10 Cumulative Environmental Impact Assessment

10.1 EPA Definition of Cumulative Environmental Impacts

The EPA's (EPA, 2021a) definition of 'cumulative environmental impacts' is:

'the successive, incremental and interactive impacts on the environment of a proposal with one or more past, present and reasonably foreseeable future activities'.

10.2 Proposal Considered for Cumulative Impacts

There is potential for cumulative impacts on environmental values such as Flora and Vegetation, Terrestrial Fauna, Inland Waters, Terrestrial Environmental Quality, Greenhouse Gas Emissions, and Social Surroundings from the implementation of the Proposal and the activities of adjacent operations. This section will outline the cumulative impact assessment (CIA) of the Proposal, considering the impacts of past and existing projects in the area, as well as reasonably foreseeable projects that have not yet started. The CIA will assess the environmental effects of projects operated by both Alcoa and other entities in the Northern Jarrah Forest region.

Projects that have been considered in the CIA include:

- Disturbance Envelopes outline as part of this ERD;
- Pinjarra Alumina Refinery Revised Proposal (Assessment 2253) (Alcoa, 2022a);
- Approved Alcoa Proposal under MS 646 and 728;
- South32 Worsley Mine Expansion – Revised Proposal (Assessment No. 2216) and MS 719;
- Newmont Boddington Gold – MS 971;
- Bushfire and forest management activities outlined in the 2024-2033 FMP; and
- Other developments in the region, including pastoral and agricultural operations.

The Proposal is time limited up to 31 December 2027, therefore any remaining clearing and ongoing operational (including rehabilitation) impacts are covered in the Pinjarra Alumina Refinery Revised Proposal (Assessment 2253) ERD. For a full understanding of cumulative impacts, defer to the Assessment 2253 ERD.

10.3 Flora and Vegetation Cumulative Impacts

10.3.1 Overview

The NJF subregion has been subject to environmental impacts from a range of past and present activities, with the key activities having an impact on flora and vegetation being clearing for agriculture (approximately 36% of the NJF subregion) and timber harvesting (42%). Other activities affecting flora and vegetation of the NJF include prescribed burning, bauxite and gold mining, timber plantations and water supply reservoirs.

This section aims to address the activities for consideration in the CIA as outlined in the ESD, focusing on flora and vegetation within the Proposal outlined in Section 5.2, with an emphasis on:

- Clearing of native vegetation and Threatened and Priority flora, including fragmentation of habitat, within the Huntly and Willowdale Mine DEs, including clearing for mining operations.
- Spread of *Phytophthora* dieback and other forest diseases, weed invasion, and changes in fire behaviour as a result of increased mining and exploration activities.

An overview of cumulative impacts of the Proposal and other developments and processes to flora and vegetation in the NJF subregion is given in Table 10-1 below.

Table 10-1: Overview of cumulative impacts to Flora and Vegetation – NJF

Impacting development / process	Duration of historic impacts	Indicative magnitude of existing disturbance		Indicative magnitude of total future disturbance	
		Area (ha)	Proportion of NJF / (ML1SA) (%)	Areas (ha)	Proportion of NJF / (ML1SA) (%)
Mining					
Huntly Mine (total including Proposal & Assessment 2253)	1976 – present	17,425	0.9 (2.5)	30,589	1.6 (4.4)
Willowdale Mine (total including Proposal)	1984 – present	6,826	0.4 (1.0)	9,905	0.5 (1.4)
Jarrahdale Mine	1963 – 1998 (closed)	4,030	0.2 (0.6)	4,030	0.2 (0.6)
Subtotal – Alcoa mining		***28,280***	***1.5 (4.0)***	***43,714***	***2.3 (6.2)***
South32 Worsley Bauxite Mine	1984 – June 2022[14]	6,467	0.3	18,137	1.0
Newmont Boddington Goldmine	1987 – May 2024	4,391[15]	0.2	6,520[16]	0.3
Subtotal – all mining		***39,139***	***2.1***	***69,181***	***3.6***
Other land uses					
Rural and urban development	Predominantly 1960s-1980s – present	~ 740,000[17] (permanent loss)	~ 39	estimates not available	~ 39
Timber harvesting	1840s – present 1999 – present under RFA	~ 803,500[18]	~ 42	No timber harvesting from 2024 onwards under 2024-2033 FMP	0
Plantations (softwood, hardwood)	1900s – present	12,550 (permanent loss)	0.7	estimates not available	N/A
Water supply reservoirs	1900s – present	8037 (permanent loss)	0.4	estimates not available	N/A
Other clearing within DBCA managed lands	1900s – present	14,687	0.8	estimates not available	N/A
Subtotal –other land uses		***1,578,774***	***83.2***	***N/A***	***N/A***
Other threatening processes					
Dieback	Identified since 1920s – present	> 122,171[19]	~ 35[20]	> 134,771[21]	~ 39
Wildfires, intensifying under European land activities	Identified since 1880s, records since 1920s – present	> 698,810[22]	> 86	estimates not available	N/A
Climate change, declining rainfall, increasing temperature	Identified since 1970s – present	estimates not available	N/A	estimates not available	N/A
Rabbits, feral pigs	Introduction late 1800s, early 1900s – present	estimates of not available	N/A	estimates not available	N/A

[14] Areas derived from “Worsley Mine Expansion (Revised Proposal)” (South32, 2022)
[15] Sourced from Annual Environmental Report (AER-408-66302) – Environmental Group Site: S0231545 Boddington Gold Environmental Group (Period Finished: May 2024)
[16] Area derived from “Newmont Boddington Gold Life of Mine Extension Project”
[17] Clearing outside DBCA managed lands, excluding Boddington mines.
[18] All DBCA managed lands except Old Growth Forest plus 17,500 ha over 2021-2023 harvest plan.
[19] Assessed as Infested within mapped area of DBCA managed lands
[20] Proportion of assessed area within DBCA managed lands
[21] Based on increase of 1050 ha/yr over 2024-2035
[22] Data available for DBCA managed lands in ML1SA

10.3.2 Pastoral and Agricultural Operations

Agriculture has caused widespread impacts to the NJF subregion, including:

- Loss of biodiversity and habitat from permanent clearing;
- Agricultural impacts to soils including erosion, salinity, compaction and acidification;
- Secondary salinity impacts to the Murray and Avon rivers from permanent clearing;
- Conversion of natural landscape to rural character; and
- Potentially the introduction of *Phytophthora* dieback via infected horticultural plants.

Agriculture within the NJF, predominantly dryland cropping and grazing, has caused approximately 87% of the permanent clearing within the subregion (Australian Bureau of Agricultural and Resource Economics and Sciences, 2024). Permanent clearing has resulted in permanent loss of native vegetation, of which approximately 30% comprised Jarrah-Marri Forest and approximately 69% woodlands of Marri, Wandoo and York Gum (in the north and east portions of the subregion).

No substantial future agricultural development is expected in the subregion. Cleared agricultural areas are expected to be retained for primary productivity (crops, stock animals, plantations) and not be subject to substantial rehabilitation.

10.3.3 Timber Harvesting

Timber harvesting has caused widespread impacts to the NJF subregion, including:

- Partial loss of biodiversity and habitat lasting up to 10 years from last harvest;
- Conversion of old growth forest to juvenile to immature forest age;
- Long term loss of mature trees and associated hollows; and
- Spread of *Phytophthora* dieback in forested areas.

Approximately 96% of the mapped portion (79%) of the NJF subregion has been subject to timber harvesting, with Old Growth Forest now limited to approximately 4% of the subregion (Section 5.2.4.5).

No further clearing of Old Growth Forest is expected to occur. Patches of mapped Old Growth Forest predominantly lie outside of existing and proposed Mine DEs. Five small patches (total area 79.5 ha) of Old Growth Forest mapped by DBCA lie within the Huntly Mine DE and none within the Willowdale Mine DE. Old Growth Forest areas within the Huntly Mine DE are within Mining Avoidance Zones.

Timber harvesting is expected to cease from 2024 onwards, at which point Forest Products Commission will continue its independent logging activities within areas that have been approved for mining, and for activities that maintain forest health (Conservation and Parks Commission, 2023).

Harvested forest is expected to progress to varying forms of Old Growth Forest in the long term, under the influence of contemporary climate and fire regimes and the effects of *Phytophthora* dieback.

10.3.4 Fire

Prescribed burning is undertaken to reduce the severity and extent of wildfires, which can have significant ecological, water quality, and amenity impacts. Prescribed burning has covered an average of 7% (range 1 to 16%) of DBCA managed forest within the subregion each year over 2000-2020.

The EPA assessed fire management of the NJF as part of its assessment of the 2024-2033 FMP (EPA, 2023f). Currently, the 2024-2033 FMP proposes to burn no more than 200,000 ha per year of vegetation. The EPA considered that prescribed burning likely has a role to play in managing forest ecosystems and conserving biological diversity and ecological integrity (EPA, 2023f).

Prescribed burning is expected to continue within the subregion in accordance with the WA Government's strategy to reduce fuel loads and minimise the likelihood and severity of large-scale wildfires. However, widespread prescribed burning to maintain a forest fuel age of approximately six years without a fine scale mosaic of long unburnt areas, has the potential to impact some obligate seeder flora and reduce habitat for fauna populations.

10.3.5 Mining and Rehabilitation

Mining has caused impacts to the NJF subregion as follows:

- Short to medium term ecological and amenity impacts during operations and until rehabilitation establishes;
- Long term loss of fauna habitats; and
- Rehabilitation restoring varying biodiversity, ecological integrity and landscape quality.

Reasonably foreseeable future activities within the NJF subregion include approved and proposed mining. The majority of Jarrah Forest cleared for mining is expected to be rehabilitated, with the exception of deep voids of the Newmont Boddington Gold mine which will be left as is and form pit lakes over time.

Mining and rehabilitation combined currently comprise approximately 2% of the subregion and with additional proposed clearing will increase to approximately 4% by 2035 (of which 2% is attributed to Alcoa). Rehabilitation has occurred to varying prescriptions and practice, with Alcoa rehabilitating about 78% of their bauxite mining.

Mining within the subregion is expected to cause a cumulative, but temporary loss of floristic diversity and ecological integrity (primarily due to the loss of coarse woody debris and mature trees) as rehabilitation of the Huntly, Willowdale, Newmont Boddington Gold and South32 Worsley Bauxite mines restore cleared native forest under varying prescriptions and practice. Mining within the subregion is expected to cause a cumulative impact over the medium to long term until rehabilitation has been completed and is established.

10.3.6 Disease and Weed Invasion

Phytophthora dieback has widely impacted DBCA managed lands within the NJF subregion, with 122,171 ha (35.0%) of the DBCA managed lands assessed for dieback classified as Infested. No data is available for Dieback impacts outside DBCA managed lands.

