Koala Habitat Rehabilitation Monitoring Report
ORU 5th Monitoring Period Yarrabilba

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Project Name: Yarrabilba
Proponent's ACN: 103 578 436
Prepared for: Lendlease
Prepared by: Dr M.N. Runkovski, K. Leopold & K. Richardt
Date: 25 October 2019
Proposed Action: To construct the Yarrabilba residential development and associated infrastructure approximately 40 kilometres south east of Brisbane, Queensland (see EPBC Act referral 3013/6791 and request to vary proposal dated 5 August 2013)

Natura Consulting – Document Control Sheet

Project	
Title:	**Habitat Rehabilitation Management Report – Offset Area 5th Monitoring Period**
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Revision History

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1 Executive summary

Natura Consulting has developed this *Habitat Rehabilitation Monitoring Report* as the 5th monitoring report after: initial baseline, 6 month, 2nd, 3rd and 4th monitoring period reports for rehabilitation within the Yarrabilba offset requirement areas as prescribed in the *Habitat Rehabilitation and Management Plan* (Natura Consulting, March 2015) and the Approval Conditions set out under the *Environmental Protection and Biodiversity Conservation Act 1999* dated 13 November 2014.

The intent of this report is to provide monitoring information to direct the rehabilitation works associated with Koala habitat within the Fauna Corridor, Greenspace Corridor and Environmental Protection Zones of the Yarrabilba Priority Development Area (PDA). Pine tree removal and assisted natural regeneration commenced six months prior to the 2nd monitoring period and has been ongoing in response to successive monitoring reports. The areas to be rehabilitated are offset requirement areas, ensuring that Koala habitat is specifically maintained within the 195 ha offset area. This report provides the 5th monitoring period data for the rehabilitation of the offset areas, with 59 sites, consistent with the 4th monitoring period, all monitored within an area of 198.2 ha in the Yarrabilba footprint. Each monitoring site is located within an offset area rehabilitation unit (ORU1 to ORU23) including road crossing rehabilitation units (CRU8, CRU11 and CU15), with the pre-clearing Regional Ecosystem (RE), management type and corridor type tabulated.

Each rehabilitation unit is to be rehabilitated to a vegetation structure and species composition that is in line with that of the pre-existing (pre-clearing) RE. This is derived from the vegetation structure and species composition of the appropriate pre-clearing RE. The final benchmark for rehabilitation is derived from the definition of remnant vegetation under the *Vegetation Management Act 1999* (canopy is 70% of the height, 50% of the cover and similar species composition of the appropriate pre-clearing RE). Interim benchmarks are also provided whereby an assessment at regular intervals will be made on the progress of the rehabilitation / revegetation efforts towards achieving this plan's outcomes. For interim benchmark years 1 to 10, vegetation structure has been quantified from a cumulative growth curve (CGC). The reference benchmark, interim benchmarks and final benchmarks have been tabulated for each RE, with the relevant rehabilitation unit also identified.

Contingency measures and corrective actions have also been provided to account for instances of when interim benchmarks are not being met. 'As constructed' data and surveyed boundaries will also be provided for each rehabilitation unit to test and demonstrate compliance within the offset area (195 ha) requirement.

The monitoring methodology that is applied has been detailed, where a minimum of two monitoring sites per rehabilitation unit has been surveyed in order to document and assess rehabilitation through time. The final locations of the 59 monitoring sites have been mapped. Monitoring includes photo point monitoring and transect and quadrat monitoring to monitor changes in species richness, percentage foliage cover for the ground layer, shrub and canopy layers, canopy height, and weed prevalence.

An assessment of site species richness and structure was undertaken to determine the 5th monitoring period condition against the baseline and benchmark values. With six monitoring periods now undertaken, it will be possible to observe trends in the data, however, the analyses made within this report are relatively basic, to identify high priority areas and guide management recommendations for different ORU and CRU based on a number of variables and RE benchmark indicators. Regardless of results in this report, ongoing passive and active management, weed control and maintenance of fencing is required to ensure restoration practices are effective within the offset areas.

