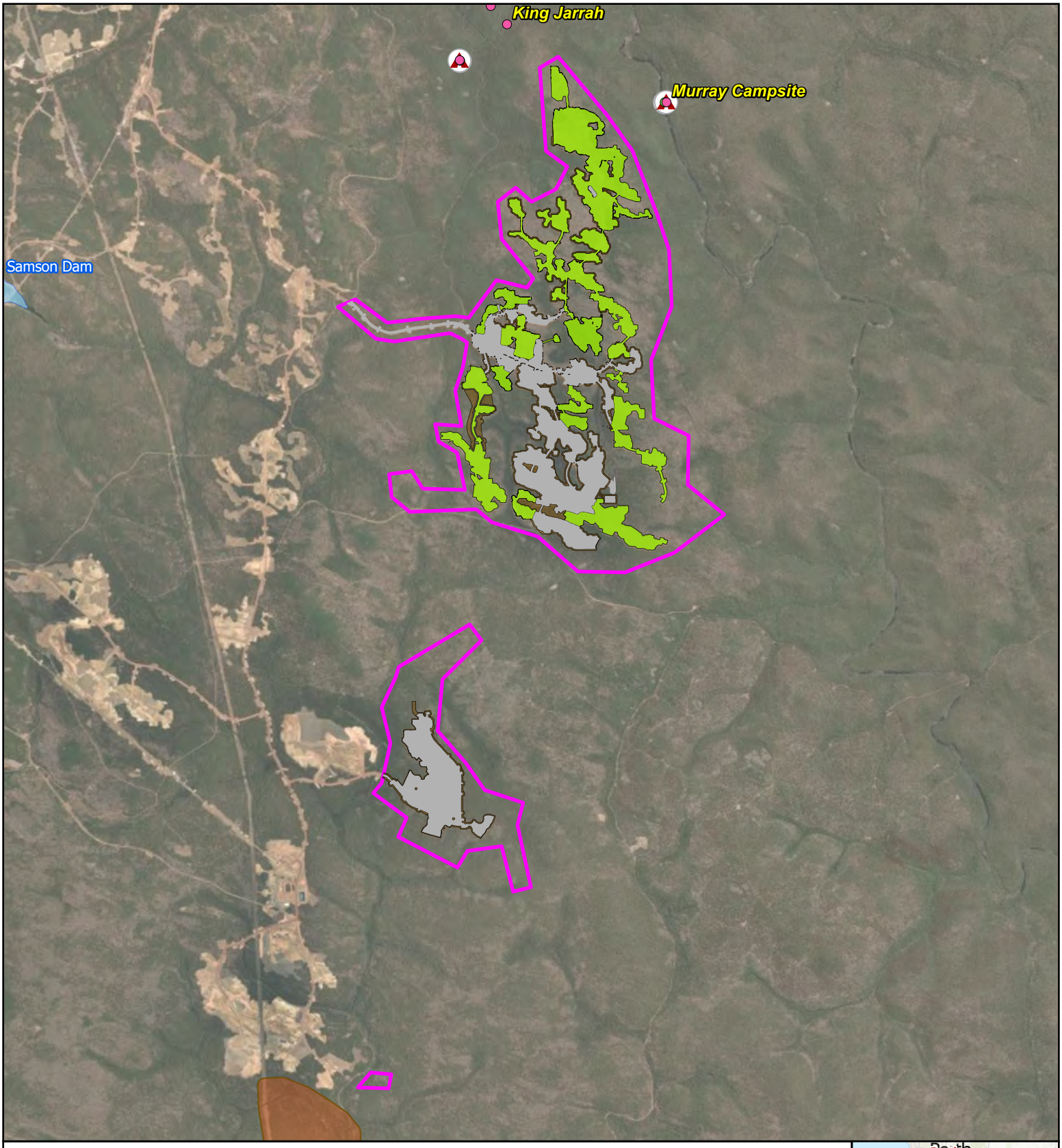
0 2 4 6 8 10 12

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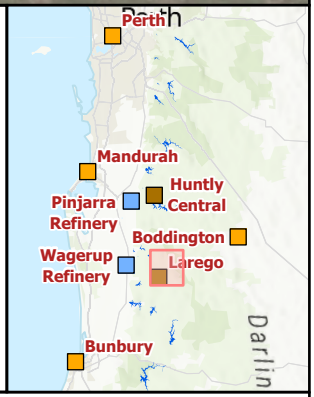
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Legend

- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Willowdale Mine DE
- Hoffman Mill MAZ
- Sensitive Receptors
  - Campsite
  - Recreation
- Reservoirs
- Campsites



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-63 Willowdale Mine DE - Sensitive Receptors

Kilometres

0 0.8 1.6 2.4 3.2 4 4.8

Scale: 1:75,060 at A4

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5.7.3.4 State Listed Heritage Places

Aboriginal Cultural and European heritage is discussed in Section 5.6 and potential direct and indirect impacts namely associated with physical disturbance and site access are identified and assessed. Potential impacts to heritage may also arise from noise, dust, light and odour that alter the feeling or sense of place associated with a site.

The Mine DEs encompass a number of Aboriginal artefact scatters, but only intersects five Registered Aboriginal Cultural Heritage sites associated with the rivers and brooks of the Huntly Mine DE (Serpentine River, Dandalup River, and Kronin Brook). These sites are protected by RPZ and established buffers and therefore impacts to the heritage value of the area is considered unlikely due to the distance from mine activity. Under worse case operational conditions, amenity values may be impacted by operational noise and dust (see Sections 5.7.4.1.2 and 5.7.4.2).

There are 14 state heritage listed places included on the WA Heritage Council State Register within 10 km of the Mine DEs. Most of these sites are located within Pinjarra or Serpentine. The Marrinup Prisoner of War Camp (place number 3103) is the only State Register European heritage place within the Mine DEs, specifically the southern Huntly Mine DE in the Del Park mine region. The site sits adjacent to rehabilitation with impacts considered unlikely.

5.7.3.5 Water Supply and Recreational Dams

Four water supply dams are intersected by the Huntly Mine DE, the Serpentine Dam (including Serpentine Pipehead Dam) and North and South Dandalup Dams. Each dam hosts a number of recreational facilities including walking trails and picnic areas, but more importantly forms part of Perth's drinking water supply scheme (Water Corporation, 2024).

Logue Brook Dam, considered a significant recreational area is located within the Larego Mine region (not included in this Proposal), is situated ~9.5 km east of the Willowdale Mine DE (particularly the Tasman region). The dam is within the Landscape Character Units (LCU1) and is consider of high scenic quality (GHD, 2025e). Logue Brook Dam is noted for its recreational opportunities, including swimming, fishing, and water sports, alongside bushwalking and mountain biking trails that traverse the surrounding jarrah forests.

Collectively, these dams contribute to the region's biodiversity and provide valuable outdoor experiences that attract both locals and tourists. The natural surroundings support ecotourism in the region with several trails and campgrounds housed within NJF and in close proximity to the Mine DEs. The Serpentine Dam, North Dandalup Dam, South Dandalup Dam, and Logue Brook Dam are significant not only for their ecological and recreational value but for their water supply functions.

The catchment areas for these dams (and other dams in the area, apart from Logue Brook Dam) are considered priority one protection areas under the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909*. The dams and priority one catchment areas as they relate the Mine DEs are provided in Table 5-84. Water Corporation have licences to take a combined 32.9 giga litres (GL) per annum from North and South Dandalup Dams and 53.8 GL per annum from Serpentine Dam for drinking water supply. The volume abstracted annually is considerably less than the allocation and is largely dependent on dam levels.

Table 5-84: Priority 1 Protected Catchment Areas and Corresponding Dams Areas of Intersection with the Mine DEs

Dam	Total P1 Catchment Area (ha)	Huntly Mine DE	Willowdale Mine DE
Conjurunup (6.47 ha)	3,921.7	Dam outside of DE. Catchment Area: 1,581.7 ha (40.3%)	-
North Dandalup (505.01 ha)	15,141.1	Dam: 105.2 ha (20.8%) Catchment Area: 2,830.9 ha (18.7%)	-
Samson Brook (55.58 ha)	7,451.7	-	Dam outside of DE (4.6 km west). Catchment Area: 28.0 ha (50.3%)
Serpentine and Pipehead (1,033.38 ha)	69,042.2	Dam: 652.3 ha (63. %) Catchment Area: 23,687.1 ha (34.3%)	-
South Dandalup and Pipehead (547.39 ha)	34,659.0	Dam: 419.8 ha (76.7%) Catchment Area: 5,871.8 ha (16.9%)	-
Stirling (387.81 ha)	25,366.6	-	Dam outside of DE (10.7 km south). Catchment Area: 398.7 ha (1.6%)

5.7.3.6 Recreational Trails and Facilities

State and local governments have identified the values and priorities relating to the recreational trails and facilities in WA, producing the WA Strategic Trails Blueprint 2022-2027 (Trails Reference Group, 2022) which classifies recreational assets to prioritise investment for the purposes of economic and social development. The Peel Regional Trails Strategy 2019 (PRTS) establishes both Jarrahdale and Dwellingup as Trail Towns, with Waroona also being identified as part of the Trails Network (Common Grounds Trails Pty Ltd, 2019). Each strategy recognises the significance of the Munda Biddi Trail and Bibbulmun Track, as well as other priority trials in the region, identifying economic development opportunities and investment strategies including tourism (visitor centre, major accommodation facility, glamping and adventure tourism).

Table 5-85 identifies the recreational trails, tracks and facilities within 10 km of the Mine DEs, with each shown in Figure 5-64 and Figure 5-65. The trails and facilities are assigned a state, regional or local significance in accordance with the WA Strategic Trails Blueprint and PRTS. Key recreational features are discussed further below:

- Bibbulmun Track – the Bibbulmun Track is a long-distance bushwalking trail stretching from the Kalamunda hills to Albany. The trail experience is focused on the natural landscape, nature interpretation, camping, health and fitness. Campsites are located approximately a day's walk apart and have varying usage. Bibbulmun Track attracts on average 5,352 visitors a year, with the various campsites being used by between 450 and 1,350 visitors on average (Outdoors Great Southern, 2021).
- Munda Biddi Trail – The Munda Biddi Trail is a nature-based, off-road mountain biking track stretching from Mundaring to Albany. The trail experience focuses on mountain

biking, exercise and fitness, the natural landscape and changing terrain. The trail is estimated to attract on average 1,558 visitors per annum (Outdoors Great Southern, 2021).

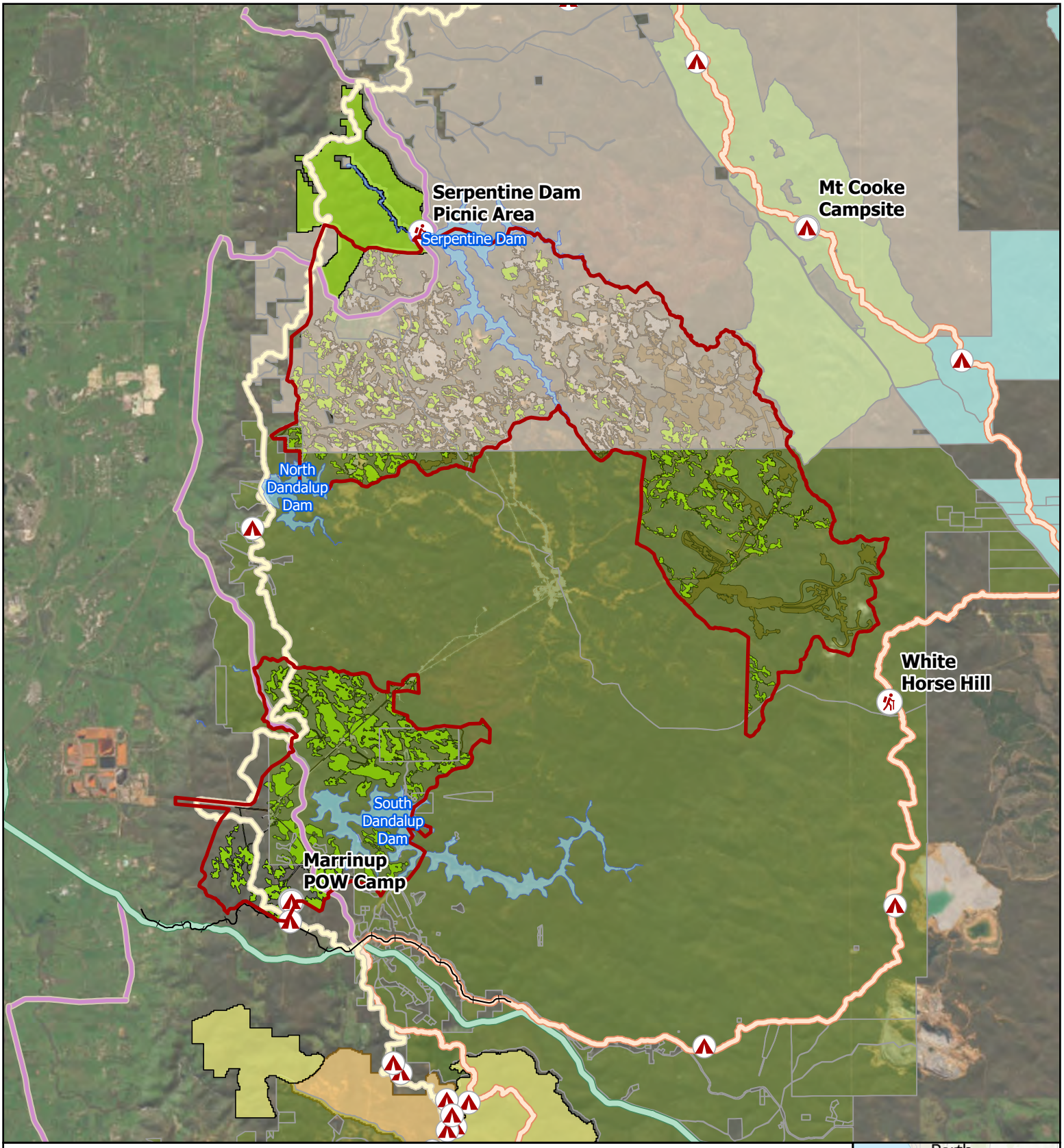
- Serpentine National Park – Serpentine National Park is situated over the Serpentine River valley as it cuts through the Darling Scarp, with scenic features including waterfalls and steep valley landforms. The National Park lies between Jarrahdale and Serpentine Dam to the east and the predominantly cleared Swan Coastal Plain to the west. The National Park is a day use recreational area with picnic areas, toilets and walk trails including connection to Jarrahdale townsite. The Serpentine Dam lies in the eastern portion of the National Park and has recreational facilities including picnic areas and toilets.
- Lane Poole Reserve – Lane Poole Reserve is situated over the Murray River valley, the only unregulated river in the NJF. The Reserve is the largest in the NJF, running approximately south-east to north-west along the river valley. The Reserve is managed for recreation and conservation and includes several campsites and trails around the former Nanga townsite at the Murray River. The Reserve is traversed by both the Bibbulmun Track and Munda Biddi Trail.

Table 5-85: Recreational assets identified within 10 km of the Mine DEs

Trial / Site ID	Assets	Values (recreational, community, scientific)	Proximity to Huntly Mine DE (bolds denotes section of asset within DE)	Proximity to Willowdale Mine DE (bolds denotes section of asset within DE)
State Significance				
S1	Munda Biddi Trail	Very high priority in PRTS Jarrahdale destination economic development Consultation – important to Jarrahdale ecotourism Mounting biking, camping Portions within Forest Disease Risk Area (FDRA)	18.8 km within DE 93.0 km within 10km	0.03 km within DE 64.5 km within 10km
S2	Bibbulmun Track	Very high priority in PRTS Dwellingup destination economic development Consultation – important to Jarrahdale, Dwellingup and WA ecotourism Bushwalking, connected to campsites Portions within FDRA	0.7 km from DE 90.3 km within 10km	0.7 km from DE 44.5 km within 10km
BT3	Mt Cooke campsite	Monadnocks Conservation Park Within FDRA	5.9km NE of DE	-
BT6	White Horse Hills campsite	State Forest Within FDRA	3.0km SE of DE	-
	Murray Campsite	Along Bibbulmun Track State Forest Within FDRA	-	0.7 km E of DE
Regional Significance				
	Serpentine National Park	Day use	364.7 ha within DE 4,285.8 ha within 10 km	-
	Lane Poole Reserve	Regional significance Consultation – important to Dwellingup ecotourism	4.4 km S of DE 2,805.7 ha within 10 km	407.0 ha within DE 14,768.7 ha within 10 km

Trial / Site ID	Assets	Values (recreational, community, scientific)	Proximity to Huntly Mine DE (bolds denotes section of asset within DE)	Proximity to Willowdale Mine DE (bolds denotes section of asset within DE)
R12	Jarrahland Wildflower Trail Scenic Drive – Kingsbury Drive	Very high priority in PRTS Tourism input to Jarrahdale 2WD	10.6 km within DE 25.2 km within 10 km	-
RS2	Serpentine Dam recreational area	Used by visitors to Jarrahland Wildflower Trail Scenic Drive and the broader area Picnic areas, toilets, lookout, café, day visits	0.3 km N of DE	-
L01	Serpentine Dam Walk	Bushwalking trail used by visitors to Jarrahland Wildflower Drive	1.1 km within DE	-
R15	Jarrahland Wildflower Trail Scenic Drive – Del Park Road	Very high priority in PRTS Tourism input to Dwellingup 2WD	10.3 km within DE 25.1 km within 10 km	-
R20	Hotham Valley Tourist Railway	Associated with Etmilyn Forest Trail. High priority in PRTS Consultation – important to Dwellingup ecotourism	0.04 km S of DE 31.3 km within 10 km	-
R22	Hotham Way Drive Trail	Very high priority in PRTS 2WD – Pinjarra-Williams Road	0.8 km S of DE 33.5 km within 10 km	-
	Bob's Crossing rest area	Campground and rest area within NJF	9.6 km S of DE	9.8 km N of DE
	Island Pool rest area	Campground and rest area within NJF	-	7.5 km N of DE
Local Significance				
LS1	Italian POW Camp	Low priority in PRTS Consultation – important to Jarrahdale history, community and ecotourism Bushwalking Day visit area	4.2 km N of DE	-
	Waterous Scout Campsite	Campground within NJF	-	9.9 km W of DE

Trial / Site ID	Assets	Values (recreational, community, scientific)	Proximity to Huntly Mine DE (bolds denotes section of asset within DE)	Proximity to Willowdale Mine DE (bolds denotes section of asset within DE)
	Bidjar Ngoulin Campsite	Campground within NJF	-	1.3 km W of DE
	Nanga Townsite	Campground within NJF	-	6.8 km N of DE
	Nanga Mill Campground	Campground within NJF	-	6.9 km N of DE
	Stringers Campground	Campground within NJF	-	6.4 km N of DE
	Dookanelly Campsite	Campground within NJF	-	9.2 km E of DE
	Chuditch Campground	Campground within NJF	-	9.0 km N of DE
	Charlies Flat Campground	Campground within NJF	-	8.4 km N of DE

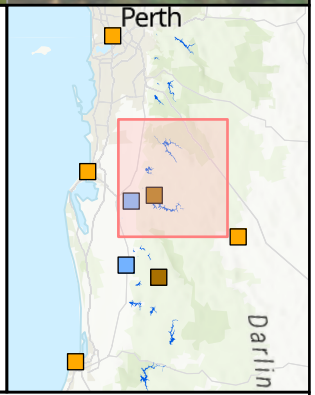


Legend

- Huntly Mine DE
- Reservoirs
- Campsites
- Recreational Sites
- Hotham Valley Tourist Railway
- Munda Biddi Trail
- Bibbulmun Track
- Hotham Way Drive Trail
- Jarrahland Wildflower Trail
- Lane Poole Conservation Reserve
- Serpentine National park

Reserve Name

- Dwellingup State Forest
- Jarrahdale State Forest
- Monadnocks Conservation Park
- Youraling State Forest
- Lane Poole Recreation Reserve
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-64 Huntly Mine DE - Recreational Trails and Facilities

Kilometres

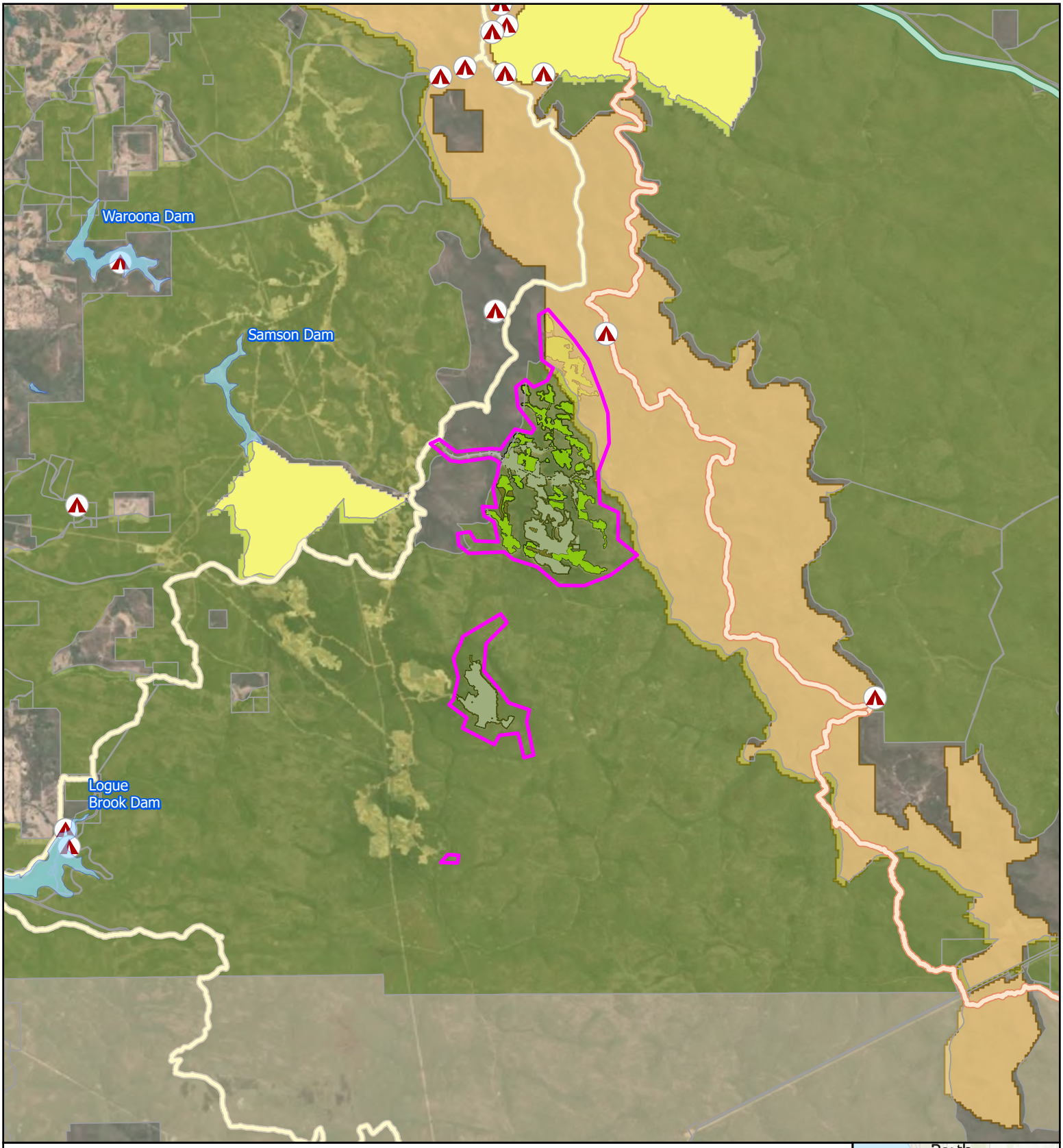
0 3 6 9 12 15 18

Scale: 1:250,000 at A4

Date Printed: 26/02/2025

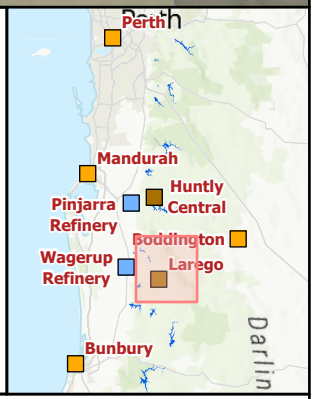
N

Alcoa



Legend

- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Campsites
- Munda Biddi Trail
- Bibbulmun Track
- Hotham Way Drive Trail
- Reserve Name
- Dwellingup State Forest
- Harris River State Forest
- Lane Poole Recreation Reserve
- Lane Poole Conservation Reserve
- Reservoirs
- Willowdale Mine DE