Introduction and spread of *Phytophthora* dieback, predominantly from timber harvesting, has caused infestation over approximately a third of the NJF (Section 5.2.4.8). Infestations are predominantly in the high rainfall zone near the Darling Scarp and in valleys.

Alcoa's monitoring programs determined that mining related *Phytophthora* dieback spreads 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 (Section 5.2.6.1).

10.3.7 Climate Change

There is a lack of data to accurately predict the magnitude of climate change impacts; however, impacts may potentially be widespread given the reduction in rainfall and increased temperatures across the NJF subregion.

10.3.8 Impacts to Biodiversity

Biodiversity is defined by the EPA as "the variability within and among genes, species and ecosystems" (EPA, 2007).

The cumulative impacts of the identified developments and impacting processes to the biodiversity of flora and vegetation within the NJF subregion include the following:

10.3.8.1 Historic and Proposed Mining

Historic and proposed mining converts Jarrah Forest to rehabilitated vegetation with varying levels of biodiversity and reduced structural diversity. Within rehabilitation areas Alcoa has attained species richness greater than 80% of that of un-mined forest control plots; however, there has historically been a lower representation of re-sprouter and ephemeral species in rehabilitated areas compared with native Jarrah Forest (Section 0).

Alcoa's historic and reasonably foreseeable future impact on local vegetation is shown in Table 10-2). Alcoa has cleared approximately 24,826 ha of vegetation since mining started (to December 2023) in the Huntly and Willowdale areas. As was to be expected, the majority of the historical clearing has been of vegetation with the P, S and T as the dominant SVTs (i.e., VTs P, PG, PS, PT, S, SP, ST, T, TS, TP; laterite-related vegetation types on ridges and slopes), with 16,936 ha of slopes and ridges vegetation types having been cleared historically. The majority of scheduled clearing by Alcoa from 2028 onwards (as per Assessment 2253; Table 10-2) is also planned to be in slopes and ridges vegetation types, with 3.649.92 ha of the 7,596.62 ha scheduled for clearing from 2028 being across slopes and ridges vegetation.

While data is not available for third party mines, it is expected that rehabilitation of large void and waste landforms (e.g., waste rock, tailings, residue areas) at these mines will achieve a lower floristic diversity, due to loss of topsoil seedbanks which provide the majority of understory species in rehabilitated areas. Total disturbance from mining will be approximately 3.6% of the NJF as of 2035, of which 1.93% is associated with Alcoa's mines.

Table 10-2: Estimates of Cumulative Impacts to Local Vegetation – Vegetation Types, Potential PECs and potential GDEs

VT	Mapped Extent (ha)	Historical clearing (prior to 2023) by Alcoa (ha)	Portion of Mapped Extent Impacted (%)	Proposed Clearing - Assessment 2385 (ha)	Cumulative Portion of Mapped Extent Impacted (%)	Scheduled clearing from 2028 – Assessment 2253 (ha)	Cumulative Portion of Mapped Extent Impacted (%)	Potential TEC/PEC	Potential GDE	Potential Conservation Significant flora habitat
Swamps and Broad valleys										
A	294.25	3.01	1.02	0	1.02	4.68	2.61	*Empodisma* peatlands	Yes	Potential Threatened (1 species – Huntly) Recorded or Potential Priority (21 species – Huntly, 9 species – Willowdale)
AC	3,153.84	20.97	0.66	13.63	1.10	13.1	1.51	*Empodisma* peatlands	Yes	
AD	302.97	0.79	0.26	0	0.26	46.26	15.53	*Empodisma* peatlands	Yes	
AW	157.57	9.69	6.15	0	6.15	16.24	16.46	*Empodisma* peatlands	-	
D	3,312.52	97.81	2.95	72.29	5.14	172.04	10.33	*Empodisma* peatlands	Yes	
DA	296.48	5.28	1.78	6.12	3.85	29.12	13.67	*Empodisma* peatlands	Yes	
DG	78.73	3.52	4.47	0.29	4.84	0.7	5.73	*Empodisma* peatlands	-	
E	495.87	10.99	2.22	23.45	6.95	43.68	15.75	*Empodisma* peatlands	Yes	
Valley floors and Lower slopes										
C	435.96	6.85	1.57	0.19	1.61	3.34	2.38	-	-	Potential Threatened (1 species – Huntly) Recorded or Potential Priority (21 species – Huntly, 9 species – Willowdale)
CQ	284.92	3.32	1.17	0	1.17	0	1.17	-	-	
CW	2,768.79	25.6	0.92	16.87	1.53	29.25	2.59	-	Yes	
Q	447.63	1.49	0.33	0	0.33	0	0.33	-	-	
W	4,453.51	199.09	4.47	40.49	5.38	10.17	5.61	-	Yes	
Slopes and Ridges – Sandy loam gravels										
P	1,868.51	133.1	7.12	102.54	12.61	419	35.04	-	-	Recorded or Potential Priority (10 species – Huntly, 2 species – Willowdale)
PG	1.21	0.9	74.38	0.01	75.21	0	75.21	-	-	
PS	10,720.53	3,042.61	28.38	841.11	36.23	1,257.17	47.95	-	-	
PT	1,847.65	623.93	33.77	19.54	34.83	7.13	35.21	-	-	
S	20,088.68	4,874.70	24.27	906.56	28.78	834.11	32.93	-	-	
SP	8,813.07	2,995.67	33.99	253.09	36.86	709.86	44.92	-	-	
SP-D	11.23	1.13	10.06	0	10.06	0	10.06	-	-	
ST	7,923.25	2,068.69	26.11	70.4	27.00	234.91	29.96	-	-	
TP	292.88	100.92	34.46	4.07	35.85	0	35.85	-	-	
Z	95.34	2.03	2.13	0	2.13	0	2.13	-	-	
Slopes and Ridges – Loam gravels										
T	3,673.21	665.91	18.13	95.74	20.74	68.37	22.60	-	-	Recorded or Potential Priority (10 species – Huntly, 2 species – Willowdale)
TS	10,474.53	2,426.40	23.16	306.89	26.09	119.37	27.23	-	-	
Slopes with Higher seasonal moisture										
PW	1,973.10	279.19	14.15	144	21.45	175.79	30.36	-	Yes	
SW	3,514.37	246.86	7.02	46.72	8.35	168.87	13.16	-	Yes	
SW-D	13.21	3.67	27.78	0	27.78	0	27.78	-		
Outcrop areas										
G	311.37	0	0.00	0	0.00	5.45	1.75	Granite communities		Potential Threatened (4 species – Huntly)
G1	435.73	11.97	2.75	9	4.81	0	4.81	Granite communities		

VT	Mapped Extent (ha)	Historical clearing (prior to 2023) by Alcoa (ha)	Portion of Mapped Extent Impacted (%)	Proposed Clearing - Assessment 2385 (ha)	Cumulative Portion of Mapped Extent Impacted (%)	Scheduled clearing from 2028 – Assessment 2253 (ha)	Cumulative Portion of Mapped Extent Impacted (%)	Potential TEC/PEC	Potential GDE	Potential Conservation Significant flora habitat
R	865.96	61.96	7.16	32.23	10.88	52.84	16.98	Granite communities		Recorded or Potential Priority (16 species – Huntly, 1 species – Willowdale)
R/G	13.67	0	0.00	0	0.00	0	0.00	Granite communities		
Disturbance beyond Alcoa's mapped extent (Vegetation Complexes – South West Forest Region of Western Australia)										
Cooke	36,779.33	166.61	0.45	116.43	0.77	70.2	0.96			
Dwellingup	436,420.50	5448.28	1.25	716.58	1.41	2,462.60	1.98			
Goonaping	3,886.12	4.64	0.12	0	0.12	0	0.12			
Helena 1	15,889.99	5.2	0.03	0	0.03	0	0.03			
Murray 1	68,695.18	322.35	0.47	5.1	0.48	0.1	0.48			
Pindalup	167,151.00	0	0.00	135.67	0.08	0	0.08			
Swamp	53,658.24	31.07	0.06	37.87	0.13	1.45	0.13			
Yarragil 1	80,202.95	755.7	0.94	94.09	1.06	560.31	1.76			
Yarragil 2	50,259.16	164.17	0.33	2.05	0.33	80.51	0.49			
Northern Jarrah Forest	***1,897,466.00***	***24,826.07***	***1.31***	***4,113.02***	***1.53***	***7,596.62***	***1.93***			

10.3.8.2 Historic Timber Harvesting

The NJF subregion has been subject to widespread timber harvesting since the 1870s, with timber harvesting having affected 42% of the NJF to date. The impact of timber harvesting on the NJF is manifested in the immaturity of the forest, with 77.6% of the total area mapped at an establishment to juvenile or immature stage of forest structure. Timber harvesting will cease from 2024 under the 2024-2033 FMP.

10.3.8.3 Climate Change

Climate change will result in a drier, hotter climate, resulting in reduced rainfall, declining groundwater and streamflows, and increased droughts and heat waves. The decline in soil moisture and seasonal waterlogging may result in loss of floristic diversity in valleys and swamps, associated with the retreat of ecotones and habitat for Threatened and Priority flora species. There is no data available to estimate the magnitude of this impact. Alcoa is committed to working with DBCA to develop a new rehabilitation objective and prescription that improves the climate resilience of rehabilitation, consistent with the forthcoming 2024 FMP.

10.3.8.4 Historic and Ongoing Wildfires

Historic and ongoing wildfires, increasing in likelihood and severity with climate change, result in deaths of mature and senescent trees, converting large areas of mature forest to immature forest in discrete events, and potentially causing irreversible impacts to granite outcrop vegetation communities. Wildfires have affected an average of 15% of DBCA managed lands within the NJF each decade over the past 20 years. As presented in Section 5.2.6.2.8 Indirect impacts – Change in fire regimes, 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. Accordingly, the Proposal is unlikely to cause a cumulative impact to the NJF in combination with changing fire regimes due to climate change.

10.3.8.5 Historic and Ongoing Prescribed Burning

Historic and ongoing prescribed burning to protect vulnerable assets from wildfires, which may reduce the prevalence of obligate seeder species and reduce floristic diversity. Prescribed burns have averaged approximately 6% of DBCA managed lands within the NJF subregion each year over the past 30 years. As presented in Section 5.2.6.2.8, the Proposal will not exacerbate the impacts of prescribed burning on the NJF subregion. Alcoa will continue to support the State Government's fire management program for the NJF, including any future modifications to prescribed burning in response to developments in research and policy with respect to biodiversity and ecological integrity.