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Overall, compared to the 4th monitoring period, improvements in general ecological health remained varied across offset sites. Whilst a fewer number of sites improved for species richness, many of the sites remained in the same condition as the 4th monitoring period, with 49% of sites already meeting the final benchmark. There was an overall trend for improvement in T1 cover (11 sites improved) and shrub cover (15 sites improved). Variables with most notable declines were T2-T3 small tree height (14 sites declined) and shrub cover (15 sites declined). Other parameters had less variation since the 4th monitoring period or remained relatively stable. Some of this variation may be attributed to seasonal variation, dry climate conditions, recruitment of lower order structural layers into higher order structural layers (i.e. movement of shrubs into T3 layers) and rehabilitation actions including continued control of exotic weeds and decreased grazing due to adequate maintenance of exclusion fencing.

Of the 59 sites, a total of 29 sites meet a benchmark for T1 canopy tree cover, 27 sites meet a benchmark for T1 canopy tree height, 54 sites meet a benchmark for T2-T3 small tree cover, 55 sites meet a benchmark for T2-T3 small tree height, 44 sites meet a benchmark for shrub cover, 53 sites meet a benchmark for shrub height, 55 sites meet a benchmark for ground cover and 30 sites meet a benchmark for weed cover of the ground layer.

In summary, this assessment reveals that rehabilitation needs to continue **prioritising weed control targeting graminoids such as *Andropogon virginicus,* herbs/shrubs such as *Lantana camara* and exotic tree species *Pinus elliotti* to assist natural regeneration and prevent weed spread and incursion**, particularly in areas adjacent to the Plunkett Conservation Reserve. **Continued infill planting in appropriate strata with appropriate species** as discussed in previous rehabilitation monitoring reports and other rehabilitation efforts need to focus on assisted regeneration in sites that are in poorest condition, have made the least improvements or fail to meet the IMO-3 benchmark targets for this year 3 (5th) monitoring period (see Table 8). **Where natural regeneration requires additional support, T1 canopy and shrub-layer species should be planted, and in some cases the removal of juvenile *Pinus elliotti* and thinning out of dominant *Acacia* species such as *A. leiocalyx* and *A. disparrima*** or native ground cover species such as *Imperata cylindrica* and *Pteridium esculentum* may improve species diversity over time by enhancing opportunities for emergence of new species from the local seed bank.

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2 Introduction

2.1 Background

The Yarrabilba development site is located on the eastern side of Waterford - Tamborine Road and to the south of Logan Village (refer to Figure 1). It is bounded by rural residential areas to the north, Plunkett Road to the south and the Plunkett Conservation Park to the east. The site consists of approximately 2,200 ha, of which 1,931 ha is controlled by Lendlease Communities (Yarrabilba) Pty Ltd. The land has been historically used for pine forestry, a military training camp in WWII and for livestock grazing, when first cleared. Yarrabilba is predominately vegetated with areas of regrowth native vegetation, regenerating pines and exotic grasslands. Some limited areas of native remnant and regrowth vegetation exist but they are mostly confined to creeks, drainage channels and wetlands.

The site is currently in the early stages of development with the growth of Yarrabilba projected to span approximately 30 years. The long-term master-planned development incorporates an extensive network of dedicated open space (in excess of 25% of the site). A significant component of the open space is dedicated to the conservation of habitat for Koalas (*Phascolarctos cinereus*).

Habitat rehabilitation is intended to improve Koala habitat quality within the site in order to significantly increase the site's carrying capacity in the medium to long term. In addition, the configuration of key elements of the open space system (Fauna Corridor, Greenspace Corridor and Environmental Protection Zone) will enhance the site's contribution to Koala movement opportunities within the context of larger areas of Koala habitat to the east and west of the site (Austecology 2012). Under the development of Yarrabilba, all existing fragments of remnant vegetation which have value for koalas will be retained (approximately 5.4% of the total site area) (Austecology 2012). The rehabilitation of the Fauna Corridor, Greenspace Corridor and Environmental Protection Zone will significantly expand on these values by providing additional Koala habitat (Natura Consulting 2011).

This report provides the 5th monitoring data for the rehabilitation of offset areas in the development site, based on the 59 sites monitored.