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-65 Willowdale Mine DE - Recreational Trails and Facilities

Kilometres

0 1.5 3 4.5 6 7.5 9

Scale: 1:140,000 at A4

Date Printed: 26/02/2025

N

Alcoa

5.7.3.7 Transport Routes

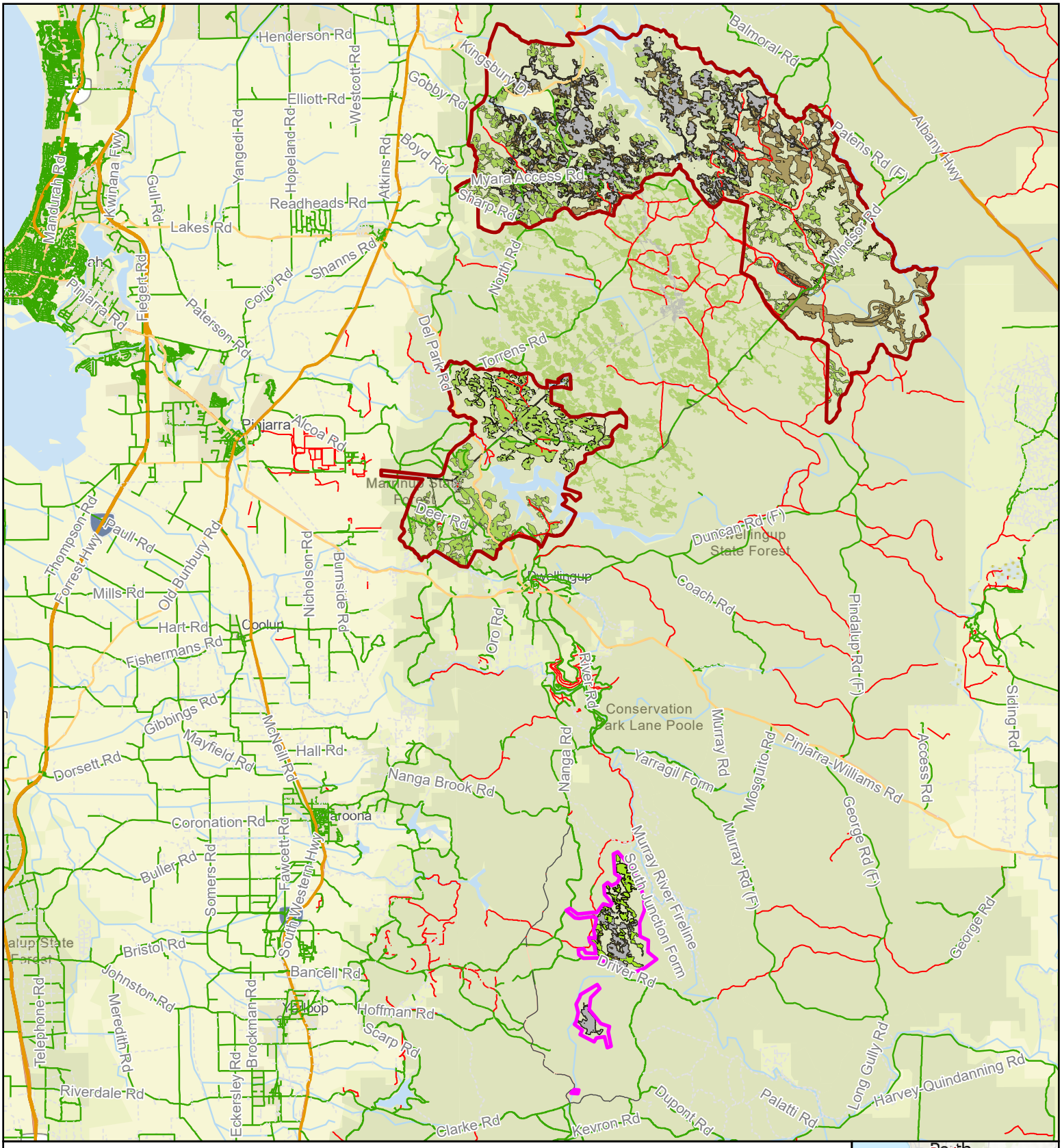
The NJF in the vicinity of the Mine DEs is permeated by a network of main roads and local roads, as presented in Figure 5-66. The network of public roads provides access for recreation by residents and tourists alike, as well as tourists passing by to other destinations (e.g., Albany). The NJF comprises large areas of State Forest and reserves that have limited public road access, most of which are unsealed gravel roads; however, there is an extensive network of forest access tracks in varying condition. Forest access tracks are primarily used by DBCA for forest management including infrequent timber harvesting, prescribed burns and fire response, as well as by apiarists.

Main roads and highways in the vicinity of the Huntly Mine DE include:

- Albany Highway (approximately 4 km east of Huntly Mine DE) – Major transport route between the Perth metropolitan region and the south coast of Western Australia. Between Jarrahdale Road and North Bannister, the highway conveys on average 3,532 vehicles per weekday of which approximately 19% are heavy vehicles (MainRoads, 2024).
- South Western Highway (approximately 3.4 km west of Huntly Mine DE) – Major transport route connecting Armadale, Bunbury and Walpole. On average 2,905 vehicles per day utilise the highway Monday to Friday, of which 16.6% are heavy vehicles (MainRoads, 2024).
- Kingsbury Drive – Main road creating a loop between South Western Highway and Jarrahdale Road, alongside Serpentine Dam. The road traverses the northern section of Huntly Mine DE with approximately 10.6 km included within. The road forms part of the Jarrahland Wildflower Trail Scenic Drive (an approximate 740 km loop from Perth along public roads and towns of the South-West Region).
- Del Park Road – Main road connecting North Dandalup and Dwellingup traversing the centre (north to south) of the southern Huntly Mine DE. Approximately 10.3 km of the road is included. The road forms part of the Jarrahland Wildflower Trail Scenic Drive.

There are no main roads and few minor roads that intersect or are within close proximity to Willowdale Mine DE.

No railway lines intersect either the Huntly Mine DE or the Willowdale Mine DE. The southern edge of the Huntly Mine DE follows the Pinjarra Dwellingup Railway which is operated by steam and diesel locomotives as part of the Hotham Tourism Railway experience.

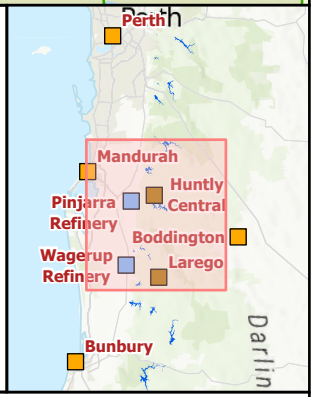


Legend

- Huntly Mine DE
- Willowdale Mine DE

Public Roads

- Freeways & Highways
- Main Roads
- Minor Roads
- Other
- Unsealed | All Weather Access: N
- Unsealed | All Weather Access: Y
- Proposed Disturbance Footprint
- Previous Rehabilitation Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-66 Huntly and Willowdale Region Transport Routes

Kilometres

0 4 8 12 16 20 24

Scale: 1:320,000 at A4

Date Printed: 26/02/2025

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Alcoa

5.7.3.8 Landscape and Visual Amenity

The Darling Plateau contains multiple sensitive receptors of varying levels of significance due to the valued natural setting and the quality seen throughout the surrounding forest and landscape. These receptors include residents, track and trail users, recreational users, campers, tourists, and road users. The existence of these receptors raises concerns regarding the potential visual impact on the area generally, and on nearby communities, private properties, State Forest, tracks, trails, campsites, and roads. Sensitive visual amenity receptors and their level of significance are identified in Table 5-86.

Table 5-86 Sensitive visual receptors and level of significance – the Mine DEs (GHD, 2025a; 2023c; 2023d)

Sensitive receptor	Level of significance
Visitors to Monadnocks Conservation Park, Jarrahdale State Forest, Dwellingup State Forest, Harris River State Forest, Youralling State Forest and Serpentine National Park.	Level 1: national / state significance
Users of Bibbulmun Track and Mundi Biddi Trail.	Level 1: national / state significance
Road users of scenic and tourist drives along Albany and South West Highway.	Level 1: national / state significance
Visitors to Serpentine Dam, North Dandalup Dam and South Dandalup Dam.	Level 2: regional significance
Visitors to regional ecotourism, recreation, art, food, wine and similar venues.	Level 2: regional significance
The Hotham Valley Tourist Railway.	Level 2: regional significance
Kingsbury Drive and Jarrahdale Road users.	Level 2: regional significance
Jarrahdale and Dwellingup townsites and rural residential areas.	Level 3: local significance
Local road users.	Level 3: local significance
Users of local tracks and trails around Jarrahdale, Serpentine Dam and North Dandalup Dam including, but not limited to, Jarrahdale to Balmoral, Prisoner of War Camp, Mundlinup Trail, Baldwin Bluff Trail, Serpentine Dam Walk, North Dandalup Circuit and North Dandalup Dam via Jarrahdale Railway Trail.	Level 3: local significance

Three Landscape and Visual Impact Assessments (LVIA) have been undertaken for areas directly relating to the Huntly Mine DE (Table 5-83). The O'Neil East LVIA (GHD, 2023c) applies to the eastern extent of the northern Huntly Mine DE and the Myara LVIA (GHD, 2025a) applies to the western extent of the northern Huntly Mine DE. Each LVIA was undertaken using a combination of desktop reviews and site inspections completed by two landscape architects in August 2022 and May 2024 respectively. The full reports have been included in Appendix 58 to Appendix 60 inclusive. The studies were undertaken based on guidance provided within Visual Landscape Planning in Western Australia: a manual for evaluation, assessment, siting and design (Environment and Sustainability Directorate, 2007) and Guidelines for Landscape and Visual Impact Assessment, Third Edition (Landscape Institute and Institute of Environmental Management & Assessment, 2013). The methods outlined in these documents are considered suitable to describe the visual landscape of the assessment area and identify landscape and visual impacts associated with the Proposal.

GHD (2025a; 2023c) described two landscape character units (LCU) for the Huntly Mine DE being Darling Plateau Forest (LCU1) and Previous and Existing Mining (LCU2) as shown in Figure 5-67. Values associated with LCU1 (more prominent within the O'Neil East mine area) include the dense vegetation of high ecological value within State Forests and reserves and high scenic value associated with the undulating topography, granite outcrops and vegetation communities, which offer opportunities for active and passive recreation. LCU1 therefore has a high landscape character value (GHD, 2025a; 2023c). LCU2 (more prominent within the Myara mine area) is associated with remnant vegetation occurring in small, fragmented patches within mining areas; and therefore, has a limited contribution to local character. Areas of revegetated forest are immature, not significantly contributing to the landscape character. There is value associated with the distinct landform features on Mount Solus but the closure of walking tracks due to mining restricts recreation value and exposure to scenic value. LCU2 therefore has a low character value (GHD, 2023c).

The Larego LVIA covers the complete Willowdale Mine DE with methodology consistent with the LVIA discussed above. The LVIA identifies three LCUs, LCU1 and LCU2 consistent with the descriptions previously supplied, and a third, LCU3, which is characterised as Undulating Rural Plains (as shown in Figure 5-68). The local values associated with LCU3 encompass the rural landscape setting, which is appreciated for its visual and scenic quality, as well as an environmental overlay that acknowledges the high biodiversity values of areas of native forest within both private and public land. In addition, Harvey River traverses through LCU3 which is of high environmental and cultural value. There are also some seasonal water features and dams within private properties. LCU3 is valued by tourists and local residents, however, as a result of the mix of natural and human made feature values, LCU3 is considered to have moderate landscape value (GHD, 2025e).

As part of the LVIA, GHD (2025a; 2024i; 2025e) assessed each LCU for the susceptibility, sensitivity and magnitude of change based on the proposal. The overall impact to LCU2 and LCU3 is considered low to negligible. LCU3 will not be impacted by the Proposal, and disturbance within LCU2 is consistent with existing values resulting in a low magnitude of change. The significance of impact to LCU1 is negligible in Myara (northwest of Huntly Mine DE) and Willowdale Mine DE where the LCU is less likely to be impacted and high in the O'Neil area (northeast of Huntly Mine DE) where the Proposal will result in a degradation of values producing a similar landscape to that of LCU2. The outcome of this assessment is provided in Table 5-87.

Table 5-87: LCU Impact Assessment for the Mine DEs (GHD, 2025a; 2023c; 2023d)

Criteria	LCU1	LCU2	LCU3 (Willowdale)
Susceptibility to change	High Proposal would have a detrimental effect on some of the areas landscape character, condition and value that could not be mitigated in the immediate future.	Low Development will unlikely have an adverse effect on this existing landscape character, condition, or existing value as the development is not uncharacteristic.	High Proposal would have a detrimental effect on some of the areas landscape character, condition and value that could not be mitigated in the immediate future.

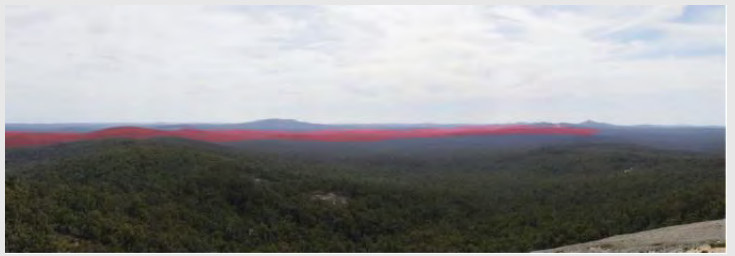
Criteria	LCU1	LCU2	LCU3 (Willowdale)
Sensitivity to change	High Elements of the landscape character including the State Forest vegetation, landscape's spatial qualities and natural characteristics won't accommodate Proposal without experiencing adverse impacts.	Low The landscape value and the susceptibility to change are both low.	Moderate Has locally important features that makes a generally positive contribution to landscape character.
Magnitude of change	Negligible – High The removal of vegetation and introduction of mining activities, haul roads and infrastructure areas would cause existing features and characteristics to resemble those of LCU2, thereby greatly reducing the value of the landscape character. This is more prevalent to O'Neil East, with change negligible for Myara and Willowdale where the impact has already occurred or is not proposed.	Negligible – Low Proposal may result in a minor loss to the forest vegetation, which is a key landscape feature of the LCU. Machinery and infrastructure would not be uncharacteristic within the existing landscape character.	Negligible Existing mined areas, proposed mining areas and rehabilitation is not proposed within LCU3.
Significance of impact	Negligible (Myara / Willowdale) – High (O'Neil East)	Negligible – Low	Negligible

No assessment was conducted for the southern Huntly Mine DE where the Proposal relates mainly to rehabilitation works and existing infrastructure (conveyor) suggesting it comprises of landscape values consistent with LCU2.

The LVIA also assessed impacts based on viewpoint, with viewpoints chosen in relation to proposed activities, existing amenities and values and elevation. Elevated viewpoints are considered to have a higher likelihood of visual amenity impacts. Within Huntly, various elevated viewpoints have been identified (GHD, 2025a; 2023d) mostly associated with the dams within the Huntly Mine DE, recreational areas and elevated areas along the Bibbulmun Track (Table 5-88). The significance of impact is considered moderate to high at each viewpoint namely due to the amount of disturbance visible or longevity.

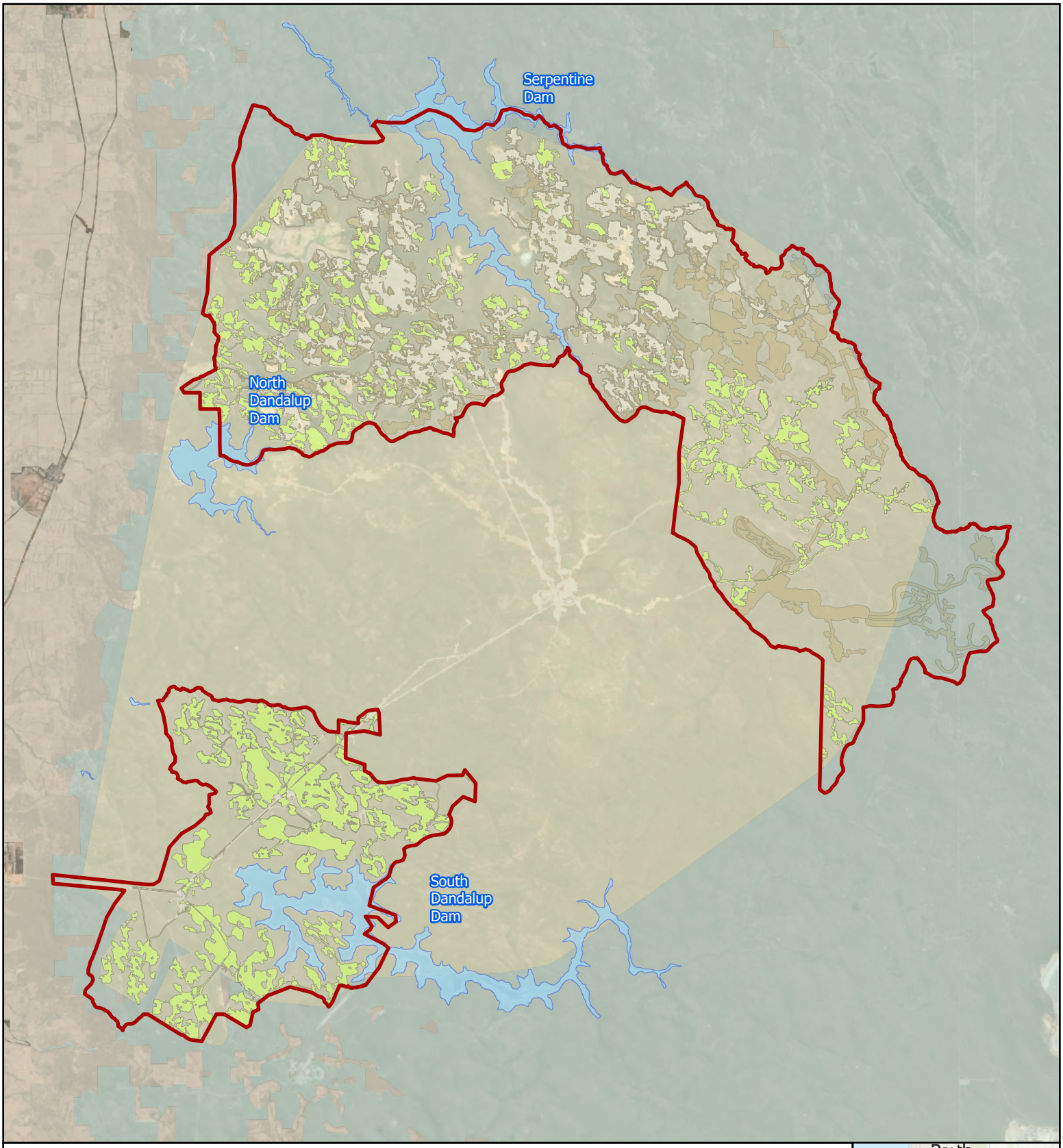
Table 5-88: Visual Impact Assessment for Huntly Mine DE (GHD, 2025a; 2023c)

Location	Assessment Summary	View of Disturbance or DE (red) where Disturbance is yet to occur
North Dandalup Dam	Disturbance will remain visible until the completion of rehabilitation works and vegetation establishes. (Significance: High – Moderate)	
Kingsbury Drive	Disturbance will remain visible until the completion of rehabilitation works and vegetation establishes. (Significance: High – Moderate)	
Serpentine Dam Picnic Area	Disturbance will remain visible until the completion of rehabilitation works and vegetation establishes. (Significance: High – Moderate)	
Mount Vincent	Disturbance will remain visible until the completion of rehabilitation works and vegetation establishes. (Significance: High – Moderate)	

Location	Assessment Summary	View of Disturbance or DE (red) where Disturbance is yet to occur
Mount Wells	Potential change includes obscured, hazy views in the distance of cleared vegetation, bear ground and pits. (Significance = Moderate)	
Boonering Hill	Potential change includes visibility of vegetation, bear ground and pits in the midground and background. (Significance = Moderate – High)	
North East Road	View is from level ground at the edge of DE and therefore equipment, machinery, and vehicles, and possible clearance of vegetation may be visible. (Significance = Moderate)	Comprises a view along an unsealed vehicle track within the Dwellingup State Forest.
Mount Cooke	Changes would be at a similar distance and scale to the existing Myara mines, and therefore would not be uncharacteristic within the existing view. (Significance = Moderate)	

The Willowdale mine region and surrounds are covered by forests and therefore views to mining will be effectively screened by vegetation (Alcoa, 2023b). The following viewpoints were identified for the Willowdale Mine DE, noting the LVIA covered an area significantly larger than the DE of the proposal:

- The Mt William fire tower affords elevated views to the north and east over the Larego area;
- Zigzag, Willowdale and Driver Roads have clearing within close proximity, which is visible.