10.3.8.6 Existing and Spreading *Phytophthora* dieback

Existing *Phytophthora* dieback infestation that spreads passively, irrespective of ongoing anthropogenic disturbance, with additional spread from mining and timber harvesting which is approximately two orders of magnitude lower. The spread of *Phytophthora* dieback is expected to cause a varying impact to biodiversity depending on site conditions

(e.g., susceptible species, soil drainage and fertility). *Phytophthora* dieback may cause a loss of biodiversity and change in vegetation structure from Jarrah open forest to open woodlands dominated by Marri and sedges (Shearer & Tippett, 1988). *Phytophthora* dieback has infested 35% of assessed DBCA managed lands within ML1SA and may spread to another 4% from 2024-2035. The Proposal is expected to contribute a very small proportion (< 0.1%) of the *Phytophthora* dieback estimated for the NJF, which is unlikely to cause a significant cumulative impact to the effects of dieback across the subregion.

10.3.8.7 Rates of Clearing

In accordance with Ministerial Approval conditions for the 2023–2027 MMP (Condition 9), Alcoa will not clear more than 800 ha of native vegetation for the MMP related mining activities per calendar year for the duration of the Exemption Order. However, it should be noted that in accordance with Ministerial Approval conditions for the 2023–2027 MMP (Condition 10), any unused capacity from the annual clearing cap (800 ha as per Condition 9) may be rolled over into the following year, but only upon approval from the State Development Minister as part of any subsequent MMP submissions.

The indicative annual maximum conceptual clearing rates within the Mine DEs are shown in Table 10-3 below. It is considered unlikely that the total amount would be cleared, as it includes clearing buffers and conceptual clearing areas.

Table 10-3: Indicative maximum annual rates of clearing within the Mine DEs

Year	Huntly Mine DE – Clearing (ha)	Willowdale Mine DE – Clearing (ha)	Total (ha)
2022	273.8	140.7	379
2023	140.3	159.3	300
2024	198	210	408
2025	739	399	1,138
2026	845	330	1,175
2027	1,170	563	1,733

10.3.9 Knowledge and survey gaps addressed in Pinjarra Alumina Refinery Revised Proposal (Assessment 2253)

The Pinjarra Alumina Refinery Revised Proposal (Assessment 2253) addresses additional Flora and Vegetation and Biodiversity impacts within Section *5.4.6 Cumulative impacts – Huntly*, particularly *Table 5-30 Cumulative impacts to Flora and Vegetation Associated with the Pinjarra Alumina Refinery Revised Proposal, Newmont Boddington Goldmine and South 32 Worsley Alumina Mine* and *5.4.6.7 Impacts to biodiversity, recreation and water management and Table 17-1 Cumulative impacts of past, present and reasonably foreseeable future activities within the NJF IBRA subregion* (Alcoa, 2022a). 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.

10.4 Terrestrial Fauna Cumulative Impacts

This section aims to address the activities for consideration in CIA as outlined in the ESD, focusing on terrestrial fauna within the Proposal outlined in Section 1, with an emphasis on:

- Clearing of native vegetation and threatened and priority fauna habitat, including fragmentation of habitat, within the Huntly and Willowdale Mine DEs, including clearing for mining operations and exploration activities.
- Exacerbation of noise, dust, odour, and light emissions to nearby sensitive receptors and wildlife as a result of increased mining and exploration activities.

10.4.1 Past and Present Activities

The NJF subregion has been subject to environmental impacts from a range of past and present activities, with the key activities in order of area of disturbance as follows:

- Agriculture.
- Timber harvesting.
- Prescribed burning.
- Bauxite and gold mining.
- Plantations.
- Water supply reservoirs.

Agriculture and timber harvesting have caused widespread impacts including:

- Loss of biodiversity and habitat from permanent clearing.
- Long term loss of mature trees and associated hollows from timber harvesting.
- Spread of *Phytophthora* Dieback in forested areas from timber harvesting.
- Agricultural impacts to soils including erosion, salinity, compaction, and acidification.
- Secondary salinity impacts to the Murray and Avon rivers from permanent clearing.
- Conversion of natural landscape to rural character and conversion of old growth forest to juvenile to immature forest age.

Mining has caused the following impacts:

- Short to medium term ecological and amenity impacts during operations and until rehabilitation establishes.
- Long term loss of fauna habitats.
- Increase in noise and light pollution.
- Increase of vehicle-wildlife collision because of increase traffic in the mine area.
- Rehabilitation restoring varying biodiversity, ecological integrity, and landscape quality.

Additionally, prescribed burning is carried out to mitigate the intensity and spread of wildfires, which can have substantial impacts on ecology, water quality, and local amenities. While water supply reservoirs have led to localised loss of incised river valley landforms and vegetation and caused widespread disruption to the migration and dispersal of aquatic fauna, they have also resulted in the creation of perennial water bodies that serve as refuges for aquatic wildlife.

The increase of mining and clearing activities in the area will result in an increase in noise and light pollution and increased in traffic movement, which may result in fragmentation of the Huntly and Willowdale Mine DE. This may impact a fauna's ability to hunt and

communicate, and may increase death via interaction with the Proposal. This could result in fauna becoming disrupted and then migrating outside of their territory.

10.4.2 Reasonably Foreseeable Future Activities

Within the NJF subregion, future activities that can be reasonably anticipated include both approved and proposed mining. It is expected that most of the Jarrah Forest that will be cleared for mining will undergo rehabilitation.

In 2024, the WA Government planned to cease native forest logging. Following this, the FPC will continue its independent logging activities within areas that have already received approval for mining. As part of the WA Government's strategy to reduce fuel loads and minimise the likelihood and severity of large-scale wildfires, prescribed burning is expected to continue within the subregion.

Other potential future activities within the subregion may include urban or rural residential development, infrastructure development, and agriculture. These activities are expected to be relatively minor and will be subject to regulation under Part V of the EP Act.

10.4.2.1 Fauna Cumulative Impacts

Cumulative impacts on the fauna within the NJF subregion may be due to the following:

- Mining and rehabilitation.
- Fragmentation.
- Timber harvesting.
- Climate change and wildfire.
- Disease and weed invasions.

An overview of cumulative impacts of the Proposal and other developments and processes to flora and vegetation in the NJF subregion is discussed in Section 10.3. The extent of impacts to vegetation, specifically in the NJF is directly related to the health and quality of fauna habitat. Clearance of Old Growth Forest is not expected to occur, as patches of mapped Old Growth Forest predominantly lie outside of existing and proposed Mine DEs. Within the Mine DEs, a small area of Old Growth Forest is within the MAZ.

Timber harvesting is expected to cease from 2024 onwards, at which point FPC will continue its independent logging activities within areas that have been approved for mining, and for activities that maintain forest health (Conservation and Parks Commission, 2023).

A breakdown of Alcoa's existing and future clearing impacts is included in Table 10-4 for the Mine DEs.

The cumulative effects of Alcoa's mining operations on fauna habitats in the Mine DE areas indicate that the Jarrah-Marri Forest will be the most affected. It is projected that 11,023 ha (14.4% of the total Mapped extent) will be cleared in the Huntly area and 4,667 ha (6% of the total Mapped extent) in the Willowdale area over the course of the 10-year mining plan. Over the course of the 10-year mining plan, it is anticipated that a cumulative total of 98.7ha, or 5.9% of Granite outcrops, will be cleared in the Huntly Region. This contrasts with the Willowdale Mine Region, where only 1 ha, or 0.07%, is projected to be cleared.

Cumulatively, the Proposal can potentially cause a significant impact to fauna habitat of the NJF to the following:

1. Forest red-tailed black cockatoo population estimates:
   1.1 Expected temporal loss of occupancy from mining until rehabilitation restores habitat to a level suitable to support foraging.
   1.2 Expected long term loss of potential hollow bearing trees in the context of the already widespread loss from historic timber harvesting.
2. Decrease of habitat due to inappropriate fire regimes:
   2.1 Widespread prescribed burning to maintain a forest fuel age of approximately six years without a fine scale mosaic of long unburnt areas, has the potential to impact flora species and reduce habitat for fauna populations.
3. Feral predators and invasive species:
   3.1 Expected temporal concentration of predation from feral animals (principally cats) as a result of fragmentation from mining across the region.
   3.2 The cat population represents an ongoing pressure on CWR mammals and other ground fauna and with no widespread treatment yet developed, the cumulative impacts is considered potentially significant.