2.2 Objectives

The intent of this report is to provide data with which to assess the rehabilitation of Koala habitat within the Offset Requirement area, which includes Fauna Corridor, Greenspace Corridor and Environmental Protection Zone.

This report is consistent with the *Habitat Rehabilitation and Management Plan* (Natura Consulting 2015), *Offset Management Plan* (Austecology 2015), *Koala Management Plan* (Austecology 2012) and *Fauna Corridor Infrastructure Master Plan* (Natura Consulting 2011). In particular the objectives of this report are to:

- describe the rehabilitation areas and provide clear and concise rehabilitation outcomes and performance indicators against which achievement of the rehabilitation will be measured
- identify contingency measures and appropriate corrective actions that will be undertaken if the performance indicators or outcomes are not being met
- outline the monitoring methodology including monitoring site locations
- assess whether rehabilitation is on-track to meet the next interim performance indicator

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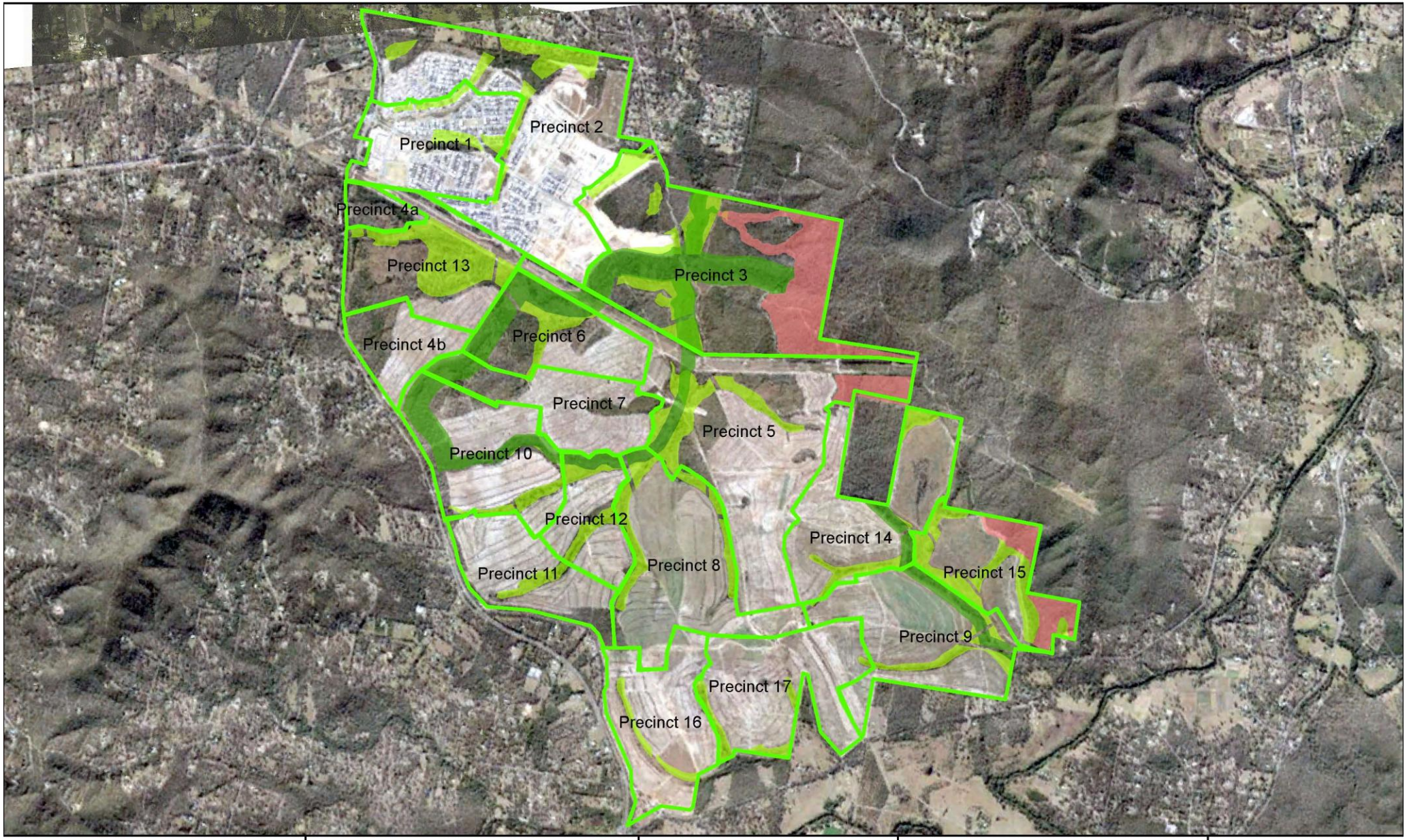