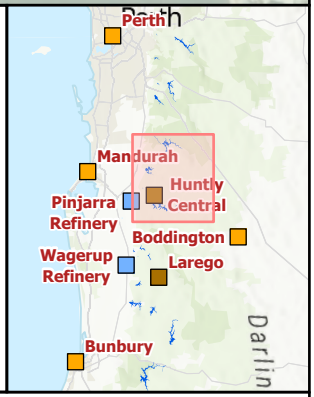


Legend

- Huntly Mine DE
- Reservoirs

Landscape Character Unit

- LCU1: Darling Plateau Vegegation
- LCU2: Previous and Existing Mining
- LCU3: Rural Zoning
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite Mining on the Darling Range in the Southwest of WA-2023 to 2027

Figure 5-67 Huntly Mine DE Landscape Character Units

Kilometres

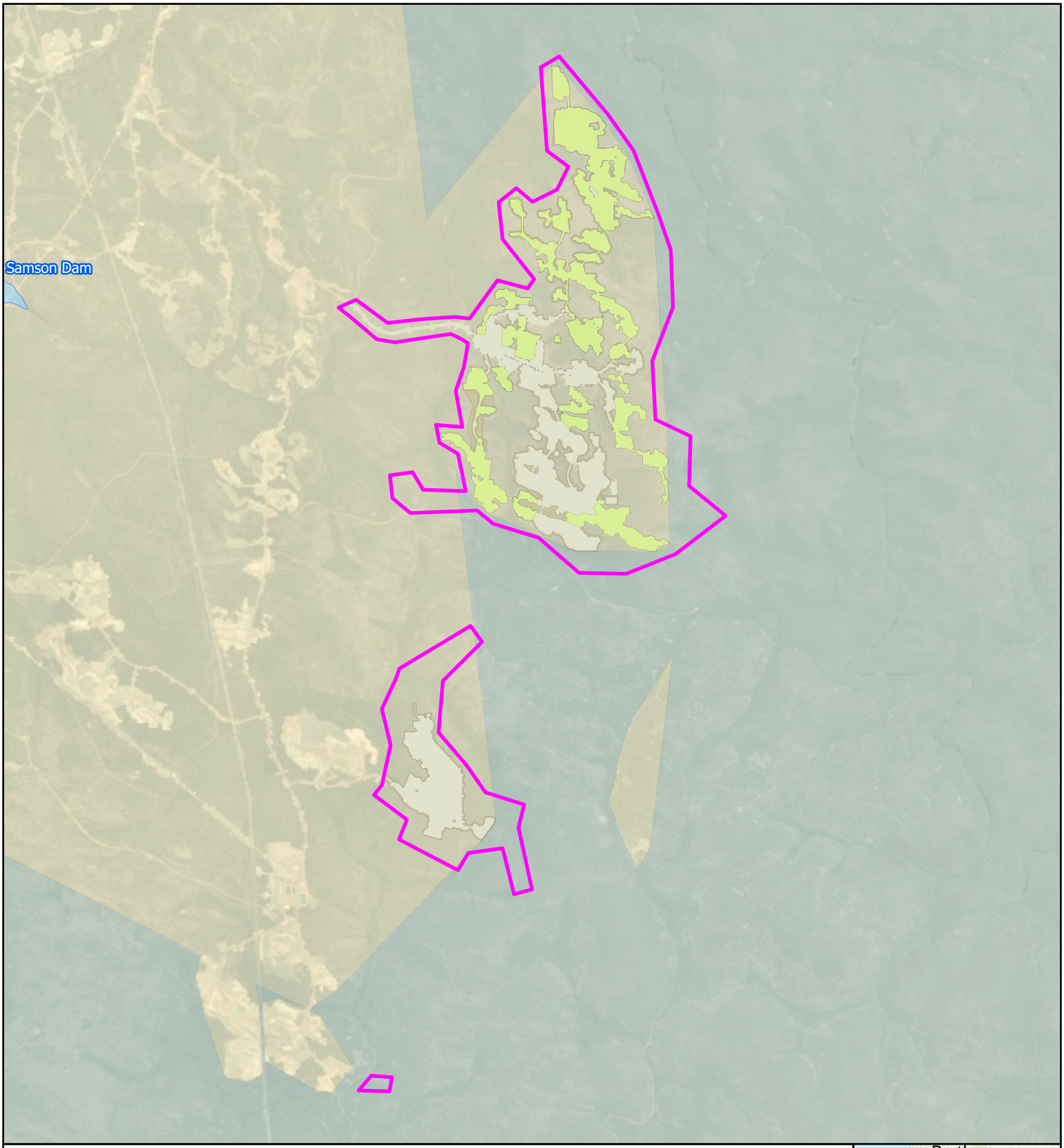
0 2 4 6 8 10 12

Scale: 1:185,926 at A4

Date Printed: 26/02/2025

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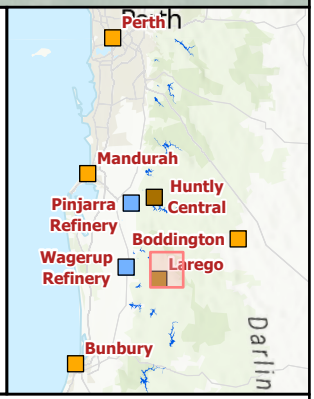


Legend

- Willowdale Mine DE
- Reservoirs

Landscape Character Units

- LCU1: Darling Plateau Vegegation
- LCU2: Previous and Existing Mining
- LCU2: Previous and Existing Mining
- LCU3: Rural Zoning
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite Mining on the Darling Range
in the Southwest of WA-2023 to 2027

Figure 5-68 Willowdale Region Landscape Character Units

Kilometres

0 0.85 1.7 2.55 3.4 4.25 5.1

Scale: 1:75,000 at A4

Date Printed: 26/02/2025

N

Alcoa

5.7.3.9 Noise

Four noise assessments have been undertaken either within, partially within or in close proximity to the Huntly Mine DE (Table 5-83). Between 18 December 2023 and 2 January 2024, GHD (2024i) established baseline sound pressure levels (dB(A)) for the O'Neil mining area (within the eastern extent of the Huntly Mine DE) at the White Horse Hills campsite located approximately 2.9 km to the east of the Huntly Mine DE. Between 4 July 2020 and 10 September 2020, Wood (2023) established baseline noise levels at Serpentine Dam recreational facilities and Mount Cooke Campsite. L_{A10} sound pressure level (noise level exceeded for 10% of the measurement period, used to understand received noise level at noise sensitive receptors) ranges for each location are provided in Table 5-89. Acquired L_{A10} ranges indicate the potential of pre-existing exceedances of the assigned noise levels for sensitive receivers at each stage of the day as set by the *Environmental Protection (Noise) Regulations 1997*. It was found that the majority of the ambient noise is typical of rural areas comprising community activities including dogs, livestock and noise from use of hand tools, traffic noises, and occasional faint rumbling and revving (GHD, 2024i; Wood, 2023).

Table 5-89: Overview of Relevant Background L_{A10} Noise Levels (GHD, 2024i; Wood, 2023)

Location	Mon – Sat (7:00 – 19:00)	Sun + PH (9:00 – 19:00)	Evening (19:00 – 22:00)	Night (22:00 – 7:00)
Assigned Noise Level*	45 + IF	40 + IF	40 + IF	35 + IF
White Horse Hills campsite	34 – 50 dB(A)		44 – 53 dB(A)	29 – 54 dB(A)
Serpentine Dam recreational facilities	45 – 53 dB(A)		25 – 45 dB(A)	20 – 52 dB(A)
Mount Cooke Campsite	38 – 50 dB(A)		21 – 57 dB(A)	28 – 45 dB(A)

**Environmental Protection Noise Regulations 1997* (IF = Influencing Factor)

GHD (2024h; 2024f) undertook a Noise Impact Assessment (NIA) for the Myara mine area and O'Neil mine area within the Huntly Mine DE based on the works outlined between 2024 and 2027, and 2026 and 2029 (inclusive of proposed future activities beyond the scope of this ERD) respectively. The reports are included in Appendix 63 and Appendix 61. All modelling undertaken represents a worst-case scenario from meteorological and operational conditions and assesses the impacts on noise sensitive receptors (NSR) located within 10 km of the assessment area (as shown in Figure 5-69). In all modelled scenarios for activities occurring in the Myara mine area, the predicted noise levels at three NSR located at Karnet Prison exceeded the day, evening and night assigned noise levels Table 5-90. In 2025, proposed activities also resulted in predicted noise level exceedances (during Sundays, public holidays, evenings and nights) at 229 Scarp Rd and at 168 Scarp Rd when tonality was also considered. The modelling undertaken for the O'Neil mine area predicted that noise levels are expected to comply with noise criteria under worst case weather conditions at all times of the day and night, including during Sundays and public holidays. During Sundays and public holidays, however, there is a risk of non-compliance during the night at White Horse Hills Campsite should tonality be evident in the received noise (GHD, 2024i). The audibility of mining noise depends on the ambient baseline levels, the weather conditions and tonal content of the noise. Although predicted noise modelling indicated mining noise from O'Neil has the potential to be audible at White Horse Hills Campsite (GHD, 2024i), it is considered unlikely as predicted noise level values only protrude 2 dB

above background noise levels. A person typically does not detect a change in noise levels below 2 to 3 dB (David Bies, 2018).

Notwithstanding the above, under realistic operational conditions, all NSRs are expected to with noise criteria at all periods of the day, with operational panning practices (mitigations referred to in Table 5-94, implemented to ensure compliance can be achieved even under worst case conditions. (GHD, 2024h; 2024i).

Noise sensitive receptors for the Huntly Mine DE and the Willowdale Mine DE are shown on Figure 5-69 and Figure 5-70 respectively.

Table 5-90: Overview of Noise Monitoring Results for Noise Sensitive Receptors with a Potential for Non-compliances (GHD, 2024h; 2024i)

Location	Mon – Sat (7:00 – 19:00)	Sun + PH (9:00 – 19:00)	Evening (19:00 – 22:00)	Night (22:00 – 7:00)
Assigned Noise Level*	45 dB L_{A10}	40 dB L_{A10}	40 dB L_{A10}	35 dB L_{A10}
Karnet Prison Farm	46 – 48 dB L_{A10}			38 dB L_{A10}
Karnet Prison Farm	46 dB L_{A10}			38 dB L_{A10}
Karnet Prison Farm infrastructure	47 – 50 dB L_{A10}			40 dB L_{A10}
229 Scarp Road	35 – 44 dB L_{A10}			29 – 40 dB L_{A10}
168 Scarp Road	30 – 36 dB L_{A10}**			25 – 31 dB L_{A10}**
White Horse Hill Campsite	28 – 32 dB L_{A10}			29 – 32 dB L_{A10}**

* *Environmental Protection Noise Regulations 1997*

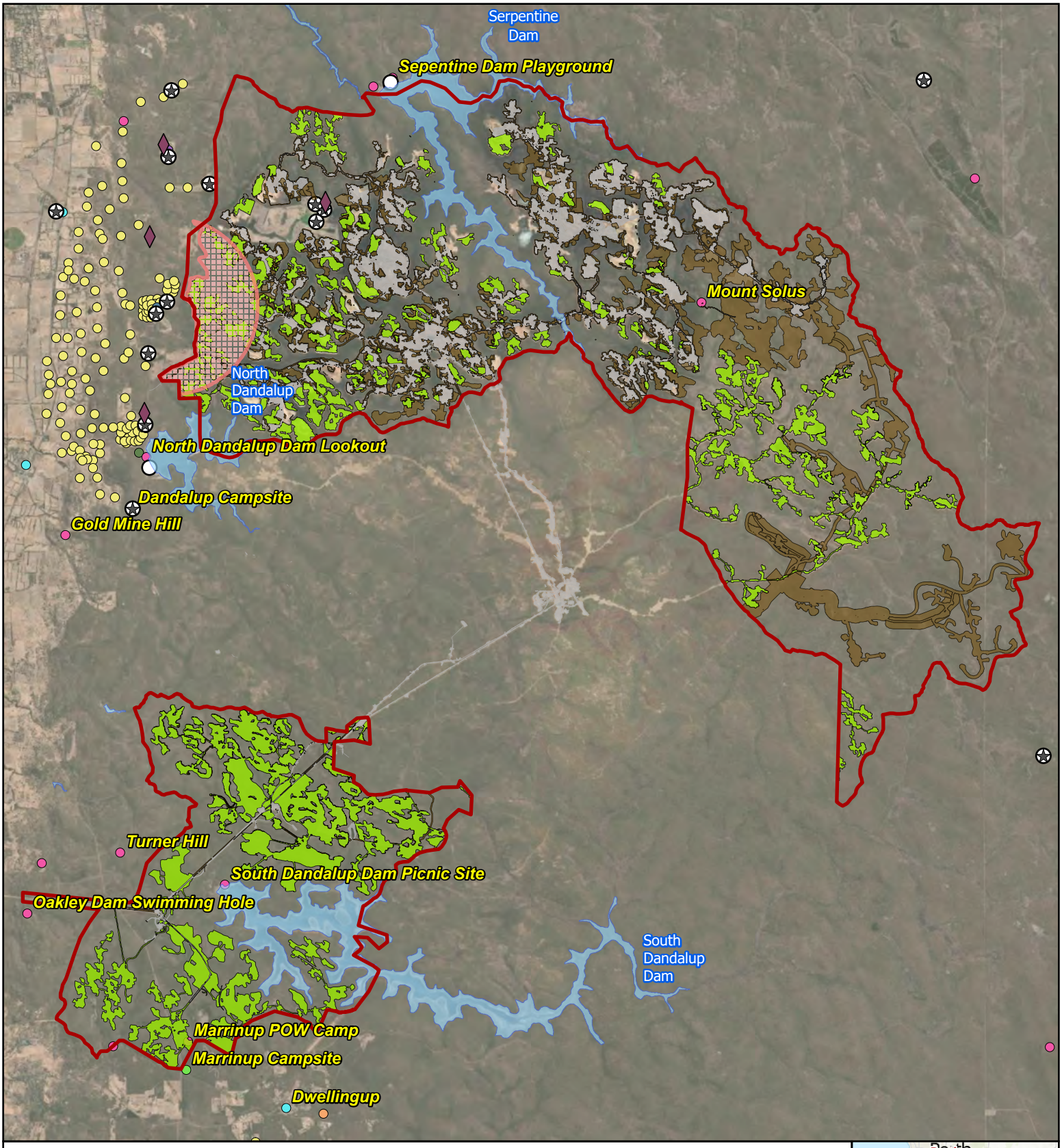
** Presents a risk of non-compliance only when tonality is considered (tonality attracts a 5 dB correction as per r. 9 *Environmental Protection Noise Regulations 1997*)

No detailed noise monitoring assessments have been undertaken for the south Huntly Mine DE. Wood (2023) undertook a NIA for the Myara North (north of Huntly Mine DE) and Holyoake (southeast of Huntly Mine DE) mine areas which includes modelling and assessment of noise emissions from operational equipment and identified noise sensitive receptors, which were adopted for mine planning within the Huntly Mine DE. Noise assessments are sensitive to the parameters used to produce the model and therefore the results of the study cannot be applied to this proposal. However given the proximity of the mining areas and similar scale of activities, it is considered logical that the outcomes of the assessment will be consistent in worst case scenarios. Wood (2023) found that night-time assigned levels could be subject to exceedances at some sensitive receptors (rural properties, walking trails and campsites) and mining noise (predominantly mobile equipment such as haul trucks, excavators, etc) may be audible over background levels (where they are exceeded by greater than 3 dB).

Blast noise measurements at Alcoa's current Myara mine area (within Huntly Mine DE) indicate that a radius of 1.2 km will be required for the blast overpressure to attenuate below the 120 dB(L) maximum limit prescribed by the *Environmental Protection (Noise) Regulations 1997* for residential receivers (including the recreational campsites). Applying this 1.2 km radius to mine areas excludes any likely impacts resulting from blast noise with

the exception of the NSR at Karnet Prison which this cannot be achieved without further operational controls being implemented as a result of proximity to open pits (GHD, 2024h; Wood, 2023). Alcoa has set internal blast noise limits to maintain compliance and minimise impacts on noise sensitive premises; this includes a maximum blast limit of 110dB LZ peak in Dwellingup or Yamba; and 115dB LZ peak at any other offsite location. GHD (2024i) reported ground borne noise and vibrations from the O'Neil mine area are expected to be insignificant at all nearby NSRs.

GHD (2024g) undertook operational noise modelling for the Larego mine region's proposed activities between 2024 to 2027; noting this assessment covers the entire Larego mine region which vastly exceeds the Willowdale Mine DE referred by this Proposal. The report has been provided in Appendix 68. The closest NSR to the Willowdale Mine DE are three campgrounds (Hoffman Mill, Bidjar Ngoulin and Murray), located 4.85 km south, 1.29 km west and 0.66 km east respectively. The noise modelling indicated that of these locations only Hoffman Mill campground was at risk of non-compliance with the daytime (Sunday and Public Holiday) Noise Regulations however the campground has been closed since November 2022 and therefore no impacts are expected. Predicted noise level exceedances were also found at several other locations; however, these locations are considered to be far from the Willowdale Mine DE for the Proposal to have resulted in these predicted exceedances.

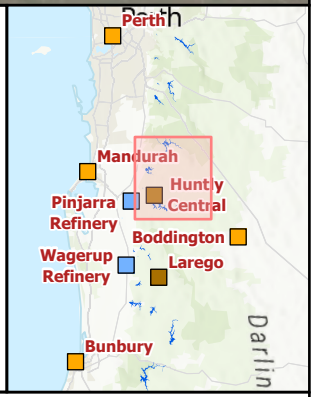


Legend

- Huntly Mine DE
- Yamba Low Impact Mining Zone
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Noise Monitoring Locations
- Noise Sensitive Receptors (Night)
- Noise Sensitive Receptors (Day)

Sensitive Receptors

- Alcoa property
- Campsite
- Cemetery
- City/Town
- Government property
- Private property
- Recreation
- Other



Bauxite Mining on the Darling Range in the Southwest of WA-2023 to 2027

Figure 5-69 Huntly Mine DE - Noise Sensitive Receptors

Kilometres

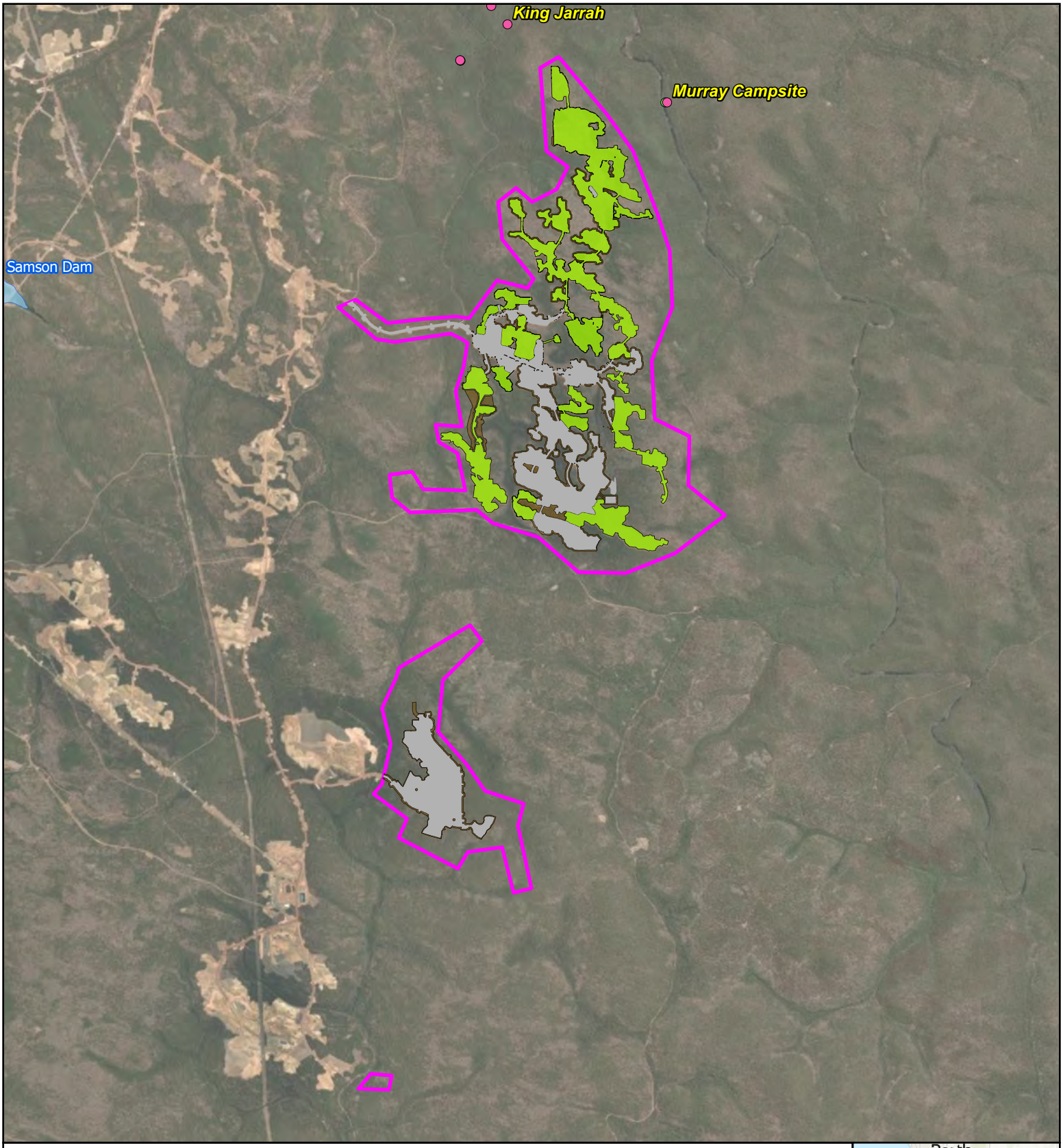
10 15 20 25 30

N

Scale: 1:175,000 at A4

Date Printed: 26/02/2025

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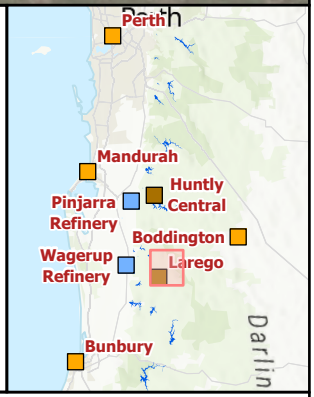
Legend

- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint
- Willowdale Mine DE
- Reservoirs

Sensitive Receptors

Type

- Campsite
- Recreation



Bauxite Mining on the Darling Range in the Southwest of WA-2023 to 2027

Figure 5-70 Willowdale Mine DE - Noise Sensitive Receptors

Kilometres

0 0.9 1.8 2.7 3.6 4.5 5.4

Scale: 1:75,060 at A4

Date Printed: 26/02/2025

N

Alcoa

5.7.3.10 Dust

GHD (2025k) undertook an Air Quality Impact Assessment (AQIA) for the Myara mining area located in the northern Huntly Mine DE, the report is provided in Appendix 64. A second AQIA was undertaken by GHD (2024j) for the O'Neil mining area, the report is provided in Appendix 66. No other air or dust impact assessments have been undertaken for the remaining Huntly Mine DE (Huntly and Del Park). The AQIA investigated potential emissions of particulate matter and combustion pollutants that could arise from construction and mining operations in the Myara and O'Neil mine areas. The main air pollutant derived from the proposed activities is dust, assessed as total suspended particulates (TSP), particulate matter 10 micrometres (µm) or less in diameter (PM_{10}), and particulate matter 2.5 µm or less in diameter ($PM_{2.5}$), respirable crystalline silica (RCS) and dust deposition.

Air quality within the Myara and O'Neil mine areas is considered to be typical of a rural area located within close proximity to a mine (existing Alcoa operations) with dominant dust sources being agricultural activities, domestic fuel burning and vehicle emissions, prescribed burning or bushfires and existing mining operations. A pre-established ambient air monitoring station at Yamba Drive operated by Acoem Australia Pty Ltd and managed by Alcoa was used to define the background air concentrations utilising a monitoring period from September 2012 to August 2023. Anomalous events were removed from the data set (as preferred by the National Environment Protection (Ambient Air Quality) Measure 1998 (Air NEPM) (NEPC, 2021)) producing a 24-hour maximum TSP and PM_{10} of 93.7 µg/m^3 and 63µg/m^3 respectively (GHD, 2025k).

GHD (2025k) conducted dispersion modelling for years two (scenario 1), three (scenario 2), and four (scenario 3) of the 2023–2027 mine plan for Myara, being the worst case years for proposed activities given the concurrent occurrence of activities throughout operations. Table 5-91 provides a summary of dust emission sources based on the proposed activities.

Table 5-91: Summary of Dust Emission Sources (GHD, 2025k)

Activity	Description	Overview of dust emission source
Clearing	• Vegetation clearing • Removal of topsoil/ overburden and handling/ stockpiling for use in mine pit rehabilitation	• Use of dozers to clear land • Use of excavators, loaders and scrapers to handle and stockpile topsoil/overburden
Mine pit development	• Drilling and blasting of caprock	• Use of drilling rig to drill holes in caprock • Blasting of caprock and removal of caprock via use of dozers • Use of excavators, loaders and scrapers to remove top layer of material
Mining	• Ore extraction and loading for transportation	• Use of excavators to extract ore • Loading of ore into haul trucks
Mine Pit Rehabilitation	• Landscaping including pre-ripping of compacted pit floors and unmined areas, regrading and burying of rocks • Overburn return including dumping and spreading of soil • Contour ripping	• Use of dozers and winged or multi-tyne to landscape mined pits • Dumping of overburden to mined areas in summer • Use of excavators, loaders and scrapers to handle/spread topsoil/overburden over rehabilitation area • Contour ripping via multi-tyne

Activity	Description	Overview of dust emission source
Transportation of extracted materials	• Transportation of ore from pit to crushers using mine haulage trucks	• Wheel generated dust from vehicle movements on unsealed surfaces (mine haul truck and low loaders) • Use of graders to maintain haulage routes
Material processing	• Ore processing including crushing and resizing of material	• Crushing and resizing of material • Transfer of processed material to conveyor
Exposed areas	• Exposed area with no vegetation ground cover • Stockpile of mined/ processed material	• Windblown dust from exposed mine pits and stockpile areas

The modelling was undertaken predicting impacts on 24 sensitive receptors comprising community services, residential, recreational or campgrounds selected from within 10 km of the Myara mine area. Predicted cumulative 24-hour TSP concentrations exceeded PM_{10} Air NEPM (NEPC, 2021) maximum concentration values and were elevated above background TSP concentrations at some sensitive receptors in all modelled years (Figure 5-71 and Figure 5-72). The predictions are overly conservative, noting background concentrations also incorporated dust generated from existing Alcoa operations. Background concentrations are responsible for approximately 77% of the cumulative dust concentrations, with no exceedances being predicted based on the incremental assessment (GHD, 2025k).