10.4.3 Knowledge and survey gaps addressed in Pinjarra Alumina Refinery Revised Proposal (Assessment 2253)

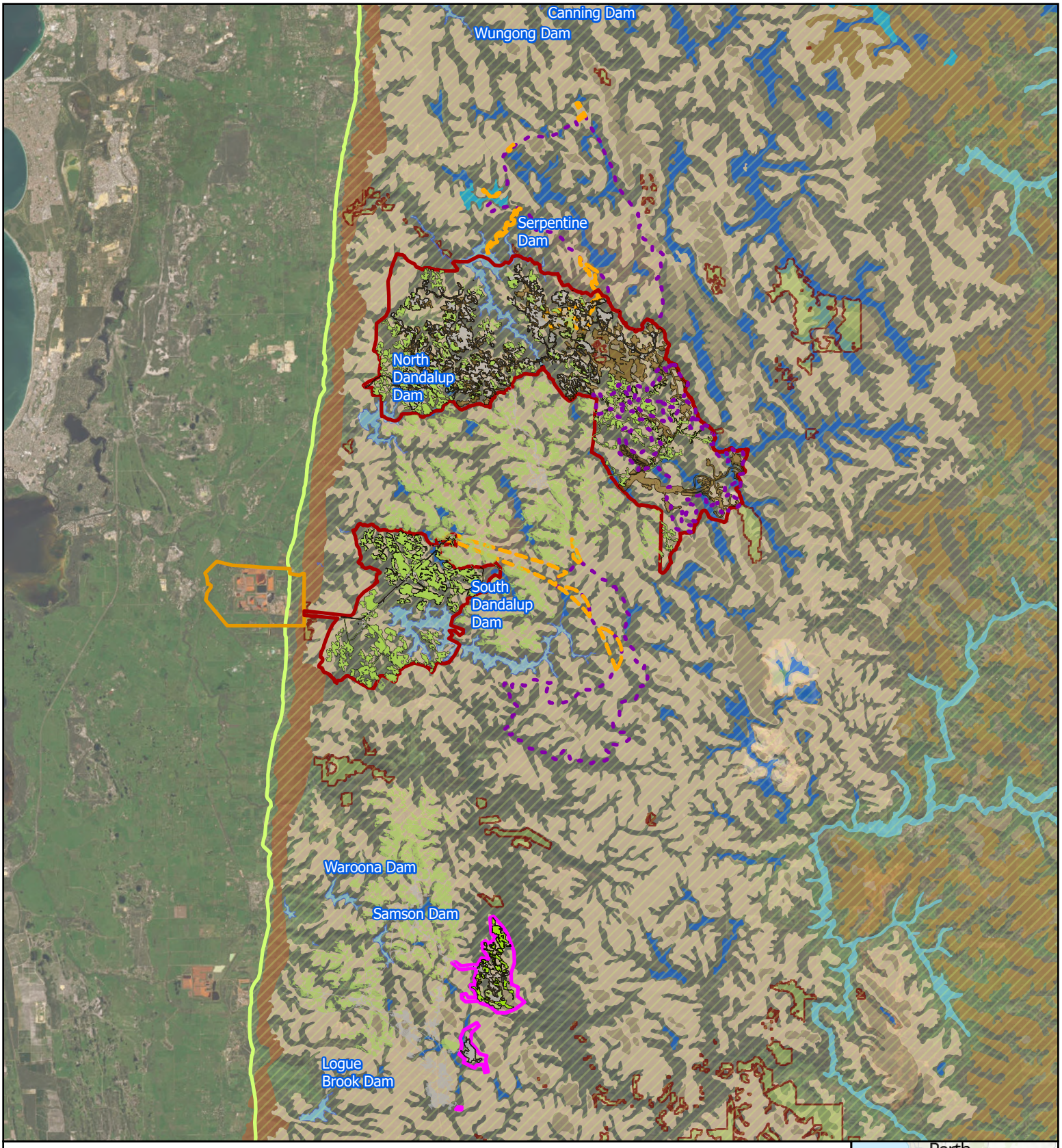
The Pinjarra Alumina Refinery Revised Proposal (Assessment 2253) ERD addresses additional Terrestrial Fauna cumulative impacts within *Table 17-1 Cumulative impacts of past, present and reasonably foreseeable future activities within the NJF IBRA subregion* (Alcoa, 2022a). While Assessment 2253 covers 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. This is particularly relevant when the time-bound nature of this Proposal (until 31 December 2027) is taken into account. The information from Assessment 2253 has been reviewed and extrapolated, where possible, to address knowledge and survey gaps within the current Proposal.

Table 10-4: Overview of Alcoa cumulative impacts to fauna habitat (Huntly Mine Region)

Description	Total Mapped extent area (ha)	Huntly Mine Region Area (ha)	Proportion of Mapped Extent (%)	FCA Endorsed	2025 – 2026 Proposed disturbance (ha) (including the Proposal, MMP, EPA Assessment 2253, Existing Proposal)	2027 – 2029 Proposed Disturbance (ha) (including the Proposal, Assessment 2253, Existing Proposal)	2030 – 2034 Proposed Disturbance (ha) (including the Proposal, Assessment 2253, Existing Proposal)	Proportion of Mapped Area remaining (%)
Blackbutt Forest	4,129	2,654	64.3%	6.2	23	14	3	1.11%
Bullich forest	8,536	6,175	72.3%	14.6	74	42	6	1.60%
Granite outcrop	1,654	1,467	88.7%	29.7	23	42	4	5.98%
Jarrah – Marri Forest	76,474	52,195	68.3%	1,494	2,699	3,586	3,244	14.41%
Melaleuca Dampland	988	915	92.6%	0.8	9	10	3	2.30%
Mine rehabilitation	16,510	7,623	46.2%	0.0	0	67	-	0.40%
Open Water (Serpentine Dam)	329	329	100.0%	0.0	0.0	0	-	0.00%
Plantation	202	167	82.7%	0.0	0.0	0	-	0.00%
Unsurveyed		30,392		6,390	119	1,115	2	
Total Area	**108,822**	**101,917**	**64.3%**	**7,935**	**2,948**	**4,875**	**3,262**	**17.48%**

Table 10-5: Overview of Alcoa Cumulative impacts to fauna habitat (Willowdale Mine Region)

Description	Total Mapped extent area (ha)	Area (ha)	Proportion of Mapped Extent (%)	FCA Endorsed	2025 – 2026 Proposed disturbance (ha) (including the Proposal, MMP, EPA Assessment 2253, Existing Proposal)	2027 – 2029 Proposed Disturbance (ha) (including the Proposal, Assessment 2253, Existing Proposal)	2030 – 2034 Proposed Disturbance (ha) (including the Proposal, Assessment 2253, Existing Proposal)	Proportion of Mapped Area remaining (%)
Blackbutt Forest	4,129	1,050	25.4%	15	4	2	7	0.7%
Bullich forest	8,536	1,920	22.5%	71	8	21	16	1.4%
Granite outcrop	1,654	92	5.6%	0	1	0	0	0.1%
Jarrah – Marri Forest	76,474	16,424	21.5%	1,901	958	803	1,005	6.1%
Melaleuca Dampland	988	43	4.4%	1	3	0	0	0.4%
Mine rehabilitation	16,510	62	0.4%	0	0	2	0	0.0%
Open Water (Serpentine Dam)	329	0	0.0%	0	0	0	0	0.0%
Plantation	202	0	0.0%	0	0	0	0	0.0%
Unsurveyed		36,984		428	12	3,879	1,082	
Total Area	**108,822**	**56,575**	**52%**	**2,415**	**986**	**4,707**	**2,111**	**9%**



Legend

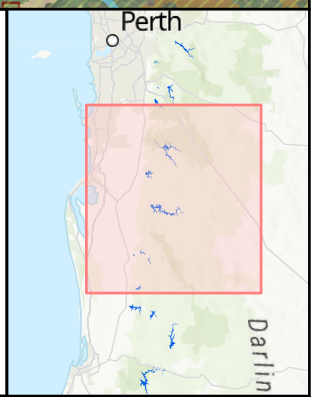
- Proposed Disturbance Footprint
- Previous Rehabilitation Footprint
- Open Areas
- Rehabilitation Footprint
- Huntly Mine DE
- Willowdale Mine DE
- Assessment 2253 Refinery Development Envelope
- Assessment 2253 Mine Infrastructure Development Envelope
- Assessment 2253 Mine Development Envelope
- IBRA sub-region (Northern Jarrah Forest)
- Reservoirs
- Old Growth Forest

Vegetation Complexes - South West forest region of Western Australia (DBCA-047)

Uplands
- Cooke
- Dalmore
- Darkin
- Darling Scarp

Vegetation Complexes - South West forest region of Western Australia (DBCA-047)

Valley Floors and Swamps
- Darkin
- Williams
- Dwellingup
- Yalanbee
- Goonaping
- Swamp



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

Figure 10-1 Cumulative Impacts to Terrestrial Ecology - Northern Jarrah Forest

Kilometres

0 5 10 15 20 25 30

N

Scale: 1:400,000 at A4

Date Printed: 26/02/2025

Alcoa

10.5 Terrestrial Environmental Quality Cumulative Impacts

This section aims to address the activities for consideration in CIA as outlined in the ESD, focusing on terrestrial environmental quality within the Proposal outlined in Section 1. Potential impacts to terrestrial environmental quality are unlikely to be as significant as other environmental values, with impacts limited to potential contamination or degradation of land systems at a more localised scale. These potentially impacts then contribute more broadly to the impact of other environmental values (see Section 9).

10.5.1 Past and Present Activities

The NJF subregion has been subject to environmental impacts from a range of past and present activities including agricultural, timber harvesting, prescribed burning, mining, and plantations. Agriculture and timber harvesting have caused widespread impacts to soils including erosion, salinity, compaction, and acidification. Impacts derived from mining are typically short to medium term (until rehabilitation has been completed). All mechanised activities and processing operations have the potential contaminate the environment through hydrocarbon spills or uncontrolled releases of waste effluent, chemicals or processing liquors. As a result of containment and other mitigation measures (refer to Section 5.4.6), potential contamination is expected to result in localised impacts and not contribute significantly to cumulative impacts.

Agricultural development has occurred over approximately 36% of the subregion, causing widespread land and soil impacts. Soil erosion averages approximately 10 t/ha/year (McFarlane, et al., 2000) and is a higher risk during excessive stocking on poor pastures during drought years (DAF, 2013). Secondary salinity affects about 2% of agricultural land in the subregion with a further 3% at risk in valleys (DAF, 2013). Agriculture has caused a moderate level of soil compaction, with soils mainly resilient but small areas of yellow soils at risk as cropping becomes more common (DAF, 2013). Agriculture has also caused subsurface soil acidification through fertiliser use, crop harvesting, and inadequate lime application, with deep sandy duplex soils particularly affected (DAF, 2013).

Timber harvesting over approximately 41% of the subregion has caused soil compaction, particularly during wet ground conditions, with higher compaction in landings and extraction tracks (Whitford, et al., 2012). The impact of harvesting has been reduced over the past two decades through improved harvesting management (Whitford, et al., 2012).

Mining over approximately 2% of the subregion has caused localised disturbance to land and soils, with loss of soil structure and removal of the bauxite layer from the upper regolith (Section 5.4.4). Bauxite mining has occurred predominantly over widespread lateritic soils with minor disturbance to alluvial soils or granite outcrops for mine infrastructure. Bauxite mining is unlikely to have substantially disturbed acid generating materials (Section 5.4.4.4) and will cause erosion in the short to medium term until rehabilitation establishes. Alcoa's mine rehabilitation has included local topsoil and overburden placement and deep and contour ripping to improve soil permeability, limit erosion and promote vegetation establishment (Section 6.1). Bauxite mining operations are expected to result in alterations of drainage channels and groundwater levels (refer Section 5.5) as result of temporary changes to the topography and soil profile. Due to the distance between operations,

alterations are expected to be localised and not result in cumulative impacts. Alcoa's rehabilitation practices reduce the likelihood of any long-term or cumulative impacts by prioritising rehabilitation using a risk-based approach and objective timeframes. The Proposal is not considered to result in any significant long-term alterations of the landscape following the completion of rehabilitation.

The closest mining operations to Alcoa's Huntly and Willowdale mines include the Newmont Boddington Goldmine and Worsley Alumina Refinery. The Newmont Boddington Goldmine has pit void, waste rock, and tailings storage landforms extending over approximately 4,374 ha or 0.23% of the subregion, which may result in long term acid and metalliferous drainage and soil erosion. The Newmont Goldmine pit void and waste landforms are regulated under the *Mining Act 1978*. Worsley Alumina Refinery has tailings storage landforms over approximately 1,300 ha or 0.07% of the subregion, which may result in long term alkaline drainage and soil erosion. The Worsley Refinery tailings storage is regulated under Part V of the *EP Act,* MS 719 covering the broader operations, with an amendment currently underassessment for further expansion (refer EPA Assessment Number 2216). Currently approved native vegetation clearing accounts for up to 5,263 ha within the Worsley's existing primary bauxite area, and an additional 8,400 ha within the extended mining areas (subject to conditions of MS 719).