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Source: Corridor Areas/Conservation: Lend Lease 2016
Development Layout: Lend Lease 2016

Desclaimer: No warranty is given in relation the data (including accuracy, reliability, completeness, currency of suitability) and no liability is accepted (including without limitation liability in negligence) for any loss, damage or costs (including subsequent damage) relating to any use of the data. Data must not be used for direct marketing purposes or be used in breach of privacy laws.

File/Date: Yarrabilba
Date: 21/09/2016

N

0 145 290 580 870 1,160 1,450
Meters

Coordinate System: WGS 1984 Zone 56S Projection: Transerve Mercator

Legend

- Ongoing Conservation Areas
- Ongoing Fauna Corridor
- Ongoing Greenspace Corridor
- Precinct Boundaries (as of 22.03.17)

Figure 1
Yarrabilba site location

3 Rehabilitation areas

3.1 Purpose of habitat rehabilitation

Koala habitat rehabilitation is to be undertaken within "Existing Assessable Koala Habitat to be protected and managed" and "Offset Areas" within Fauna Corridors, Greenspace Corridors and Environmental Protection Zones. This totals an area of 1,981,771 m^2 (198.2 ha) in the offset areas and an additional 754,657 m^2 (75.5 ha) within existing assessable Koala habitat areas outside of offset areas, comprising a combined area of 2,736,428 m^2 (273.6 ha) to be rehabilitated.

The Koala habitat rehabilitation area has been divided into offset rehabilitation and habitat rehabilitation units and crossing rehabilitation units. This report is relevant to the offset and crossing rehabilitation units only.

3.2 Offset rehabilitation units (ORU)

Koala habitat rehabilitation is to occur within offset rehabilitation units as shown in Figure 2. Each rehabilitation unit (ORU1 to ORU23) is a mapped polygon, where the polygon boundaries are the mapped Pre-Clearing Regional Ecosystems. The Regional Ecosystem (RE) code applicable to each unit was determined by overlapping Pre-Clearing Regional Ecosystem mapping (Queensland Government 2015b) with Offset Requirement area mapping within the Fauna Corridors, Greenspace Corridors and Environmental Protection Zones.

The Table 1 presents a summary of rehabilitation unit attributes, including:

- the area of the rehabilitation unit in square metres
- the corridor within which the rehabilitation unit is located
- the RE code for pre-clearing vegetation within the rehabilitation unit and the landzone / geology of the rehabilitation unit

It is noted that the minimum rehabilitation unit size is ~2,500 m^2 to reflect the mapping limitation of the Pre-Clearing Regional Ecosystems mapping dataset (Queensland Government 2015a).

3.3 Crossing rehabilitation units (CRU)

Rehabilitation and monitoring will also be undertaken where road and infrastructure is proposed to traverse an Offset Requirement area. Crossing rehabilitation units have been identified by overlaying the proposed internal road network (currently under review) with the Pre-Clearing Regional Ecosystem mapping (Queensland Government 2015a) and Offset Requirement area mapping. Each crossing rehabilitation unit (CRU1 to CRU15) is a mapped polygon overlayed over offset rehabilitation units. It is noted that these locations are indicative and may change with the final alignment of roads. Table 2 presents a summary of the crossing rehabilitation units, which are subject to rehabilitation actions outlined in this report.