In all scenarios the three sensitive receptors located in the vicinity of the Karnet Prison (residential) were the greatest impacted with predicted incremental PM_{10} concentrations contributing approximately 50% to the 50 µg/m^3 limit (NEPC, 2021). These receptors were the only receptors to be located within the Huntly Mine DE. In scenario one (year two), three residential receptors (two in Keysbrook and one in North Dandalup) and two recreational receptors (Serpentine and North Dandalup Dam) were shown to have cumulative impacts with TSP background concentrations and PM_{10} 24-hour concentration limits being exceeded (Figure 5-73 and Figure 5-74). Incremental concentrations at these locations represented less than 33% of the concentration limits, with the exception of Serpentine Dam recreational facilities of which operations resulted in predicted TSP and PM_{10} concentrations of 54% and 45% of the limits respectively. The cumulative 24-hour TSP concentration limit was also exceeded at Serpentine Dam recreational facilities for scenarios two and three, with incremental 24-hour TSP concentrations comprising 47% and 33.5% of the background concentrations respectively. In all scenarios 24-hour PM_{10} concentration limits were exceeded at most sensitive receptors, with the only receptors never to be impacted being located to the east of the Huntly Mine DE (Bibbulmun Nerang Campsite and Boonering Hill) and Keysbook Fire Station (to the west). No incremental exceedances of 24-hour and annual TSP, PM_{10}, $PM_{2.5}$ and RCS criteria were predicted (GHD, 2025k). Dust deposition was predicted to be greatest in year two at the Karnet Prison with predicted volumes ranging from 1.7 to 2.0 g/m^3/month depending on location (Figure 5-75). At all other locations predicted dust deposition volumes were less than 0.6 g/m^3/month for all scenarios and therefore below acceptable guideline values (GHD, 2025k).

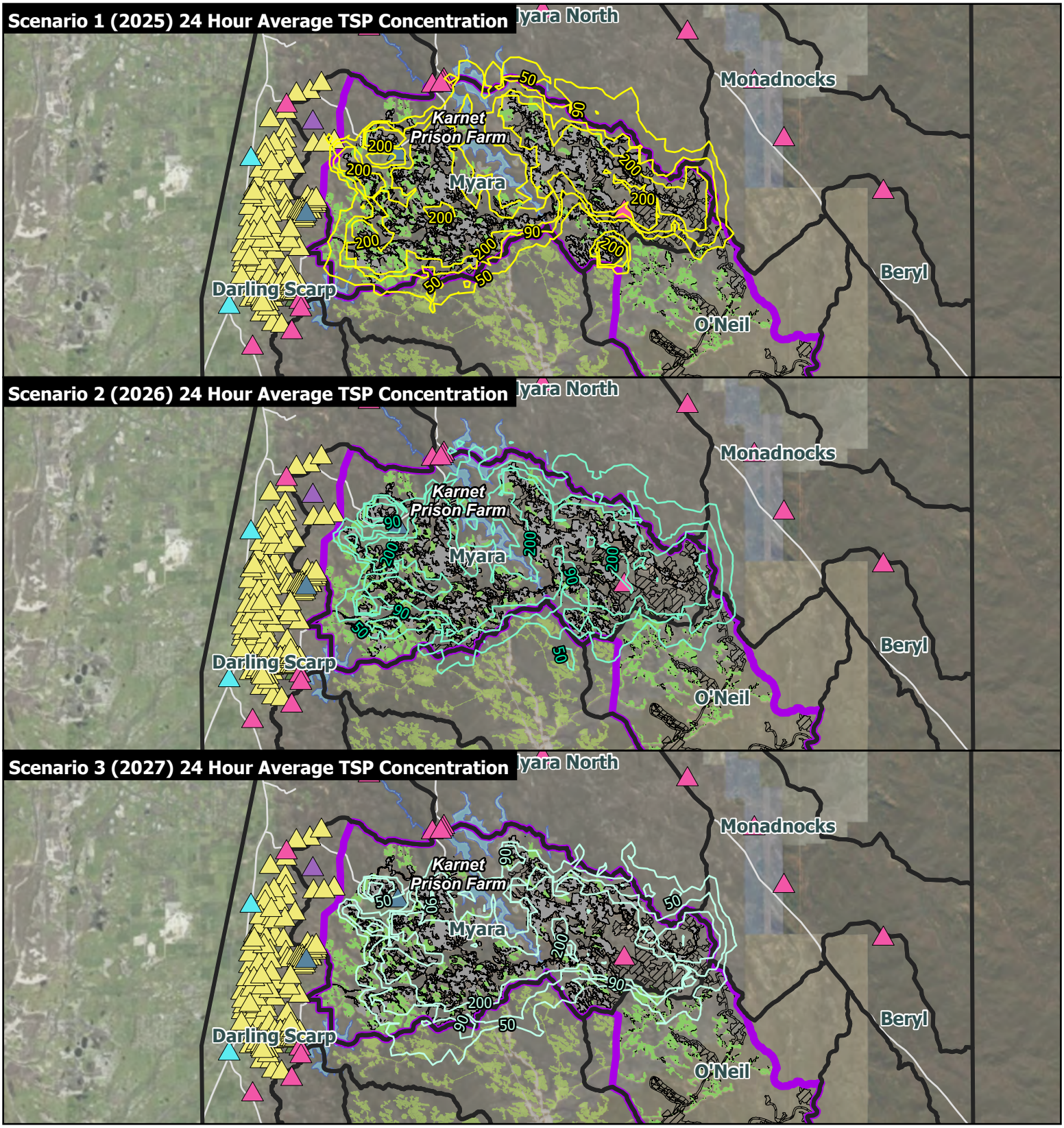
The GHD (2024j) AQIA for O'Neil mine area considered operations and cleared areas for the 2025 to 2029 mine plan. Dispersion modelling was undertaken for year 2027 and 2028, being considered the worst-case years for proposed and open areas. Scenario one (2027)

represents mining 13 Mtpa and included areas also under development and undergoing rehabilitation. The modelling predicted exceedances of PM_{10} maximum cumulative 24-hour average concentrations at two of the 43 identified sensitive receptors; White Horse Hill Campsite and Boonering Hill of 53.5 and 56 µg/m^3, respectively; however, this can be attributed to the high PM_{10} background concentration, which accounts for 95% of the PM_{10} 24-hour criterion of 50 µg/m^3 (GHD, 2024j). Predicted incremental and cumulative concentrations for TSP and $PM_{2.5}$ were in compliance with assessment criteria for all receptors. Compliance with the maximum increase dust deposition criteria (2 g/m^2/month) was predicted at all receptors (GHD, 2024j). The mine plan for 2028 is not considered in this proposal.

All gaseous emissions (such as NO_x, CO and SO_2) associated with both construction and mining activities are considered manageable and relatively minor. With implementation of standard construction management and operational controls these emissions are not expected to result in significant adverse air quality impacts to sensitive receptors of the environment (GHD, 2025k; 2024j).

GHD (2025l) undertook an air quality impact assessment for the Larego mine region's proposed activities between 2025 to 2027; noting this assessment covers the entire Larego mine region which vastly exceeds the Willowdale Mine DE referred by this proposal. The report has been provided in Appendix 68. Of the three years modelled, the only predicted exceedance of the compared guideline values was for Hoffman Mill in 2025 under worse case conditions, whereby a 24-hour TSP result of 109.7 µg/m^3 was predicted (GHD, 2025l), exceeding background concentrations (Figure 5-72). Hoffman Mill while located 1.2 km south of the Willowdale Mine DE (Tasman mine region) where no new activities are proposed has been closed since November 2022 and therefore no impacts are expected. The assessment did not predict any other air quality impacts for the Larego mine region (Figure 5-74 and Figure 5-76).

Data gaps remain for the southern extent of the Huntly Mine DE (Huntly and Del Park region). It is to be noted that this area comprises mostly rehabilitation works and an existing conveyor and therefore any dust related impacts would be expected to lessen as rehabilitation works progress. Predicted incremental annual average dust deposition during worst-case scenarios are shown on Figure 5-75 and Figure 5-76 respectively.



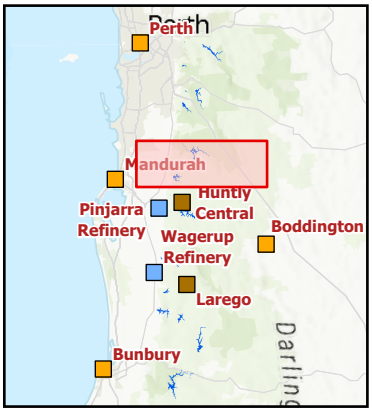
Legend

- Huntly Mine Development Envelope
- Mining Regions
- Disturbance Footprint
- Rehabilitation Footprint
- Cleared Areas
- Major Dams

Sensitive Receptors

- Alcoa property
- City/Town
- Government property
- Other
- Private property
- Recreation

- Scenario 1 (2025) 24 Hour Average TSP Concentration
- Scenario 2 (2026) 24 Hour Average TSP Concentration
- Scenario 3 (2027) 24 Hour Average TSP Concentration



Bauxite Mining on the Darling Range in the Southwest of WA-2023 to 2027

Figure 5-71 Huntly Mine DE 24 Hour Average TSP Concentration Scenario

Kilometres

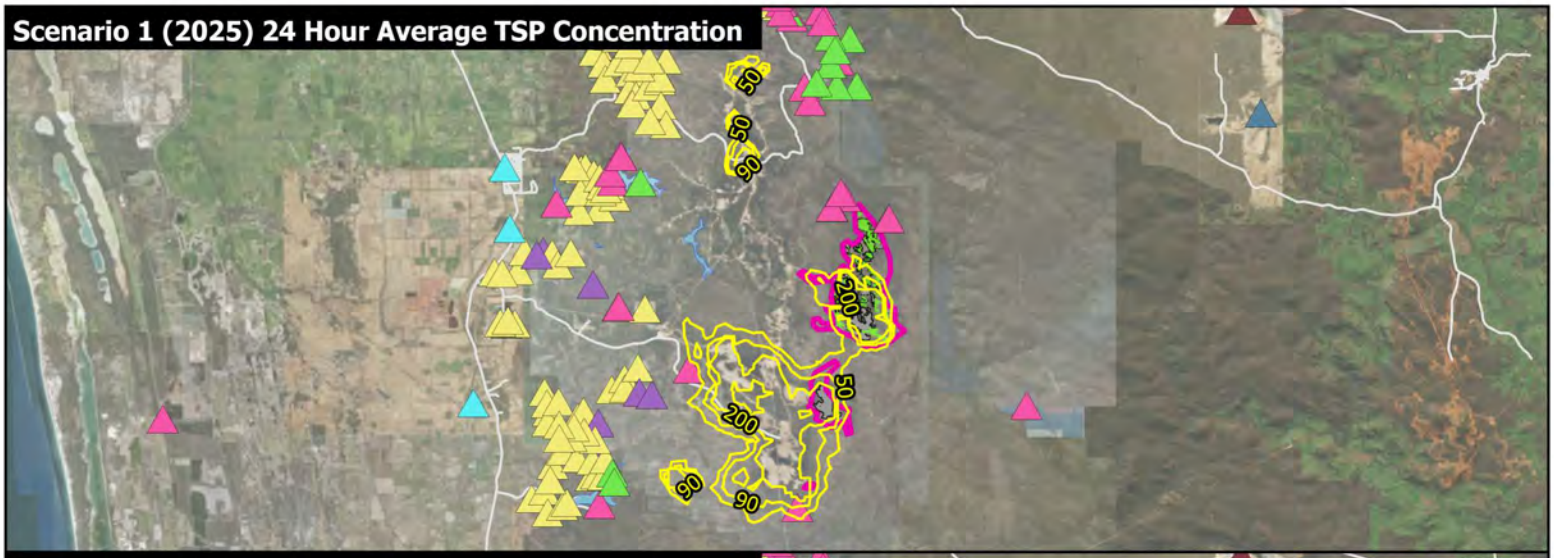
0 1 2 4 6 8 10

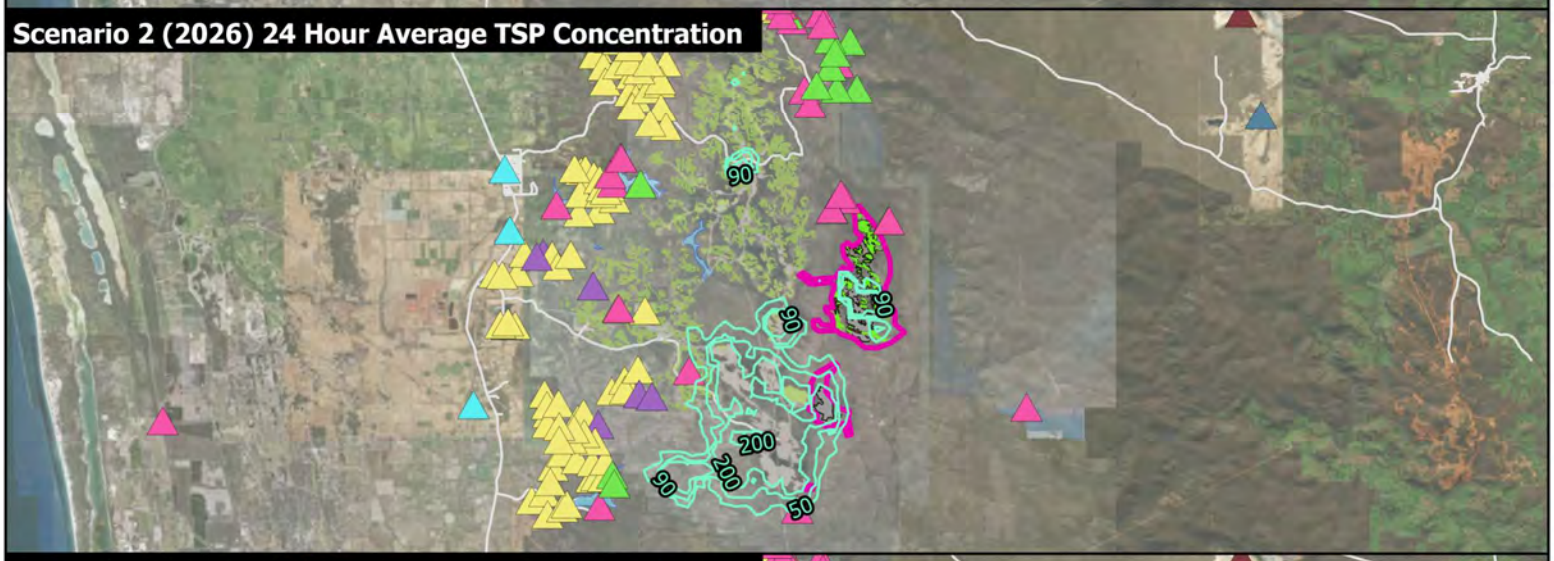
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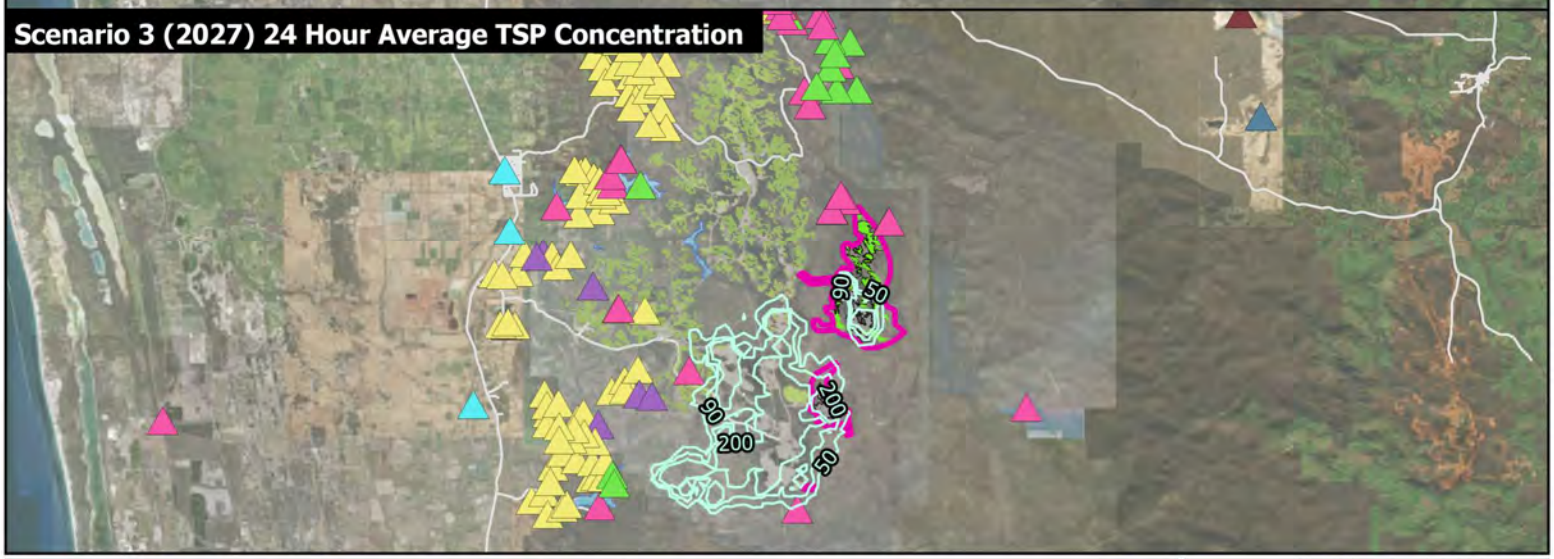
Date Printed: 31/10/2024

N

Alcoa







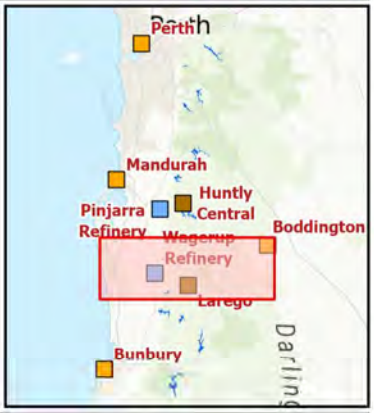
Legend

- Willowdale Mine Development Envelope
- Proposed Disturbance Footprint
- Rehabilitation Footprint
- Open Areas
- Major Dams

Sensitive Receptors

- Alcoa property
- Campsite
- City/Town
- Government property
- Mine
- Other
- Private property
- Recreation

- Scenario 1 (2025) 24 Hour Average TSP Concentration
- Scenario 2 (2026) 24 Hour Average TSP Concentration
- Scenario 3 (2027) 24 Hour Average TSP Concentration



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-72 Willowdale Mine DE 24 Hour Average TSP Concentration Scenario

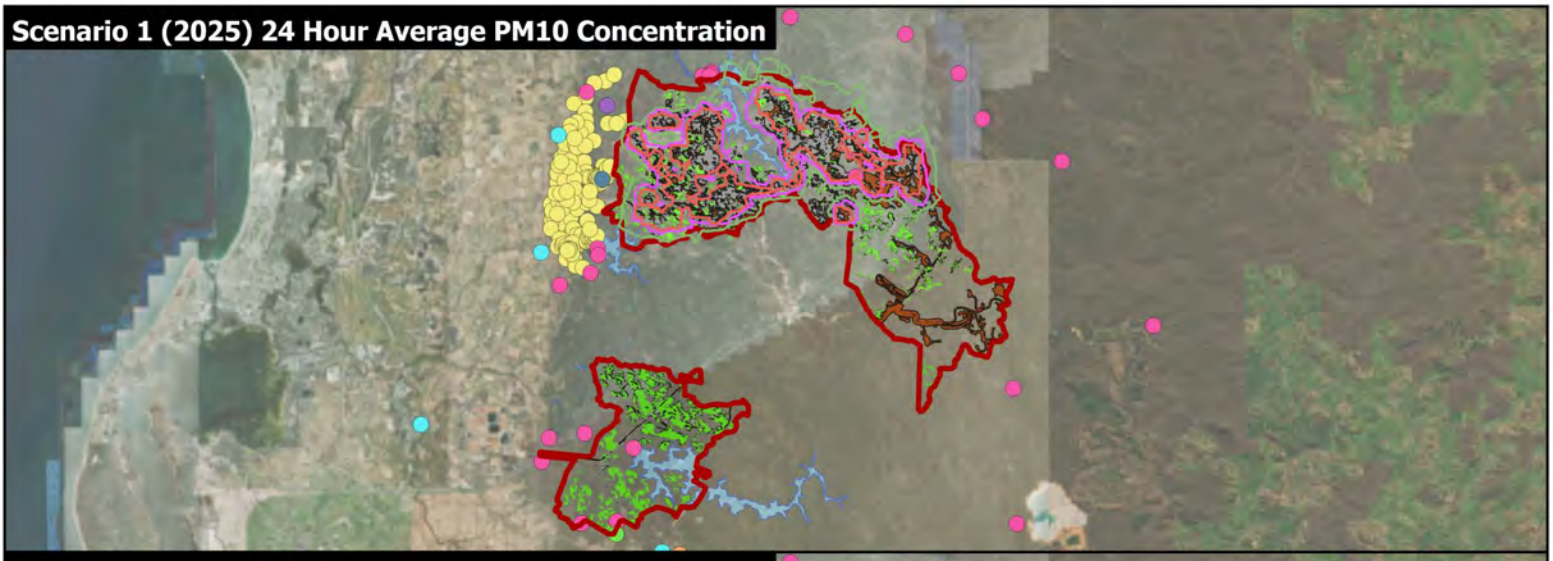
Kilometres
0 1 2 4 6 8 10

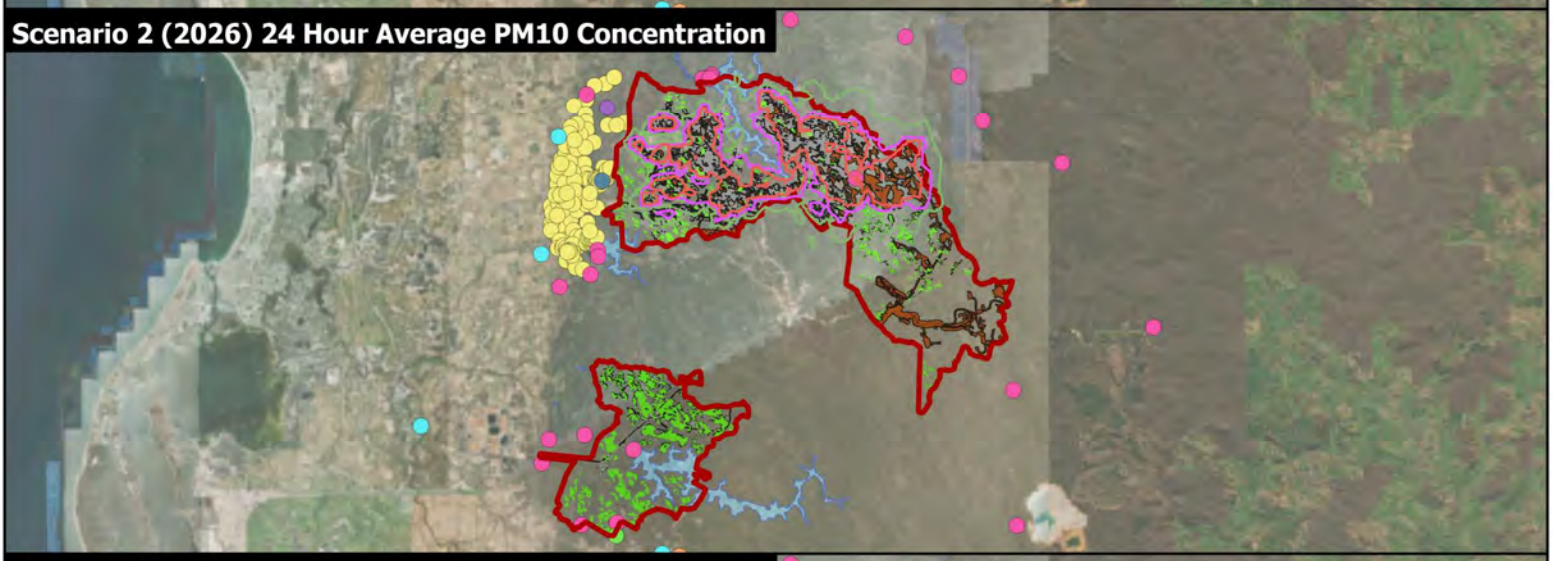
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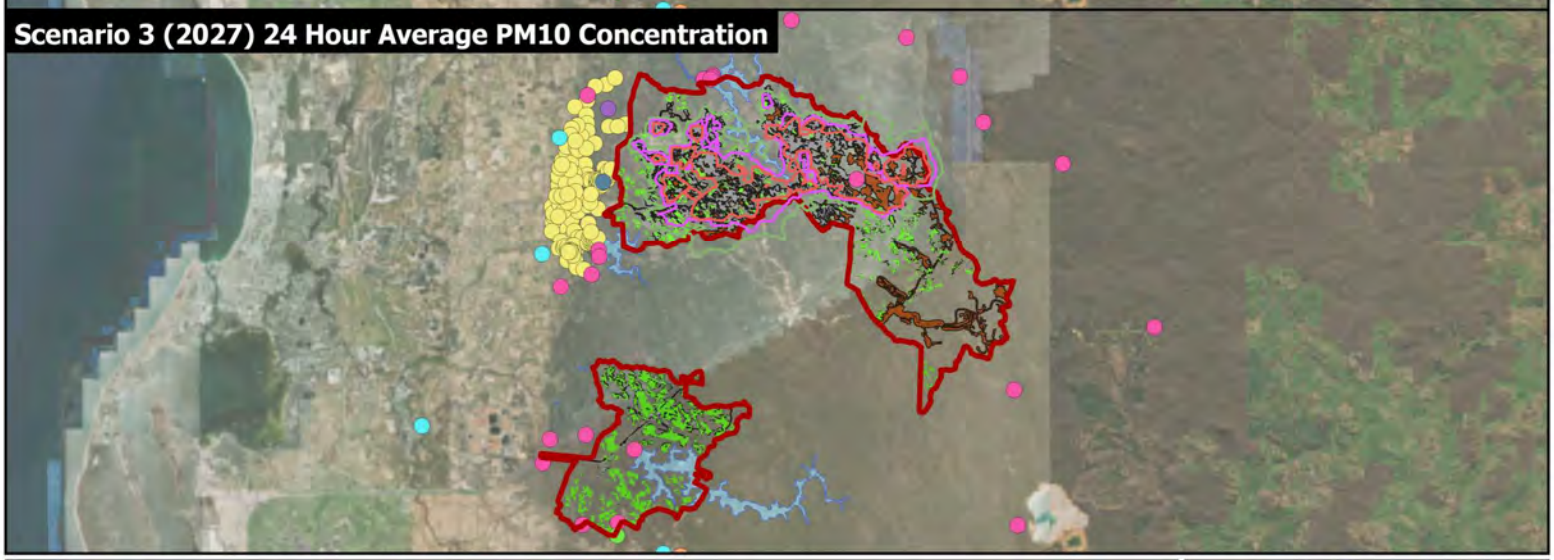
Date Printed: 28/02/2025