10.5.2 Reasonably Foreseeable Future Activities

No substantial future agricultural development is expected in the subregion. Cleared agricultural areas are expected to be retained for primary productivity. Minor clearing may occur for urban, rural residential, and infrastructure development.

Existing agricultural activities are expected to continue to cause widespread impact to soils through salinity, erosion, compaction and acidification. Subsurface soil acidification is expected to increase with continuing fertiliser application and cropping.

Native Timber harvesting ceased in 2024 under the 2024-2033 FMP, except for logging for maintenance of forest health (e.g., ecological thinning). Soil compaction in harvested forest is expected to naturally remediate over the long term as the forest progresses into various forms of old growth forest. Some re-compactions (resulting from vehicle and machinery operations) may occur for logging activities to maintain forest health.

Mining will increase to a total of 3.9% of the subregion (including existing), of which the Proposal will comprise about 0.9% (or 0.4% of the NJF). Bauxite mining will occur predominantly over lateritic soils and cause soil erosion in the short to medium term until rehabilitation establishes. The pit void, waste rock and tailings storage landforms will increase in extent at Newmont Boddington Goldmine and Worsley Alumina Refinery, however, will remain a small proportion (approximately 0.3%) of the subregion. The mine waste landforms will be operated and rehabilitated in accordance with approvals under the Mining Act and/or Part V of the EP Act.

Rehabilitation is a critical component to Alcoa's environmental management and protects terrestrial environmental quality through achieving the objective of a self-sustaining Northern Jarrah Forest ecosystem that meets multiple uses, including recreation (refer to Section 6.1). Alcoa commences rehabilitation as soon as practicable from mining completion, with a risk-based process utilised to determine rehabilitation priority. On average rehabilitation is typically completed within six years of commencement, and as of June 2023, Alcoa had

rehabilitated 79.8% of areas cleared for mining operations. Similar commitments are made for Worsley Alumina whereby it is stated Worsley maintains a progressive rehabilitation program, typically rehabilitating 70-80% of the proposed vegetation clearing within 10 years of clearing thereby minimising the cumulative impacts (South32, 2022). Rehabilitation aims to minimise long-term alterations and impacts to the local landforms and topography of the region, thereby reducing erosion and retaining soil structure (as a result of rehabilitation timing and material handling). Avoidance mechanisms reduce impact drainage features with rehabilitation efforts aiming to restore the topography of mining impacted areas to blend with the natural terrain.

10.5.3 Knowledge and survey gaps addressed in Pinjarra Alumina Refinery Revised Proposal (Assessment 2253)

The Pinjarra Alumina Refinery Revised Proposal (Assessment 2253) ERD addresses additional Terrestrial Environmental Quality cumulative impacts within *Table 17-1 Cumulative impacts of past, present and reasonably foreseeable future activities within the NJF IBRA subregion* (Alcoa, 2022a). 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. This is particularly relevant when the time-bound nature of this Proposal (until 31 December 2027) is taken into account. The information from Assessment 2253 has been reviewed and extrapolated, where possible, to address knowledge and survey gaps within the current Proposal.

10.6 Inland Waters Cumulative Impacts

This section aims to address the activities for consideration in the CIA as outlined in the ESD, focusing on inland water within the Proposal outlined in Section 5.5, with an emphasis on:

- alteration of the existing hydrological regime from ground disturbance because of mining and associated activities, and
- run-off (i.e., mobilisation) of pollutants or contaminant release into catchments and drinking water reservoirs from mining and associated activities.

Section 5.5 identifies the greatest risk of impact to inland waters to be associated with:

- changes to both the surface water and groundwater regimes;
- increases in the rate of saline groundwater discharge to surface water systems;
- increases of sediment loads in surface water; and
- contamination of surface water or groundwater resources.

In most cases pathways for these impacts are linked to the removal of vegetation and alteration of the landscape for mining infrastructure (e.g., stockpile areas, haul roads, creek crossings etc) and mining. Operations may also result in minor localised impacts on water quality resulting from the release of contaminants introduced or generated within the mine areas.

In addition to mining, timber harvesting, catchment activities such as agriculture, plantations, and prescribed burning all result in the temporary or permanent loss of native vegetation and alteration of landscape.

Agriculture and timber harvesting have also resulted in the widespread loss of vegetation, impacts to soils including erosion, salinity, compaction, acidification, and secondary salinity impacts to the Murray Rivers from permanent clearing. Agricultural activities also occur within all relevant river basins west of the Darling scarp on the Swan Coastal Plain.

Mining typically results in short to medium term impacts which are unlikely to have a prolonged effect on the local environment. The percentage of land within the NJF impacted by these activities is presented in Sections 10.3 and 10.5 as they relate to flora and vegetation and terrestrial environmental quality.

In addition to the above, the construction and operation of water supply reservoirs have had direct impacts on land, water, and ecological values. Reservoirs located within the Serpentine, Dandalup, and Harvey River basins have caused localised loss of incised river valley landforms and vegetation (i.e., Murray vegetation complexes), and widespread disruption to aquatic fauna migrations and dispersal; they have, however, created perennial waterbodies that provide refuges for aquatic fauna.

The Murray Rivers remains a wild river and is not dammed due to poorer water quality unfit for drinking purpose as a result of secondary salinity from cleared agricultural upper catchments.

10.6.1 Past and Present Activities

Hydrological and water quality impacts from agriculture, damming, and climate change have impacted riparian and aquatic ecosystems. Secondary salinity from widespread agricultural clearing has resulted in salinisation of the Murray Rivers, which has impacted their potential beneficial use for drinking water as well as aquatic ecological values within the NJF subregion and the SCP downstream.

Damming of the Serpentine, Dandalup, and Harvey Rivers (and Wungong Brook) has diverted flows for the beneficial use of drinking water, which has substantially reduced environmental flows in downstream rivers with associated environmental impacts to aquatic and riparian ecosystems on the SCP. The dams release limited flows (<10% of inflow) to maintain downstream uses (Alcoa, 2022a).

The impact of timber harvesting on the water table in the NJF is multifaceted. While timber harvesting can temporarily slow the decline of groundwater levels (possibly leading to short-term increases in streamflow) the long-term effects on groundwater resources are complex and influenced by various factors including climate change and land management practices. Bari and Ruprecht (2003) identified the thinning of high rainfall catchments resulted in a maximum groundwater yield increase of 8 to 18% (depending on the level of reduction of vegetation cover and catchment characteristics). The subsequent recovery of vegetation has led to water yields returning to pre-disturbance levels after 12 to 15 years (Bari & Ruprecht, 2003). The removal of forest vegetation is also linked to declining stream flow quality resulting from increased salinity and sedimentation (Harper, Smettem, Ruprecht, Dell, & Liu, 2019).

Mining has occurred within several surface water catchments across the Darling Range including regulated (i.e., PDWSAs) and unregulated catchments of the Murray, Serpentine, and Harvey Rivers (see Figure 10-2). When considering Alcoa's operations, the former

Jarrahdale Mine (now closed) and Huntly Mine have predominantly operated within PDWSAs, including:

- Serpentine (11.1)% of this catchment);
- Serpentine Pipehead (5.8% of this catchment);
- North Dandalup (30.5% of this catchment);
- South Dandalup (7.1% of this catchment); and
- Conjurunup Creek (42.8% of this catchment).

Approximately 9% occurred in the unregulated Murray River catchment and 4% in the unregulated Serpentine River catchment. Mining within these PDWSAs to date has not necessitated any of these reservoirs to be shut down due to salinity, turbidity, or contaminant discharges.

Salinity and turbidity monitoring data available for the Serpentine, South Dandalup, and Wungong Brook PDWSAs indicates past and existing mining has not caused elevated salinity or turbidity at offtakes (see Section 5.5.4.5). This issue, however, remains a community concern over fears mining (and other land clearing activities) in catchments may contaminate drinking water sources.

The Willowdale Mine has mostly operated within the unregulated Murray and Harvey River catchments and the regulated Samson Brook Harvey River catchment (Samson Brook Dam and Stirling Dam) PDWSAs (see Figure 10-2). To date mining has not necessitated either reservoir to be shut down due to salinity, turbidity, or contaminant discharges.

The Newmont Boddington Goldmine and Worsley Mine have operated in the catchments of the Hotham and Williams rivers, which are tributaries of the unregulated Murray River catchment. Worsley Alumina Refinery lies in the unregulated catchment of the Collie River.

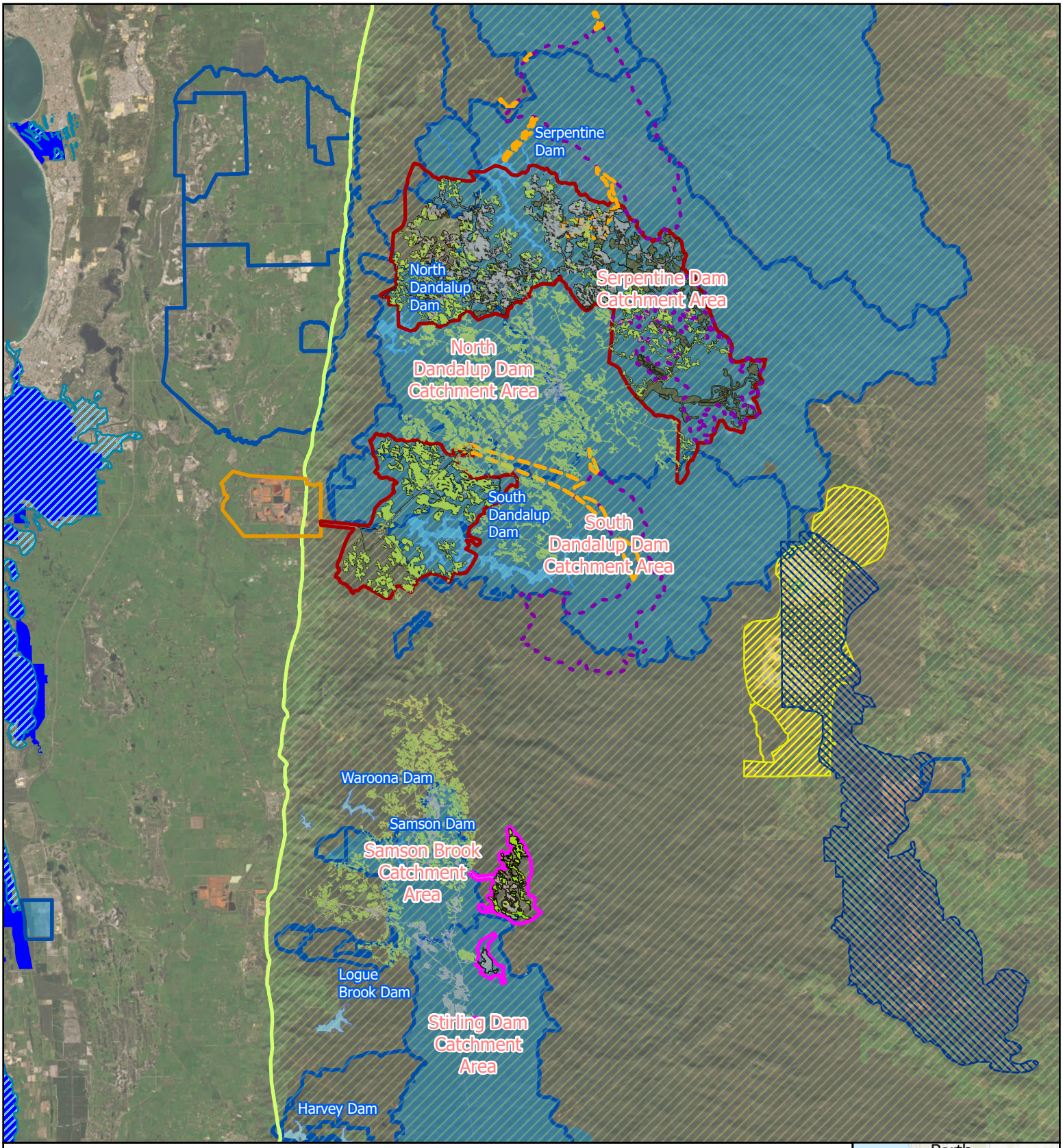
Mining within catchments of PDWSAs is hydrologically disconnected from downstream rivers and the Peel-Yalgorup System Ramsar wetlands, as drinking water dams either release no water downstream (e.g., Wungong, South Dandalup) or only very limited releases (e.g., Serpentine, North Dandalup, Stirling etc). Given the lack of substantial impact to reservoir water quality to date, the attenuating effects of reservoirs and the limited to no releases downstream, mining within PDWSAs is expected to have caused negligible impact to the downstream Peel-Yalgorup Ramsar wetlands.

Mining occurs in unregulated portions of the Serpentine and Harvey rivers, as well as the Murray River. Downstream and on the Swan Coastal Plain, these catchments are hydrologically connected to, and discharge into, the Peel-Yalgorup Ramsar wetlands. The total area of Alcoa's mining and rehabilitation operations within the unregulated catchments is approximately 18,000 ha, which represents about 3% of the approximately 540,000 ha of agriculture and intensive land use within the catchment of the Ramsar wetlands (DAFF, 2024). Given (i) the operational area is a fraction of the total mined area, (ii) about two thirds of these areas have been rehabilitated, and (iii) the limited use of fertilisers at these sites, mining is expected to have contributed only very minor to negligible water quality impacts to the Ramsar wetlands when compared to agriculture and other intensive land uses.

Mining in the unregulated Murray River catchment is unlikely to have caused significant impact to the Murray River section within Lane Poole Reserve. To date mining has not resulted in any catastrophic contaminant discharges that have affected either recreational usage or the amenity at Lane Poole Reserve or downstream.

The Newmont Boddington Goldmine has pit void, waste rock, and tailings storage landforms that may result in long term acid and metalliferous drainage runoff within the Hotham River catchment, a tributary of the Murray River. The Newmont Goldmine pit void and waste landforms are regulated under the *Mining Act 1978*.

Climate change impacts are likely to be responsible for the largest impacts to the NJF. The NJF has experienced a notable decline in rainfall since the 1970s (Harper, Smettem, Ruprecht, Dell, & Liu, 2019). Changes in precipitation patterns have disrupted hydrological balance in the region resulting in declining groundwater levels (Macfarlane C. , Grigg, McGregor, Ogden, & Cilberstein, 2018) and reduced stream flow.



Legend

- Huntly Mine DE
- Willowdale Mine DE
- IBRA sub-region (Northern Jarrah Forest)
- Proposed Disturbance Footprint
- Rehabilitation Footprint
- Open Areas
- Previous Rehabilitation Footprint
- Assessment 2253 Refinery Development Envelope
- Assessment 2253 Mine Infrastructure Development Envelope
- Assessment 2253 Mine Development Envelope

Public Drinking Water Source Areas (DWER-033)

priority

- P1
- P2
- P3
- P3*
- Catchments
- Directory of Important Wetlands in Australia - Western Australia (DBCA-045)
- Reservoirs

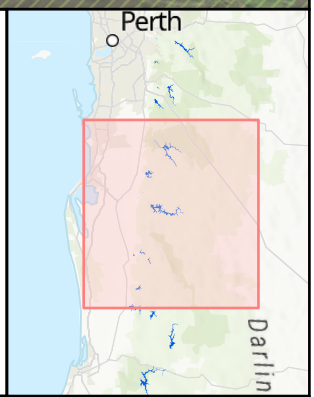
EPA Referred Significant Proposals (DWER-120)

Proponent

- Newmont Boddington Gold Development Envelope
- South32 Worsley Alumina Development Envelope

Ramsar Sites (DBCA-010)

- DRAFT Proposed Area
- Existing



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

Figure 10-2 Cumulative Impacts to Inland Waters - Northern Jarrah Forest

Kilometres

0 4 8 12 16 20 24

Scale: 1:400,000 at A4

Date Printed: 26/02/2025

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Alcoa

10.6.2 Reasonably Foreseeable Future Activities

No substantial future agricultural development is expected in the subregion. Cleared agricultural areas are expected to be retained for primary productivity and are likely to continue to cause secondary salinity to the Murray River.

Climate change pressures are likely to exacerbate impacts derived from large scale clearing and altered land uses in the region. Minor clearing may occur for urban, rural residential, and infrastructure development.

Dams are expected to remain in place and continue to divert water from downstream rivers with associated environmental impacts.

Hydrological and water quality impacts from agriculture, damming, and climate change are expected to continue to impact riparian and aquatic ecosystems and associated cultural heritage values.

Timber harvesting within the NJF ceased in 2024. As discussed above, the return of vegetation will result in the decline of the water table and increase in canopy cover. Returning vegetation is expected to result in gradual changes to the hydrological regimes in the local area over the next 15 years as hydrological and hydrogeological systems return to pre-mining conditions. Thinning will continue to be undertaken where required to support ecological health as required by the 2024–2033 FMP.

Mining will increase to a total of 3.9% of the subregion (including existing), of which the Proposal will comprise about 0.9%. The Proposal DEs predominantly intersects with PDWSAs of Serpentine Dam catchment (22,527 ha or 34.3% of catchment), other PDWSA catchment areas are intersected much less in area, but some of these catchments are smaller and the proportion of catchment within the DE is greater; such as South Dandalup Pipehead Dam (48.9% of catchment), Serpentine Pipehead Dam (39.8% of catchment), Conjurunup Creek (40.3% of catchment) (see Section 5.5.7.4). The PDWSA catchment areas intersected by the Proposal is not intersected by any other mining operations, except for a small portion of the South Dandalup Dam catchment area (Boddington Gold).

The Willowdale broader operations (existing) will continue to operate within the Stirling Dam PDWSA as well as unregulated Murray and Harvey River catchments (see Figure 10-2). As such these operations will now contribute to cumulative impacts to the PDWSAs covered by the Huntly Mine.

A summary of the historical, current Proposed, and future estimates of clearing within PDWSAs and RPZs is provided in Section 5.5.7.5.

Boddington Goldmine will remain within the unregulated Murray River catchment. Worsley Mine including the Primary Bauxite Area (PBA) and Extended Mining Areas (EMAs) will mostly occur within the unregulated Murray River catchment (see Figure 10-2) and not contribute cumulative impacts to the PDWSAs covered by the Huntly Mine or Willowdale Mine. The western portions of the Central and Hotham North EMA may lie in the upper catchment of the Serpentine PDWSA and contribute minor additional clearing to that PDWSA.

Mining and rehabilitation work undertaken within catchments of PDWSAs are unlikely to cause significant impacts to drinking water quality from salinity, turbidity, or other contaminants, as has been demonstrated by detailed assessments and historical monitoring

data for the Serpentine Dam and South Dandalup Dam (see Section 5.5.4.4). The Huntly and Willowdale mines will operate within different PDWSAs and will not contribute to cumulative impact risks to in any one PDWSA.

Small portions of mining in the unregulated catchment portions of the Murray River will occur at Huntly (South Dandalup unregulated sub-catchment) and Willowdale (Mid-Murray sub catchment). Mining in the unregulated Murray River catchment is highly unlikely (rare event) to result in a catastrophic contaminant discharge that results in a significant impact to recreational usage or amenity of Lane Poole Reserve or downstream. Contaminant spills and leaks within mined areas are expected to be remediated (see Section 5.4) rather than discharging into downstream rivers.

The pit void, waste rock, and tailings storage landforms will increase in extent at Newmont Boddington Goldmine and Worsley Alumina Refinery although will remain only a small proportion (approximately 0.3%) of the subregion. Mine waste landforms at these mines may result in long term acid and metalliferous drainage in the Murray (and Collie) River catchments and will be operated and rehabilitated in accordance with approvals under the Mining Act and/or Part V of the EP Act.

10.6.3 Knowledge and survey gaps addressed in Pinjarra Alumina Refinery Revised Proposal (Assessment 2253)

The Pinjarra Alumina Refinery Revised Proposal (Assessment 2253) ERD addresses Inland Waters cumulative impacts, within Section *8.4.11 Cumulative impacts and Table 17-1 Cumulative impacts of past, present and reasonably foreseeable future activities within the NJF IBRA subregion* (Alcoa, 2022a). 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. This is particularly relevant when the time-bound nature of this Proposal (until 31 December 2027) is taken into account. The information from Assessment 2253 has been reviewed and extrapolated, where possible, to address knowledge and survey gaps within the current Proposal.