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Alcoa







Legend

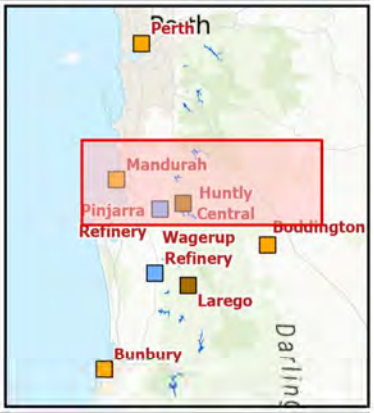
- Huntly Mine DE
- Proposed Disturbance Footprint
- Rehabilitation Footprint
- Open Areas
- Reservoirs

Sensitive Receptors

- Alcoa property
- Campsite
- Cemetery
- City/Town
- Government property
- Private property
- Recreation
- Other

24 Hour Average PM10 Concentration

- 25
- 50
- 100



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Kilometres

0 2.5 5 10 15 20 25

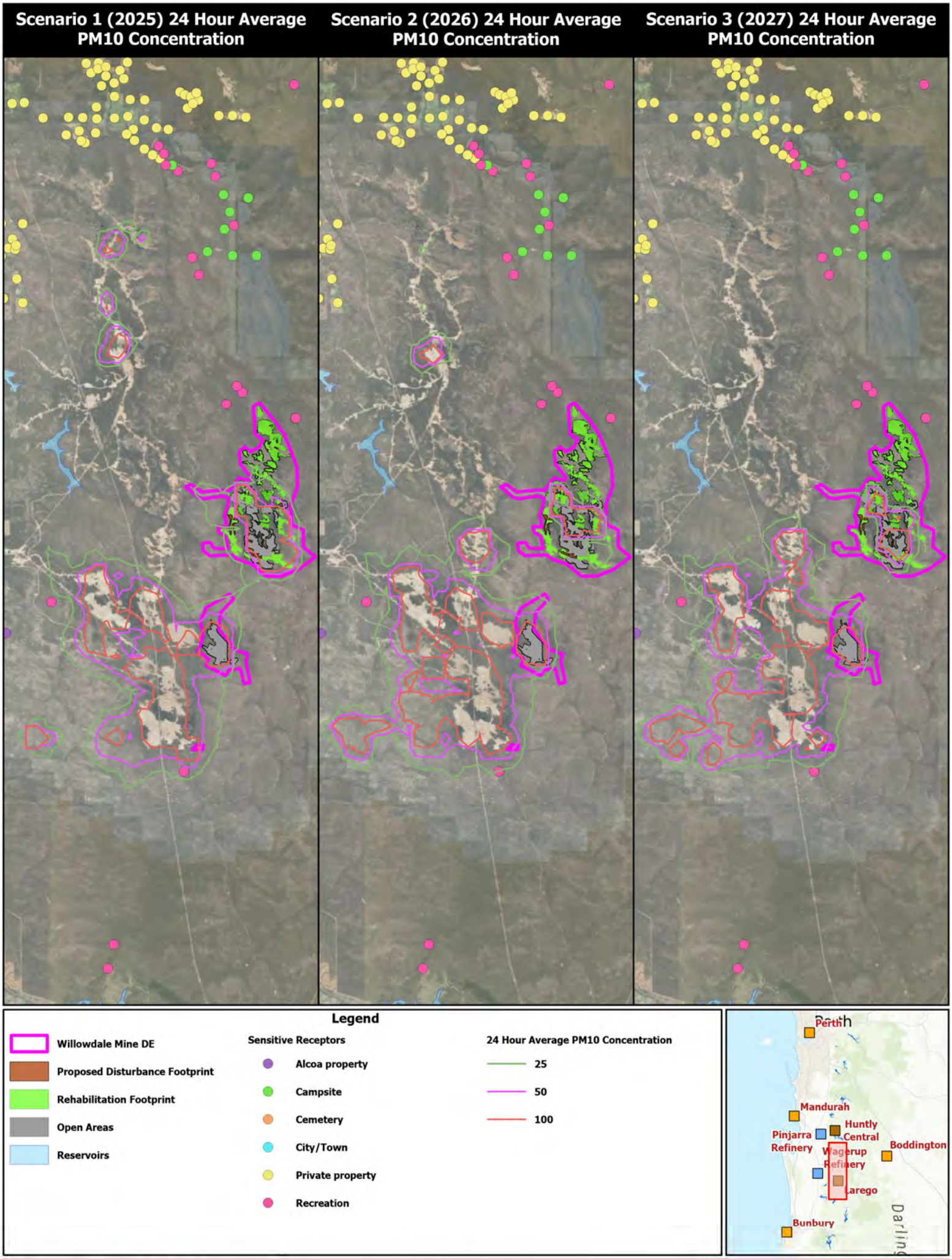
N

Alcoa

Figure 5-73 Huntly Mine DE - 24 Hour Average PM10 Concentration Scenario

Scale: 1:550,000 at A4

Date Printed: 28/02/2025



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Kilometres

0 1 2 4 6 8 10

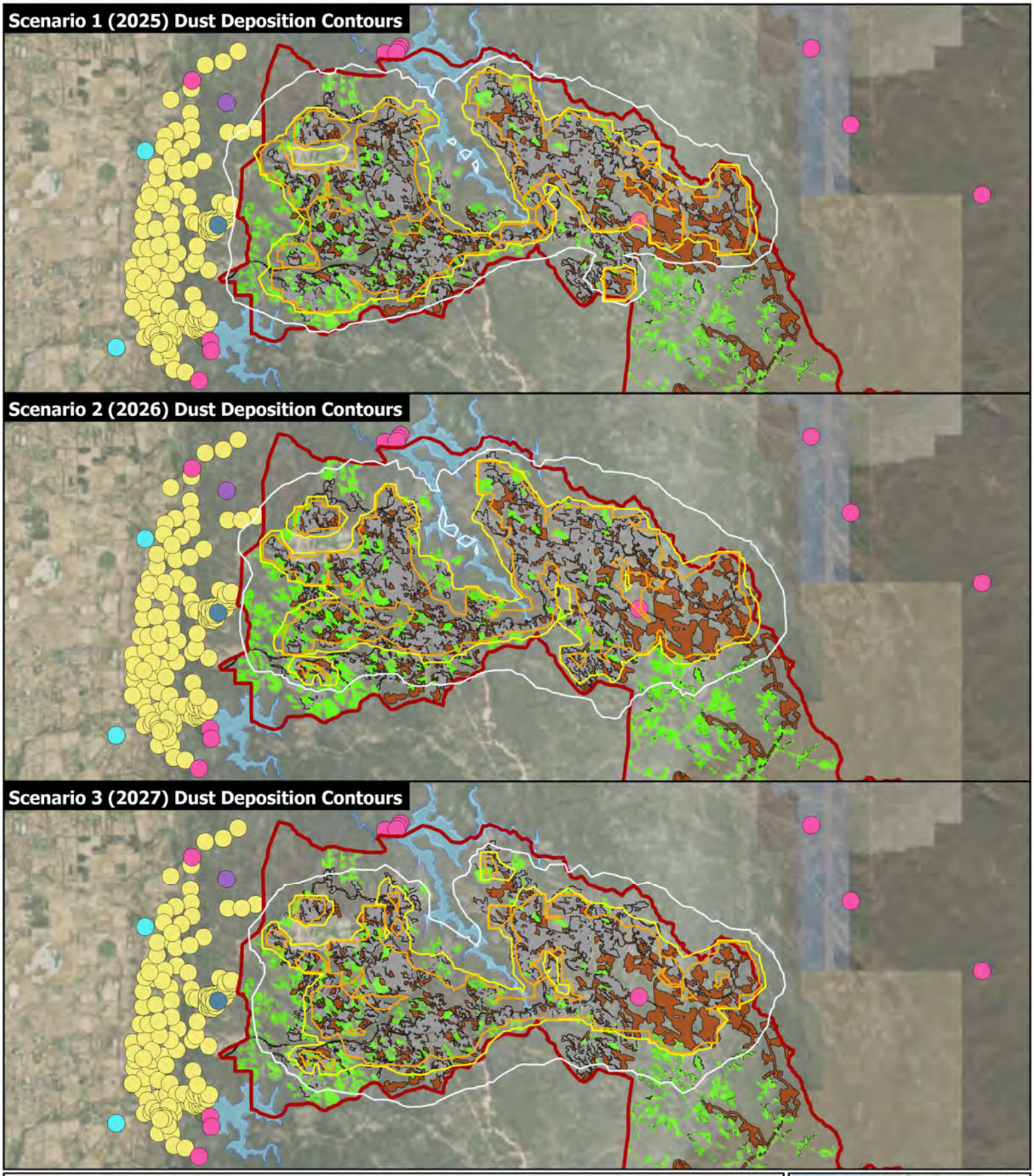
Scale: 1:200,000 at A4

Date Printed: 28/02/2025

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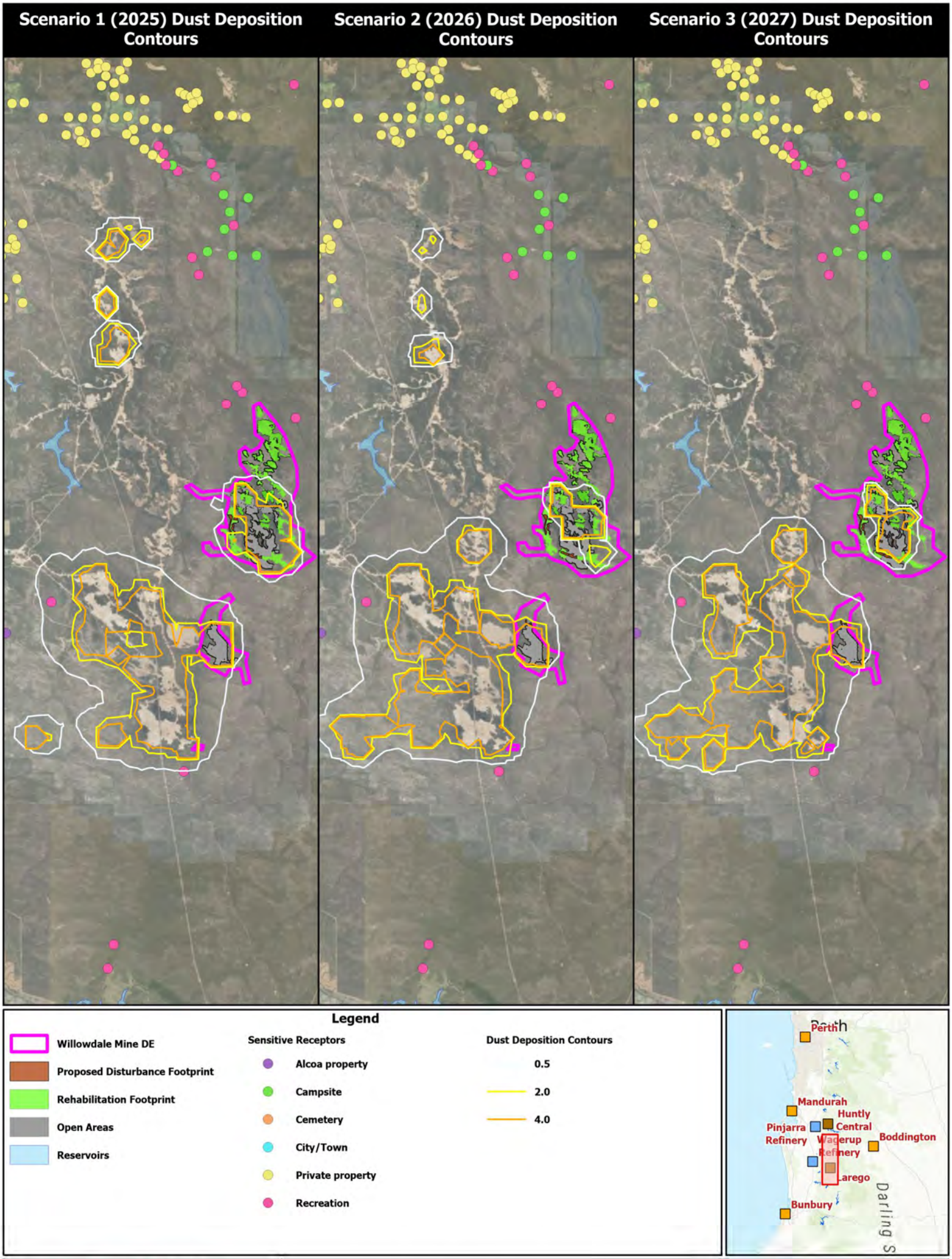
Alcoa

Figure 5-74 Willowdale Mine DE - 24 Hour Average PM10 Concentration Scenario



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-75 Huntly Mine Region Predicted Incremental Annual Average Dust Deposition (worst case scenario)



Bauxite mining on the Darling Range in the Southwest of WA - 2023 to 2027

Figure 5-76 Willowdale Mine Region Predicted Incremental Annual Average Dust Deposition (worst case scenario)

5.7.3.11 Light

Prevailing light sources within the Mine DEs are dominated by the existing mine facilities situated along the existing conveyor line and the mine pits in operation. The townsite of Jarrahdale, Harvey and Yarloop emit comparatively limited light. Other recognisable light sources within or adjacent to the Huntly Mine DE include Karnet Prison and North Dandalup; and Wagerup Alumina Refinery in the vicinity of the Willowdale Mine DE.

The main light sources associated with mining activities will comprise permanent lighting at mine facilities and conveyor transfer stations, vehicle headlights and mobile LED light towers at operating mine pits. Due to the distance from townsites, rural properties and overnight campsites, it is unlikely that lighting associated with mining activities will have a significant impact on night-time amenity.

5.7.3.12 Odour

No works have been undertaken to assess the impacts of odour caused by the proposal; however, it is considered unlikely that the proposed works will result in any increased odour.

5.7.4 Potential Environmental Impacts

The following Proposal activities have the potential to impact social surroundings (amenity):

- Clearing of native vegetation;
- Operations, mining, refining and other operational activities including transport;
- The physical presence of infrastructure; and
- Rehabilitation activities.

The Proposal may result in the following potential impacts to social surroundings (amenity):

- Impacts to visual amenity and sense of place from clearing of vegetation, mining and construction activities and dust generation;
- Impacts to amenity and sense of place from construction and operational noise and audibility of machine derived tones; and
- Impacts on recreational use of areas due to direct disturbance, noise, dust deposition and traffic.

Potential impacts to the economic surroundings of the Proposal are considered to be indirect and associated with impacts to the tourism value of the area and supply of drinking water. Table 5-92 presents an overview of the potential impacts to amenity receptors identified in the vicinity of the Huntly and Willowdale Mine DE.

Table 5-92: Potential impacts to amenity receptors

ID	Asset	Access	Visual Impact	Noise Impact	Dust Impact	Impact Potential
-	105 Preece Road, Keysbrook	Not restricted	Unlikely	Noise from rehabilitation activities and infrastructure may be audible but is compliant.	Potentially for cumulative exceedance of guideline values resulting from high background levels.	Unlikely
-	168 Scarp Road, Keysbrook	Not restricted	Unlikely	Potential for exceedance of Noise Regulations only when considering tonality influences.	Potentially for cumulative exceedance of guideline values resulting from high background levels.	Construction and mining noise may be audible.
-	2136 Kingsbury Drive, Jarrahdale	Not restricted	Unlikely	Unlikely	Unlikely	Unlikely
-	229 Scarp Road, Keysbrook	Not restricted	Unlikely	Potential for exceedance of Noise Regulations (Sundays & Public Holidays, evenings and nights).	Potentially for cumulative exceedance of guideline values resulting from high background levels.	Construction and mining noise likely audible.
-	311 Firns Road, Serpentine	Not restricted	Unlikely	Unlikely	Unlikely	Unlikely
-	341 Balmoral Road, Jarrahdale	Not restricted	Unlikely	Unlikely	Unlikely	Unlikely
-	88 Yamba Drive, Keysbrook	Not restricted	Unlikely	Noise from rehabilitation activities may be audible but is compliant.	Unlikely	Unlikely
-	939 Scarp Road, Keysbrook	Not restricted	Unlikely	Noise from rehabilitation activities may be audible but is compliant.	Unlikely	Unlikely
-	Albany Highway	Not restricted	Unlikely	Unlikely	Unlikely	No impacts presented by Proposal
-	Bibbulmun Nerang Campsite	Not restricted	Unlikely	Unlikely	Unlikely	Unlikely
S2	Bibbulmun Track	Not restricted	Potential for construction and mining activity to be visible at some locations.	Unlikely	Unlikely	Unlikely
BT3	Bibbulmun Track Mount Cooke Campsite	Not restricted	Construction and mining activity to be visible in the distance.	Unlikely	Unlikely	Unlikely
-	Boonering Hill	Not restricted	Construction and mining activity to be visible in the distance.	Noise from rehabilitation activities may be audible but is compliant.	Potential for exceedances of PM_{10} maximum cumulative 24-hour average concentrations resulting from high background levels.	Impact to views resulting from Proposal, and potential minor impacts from noise and dust on amenity value.
MB3	Dandalup Campground (Munda Biddi Trail)	Not restricted	Unlikely	Unlikely	Unlikely	Unlikely
-	Dwellingup	Not restricted	Unlikely	Noise from rehabilitation activities may be audible but is compliant.	Unlikely	Unlikely Impact to amenity values in the area may indirectly impact tourism effecting local operators or businesses which cater to visitors (hotels, cafes, etc.), considered unlikely.
-	Dwellingup State Forest	Restricted around mining operations only.	Certain	Construction and operation noise will be audible at locations depending on proximity to activity.	Dust will be generated from open areas, construction and operation.	Amenity values will be impacted, noting most activity is related to rehabilitation works.
-	Harris River State Forest	Not restricted	Unlikely	Unlikely	Unlikely	No direct impacts presented by Proposal
R20	Hotham Valley Tourist Railway	Not restricted	Open areas and rehabilitation works will be visible at some locations.	Noise from rehabilitation activities may be audible,	Dust will be generated from open areas and rehabilitation activities.	Amenity values will be impacted, noting most activity is related to rehabilitation works.
R22	Hotham Way Drive Trail	Not restricted	Open areas and rehabilitation works will be visible at some locations.	Noise from rehabilitation activities may be audible.	Dust will be generated from open areas and rehabilitation activities.	Amenity values will be impacted, noting most activity is related to rehabilitation works.

ID	Asset	Access	Visual Impact	Noise Impact	Dust Impact	Impact Potential
-	Jarrahdale	Not restricted	Unlikely	Unlikely	Unlikely	No direct impacts presented by proposal. Impact to amenity values in the area may indirectly impact tourism effecting local operators or businesses which cater to visitors (hotels, cafes, etc.), considered unlikely.
-	Jarrahdale State Forest	Restricted around mining operations only.	Certain	Construction and operation noise will be audible at locations depending on proximity to activity.	Dust will be generated from open areas, construction and operation.	Amenity values will be impacted.
R15	Jarrahland Wildflower Trail Scenic Drive – Del Park Road	Not restricted	Open areas and rehabilitation works will be visible at some locations.	Noise from rehabilitation activities may be audible.	Dust will be generated from open areas and rehabilitation activities.	Amenity values will be impacted, noting most activity is related to rehabilitation works.
R12	Jarrahland Wildflower Trail Scenic Drive – Kingsbury Drive	Not restricted	Open areas, construction, mining, and rehabilitation works will be visible at some locations.	Noise from activities may be audible.	Dust will be generated from open areas and rehabilitation activities.	Amenity values will be impacted.
-	Karnet Prison Farm	Not restricted	Open areas, construction, mining, and rehabilitation works will be visible.	Likely exceedance of Noise Regulations at all times.	Potentially for cumulative exceedance of guideline values with Proposal contributing a large portion.	Amenity values will be impacted.
-	Karnet Prison Farm infrastructure	Not restricted	Open areas, construction, mining, and rehabilitation works will be visible.	Likely exceedance of Noise Regulations at all times.	Potentially for cumulative exceedance of guideline values with Proposal contributing a large portion.	Amenity values will be impacted.
-	Keysbrook	Not restricted	Unlikely	Noise from activities may be audible at rural properties but is compliant.	Potentially for cumulative exceedance of guideline values resulting from high background levels at rural properties.	Unlikely to impact townsite but potential to have some impact on rural properties.
-	Keysbrook Fire Station	Not restricted	Unlikely	Unlikely	Unlikely	Unlikely
-	Lane Poole Reserve	Restricted around mining operations only.	Certain	Construction and operation noise will be audible at locations depending on proximity to activity.	Dust will be generated from open areas, construction and operation.	Amenity values will be impacted.
-	Lot 813 Hines Road, North Dandalup	Not restricted	Unlikely	Noise from rehabilitation activities may be audible but is compliant.	Potentially for cumulative exceedance of guideline values resulting from high background levels.	Unlikely
-	Marrinup Prisoner of War Camp	Not restricted	Unlikely	Noise from rehabilitation activities may be audible but is compliant.	Unlikely	Unlikely
-	Monadnocks Conservation Park	Not restricted	Construction and mining activity to be visible in the distance.	Construction and operation noise will be audible at locations depending on proximity to activity.	Dust will be generated from open areas, construction and operation and has the potential to infringe on the park.	Amenity values will be impacted.
-	Mount Cooke	Not restricted	Construction and mining activity to be visible in the distance.	Unlikely	Unlikely	Unlikely
-	Mount Vincent	Not restricted	Disturbance will remain visible in the distance until vegetation re-establishes.	Unlikely	Unlikely	Unlikely
BT5	Mount Wells	Not restricted	Construction and mining activity to be visible in the distance.	Unlikely	Unlikely	Unlikely
-	Mt William fire tower	Not restricted	Disturbance may be visible in the distance.	Unlikely	Unlikely	Unlikely
S1	Munda Biddi Trail	Not restricted	Potential for construction and mining activity to be visible at some locations.	Construction and operational noise likely audible at some locations.	Dust will be generated from open areas and rehabilitation activities.	Amenity values will be impacted, noting most activity is related to rehabilitation works.
-	North Dandalup	Not restricted	Unlikely	Unlikely	Potentially for cumulative exceedance of guideline values resulting from high background levels.	Unlikely