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Table 10-6: Indicative cumulative impacts to Public Drinking Water Catchments

Public Drinking Water Source Areas	Catchment Area (ha)	Current disturbance (ha)	2025 – 2026 Proposed disturbance (ha) (including the Proposal, MMP, EPA Assessment 2253, Existing Proposal)	2027 – 2029 Proposed Disturbance (ha) (including the Proposal, Assessment 2253, Existing Proposal)	2030 – 2034 Proposed Disturbance (ha) (including the Proposal, Assessment 2253, Existing Proposal)	Total future mined area (ha)	Proportion of catchment total future mined (%)
Huntly Mine Region							
Conjurunup Creek Pipehead Dam Catchment Area	3,921.7	1,680.0	7	0	0	1,687	43.0%
Dirk Brook Reserve	13,945.1	861.0	83	24	0	968	6.9%
Gooralong Brook Water Reserve	4,120.8	0.0	0	46	0	46	1.1%
North Dandalup Dam Catchment Area	15,141.1	4,612.0	228	130	0	4,970	32.8%
Serpentine Dam Catchment Area	66,160.9	7,360.0	3,243	4,396	215	15,214	23.0%
Serpentine Pipehead Dam Catchment Area	2,881.3	167.0	0	0	0	167	5.8%
South Dandalup Dam Catchment Area	30,804.5	2,196.0	228	117	0	2,541	8.2%
South Dandalup Pipehead Dam Catchment Area	3,854.5	628.0	13	0	884	1,525	39.6%
Wungong Brook Catchment Area	12,821.9	0.0	0	0	33	33	0.3%
Grand Total	**153,651.8**	**17,507.0**	**3,804**	**4,715**	**2,492**	**28,520**	**18.6%**
Willowdale Mine Region							
Bancell Brook Catchment Area	1,838.0	111.0	0	0	51	162	8.8%
Harvey Dam Catchment Area	12,707.0	0.0	0	0	253	253	2.0%
Samson Brook Catchment Area	7,451.7	2,171.0	147	174	1	2493	33.5%
Stirling Dam Catchment Area	25,366.6	988.0	657	446	913	3004	11.8%
Grand Total	**47,363.3**	**2,689.0**	**1,047**	**918**	**2,109**	**6763**	**14.3%**

10.7 Social Surroundings (Heritage) Cumulative Impacts

This section aims to address the activities for consideration in CIA as outlined in the ESD, focusing on social surroundings (Heritage) within the Proposal, with an emphasis on:

- Increased risk of damaging an Aboriginal site or impacting on physical Aboriginal cultural heritage as a result of increased mining and exploration activities.
- Increased risk of impacting intangible heritage values including restricting the ability of Noongar People to access country due to mining and exploration activities.
- Increased risk of damaging non-Aboriginal (mostly European) heritage including historical features or artefacts as a result of increase mining and exploration activities.

Land clearing, primarily for the agriculture and timber industries has been carried out within the area for more than a century, which have been the most significant contributors to long-term cumulative impacts to both tangible and intangible cultural heritage values. Mining over the past several decades has also contributed to cumulative impacts to cultural heritage.

In addition to archaeological and ethnographic sites, Aboriginal cultural heritage values may be associated with natural waterways, landscape features (e.g., granite outcrops and domes), and environmental features such as culturally important vegetation communities, as well as cultural practices and traditions associated with the area.

10.7.1 Land Clearing

Agriculture across approximately 36% of the subregion has caused permanent loss of native vegetation in the vicinity of farming towns such as Boddington, the Perth Hills, and pockets of land in the vicinity of Jarrahdale and Dwellingup. This has caused widespread conversion of landscape character from native forests and woodlands to rural. Agricultural clearing and ground disturbance have caused widespread loss of Aboriginal cultural heritage, both through impact to archaeological and ethnographic sites as well as to hunting grounds and other environmental resources, and the ability for people to undertake cultural practices in the landscape.

Timber harvesting over approximately 41% of the subregion has caused a widespread conversion of landscape character from old growth forest (very large trees spaced apart) to a predominantly juvenile-to-immature age forest (denser stands of smaller trees). Old growth forest remains in fragmented areas over approximately 2% of the subregion, most of which lies in the east and south-east portions of forested areas, away from the historic centres of timber industry in Jarrahdale and Dwellingup. Timber harvesting may have caused loss of Aboriginal cultural heritage from ground disturbance, particularly when undertaken in valleys. The former timber industry has left behind European cultural heritage near Jarrahdale and Dwellingup as well as shield/reference trees scattered throughout the forest.

No substantial future agricultural development is expected in the subregion. Cleared agricultural areas are expected to be retained for primary productivity. Minor clearing may occur for urban, rural residential and infrastructure development.

Native Timber harvesting ceased in 2024 under the 2024-2033 FMP, except for logging for maintenance of forest health (e.g., ecological thinning).

Mining will increase to a total of 3.9% of the subregion (including existing activity), of which the Proposal will comprise about 0.9%.

10.7.2 Waterways

Inland Waters is a key component of Aboriginal cultural values, with Aboriginal life traditionally revolving around waterways and the associated food resources and social and aesthetic values. Agriculture has resulted in widespread impacts to the water quality of waterways in the NJF and SCP subregions, including salinisation of the Murray River.

Water supply reservoirs along the Darling Scarp have disrupted aquatic fauna migration and substantially reduced flow in the Serpentine and Dandalup Rivers downstream. Climate change has resulted in a decline in river flows since the 1970s. 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.

10.7.3 Land Access

Aboriginal access to country has historically been restricted through agricultural, urban, and rural residential development of the NJF and SCP subregions, with Aboriginal people displaced or forcibly removed from their traditional lands. Access to country has been available (to a more limited extent than in pre-Settlement time) within publicly accessible State Forest, National Parks, and recreational reserves in the NJF and SCP subregions. The Huntly and Willowdale mines have temporarily restricted public access to State Forest as mine regions have been progressively opened and pending closure and the handing back of mine regions to State Government.

Huntly Mine and Willowdale Mine will restrict public access to additional 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 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 mitigate the historical and ongoing lack of Noongar People's access to country caused by various post-settlement land uses, Alcoa is engaging with GKB AC on programs to facilitate access to operational areas where it is safe to do so. In addition, Alcoa and GKB AC are cooperatively developing a Cultural Heritage Management Framework that is designed to guide management of both tangible and intangible cultural heritage values across the areas where Alcoa can control or influence outcomes.

10.7.4 Aboriginal Heritage Places

Mining undertaken prior to the commencement of the *Aboriginal Heritage Act 1972* may have caused some loss of Aboriginal cultural heritage due to disturbance of unrecorded archaeological sites and materials. However, since the introduction of legislative protections, Alcoa has routinely undertaken heritage investigations ahead of development activities (albeit to varying standards historically). In addition, the landform and environment units most likely to contain places of cultural heritage places, typically water courses and granite outcrops, have been largely protected from mining activities. An exception is the mine infrastructure crossings of the various waterways that run through Alcoa's operational areas,

which are subject to detailed heritage investigation and consultation. Contemporary mining areas are subject to Aboriginal heritage investigations in accordance with the Noongar Standard Heritage Agreement standards, with the focus on identified heritage places being avoided and cultural materials managed *in situ*.

10.7.5 Minimising Cultural Heritage Impacts

Alcoa is in the process of engaging with the GKB AC Traditional Owners to co-design a CHMP that will apply to the Proposal (and potentially other operational areas). No impacts to cultural heritage sites are anticipated from the Proposal apart from the installation of water turbidity monitors into the Serpentine River. Alcoa has consulted with the GKB AC and its members in relation to the proposed water monitoring network and has received support from the GKB AC's Cultural Advice Committee to seek consent under Regulations 7 and 10 of the *Aboriginal Heritage Regulations 1974* for installations within the Registered site boundary. Alcoa has committed to engaging Cultural Monitors and GKB AC are investigating additional ways in which GKB AC members can be involved in ongoing data collection and other environmental management activities. Once agreed, these activities will be documented in either the CHMP or another appropriate document (i.e., a commercial contract if the activities are to be undertaken on a fee-for-service basis).

No State Heritage Register sites or Local Heritage Survey Places will be affected by the Proposal.

10.7.6 Knowledge and survey gaps addressed in Pinjarra Alumina Refinery Revised Proposal (Assessment 2253)

The Pinjarra Alumina Refinery Revised Proposal (Assessment 2253) ERD addresses additional cumulative Heritage impacts in relation to Social Surroundings (Heritage), within Section *11.6 Assessment and significance of residual impacts* (Alcoa, 2022a). While Assessment 2253 covers different clearing areas than this Proposal, does not include Willowdale and is still pending residual impact assessments and further Aboriginal heritage surveys, the cumulative impact information for surrounding mines is considered relevant and should be considered. As stated in Assessment 2253, the cumulative impacts to access to Country could potentially cause a significant residual impact to Aboriginal cultural values of the NJF. This is particularly relevant when the time-bound nature of this Proposal (until 31 December 2027) is taken into account. The information from Assessment 2253 has been reviewed and extrapolated, where possible, to address knowledge and survey gaps within the current Proposal. However, it is noted that additional surveys and consultation is required to ensure Social Surroundings (Heritage) cumulative impacts are known and avoided as far as practicable.

10.8 Social Surroundings (Amenity) Cumulative Impacts

This section aims to address the activities for consideration in the CIA as outlined in the ESD, focusing on social surroundings (Amenity) within the Proposal, with an emphasis on:

- Reduced visual and social amenity from the clearing of natural areas to facilitate mining activities.
- Exacerbation of noise, dust, odour, and light emissions to nearby sensitive receptors, including people and wildlife, as a result of increased mining.

Many land-uses and activities within the area carried out over several decades have resulted in long-term cumulative impacts to visual amenity, and various short-term impacts associated with dust, noise, and light generation.

10.8.1 Visual and Social Amenity

The main land-uses within the NJF are timber harvesting, agriculture, and mining comprising of approximately 41%, 36%, and 2% respectively, of the loss of native vegetation and conversion of landscape character. No substantial future agricultural development is expected in the subregion; however, cleared agricultural areas are expected to be retained for primary productivity. Native Timber harvesting ceased in 2024 under the 2024-2033 FMP, except for logging for maintenance of forest health (e.g., ecological thinning). Harvested forest is expected to progress towards old growth forest landscape (currently comprising only 1-2% of the subregion) over several decades to centuries. Mining will increase to a total of 3.9% of the subregion (WAFA, 2022), of which the Proposal will comprise about 0.9%.

These land uses cause visual impacts until rehabilitation restores the forest canopy, with rehabilitation efforts often resulting in a different landscape comprising exotic forest and denser tree stands. Survey of recreational users (Rosa, Geneletti, Morrison-Saunders, Sanchez, & Hughes, 2020) indicated that bushwalkers have usually avoided the rehabilitated areas while mountain bikers have not, and that the recreationists' perception of rehabilitated areas has been 'largely shaped by the absence of large and old trees and natural landforms'. Mine rehabilitation under contemporary prescriptions is expected to have a less dense canopy and understorey that is closer to un-mined forest, however these areas are yet to be opened to recreational users.

Views into mined areas are generally screened by topography and surrounding un-mined forest but are visible from some elevated viewpoints as well as where mine infrastructure (e.g., conveyors and haul roads) crosses public roads. Haul road crossings of public roads have occurred for the Huntly Mine (Kingsbury Drive), Willowdale Mine (Nanga Road) and Worsley Mine (Pinjarra-Williams Road). The Bibbulmun Track running east of the DE provides access to several elevated viewpoints within the Monadnocks Conservation Park and the White Horse Hills to the south and therefore mining may cause a cumulative visual impact along the Bibbulmun Track over the long term.

There are 12 existing mining operations and an additional 17 historic projects within a 2 km radius of the Bibbulmun track. A further nine projects are yet to be developed and an additional six are currently proposed. Most projects include open or rehabilitated pits targeting precious metals, alumina, industrial minerals, or construction materials. Visual impacts along the Bibbulmun track are anticipated to be worse in the northern extent where mountains provide elevated views. These may provide views of North Bannister Resource Recovery Facility, Alcoa's existing Huntly and Myara North Operations, Boddington Gold Mine, and Worsley Alumina Operations from certain vantage points. Impacts to visual amenity are likely to be less in the southern extent where the terrain is flatter; however, waste rock landforms may be visible in the distance and alteration of landscape along the track from past operations. From Boonering Hill an approximately 7,000 ha plantation is also visible, and another from Mount Cook. Rehabilitation is expected to reduce visual impacts in the long term.

The Munda Biddi trail typically traverses areas of lower elevations but does intersect several of Alcoa's mining areas where adjacent disturbance may be visible through screening. Few other mining operations lie along the trail, with the most noticeable being Worsley Alumina. The trail quite commonly traverses agricultural areas.

Huntly and Willowdale Mine will restrict public access to additional areas of State Forest (noting Alcoa's existing operational footprint) that may be used by some residents and visitors for informal recreation outside of defined trails and facilities that are managed and promoted. 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. Boddington Goldmine and Worsley Mine lie predominantly over private land and are not expected to substantially restrict public access (see Figure 10-3).

10.8.2 Noise, Dust, and Light Emissions

Mining over approximately 2% of the subregion has caused localised noise, light, and dust emissions that have caused elevated noise, nighttime illumination, and dust deposition in the vicinity, most of which comprises Jarrah Forest. Mining will continue to cause localised noise, light, and dust emissions. Neighbouring mines such as Boddington Gold and Worsley are not expected to contribute to cumulative noise, light, or dust levels at receptors in the vicinity of the Mine DE due to their distance away. Similarly, it is unlikely that Alcoa's other operations will have a cumulative impact from noise and dust but may have potential cumulative visual impacts from elevated viewing areas.

Mining in the DE may cause audible noise levels in the short to medium term within the NJF and along nearby sections of the Bibbulmun track and Munda Biddi trail, during adverse meteorological conditions and certain operational scenarios (see Section 5.7.4). The audible noise levels along these sections will be concurrent with audible noise levels from Alcoa's other operational areas and potentially with sections near the Boddington Gold mine. Mining may therefore create audible noise levels along two or three track sections at the same time, causing a cumulative impact over the short to medium term.

Timber harvesting has also caused periods of localised noise emissions and heavy vehicle traffic along public roads during harvesting operations, as timber and wood products are hauled to timber mills and other premises. Native Timber harvesting ceased in 2024; however, haulage of timber is likely to continue following mine clearing.

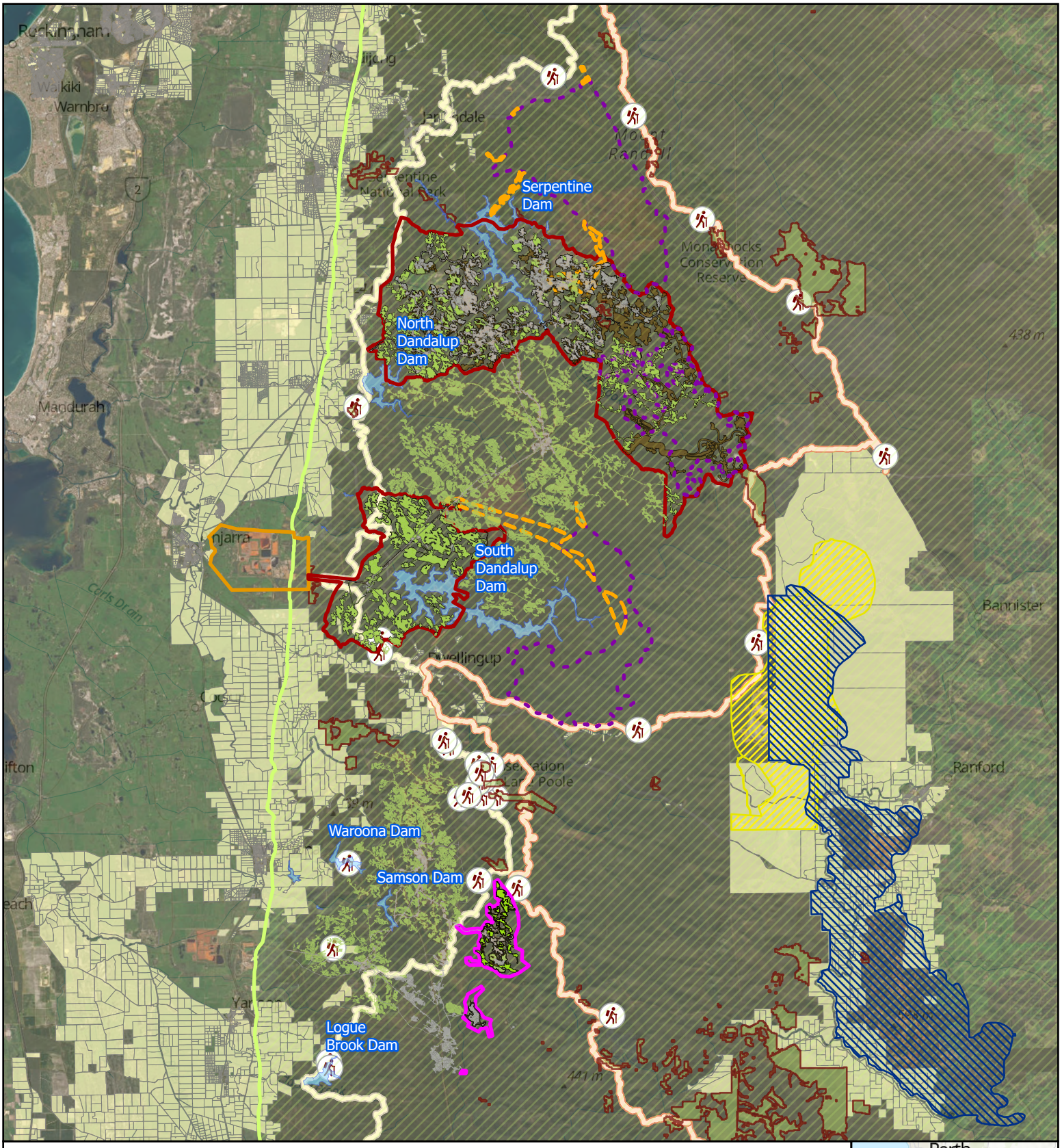
Noise and air blast modelling and historic monitoring results indicate that noise and vibrations levels resulting from the implementation of the Proposal would be managed in accordance with statutory requirements and do not pose a health, safety, or structural damage risk to sensitive receptors in the vicinity. The Proposal represents an extension of current mining practices over time with no increase in the rate of mining and associated equipment use which would contribute to noise emissions. Given the relatively large distance between major noise generating activities, including those associated with other mining operations or farming, cumulative noise, and vibration impacts have not been identified.

Prescribed burning has occurred over an average of 7% per year (during 2000-2020) of DBCA managed forest in the subregion. Prescribed burns can cause episodic amenity impacts to urban and rural receptors across the Southwest region depending on meteorological conditions. Prescribed burning is expected to continue in accordance with the WA Government's strategy to reduce fuel loads and minimise wildfires and will result in

episodic amenity impacts to urban and rural receptors across the Southwest region, including those in the vicinity of the Mine DE.

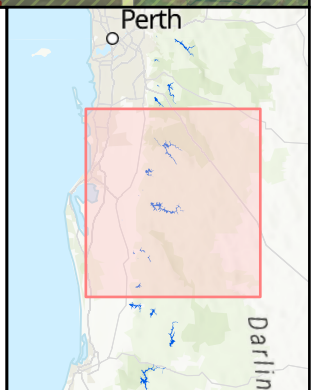
10.8.3 Knowledge and survey gaps addressed in Pinjarra Alumina Refinery Revised Proposal (Assessment 2253)

The Pinjarra Alumina Refinery Revised Proposal (Assessment 2253) ERD addresses additional Noise, Dust, and Light Emission cumulative impacts in relation to Social Surroundings (Amenity), within Section *12.4.8 Cumulative Impacts* and *Table 17-1 Cumulative impacts of past, present and reasonably foreseeable future activities within the NJF IBRA subregion* (Alcoa, 2022a). While Assessment 2253 covers different clearing areas than this Proposal, does not include Willowdale and is still pending residual impact assessments and further Aboriginal heritage surveys, the cumulative impact information for surrounding mines is considered relevant and should be considered. This is particularly relevant when the time-bound nature of this Proposal (until 31 December 2027) is taken into account. The information from Assessment 2253 has been reviewed and extrapolated, where possible, to address knowledge and survey gaps within the current Proposal. However, it is noted that additional surveys and consultation is required to ensure Social Surroundings (Heritage) cumulative impacts are known and avoided as far as practicable.



Legend

- Huntly Mine DE
- Willowdale Mine DE
- Assessment 2253 Refinery Development Envelope
- Old Growth Forest
- Reservoirs
- EPA Referred Significant Proposals (DWER-120)
- Proponent
- Newmont Boddington Gold Development Envelope
- South32 Worsley Alumina Development Envelope
- IBRA sub-region (Northern Jarrah Forest)
- Bibbulmun Track
- Munda Biddi Trail
- Assessment 2253 Mine Development Envelope
- Assessment 2253 Mine Infrastructure Development Envelope
- Rehabilitation Footprint
- Proposed Disturbance Footprint
- Previous Rehabilitation Footprint
- Open Areas



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

Figure 10-3 Cumulative Impact to Social Surrounds - Northern Jarrah Forest

Kilometres

0 5 10 15 20 25 30

Scale: 1:400,000 at A4

Date Printed: 26/02/2025

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Alcoa

10.9 Greenhouse Gas Emissions Cumulative Impacts

Please refer to Section 5.8 (Greenhouse Gas Environmental Management Plan (Alcoa, 2024a)).