ID	Asset	Access	Visual Impact	Noise Impact	Dust Impact	Impact Potential
-	North Dandalup Dam	Not restricted	Construction and mining activity to be visible in the distance.	Unlikely	Potentially for cumulative exceedance of guideline values resulting from high background levels.	Amenity values will be impacted, noting most activity is related to rehabilitation works. Impact to water quality (refer Section 6.3) although unlikely, could have implications for the provision of drinking water.
-	Pinjarra	Not restricted	Unlikely	Unlikely	Unlikely	No direct impacts presented by proposal. Impact to amenity values in the area may indirectly impact tourism effecting local operators or businesses which cater to visitors (hotels, cafes, etc.), considered unlikely.
LS1	POW ruins campsite	Not restricted by Proposal.	Unlikely	Unlikely	Unlikely	Unlikely
-	Serpentine	Not restricted	Unlikely	Unlikely	Unlikely	No direct impacts presented by proposal. Impact to amenity values in the area may indirectly impact tourism effecting local operators or businesses which cater to visitors (hotels, cafes, etc.), considered unlikely.
-	Serpentine Dam	Not restricted	Potential for construction and mining activity to be visible at some locations.	Noise from activities may be audible.	Potentially for cumulative exceedance of guideline values with Proposal contributing a large portion.	Amenity values will be impacted. Impact to water quality (refer Section 5.5) although unlikely, could have implications for the provision of drinking water.
RS2	Serpentine Dam recreational area	Not restricted	Construction and mining activity to be visible in the distance.	Noise from activities may be audible.	Potentially for cumulative exceedance of guideline values with Proposal contributing a large portion.	Amenity values will be impacted.
-	Serpentine National Park	Restricted around mining operations only.	Potential for construction and mining activity to be visible at some locations.	Noise from activities may be audible.	Potentially for cumulative exceedance of guideline values with Proposal contributing a large portion.	Amenity values will be impacted.
-	Serpentine Pipehead Dam	Not restricted	Unlikely	Noise from activities may be audible at some locations.	Potentially for cumulative exceedance of guideline values close the DE.	Amenity values may be impacted.
O12	South Dandalup Dam	Not restricted	Disturbance will remain visible in the distance until vegetation re-establishes.	Noise from rehabilitation activities may be audible.	Dust will be generated from open areas and rehabilitation activities.	Amenity values will be impacted, noting most activity is related to rehabilitation works. Impact to water quality (refer Section 5.5) although unlikely, could have implications for the provision of drinking water.
-	South Western Highway	Not restricted	Unlikely	Unlikely	Unlikely	No impacts presented by Proposal
BT6	White Horse Hills Campsite	Not restricted	Construction and mining activity to be visible in the distance.	Mining noise may be audible with a risk of non-compliance during the night when operations are undertaken in the southeast of the O'Neil mine area.	Potential for exceedances of PM_{10} maximum cumulative 24-hour average concentrations resulting from high background levels.	Potential minor impact to amenity values views resulting from Proposal.
-	Youralling State Forest	Not restricted	Unlikely	Unlikely	Unlikely	No direct impacts presented by Proposal

5.7.4.1 Direct Impacts

5.7.4.1.1 Impact to Visual Amenity from Mining Operations and Infrastructure

Impacts to landscape character occur as a result of clearing and mine operation with impacts lasting until rehabilitation has been completed and vegetation established. Visual impacts are considered medium to long term as staged rehabilitation within existing and future mining areas occurs. Alcoa is committing to improving timeframes for rehabilitation, with rehabilitation intended to commence as soon as practicable from mining completion, with a risk-based process utilised to determine rehabilitation priority (which includes visual impacts). Rehabilitation becomes established to a mature stage at 16 to 30 years from completion (GHD, 2025a).

Three LCUs were identified across the DE, noting no formal visual impact assessment was completed for the south Huntly Mine DE. Of the three LCUs, construction and mining activity within O'Neil East mine area (northeastern Huntly Mine DE) was the only location considered to result in a high impact; namely due to the limited existing disturbance, meaning new works would have a greater impact to the visual amenity of the area. Landscape values within LCU1 included the State Forest vegetation, spatial qualities and natural characteristics which offer a high value for ecotourism in the area and are heavily linked with the sense of place. Most activity is proposed within LCU2 of which mining disturbance is already considered characteristic of the area, which provides for a low landscape value and limits the magnitude of change. LCU3 was noted within the Willowdale area but will not be impacted by the Proposal (GHD, 2025a; 2025e).

GHD (2025a; 2025e) identified representative viewpoints in the vicinity of the DE from which the mine pits or infrastructure may potentially be visible, through a zone of theoretical visibility (ZTV) assessment and viewpoint assessment. The assessment comprised a review of land use and features to identify where residents or visitors could have views within the ZTV towards the DE, including urban and rural properties, public roads and recreational trails and facilities. Elevated viewpoints are considered to have a higher likelihood of visual amenity impacts, with the ridge to the east of the DE providing many viewing locations along the Bibbulmun track. The Bibbulmun Track is of state significance and visual impacts to the elevated viewpoints may affect a few to several thousand visitors each year. The visual impacts that may occur at the elevated viewpoints are expected to gradually increase as mining progresses.

Due to the proximity of the DE, mining disturbance such as cleared vegetation, bare ground and pits will be visible in the mid to background from Mount Cooke, Mount Vincent, Mount Wells and Boonering Hill (Table 5-88).

Mining disturbance will also be visible from ground level where disturbance runs adjacent to local roads, the Hotham Tourism Railway and in the background from several vantage points around the dams within the Huntly Mine DE. Rehabilitation reduces much of the visual impact from about five years of age, as the canopy begins to obscure the ground and blend with the colour of the surrounding forest. The mitigating effect of rehabilitation is greater when viewed from a distance of a few kilometres (GHD, 2023d). Alcoa uses a risk-based process to determine rehabilitation priority, ensuring rehabilitation is completed as soon as practicable following mining. On average rehabilitation is typically completed within six years

of rehabilitation commencing and so visual impacts at the elevated viewpoints are expected to be substantially reduced by about 2035.

The Willowdale Mine DE is more secluded with impacts to be less noticeable and therefore less significant in terms of visual amenity impact.

5.7.4.1.2 Impacts to Amenity through Construction and Operational Noise

Potential noise generating sources during construction, mining and rehabilitation activities include:

- Fixed plant: ROM, crusher, diesel generators and overland conveyors; and
- Mobile plant in mine pits and haul roads: excavators, haul trucks, loaders, graders, dozers, scrapers, blast drills, road trains, ancillary trucks, rock breaking excavators, watercarts.

The dominant noise sources affecting the received levels at NSRs are the operational mobile equipment within mine pits and haul roads and undertaking development and rehabilitation activities. Fixed plant is located relatively centrally within the mine regions and is generally further from NSRs, thereby contributing less noise.

NSRs within or within close proximity to the Huntly Mine DE are the most impacted by operational noise with other mine areas being further away from developed areas and overnight recreational spaces. Karnet Prison is the most impacted area with GHD (2024h) predicting likely exceedances under worse case conditions (Table 5-90) of a maximum 10 dB(A) over limits prescribed in the *Environmental Protection (Noise) Regulations 1997*, and is in close enough proximity to mine areas to be impacted by blast noise. Noise management will need to be implemented at this location (see Section 5.7.5), which is included in a Noise Sensitivity Zone as shown in Figure 5-69. Despite potential impacts arising from the proposal, Karnet Prison is situated within existing Alcoa mining areas and so proposed works do not present new impacts.

GHD (2024h; 2024i) also predicted potential noise impacts for rural Keysbrook residential properties in 2025 based on the mine plan for the Myara mine area and for White Horse Hills Campsite in 2027 based on the mine plan for the O'Neil mine area. Noise management will need to be implemented at this location (see Section 5.7.5) which is included in a Noise Sensitivity Zone as shown in Figure 5-69.

The audibility of mining noise at the NSRs depends on the ambient baseline levels, weather conditions and tonal content of the noise. Baseline noise levels established for the Huntly Mine DE (Table 5-89) range significantly based on location with potential shown for baseline levels to exceed prescribed noise limits (note baseline levels are likely to include operational noise from Alcoa's existing operations). Mining noise is assessed as audible if the predicted noise level values protrude above the ambient monitoring data by more than 3 dB as a person typically does not detect a change in noise levels below 2 to 3 dB (David Bies, 2018). Operational noise is likely to be audible at Karnet Prison and potentially at rural Keysbrook residential properties and White Horse Hills Campsite under worse case conditions and the location of activity (GHD, 2024h; 2024i), however it is also realistic to assume that operational noise will be audible at locations within the DE at locations within close proximity to activity. This produces a potential for amenity to be diminished when conducting recreational activities within the NJF however all campsites are unlikely to be impacted by noise.

Notwithstanding the above, under realistic operational conditions, all NSRs are expected to comply with noise criteria at all periods of the day. With operational noise management planning practices such as those detailed in Section 5.7.5, noise compliance can be achieved.

No noise assessments have been undertaken for the south Huntly Mine DE. Proposed works in the south Huntly Mine DE are primarily associated with rehabilitation and an existing conveyor and so noise impacts would be expected to be existing or short term. However, it is noted that the townsite of Dwellingup is in proximity and so noises derived from rehabilitation works may be audible.

The Willowdale Mine DE is secluded within the NJF with fewer identified NSRs in proximity. Based on proximity to both DE operational noise may be audible at locations on the Munda Biddi trail and Bibbulmun track. There were no other impacts predicted for any other NSRs.

5.7.4.1.3 Impacts to Amenity from Blasting Noise and Vibration

Blasting will occur on an approximately daily basis during mining, generating air blast noise and vibration. The assessment indicates that the peak air blast level will attenuate within a 1.2 km radius to be below the 120 dB(L) maximum limit prescribed in the Noise Regulations for residential receivers (GHD, 2024h; Wood, 2023). Mining will not occur within 1.2 km of townsites and is unlikely to occur within 1.2 km of any recreational campsite. Karnet Prison and 229 Scarp Rd, Keysbrook are located within 1.2 km of a pit and so mitigation measures as included in Section 5.7.5 will need to be implemented.

The assessment indicates that ground borne vibration from blasting is likely to attenuate within approximately 200 m to below the 5 mm/s limit recommended by Australian Standard 2187.2 to avoid damage to buildings and surrounding structures (GHD, 2024h; Wood, 2023). Blasting will not occur within 200 m of buildings or structures and so is unlikely to cause damage.

No formal blast assessments have been undertaken for the south Huntly or Willowdale Mine DE, however the same criteria discussed above has been applied to all mine areas and no impacts have been identified within these DE.

5.7.4.2 Indirect Impacts

5.7.4.2.1 Impacts to Amenity from Dust Deposition

The Proposal will generate dust emissions from mine development, mining and rehabilitation as well as from open areas in the period between clearing and completion of rehabilitation. Dust deposition has potential to cause nuisance and impacts to amenity. Dust emissions will vary substantially between and within years as the activities progress over the DE.

The greatest potential impact occurs in the vicinity of Karnet Prison which experiences the highest potential dust deposition and changes to air quality concentrations due to being located within the Huntly Mine DE in close proximity to mining operations. Impacts are anticipated to be the worst in initial years of the Proposal when activities are in the closest proximity. In year 2, dust deposition is predicted under worse case operational and meteorological conditions to contribute up to 2 g/m^2/month of dust deposition to the Karnet Prison farm area and result in predicted incremental PM_{10} concentrations of up to 78.8 $\mu g/m^3$ (GHD, 2025k). This shows the potential for air quality guideline limits to be

exceeded at this location from activities directly relating the proposal, noting that background concentrations for the area make up the remaining dust in air and are also considered high.

PM_{10} concentration limits from the Air NEPM (NEPC, 2021) were not predicted to be exceeded in any scenario based on operational activities alone. Background concentrations of air borne dust is responsible for a large portion of the cumulative concentration (GHD, 2025k). Cumulative 24-hour PM_{10} concentrations are predicted to be exceeded at a number of sensitive receptors over the life of the Proposal as a result of high background concentrations (GHD, 2025k), with receptors in closest proximity to the Huntly Mine DE having the greatest potential impact, namely rural properties between Keysbrook and the Huntly Mine DE (refer to Figure 5-71 to Figure 5-75), and White Horse Hill Campsite and Boonering Hill.

The assessment showed that the proposed activities are unlikely to have a significant impact on air quality in the area when considering the dust generation potential of the Proposal in isolation. When also factoring the background concentration of airborne dust, there is the potential for cumulative exceedances of guideline concentration values at most sensitive receptors considered for the Huntly Mine DE. The Proposal therefore has the potential to impact on the experience of visitors utilising recreational areas (such as Serpentine Dam recreational area of North Dandalup Dam) or nearby residential properties under worse case operational conditions, should the Proposal activities be undertaken in close proximity.

GHD (2025l) completed an air quality impact assessment for the Larego mine region (covering the Willowdale Mine DE) which predicted potential dust impacts at Hoffman Mill campground which has been closed since November 2022 and thus no impacts are expected.

5.7.4.2.2 Impacts to Amenity from Light Spill

No formal assessments have been undertaken to identify impacts relating to light spill from the operations. Alcoa (2023b) have identified light sources in the vicinity of the mine region to be:

- Alcoa mine facilities including permanent lighting at mine facilities and conveyor transfer stations, vehicle headlights and mobile light towers at operating mine pits.
- Townsites including North Dandalup, Keysbrook, and Waroona and surrounding rural properties (which emit limited light).
- Other mines.

Due to the distance from towns, most rural properties and overnight campsites, it is unlikely that lighting for the new mine facilities will have a significant impact on nighttime amenity. The proposed Huntly and Willowdale pits are expected to have similar light emissions to the existing pits in the region. Review of existing operations indicate that substantial radiance extends for a radius of approximately 1-2 km from pits. Huntly and Willowdale pit lighting may be seen from elevated vantage points but is unlikely to visible from rural properties, townsites or campsites as they lie more than 2 km from the mine areas.

5.7.4.2.3 Impacts to Amenity from Traffic During Operations

No formal assessments have been undertaken to identify impacts relating to traffic.

The Proposal is not expected to result in significant increase in the operational workforce or in workforce travel routes from the existing operations. The operational workforce is expected to comprise approximately 160 personnel during the day shift and 75 personnel during the night shift. All operations personnel would be Drive In Drive Out as per current operations.

At Huntly, access along North Road remains open to allow public access from Huntly Road to the intersection with Whittaker Road. Access roads to the east of the McCoy and O'Neil mining regions will remain closed to the public until mining activity is complete.

Alcoa installed gates around the perimeter of the Myara region in April 2011. Access is closed to the public south of Kingsbury Drive and east of Scarp Road. Access plans were reviewed with the DBCA and the Water Corporation to determine an appropriate boundary prior to the installation of gates. An extension of the Myara region will require a new access and gating plan be developed with DBCA in coming years.

A sealed road runs from Scarp Road to the west of the Myara crusher site and can be accessed via Hines Road in North Dandalup. Large service vehicles and machinery are not permitted to access Myara from this road to reduce heavy vehicle interaction with surrounding neighbours. These vehicles must access the site via the haul road system from McCoy instead.

At Willowdale, access around the mining region is provided by Scarp Road on the western flank from Nanga Brook Road through to Willowdale Road. Access from Nanga Brook Road through to Nanga Road on the eastern boundary of the Orion mining region has been maintained via an underpass beneath the northern arterial mine haul road. Nanga Road provides public access north and south along the western boundary of the Lane Poole Reserve, outside of the mining area. An underpass is in place to maintain north-south access along Nanga Road. A section of King Jarrah Track was also closed to the public for the period of Keats mining.

Willowdale Road provides public access from the South Western Highway to Zig Zag Road, which diverts onto Nanga Road and Driver Road to access forest regions to the east. East-west access has been maintained along Driver Road via an underpass to enable access to Logue Brook Road on the eastern boundary of the mine. From Willowdale Road the public can use Hoffman Road and then Dandenong Formation to head south along the western boundary of the mine. Kevron Road and Clarke Road form the southern boundary of the Larego mine region. Official access to Willowdale mine is via the security gate at the Arundel offices on Willowdale Road. Approved personnel are granted access through the security gates using a personal identification number, which records personnel and contractor vehicular movement.

In the interest of safety, some public roads and forest access ways, within and adjacent to the mine regions, are closed and manned by sentries for short periods during blasting. Access to Disease Risk Areas (DRA) within the mine is by a permit system for all vehicles. This system was developed through the Alcoa/DEC (now DBCA) Working Arrangements.

5.7.4.2.4 Impact on Recreational Use of Areas

The Proposal is not expected to have any direct impacts on recreational areas or prevent access to recreational facilities. Noise generated from plant and machinery may be audible at some locations used for recreational purposes, as well as the potential for some locations to experience elevated dust levels if not appropriately managed. Most activities will occur amongst existing operations resulting in a negligible to low magnitude of change for much of the DEs.

For safety reasons, there are restrictions to public access within the Mine DEs. These restrictions mostly apply to areas of State Forest that may be used by some local residents and visitors for informal recreation outside of defined trails and facilities that are managed and promoted. Public access is restricted by signage, gates and obstructions to roads and forest tracks where required.

Information is not available on the extent of informal recreation; however, the majority of recreational use is expected to be via formal trails and facilities that are maintained (e.g., with signage and parking) and promoted (e.g., with maps and guidance). The restriction to public access of the DE will occur for an extended period until rehabilitation has sufficiently established and the regions are closed and relinquished, at which point the DE will revert to State Forest and be open to public access. Over this period, members of the public will continue to have access to extensive areas of State Forest as well to Serpentine National Park, Monadnocks Conservation Park and Lane Poole Reserve.

The NJF has high tourism values, with the conservation areas and recreational facilities considered a draw for visitors to the area. While the Proposal does not directly impact access to managed areas, the experience had by visitors has the potential to be diminished due to the impact of amenity values described in previous sections. This has the potential to have an indirect impact to local business which rely on visitors to the area. Any indirect impacts are considered to be minor due to the avoidance of conservation areas and recreational facilities which are associated with the highest values.

5.7.5 Mitigation

Alcoa is experienced in preventing and managing impacts to social surroundings in the NJF, having operated in the area since 1963. Alcoa's environmental management incorporates the mitigation hierarchy consistent with Western Australian guidance, which is in order of priority:

- Impact avoidance;
- Impact minimisation; and
- Rehabilitation.

Recreational Trails and Facilities Management Plans (RTFMP) for the Huntly and Willowdale mines (Appendix 9 and Appendix 11) are currently being implemented as part of existing operational practises and are expected to be revised to reflect the information, mitigations and outcomes provided in this ERD. Therefore, the ERD is considered to take precedence over the RTFMPs.

Another primary aspect of Alcoa's mitigation measures includes the active avoidance and appropriate planning of activities around sensitive areas. Alcoa have implemented and will continue to utilise Mining Avoidance Zones (MAZ) and Limited Disturbance Areas (LDA)

(refer Figure 5-77 and Figure 5-78). In addition, Mining Sensitivity Zones (MSZs) are proposed based on social impact assessments, whereby further mitigations may be required to ensure impacts are acceptable. The implementation of MAZs, LDAs and MSZs is considered an overly cautious approach suitable to ensure compliance with associated regulations and standards.

MSZ are established based on the criteria described in Table 5-93 and include the above-mentioned Noise Sensitivity Zones. Clearing or mining within the MSZs will require an area specific management plan to detail avoidance and minimization measures. Three Noise Sensitivity Zone types (Figure 5-77 and Figure 5-78) are proposed:

- Do Not Mine Zone – determined by final noise modelling whereby no mining will occur to maintain compliance with Assigned Levels
- Premium Mining Zone – high sensitivity whereby noise emissions may be controlled through an optimized mining (low noise) fleet which considers engine bay treatments, upgraded exhaust silencers or smaller/lower powered fleet to provide a noise reduction of 10 dB compared to the standard fleet. In addition, active modelling and customized noise controls may also be implemented.
- Attenuated Mining Zone – medium sensitivity whereby mining may be controlled through an optimized mining (low noise) fleet which considers engine bay treatments or upgraded exhaust silencers to provide a noise reduction of 5 dB compared to the standard fleet. In addition, active modelling and customized noise controls may also be implemented.

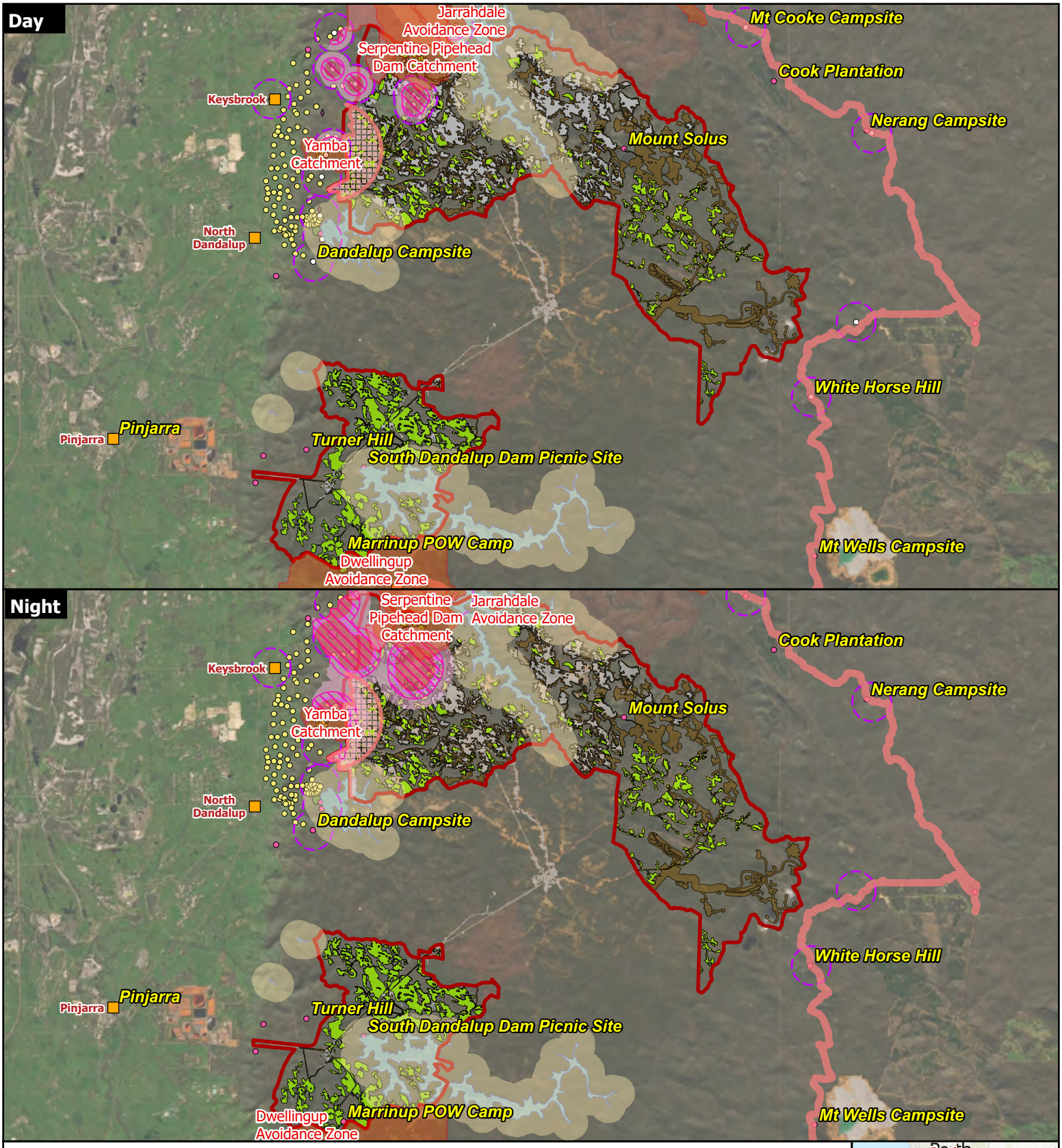
Alcoa is currently revising its noise model and a Noise Management Plan will be developed if acceptable impacts are not met and Mining or Noise Sensitivity Zones are required. Alcoa intends for the Noise Management Plan (and other management plans being developed and revised) to align with the mitigations proposed (and in some cases implemented) in Table 5-93 as a minimum standard.

Mitigation measures associated with social surroundings (amenity) impacts are detailed in Table 5-94.

Table 5-93: Mining Sensitivity Zones

Factor	Criteria	Applicability	Recommended Buffer
Visual	• maintain effective visual screening in the foreground • avoid activities in the mid ground where foreground visual screening is absent • background visibility from elevated distance viewpoints is not considered in the MSZ.	• residential properties • recreational campsites • recreational day use areas • State and regional • significant trails	Default 200 m visual screening provided for foreground, there may be opportunities to reduce the buffer distance subject to ground truth transect and consideration of local topography and vegetation structure that demonstrates effective screening, noting that the understorey vegetation screening may be substantially reduced following prescribed burns

Factor	Criteria	Applicability	Recommended Buffer
Noise	• daytime criteria: 40 dB (A) L_{A10} assigned noise level from 9 am to 7 pm during Sundays and public holidays • nighttime criteria: 35 dB(A) L_{A10} assigned noise level from 10 pm to 7 am (or 9 am Sunday and public holidays) • adopted from Regulation 8, Noise Regulations	• residential properties (daytime and night-time) • recreational campsites (daytime and night-time) • recreational day use areas (daytime only) • State and regional • significant trails	500 m to comply with 40 dB(A) – daytime Do Not Mine Zone 1100 m to comply with 35 dB(A) – nighttime Do Not Mine Zone
Blast Over-pressure	• 120 $dB_{LZ\ peak}$ • adopted from Regulation 11, Noise Regulations	• residential properties	1200 m to comply with 120 $dB_{LZ\ peak}$
Dust deposition	• Deposited dust: 2g/m^2/30 days (above background levels) • adopted from Draft Guideline: Dust Emissions (DWER, 2021d)	• residential properties • recreational campsites • recreational day use areas	500 m to comply with 2g/m^2/30 days

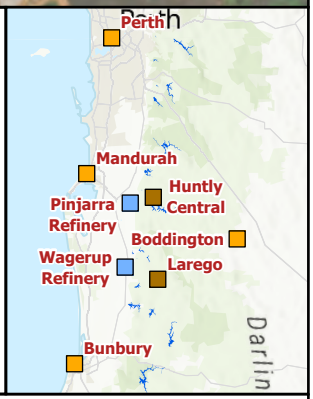


Legend

Mining Avoidance Zones
- Mining Avoidance Zones
- National Parks
- Conservation Parks
- Yamba Low Impact Mining Zone
- Bibbulmun Track
- Do Not Mine Sensitivity Zone

Limited Disturbance Area
- 1km Reservoir Top Water Level
- Premium Sensitivity Zone
- Attenuated Sensitivity Zone
- Blast Sensitivity Zones
- Huntly Mine DE
- City/Town
- Reservoirs

Sensitive Receptors
- Alcoa property
- Campsite
- City/Town
- Government property
- Private property
- Recreation
- Other
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite Mining on the Darling Range in the Southwest of WA-2023 to 2027

Figure 5-77 Huntly Mine DE - Mining Avoidance and Noise Sensitivity Zones

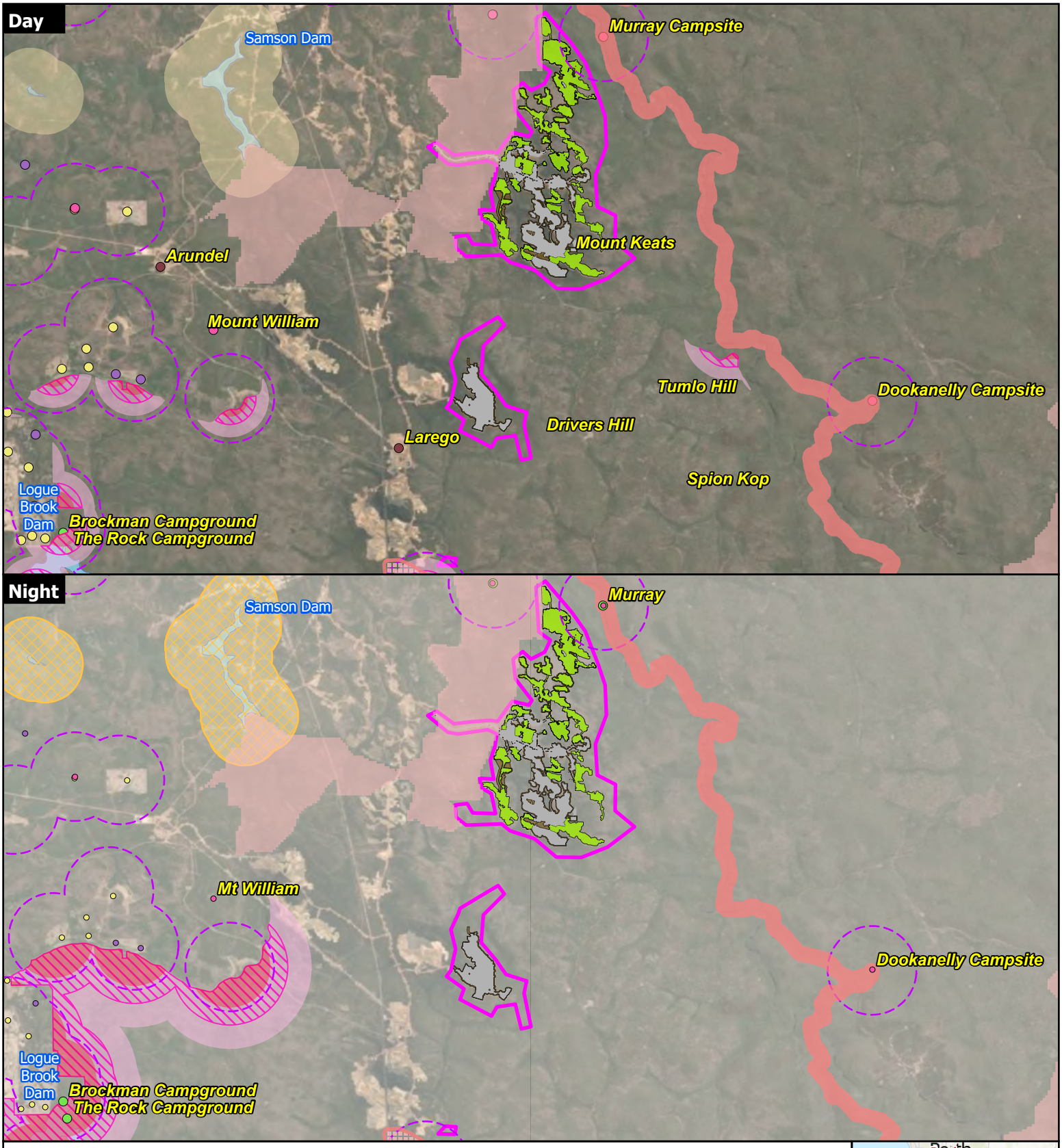
Kilometres
0 2 4 6 8 10 12

Scale: 1:320,000 at A4

Date Printed: 27/02/2025

N

Alcoa



Legend

Mining Avoidance Zones

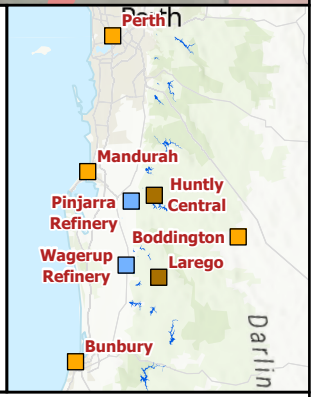
- Mining Avoidance Zones
- National Parks
- Conservation Parks
- Yamba Low Impact Mining Zone
- Bibbulmun Track
- Do Not Mine Sensitivity Zone (Day)

Limited Disturbance Area

- 1km Reservoir Top Water Level
- Blast Sensitivity Zones
- Premium Sensitivity Zone (Day)
- Attenuated Sensitivity Zone (Day)
- Willowdale Mine DE
- Mine
- Reservoirs

Sensitive Receptors

- Alcoa property
- Campsite
- Private property
- Recreation
- Proposed Disturbance Footprint
- Open Areas
- Rehabilitation Footprint



Bauxite Mining on the Darling Range in the Southwest of WA - 2023 to 2027

Kilometres
0 5 10 15 20 25 30

N

Figure 5-78 Willowdale Mine DE - Mining Avoidance and Noise Sensitivity Zones

Scale: 1:140,000 at A4

Date Printed: 27/02/2025

Alcoa

Table 5-94: Avoidance and minimisation of potential impacts to social surroundings (amenity)

Potential Impacts and Mitigations	Industry standard, best practice and certainty of effectiveness
Clearing and other operational activities result in visual amenity impacts and decreased amenity values.	
Avoid	
Implement Mining Avoidance Zones for significant areas of recreation and conservation value, including • Dwellingup, Kingsbury Drive area, Hoffman Mill, Bibbulmun Track, portions of Lane Poole Recreation Reserve, and other significant conservation areas as shown in relevant maps. • 200 m public roads or recreational trails buffers (or as determined through visual impact assessments) to prevent impacts on screening vegetation within Hoffman Mill, Logue Brook Dam, Balmoral POW Camp, and Dwellingup Recreation Reserve. as shown in Figure 5-77 and Figure 5-78.	Established practise, high certainty.
Implement Noise and Mining Sensitivity Zones where modelling indicates unacceptable impacts, whereby an area specific management plan will be developed to ensure appropriate mitigations (avoidance and minimisation) to ensure acceptable impacts	Established practise, high certainty
Earthworks, mine pit locations and haul road networks will be sited within the natural topographic context of the landscape where practicable to do so, and, where possible, situated beyond the natural screening of vegetation.	Best practice technique may be affected by bushfires, moderate certainty.
No clearing or mining of ore in conservation reserves.	Best practice technique may be affected by bushfires, moderate certainty.
MAZs and LDAs are demarcated in construction spatial data to guide construction personnel and included on construction maps to avoid environmental pollution.	Established practise, high certainty.
Develop MAZs to prevent direct impacts to screening vegetation within 200 m of public roads or recreational trails and facilities, where possible.	Best practice technique, may be affected by bushfires, moderate certainty.
Minimise	
If mining is proposed within 200 m of a sensitive receptor (including the recreational trails, public roads, and elevated viewpoints), then visual amenity assessments are required. If mining is predicted to be visible from visually sensitive sites (as identified in Section 5.7.3), then a Visual Management Plan must be prepared and implemented in consultation with key stakeholders.	Proposed practise, moderate certainty.
Where possible, stagger mining activities which are visible from visually sensitive sites.	Established practise, moderate certainty.
Minimise landscape and visual impacts to recreational facilities and road interfaces with the provision of screening corridors (based on existing vegetation density and topography) suitable to the area, where possible.	
The material and structural finishes for all built form elements will be compatible with surrounding visual environment to assist the Proposal built form to blend in with surrounding existing vegetation when viewed from elevated distant viewing locations.	Industry standard, high certainty.
Rehabilitate	
Where mine pits, haul roads, and other infrastructure are proposed to be located near existing road corridors or visible from visually sensitive sites, rehabilitation will be commenced as soon as practicable, taking into account a prioritisation process.	Established practice however commencement timeframes may vary due to a range of factors, moderate certainty.
During rehabilitation of mine pits, contouring of the excavated pits will tie them into the surrounding landform and rehabilitation planting will restore the vegetated character of the area when vegetation reaches suitable coverage.	
Noise and vibration impacting upon sensitive receptors.	
Avoid	
Implement Mining Avoidance Zones for significant areas of recreation and conservation value, including the Dwellingup, Kingsbury Drive area, Bibbulmun Track and Lane Pool Recreation Reserve Mining Avoidance Zones, as shown in Figure 5-77 and Figure 5-78.	Established practise, high certainty.
Establish Mining or Noise Sensitivity Zones to minimise noise amenity impacts to potentially impacts sensitive receptors identified through noise impact assessments, with indicative locations detailed in Figure 5-69 and Figure 5-70. Clearing or mining within the MSZs will require an area specific management plan to detail avoidance and minimization measures. Noise Sensitivity Zones consist of: • Do Not Mine Zone – determined by final noise modelling whereby no mining will occur to maintain compliance with Assigned Levels • Premium Mining Zone – high sensitivity whereby noise emissions may be controlled through an optimized mining (low noise) fleet which considers engine bay treatments, upgraded exhaust silencers or smaller/lower powered fleet to provide a noise reduction of 10 dB compared to the standard fleet. In addition, active modelling and customized noise controls may also be implemented, such as no simultaneous working group within 4 km, smaller charge masses utilised, permissible work hours or noise monitoring • Attenuated Mining Zone – medium sensitivity whereby mining may be controlled through an optimized mining (low noise) fleet which considers engine bay treatments or upgraded exhaust silencers to provide a noise reduction of 5 dB compared to the standard fleet. In addition, active modelling and customized noise controls may also be implemented, such as no simultaneous working group within 4 km, smaller charge masses utilised, permissible work hours or noise monitoring	Proposed practise, moderate certainty.

Potential Impacts and Mitigations	Industry standard, best practice and certainty of effectiveness
Implement the Low-Impact Mining Zone for the Yamba area, as shown in Figure 5-77.	Proposed practise, moderate certainty.
The main blast follows a pilot shot which produces lower levels of noise than the main blast. If the pilot blast is above internal pilot noise limits, the main blast is postponed.	Established practise, high certainty.
Noise generated by mining operations is managed to meet the requirements of the *Environmental Protection (Noise) Regulations 1997*. Alcoa does not mine in areas where the pre-mining noise assessment identifies that noise impact on Noise Sensitive Premises (Highly Sensitive Area) cannot be managed below 35dB L_{A10}.	Established practise, high certainty.
Blasting delayed or avoided when wind or weather conditions are likely to impact on amenity of nearby receptors.	Established practise, high certainty.
A blast may not proceed if the predicted impact at a neighbouring property is above the limit identified in the *Environmental Protection (Noise) Regulations 1997*.	Established practise, high certainty.
Minimise	
Noise-sensitive zones have been established which restrict mining activities in more sensitive areas to manage noise impacts to NSRs.	Proposed practise, moderate certainty.
Neighbours are invited to be notified on blasting timing.	Established practise, high certainty.
Alcoa applies internal noise limits of 110 dB at Dwellingup and the Yamba sub-division in Keysbrook, and 115 dB at all other locations.	Established practise, high certainty.
Willowdale schedules mining adjacent to neighbouring properties (on western and northern boundaries) during the daytime and/or when atmospheric conditions will minimise the noise levels received by neighbours.	Established practise, high certainty.
Construction noise will be kept as low as practicable, ensuring it is carried out in with respected to control of noise as outlined in Section 6 of AS 2436-1981 “Guide to Noise Control on Construction, Maintenance and Demolition Sites”.	Proposed practise, moderate certainty.
If mining is proposed within 2 km of a sensitive receptor, then commission noise assessments are required. If predicted noise levels at noise -sensitive sites may exceed assigned levels under the *Environmental Protection (Noise) Regulations 1997*, then a Noise Management Plan must be prepared and implement in consultation with key stakeholders.	Proposed practise, moderate certainty.
Blasting only permitted during specified hours.	Established practise, high certainty.
Noise emissions are managed through regular maintenance (including change out of conveyor rollers and idler cleaning).	Established practise, high certainty.
Alcoa’s noise management system includes live noise modelling at an operation level with fixed and attended noise monitors, predictive modelling, procedures, training, implemented as part of the Integrated Noise Management System.	Established practise, high certainty.
Undertake long-term and short-term planning using noise modelling of planned mine operations over historic and forecast weather conditions to predict audible noise over periods of peak usage.	Established practise, high certainty.
Utilise weather forecasts to predict blast overpressure during periods of peak usage. Postpone blasting if blast overpressure is predicted to exceed standard or use alternative charges to reduce overpressure to standard.	Established practise, high certainty.
Optimum blast charge sizing and spaces to avoid unnecessary energy release which has the potential to generate dust and other emissions.	Established practise, high certainty.
Dust deposition impacting upon sensitive receptors.	
Avoid	
Implement Mining Avoidance Zones for significant areas of recreation and conservation value, including the Dwellingup, Kingsbury Drive area, Bibbulmun Track, and Lane Pool Recreation Reserve Mining Avoidance Zones, as shown in Figure 5-77 and Figure 5-78.	Alcoa’s established practices, high certainty.
Minimise	
If mining proposed within 2 km of a sensitive receptor, then commission dust assessments. Implement Mining Sensitivity Zones (MSZ) which are determined by Social Impact Assessments maintain dust impacts to an acceptable level. This may include a 500 m buffer around residential properties, recreational campsite and recreational day use areas to maintain dust to 2g/m^2/30 days (above background levels). If predicted dust levels at dust-sensitive sites may exceed relevant criteria for dust deposition or 24-hour Ambient Air National Environmental Protection Measure (NEMP), then prepare and implement a Dust Management Plan in consultation with key stakeholders.	Proposed practise, moderate certainty.
Seals are well maintained to provide inlet air filtration for respirable particles, and use of positive pressure air inside cabs to prevent dust penetration	Established practise, high certainty.
Dust suppression techniques on high traffic roads, based on the environmental conditions.	Established practise, moderate certainty.
Most of the conveyor system is covered to minimise dust emissions.	Established practise, high certainty.
Transfer chutes are fitted at the end of the conveyor belts to ensure controlled loading of ore to and from the belt.	Established practise, high certainty.
Rehabilitate	
Rehabilitation within the DE will be undertaken as presented in Section 1.4	Rehabilitation is an established practice but commencement timeframes may vary due to a range of factors, moderate certainty.
Minimise open area footprint and rehabilitate as soon as practicable	
Mine pits within the DE close to receptors will be prioritised for rehabilitation as far as practicable.	

Potential Impacts and Mitigations	Industry standard, best practice and certainty of effectiveness
Light spill impacting upon sensitive receptors decreasing amenity values.	
Avoid	
Implement Mining Avoidance Zones for significant areas of recreation and conservation value, including the Dwellingup, Kingsbury Drive area, Bibbulmun Track and Lane Pool Recreation Reserve Mining Avoidance Zones, as shown in Figure 5-77 and Figure 5-78.	Established practise, high certainty.
Minimise	
Mine planning considers separation distances from sensitive receptors.	Established practise, high certainty.
Permanent and temporary lighting positioned to face away from nearby sensitive receptors, thus minimising direct lighting as well as light spills during night-time operations, while maintaining a safe working environment for employees.	Established practise, moderate certainty.
Clearing and mining restricts access to conservation and recreational values impacting local economies (e.g., hospitality and ecotourism), quality of life and sense of place.	
Avoid	
No clearing or mining in conservation reserves.	Established practice across Alcoa operations and can be implemented with a high certainty.
Implement Mining Avoidance Zones for significant areas of recreation and conservation value, including the Dwellingup, Kingsbury Drive area, Bibbulmun Track and Lane Pool Recreation Reserve Mining Avoidance Zones, as shown in Figure 5-77 and Figure 5-78.	Established practise, high certainty.
Minimise	
Reduce visual impact/visual amenity zone from public infrastructure.	Established practise, moderate certainty.
Fencing, bunding & signage.	Established practise, moderate certainty.
Visitor access protocols.	Established practise, moderate certainty.
Complaints handling and response.	Established practise, moderate certainty.
Providing interim and temporary agreement to community for ad hoc access.	Established practise, moderate certainty.
Prioritisation of mining in close proximity to significant recreational areas to facilitate continuity of community land use.	Established practise, moderate certainty.
If mining proposed within 2 km of sites, then commission noise, dust and visual assessments.	Established practise, moderate certainty.
The Larego and Myara Recreational Trails and Facilities Management Plans (RTFMP) have been developed in consultation with DBCA and relevant stakeholders and will be implemented.	Established practise, moderate certainty.
Consultation with Munda Biddi Trail Foundation and DBCA on any impacts to Munda Biddi Trail.	Established practise, moderate certainty.
Rehabilitate	
Prioritisation of mining and rehabilitation near significant recreational areas to facilitate continuity of community land use.	Rehabilitation is an established practice however commencement timeframes may vary due to a range of factors, moderate certainty.
Adherence to Completion Criteria – land use objectives.	
Change to road access and increase in traffic.	
Minimise	
Any public road crossing will comply with all relevant standards and specifications as applied by Main Roads WA and other decision makers including relevant local governments.	Industry standard techniques, high certainty.

5.7.6 Assessment and Significance of Residual Impact

The Proposal does not directly impact upon any recreational areas or associated access; however, there are several potential indirect impacts likely to alter the sense of place and experience of community and visitors utilising the recreational aspects of the area.

The assessments undertaken have identified potential noise and dust impacts are possible under worse case meteorological and operational conditions. Noise and dust emissions can be managed to prevent regulatory non-compliances but there is the potential for minor residual impacts such as the audibility of plant and machinery depending on the location of operations to recreational areas (i.e., Serpentine and North Dandalup Dam) and for dust to be generated from open spaces. These impacts are not considered significant but may affect one's experience of the area.

Visual amenity impacts from elevated vantage points (particularly along the Bibbulmun track) are also unlikely to be avoidable in the short to medium term as operational impacts will be visible within the background of the landscape until rehabilitation establishes. Similar is to be expected along road edges where screening corridors cannot be appropriately identified. Avoidance measures will be implemented where possible, with screening buffers to be implemented.

Low potential traffic, dust and light spill impacts to amenity are expected, however are expected to be similar to current and previous operational impacts.

Residual impacts are summarised in Table 5-95. Residual impacts are more likely in the Huntly Mine DE where sensitive receptors are in a closer proximity, compared to Willowdale which is more secluded.

5.7.7 Environmental Outcomes

Table 5-96 presents proposed environmental outcomes with respect to social surroundings (amenity). The proposed environmental outcomes:

- reflect specific and measurable environmental states
- have a clear boundary, size, extent, or limit
- are consistent with the EPA's objective to protect social surroundings from significant harm.

Table 5-96 identifies where another statutory decision-making process can mitigate the potential environmental impacts of the Proposal on the environment to be consistent with the EPA's factor objective.

Table 5-95: Residual Impacts to Social Surroundings (Amenity)

Potential environmental impact	Residual impact	Likelihood of significant impact
Impacts to amenity through construction and operational noise following the implementation of Noise Sensitivity Zones.	• Subject to implementation of Noise and Mining Sensitivity Zones and operational noise management, mining operations are not expected to result in exceedance of Assigned Levels at the nearest noise sensitive receivers. • Subject to implementation of operational management, blast overpressure is unlikely to exceed limits at noise sensitive receivers. • Ground-borne vibration is expected to be insignificant at all nearby noise sensitive receptors. • Mining operations are unlikely to be audible at townsites, campgrounds, or at rural properties under normal and planned operational conditions.	Unlikely
	• Mining may potentially be audible during worst-case meteorological conditions and mining scenarios at the rural properties east of Keysbrook (Scarp Road) and at Karnet Prison. • Mining noise may also be audible throughout the NJF and unnamed walking trails which are managed or maintained.	Potential
Impacts to amenity from light spill	• Permanent lighting at the new facilities is unlikely to affect nighttime amenity at sensitive receptors due to the distance from receptors. • Temporary lighting at pits is unlikely to affect nighttime amenity at townsites, or campgrounds. Subject to implementation of lighting management, temporary lighting at the western extent of the Huntly Mine DE may be visible to rural properties from a distance.	Unlikely
Impacts to amenity from traffic	• Construction and operational traffic are unlikely to substantially increase traffic through townsites or recreational areas or the Jarrahland Wildflower Scenic Drive. • Construction and operational traffic may contribute to peaks in traffic numbers during peak commuting at the start and end of shifts but is not expected to affect amenity for the majority of the day.	Unlikely
Impacts to visual amenity from mining operations and infrastructure following the implementation of Mining Avoidance Zones and vegetation screens/buffers.	• The Proposal may cause visual impacts along roadside where screening corridors can't be adequately implemented. The impact is considered to be minor and short term being visible while people are commuting. The extensive presence of forest vegetation is expected to predominantly screen the visual effects of the Proposal to Jarrah Forest landscape values and prevent major impacts to visual amenity. • Maintenance of visual screening corridors at the interface with recreational facilities and public roads will further reduce the likelihood of visibility of the Proposal to visual receptors.	Unlikely
	• The Proposal will cause high to moderate visual impact to elevated viewpoints associated with the Bibbulmun Track. The Bibbulmun Track is of state significance and visual impacts to the elevated viewpoints may affect a few to several thousand visitors each year. The Monadnocks Conservation Park is notable for having the highest elevation hills in the Darling Plateau and the panoramic views are promoted by the Bibbulmun Track Association and bushwalking websites. A Mining Avoidance Zone will be implemented around the Bibbulmun Track. • The duration of high to moderate visual impacts to elevated viewpoints is expected to last approximately 16-17 years from the commencement of operations to allow for the establishment of rehabilitation. • The Proposal may cause moderate visual impacts from Serpentine and North Dandalup Dam where in completed rehabilitation or slow establishing vegetation allows cleared landscapes to be visible in the distance. • Visual impact to elevated viewpoints from the Proposal will be cumulative with existing visual impact to elevated viewpoints at Mount Wells and on the White Horse Hills from Boddington and other Alcoa operations.	Potential
Impacts to amenity from dust deposition following the implementation of Mining Avoidance Zones.	• Subject to implementation of operational management, mining is unlikely to cause exceedance of dust deposition criteria at townsite, rural properties and recreational trails. Cumulative impacts resulting from high background dust concentrations are also likely, however the Proposal is unlikely to be the key contributor.	Unlikely
	• Elevated dust deposition is likely to occur at the Karnet Prison based proximity to operations and number of open areas.	Potential
Impacts on recreational use of areas following the implementation of Mining Avoidance Zones.	• The Proposal will restrict public access to large areas of State Forest that may be used by some local residents and visitors for informal recreation outside of defined trails and facilities that are managed and promoted. • The restriction of public access to State Forest will occur for an extended period until rehabilitation has sufficiently established and the regions are closed and relinquished, at which point the Mine DEs will revert to State Forest and be open to public access. Over this period, members of the public will continue to have access to extensive areas of State Forest surrounding Huntly and Willowdale as well to conservation and recreational reserves. • The restriction of public access from the Proposal will be cumulative with the existing restriction to access of State Forest within the existing and historic regions mining areas. • The cumulative restriction to public access may impact Noongar access to Country and associated Aboriginal cultural values of the NJF.	Potential

Table 5-96: Proposed Environmental Outcomes – Social Surroundings (Amenity)

Potential environmental impact	Environmental outcome	Other Statutory Process	Monitoring of outcomes
Impacts to amenity through construction and operational noise	No blasting within 1200 m of sensitive receptors to attenuate the blast overpressure to below 120dB LZ Peak maximum limit. If the limit is expected to be exceeded, consultation, development and implementation of a Noise Management Plan will occur.	Assessment and approval of the MMP and subsequent FCAs include consultation with key regulatory agencies. *Environmental Protection (Noise) Regulations 1997*	To be developed and included in Noise Management Plans / Blast Management Plans, where required.
	A maximum blast noise limit of 110dB LZ peak in Dwellingup or Yamba; and 115dB LZ peak at any other offsite location will be established. If the limit is expected to be exceeded, consultation, development and implementation of a Noise Management Plan will occur.		
	No exceedance of Assigned Levels under the Noise Regulations at the nearest noise sensitive receivers due to mining operations. If the limit is expected to be exceeded, consultation, development and implementation of a Noise Management Plan will occur.		
	Implement a 500 m daytime Do Not Mine Zone around sensitive receptors to comply with 40 dB(A). If the limit is expected to be exceeded, consultation, development and implementation of a Noise Management Plan will occur and may include mitigations.		
	Implement a 1,100 m nighttime Do Not Mine Zone around sensitive receptors to comply with 35 dB(A)		
	No clearing or direct disturbance for mining or infrastructure within the Mining Avoidance Zones (noting rehabilitation and monitoring activities may still be undertaken).	Assessment and approval of the MMP and subsequent FCAs include consultation with key regulatory agencies.	Annual reporting of clearing extent

Potential environmental impact	Environmental outcome	Other Statutory Process	Monitoring of outcomes
	All cleared areas within the Huntly and Willowdale Development Envelope rehabilitated to Jarrah Forest ecosystem to completion criteria agreed with DBCA.	Rehabilitation Management Plan and Schedule developed in accordance with MMP approval conditions and aligns with the Rehabilitation Completion Criteria reviewed by DBCA and approved by the Department of State Development.	Annual monitoring and reporting of rehabilitation extent and performance against completion criteria
Impacts to visual amenity from mining operations and infrastructure	No clearing or direct disturbance within defined visual screening corridors (minimum 200 m unless an alternative determined through a visual impact assessment) at the interface with recreational facilities and public roads.	Assessment and approval of the MMP and subsequent FCAs include consultation with key regulatory agencies.	Annual reporting of clearing extent
Impacts on recreational use of areas	No interruption to public access or direct impact to managed recreational areas within the DE.	Assessment and approval of the MMP and subsequent FCAs include consultation with key regulatory agencies.	-
Impacts to amenity from dust deposition	No exceedance of Assigned dust deposition levels or incremental PM10 concentration limits established by the Air NEPM (NEPC, 1998) at sensitive receptors.	Air NEPM	Annual reporting of clearing extent
	No mining within 500 m of sensitive receptors to comply with 2g/m2/30 days limit increase	Assessment and approval of the MMP and subsequent FCAs include consultation with key regulatory agencies.	To be developed and included in the Dust Management Plan, where required.

5.8 Key Environmental Factor – Greenhouse Gas Emissions

5.8.1 EPA Objective

The EPA's environmental objective for Proposal where greenhouse gas (GHG) emissions are a significant factor is "To minimise the risk of environmental harm associated with climate change by reducing greenhouse gas emissions as far as practicable" (EPA, 2024e).

5.8.2 Policy and Guidance

The assessment and management of GHG emissions associated with the Proposal and ongoing existing operation of the facilities has been undertaken with consideration to the following State and Commonwealth Policies and Guidelines:

- *WA Environmental Factor Guideline – Greenhouse Gas Emissions* (EPA, 2024e)*;*
- *Instructions on how to prepare an Environmental Review Document* (EPA, 2024c)*;*
- *Template Greenhouse Gas Environmental Management Plan* (EPA, 2023e)
- *Greenhouse Gas Emission Policy for Major Projects* (GoWA, 2024c)
- *National Greenhouse and Energy Reporting Act 2007*
- *National Greenhouse and Energy Reporting Regulations 2008*
- *National Greenhouse and Energy Reporting (Measurement) Determination 2008*
- *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015*

In November 2024 the EPA updated its Environmental Factor Guideline for GHG Emissions to ensure compatibility with existing frameworks while presenting an opportunity to streamline information requirements and regulations with the Commonwealth's Safeguard Mechanism.

In the updated guidance an expert review to demonstrate how best practice measures have been adopted by a proponent may be required; however, this is not a mandatory requirement and would generally only be required where a new technology is proposed, benchmarking shows the technology is poor practice, or there is likely to be substantial (more than 30%, and above 100,0000 tonnes CO2-e in any year) reliance on offsets (EPA, 2024e). From its consideration of the EPA's guidance, Alcoa is of the view that a peer review is not required to support Assessment 2384 and 2385. Likewise, Alcoa does not consider it necessary to prepare a GHG environmental management plan to support the assessments as the pertinent information can be provided in this chapter.

5.8.3 Receiving Environment

Climate change is a global issue. In 2015, world leaders reached an agreement to keep the global average temperature increase below 2ºC and pursue efforts to limit the increase to 1.5ºC. This is referred to as the Paris Agreement. The Paris Agreement requires countries to submit increasingly ambitious Nationally Determined Contributions (NDCs). Australia's current NDC is to reduce Australia's net greenhouse gas emissions to 43% below 2005 levels by 2030 and to achieve net greenhouse gas emissions to zero by 2050. The NDC has been legislated in the *Climate Change Act 2022*.

A number of strategies have been put in place to support the achievement of Australia's ambitions, including the Safeguard Mechanism. The Federal Government has also announced six sectorial decarbonisation plans, which between them will cover all major components of the economy, including resources and industry (DCCEEW, 2023f). These plans will also support the development of Australia's 2035 emission reduction targets. The Safeguard Mechanism is one of the current emission reduction policies that will contribute Australia's Net Zero plan.

5.8.4 Scope of this Proposal

The scope of this Proposal is limited to Alcoa's mining operations as described in the 2022–2026 Mining and Management Program (MMP) and the 2023–2027 MMP, and to the time period covered by these MMPs i.e., 2022-2027. The Proposal's ESD (EPA, 2024) states that the Proposal includes "the production, processing (crushing) and transport of wet bauxite ore, the abstraction of water, exploration drilling, and rehabilitation works". As such the Proposal excludes activities associated with Alcoa's alumina refineries. Therefore, this GHG assessment is limited to emissions associated with mining activities at Alcoa's Huntly and Willowdale mines for the period 2022 to 2027. However, the emissions estimates are for the full operations of Huntly and Willowdale Mines during this period, which geographically extend to the bauxite stockpile at the Pinjarra and Wagerup refineries respectively.

5.8.4.1 Scope 1 emissions

5.8.4.1.1 Safeguard Mechanism

For scope 1 emissions reported under the National Greenhouse and Energy (NGER) scheme the EPA allows the option for Proponents to demonstrate compliance with the Safeguard Mechanism. Alcoa has adopted this option for this Proposal as both Huntly Mine and Willowdale Mine are NGER facilities registered under the operational control of Alcoa of Australia Limited.

In accordance with NGER, reported scope 1 and 2 emissions include those produced by contractors and their equipment working onsite under Alcoa's operational control. Historically the Forest Products Commission (FPC) harvested timber from the land prior to mining. Alcoa then took operational control of the harvested area, therefore emissions related to operating equipment involved in harvesting were not included in Alcoa's NGER footprint. Since early 2024, the salvaging of timber ahead of clearing for mining is now undertaken by a contractor under Alcoa's operational control and included in the NGER footprint.

There is natural variability in the Huntly and Willowdale Mines' scope 1 emissions intensity, primarily due to changes to the average haul-distance. Haul distances typically increase as mining occurs further away from the crusher in the latter years of mining in a particular region, as is the case at the Huntly mine, and to a lesser extent the Willowdale mine, during the period of this Proposal. However, the Safeguard Mechanism will require net scope 1 emissions covered under this scheme to be maintained at or below 100,000 tonnes of carbon dioxide equivalent (t CO_2e) per year.

Neither Huntly nor Willowdale mines' production-adjusted baseline values are expected to exceed 100,000 t CO_2e per year and therefore this threshold value will be the sites' default baseline. Settings for the Safeguard Mechanism, including the threshold value, will be

reviewed at regular intervals by the Climate Change Authority (CCA) to ensure alignment with Australia's targets, including net zero 2050.

The Mines will not be eligible to generate Safeguard Mechanism Credits (SMCs) when using the threshold value as the baseline.

Scope 1 emissions reported under NGER and forecast emissions for the remainder of the Proposal period are presented in Table 5-97 along with the relevant Safeguard Mechanism baseline.

How Alcoa will maintain the Huntly Mine's scope 1 emissions below its Safeguard Mechanism baseline will depend on the technology development, marginal cost of abatement, access to third party funding and timing of mine region moves. Scope 1 mitigation options assessed are presented in Table 5-98. Decarbonisation technology for the mines is predominately under development and with commercialisation not expected until later in the mine life, after the period of this Proposal. Emission reduction options will not be limited to maintaining emissions below the current Safeguard Mechanism threshold and therefore, actions will also be considered for Willowdale Mine.

Table 5-97: Scope 1 Emissions reported under NGER and Forecast Emissions

Period	Huntly Mine (t CO_2e)		Willowdale Mine (t CO_2e)	
	Unmitigated scope 1 emissions	Baseline	Unmitigated scope 1 emissions	Baseline
2021-22	97,674	100,000	34,532	100,000
2022-23	95,205	100,000	33,793	100,000
2023-24	95,930	100,000	38,472	100,000
2024-25	*92,900*	100,000	*43,900*	100,000
2025-26	*111,400*	100,000	*42,300*	100,000
2026-27	*118,500*	100,000	*44,900*	100,000
2027-28	*124,900*	100,000	*48,900*	100,000

Note: *Italics* indicates predicted emissions
For NGER emissions are reported on an Australian financial year (July to June).

Table 5-98: Scope 1 Mitigation Options Assessed

Target Horizons	GHG Mitigation Option	Description	Mitigation Hierarchy	Current Status	Technology Readiness
Short Term (2024-2030)	Fuel additive	An additive being blended with all diesel use to realise ~5% efficiency gains	Reduce	In implementation	Proven system
	Mining equipment fleet transition pathways studies	Studies to assess opportunities to progressively reduce emissions from all fleet classes and other equipment, as technologies become commercially viable. Options under consideration include (but not limited to), renewable diesel, hybrid diesel-battery haul truck, battery electric ancillary fleet and battery electric vehicles.	NA	Progressing through preliminary studies	Small scale trials

Target Horizons	GHG Mitigation Option	Description	Mitigation Hierarchy	Current Status	Technology Readiness
	Zero emission haul truck studies	Studies to explore battery electric and renewable diesel trucks with smaller payload for combined zero emission and complementary environmental footprint benefits such as reduced noise, reduced land clearing and enhanced water management.	NA	Progressing through preliminary studies	Small scale trials
	Ongoing truck utilisation and optimisation projects	Continuously reviewing and improving practices regarding payload size, idle times, route optimisation etc. to reduce fuel burn per trip.	Reduce	Ongoing - continuous improvement practice	N/A – operational
Longer term (2030 onwards) *Net zero 2050 Alcoa corporate target*	Zero emissions haulage fleet and equipment transition pathways review	Potential to implement lower emissions haulage fleet and equipment transition pathways, if and when commercially favourable, following studies in the short term horizon.	Reduce / avoid*	Pending commercial and technical outcomes of studies	Small scale trials
Ongoing obligation	Surrender offsets as required by the Safeguard Mechanism	If emissions cannot be avoided or reduced to below the levels required under the Safeguard Mechanism baselines, carbon credits will be surrendered. These credits will comply with the requirements of the Safeguard Mechanism.	Offset	Legislative obligation	N/A

Note: *Electrification options may increase scope 2 emissions for a short period, however this will be mitigated by ongoing decarbonisation of the South West Interconnected Scheme (SWIS).

5.8.4.1.1.1 Reliance On Offsets

The Proposal is not anticipated to surrender Australian Carbon Credit Units (ACCUs) equal to or more than 30% of its expected baseline scope 1 emissions in any year of operation for either the Huntly Mine or Willowdale Mine based on current forecasts. As such, in line with the EPA's guidance, Alcoa does not consider that an expert review of whether offsets that satisfy integrity principles are likely to be reasonably practicable and available at the time of proposed future surrender is necessary.

5.8.4.1.2 Scope 1 emissions from vegetation clearing

The Proposals' ESD requires a consideration of the GHG emissions and by inference loss of carbon sequestration, associated with land clearing. Any consideration of carbon sequestration needs to factor in the counterbalance associated with Alcoa's extensive rehabilitation activities. Alcoa progressively rehabilitates mined regions in the areas that it operates and has a goal to maintain a corporate-wide annual ratio of 1:1 or better for mine rehabilitation to mine disturbance (Alcoa, 2024c)

Guidance on the GHG accountancy practices associated with forest clearing and rehabilitation is an emerging area, these emissions are currently not captured by NGERs or regulated by the Safeguard Mechanism. Alcoa has adopted the term 'non-NGERs related Scope 1 emissions' to describe these forest clearing emissions.

Alcoa has a study underway to estimate the non-NGERs related Scope 1 emissions from vegetation clearing and carbon sequestration from rehabilitation using the Full Carbon Accounting Model (FullCAM).

It is likely that the review will confirm that the carbon sequestration associated with rehabilitation will need to be considered across the life-cycle of rehabilitation to reflect varying rates. As such this assessment is best considered as part of Alcoa's Pinjarra Alumina Refinery Revised Proposal (EPA Assessment 2253) which is assessing a 20 year operational mining period, which will incorporate emissions associated with these Proposals.

5.8.4.1.2.1 Clearing GHG emissions

To estimate the non-NGERs related Scope 1 emissions a worst-case scenario was used whereby it was assumed that all the carbon stock in the cleared forest would be released to the atmosphere. Since Alcoa no longer burns any cleared forest products, further study is underway to understand potential pathways for direct release to the atmosphere, which relate to how the cleared forest products will be used. Use of the cleared forest products has recently altered following the cessation of native timber harvesting by the Forest Production Commission.

5.8.4.1.2.2 Sequestration by rehabilitation

The GHG emissions from clearing are counterbalanced by the carbon sequestration provided by Alcoa's rehabilitation planting. The sequestration rate varies with the age of the rehabilitation and Alcoa has used the forest growth rate simulated in the FullCAM model. Cleared areas will be matched by rehabilitated areas elsewhere within the Huntly and Willowdale Mines.

5.8.4.1.2.3 Estimated GHG emissions from clearing

GHG emissions from clearing have been initially estimated from a consideration of the hectares of clearing potentially undertaken in each year across the Proposal's life, and the assumption that rehabilitation would be completed in the same year elsewhere within the Huntly and Willowdale Mines. The total sequestration of a year's rehabilitation was estimated over the period starting from the year of planting up until 2050.

The estimated non-NGERs related Scope 1 GHG emissions from the clearing undertaken during the years 2022 to 2027 are:

Huntly Mine - 1,827,798 CO2e

Willowdale Mine - 1,175,443 CO2e

For the Huntly Mine it is estimated that the carbon sequestration associated with the rehabilitation undertaken between 2022 and 2027 will exceed the estimated clearing emissions over that period by approximately 2045. The corresponding date for the Willowdale Mine is estimated to be post 2050.

5.8.4.2 Scope 2 Emissions

Scope 2 emissions at both Huntly and Willowdale mines are not expected to exceed 100,000 t CO_2e in any year.

5.8.4.3 Scope 3 Emissions

Scope 3 emissions were estimated using the Greenhouse Gas Protocol (WRI and WBCSD, 2011) methodology for the categories listed in Table 5-99. The calculations have been done on the year with the highest production for each site during the proposal period. Other scope 3 categories were not included due to their relatively minor nature and the degree of assumptions needed in the calculations or for category 11 (use of sold products), due to the wide range of potential products with very different emissions, such as drink cans compared to an aeroplane panel. The ability of aluminium to be infinitely recycled also affects the ability to calculate downstream scope 3 emissions. The categories used here, along with the reported scope 1 and 2 emissions, are consistent with the International Aluminium Institute's (IAI) cradle-to-gate primary aluminium life cycle assessment (IAI, 2022).

Table 5-99: Scope 3 Emissions reported under NGER and Forecast Emissions

Cat.	Description	Inclusions	Comments	Huntly (2021/22)			Willowdale (2027/28)		
				Scope 3 total Mt CO_2e	Scope 3 in WA Mt CO_2e	Scope 3 t CO_2e/ t bauxite	Scope 3 total Mt CO_2e	Scope 3 in WA Mt CO_2e	Scope 3 t CO_2e/ t bauxite
3	Fuel and energy related activities (not included in scope 1 and 2)	Fossil fuels and electricity import	Estimated using scope 3 factors from the National Greenhouse Account Factors (DCCEEW, 2024). Electricity supplied to Willowdale mine is predominately produced by the directly connected Wagerup Refinery therefore there are no unaccounted transmission losses and other scope 3 emissions are included in category 10.	0.031	0.006	0.001	0.012	<0.001	0.001
9	Downstream transportation and distribution	Rail transport of bauxite from Pinjarra Refinery to Kwinana Refinery. Rail transport of alumina from Pinjarra and Wagerup refineries to Alcoa's Kwinana or Bunbury ports. Sea transport of alumina from to smelting customers	Estimated using the default emissions intensity values for rail transport of bulk freight on a non-dedicated line and bulk freight water transport from Safeguard Mechanism. The sea transport distance is an average value based on potential customers.	0.345	0.017	0.013	0.143	0.003	0.013
10	Processing of sold products	Alumina refining and aluminium smelting	Scope 3 emissions were estimated using the refinery emission rates including upstream scope 3 (minus bauxite). For smelting the 2022 IAI (2023) cradle to gate intensity for anode production, electrolysis (minus transport) and casting of 12.2 t CO_2e/t aluminium (Al) was used in the estimation. Due to differing electricity sources the emissions intensity of global aluminium smelters range from <2 to ~20 t CO_2e/t Al creating the greatest potential source of variation in the scope 3 calculations for the mines. Kwinana Refinery produces some alumina for use in chemical applications and not for metal production; therefore, this is excluded from the emissions from smelting estimation.	44.501	3.726	1.732	20.605	1.639	1.873
	Total			**44.877**	**3.749**	**1.746**	**20.763**	**1.642**	**1.888**

Alcoa's integrated mining and refining system in Western Australia minimises scope 3 emissions from transport as the refining occurs within 100 km of mining, significantly reducing the volumes required to be transported over long distances compared to raw bauxite. As both Pinjarra and Wagerup refineries are predominately fuelled by natural gas, rather than coal as occurs at many other global refineries, this also reduces Huntly and Willowdale Mines' scope 3 emissions.

To further reduce downstream emissions, as a fully integrated aluminium business, Alcoa Corporation is investing in technology development to decarbonise the aluminium industry. The technology roadmap includes three key innovations, ELYSIS™, Refinery of the Future (RoF), and ASTRAEA™ (Alcoa Corporation, 2022a).

- **ASTRAEA™** Likely the most effective way to avoid emissions with aluminium production is to recycle it. Aluminium is already infinitely recyclable, and Alcoa is working to recycle even more of it. Alcoa has patented technology called ASTRAEA™ that can purify low-value automotive scrap, removing impurities to make aluminium with higher purity than commercial-grade metal produced at a smelter.
- **ELYSIS™** Alcoa is in a joint venture to commercialise ELYSIS™, a process that emits oxygen as a by-product and eliminates all of the scope 1 greenhouse gas emissions associated with traditional smelting. This innovation involves replacing the carbon anodes used in traditional aluminium smelting with inert, proprietary materials. ELYSIS™ is a partnership between Alcoa and Rio Tinto, facilitated by Apple with funding support from the Canadian and Quebec Governments.
- **Refinery of the Future** Alcoa's global alumina refinery portfolio, including its Western Australian operations, already has the lowest carbon footprint among global producers. Despite this, the alumina refining processes are hard to abate emissions, owing in part to the scale of energy requirement, energy intensity and inherent complexity. Today, its existing facilities are reliant on natural gas for both process heat and internal electricity generation. Refinery of the Future is investigating decarbonisation, fresh water use reduction and bauxite reside elimination opportunities for alumina refining. The work includes research and development of Electric Calcination with support from the Australian and Western Australian governments. The final stage in the alumina refinery process, calcination, currently uses fossil fuels such as natural gas to heat alumina hydrate crystals to remove water molecules. A pilot project planned at Pinjarra Alumina Refinery, will use renewable energy to drive the calciner - eliminating carbon emissions and allowing residual energy currently lost to the atmosphere as steam to be captured and reused.

As a strong and lightweight material that can be infinitely recycled, aluminium can help significantly reduce GHG emissions and energy consumption. Aluminium products contribute to the decarbonisation of society through the light weighting of vehicles, improved energy efficiency of buildings, preservation of food and beverages and many other ways. Alcoa has committed to expand its SUSTANA™ line of low carbon products and develop and/ or enhance other low carbon products, to support its customers in reducing their carbon footprint. One of the products in this line is EcoSource™, alumina with carbon emissions (scope 1 and 2 mining and refining) less than half of the industry average (Alcoa Corporation, 2023).

The Safeguard Mechanism will support the reduction of most of Huntly and Willowdale Mines' Australian scope 3 emissions. As shown in Table 5-99, the majority of scope 3

emissions occur in other jurisdictions, some with established emission reduction schemes such as Europe and Quebec, and others such as the People's Republic of China are still developing, with the electricity sector covered and expansion to industry, including aluminium, expected in the coming years. Some aluminium producing regions, including some developing nations, are yet to set limits for industry.

5.8.5 Environmental Outcomes

Alcoa considers that the legislative requirements of the Safeguarding Mechanism will adequately regulate the Proposal's reduction in non-clearing related net scope 1 emissions, with standard regulatory reporting requirements (NGER) already in place. Alcoa does not consider additional conditions are required to ensure consistency with the EPA's environmental factor objective for Greenhouse Gas. As such and as consistent with the updated GHG Emissions Environmental Factor Guideline, no GHG Management Plan is required for the Proposal.