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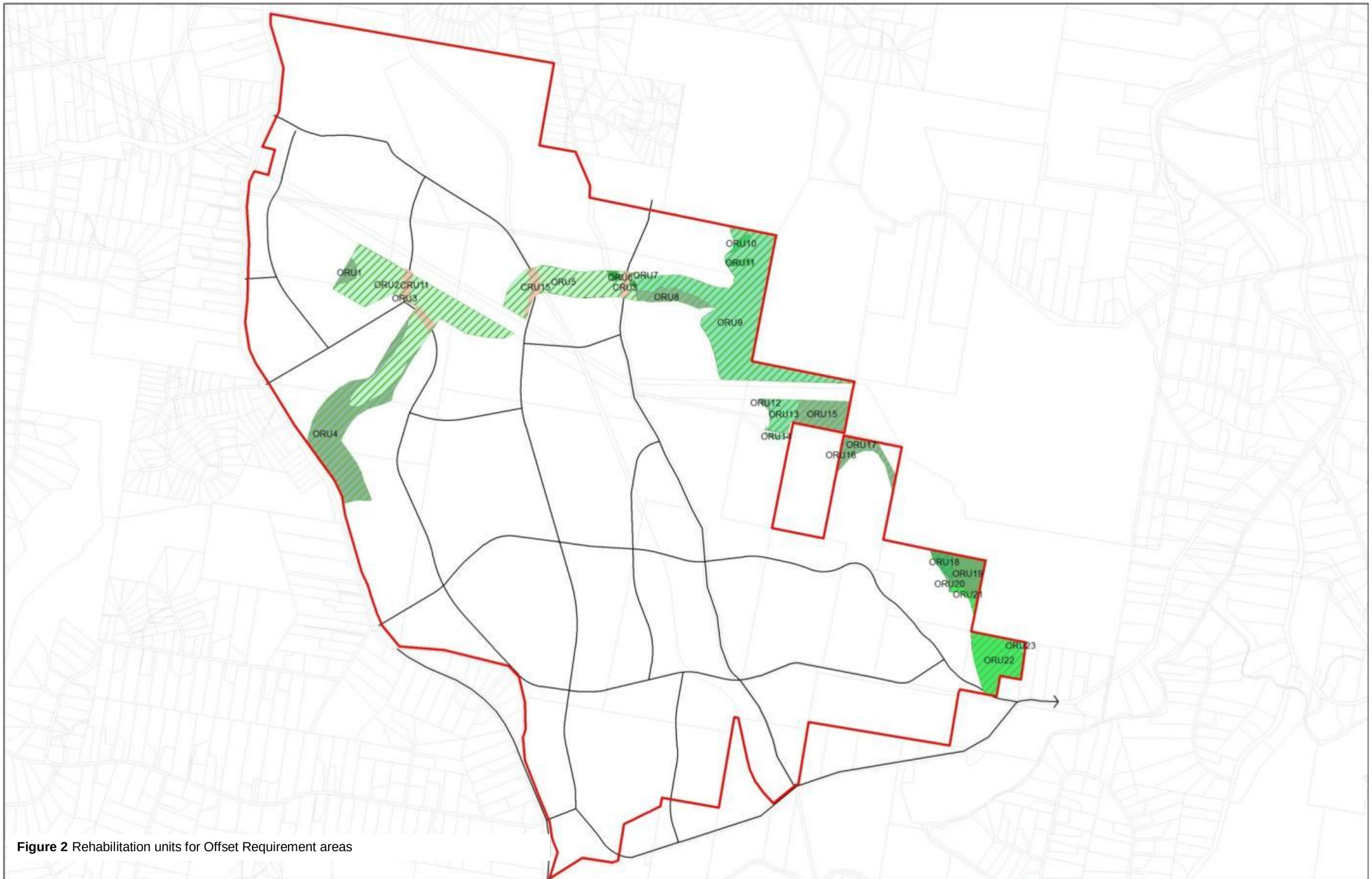

Figure 2 Rehabilitation units for Offset Requirement areas

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Table 1 Offset rehabilitation units (ORU) within the corridor network

Rehab. Unit	Area (m^2)	Corridor Type	RE Code(s)	Landzone / Geology
ORU1	16,933	Greenspace Corridor	12.9-10.17 / 12.9-10.2	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU2	439,297	Fauna Corridor / GreenSpace Corridor	12.3.11 / 12.3.6 / 12.3.7	Recent quaternary alluvial systems – alluvial river and creek flats
ORU3	1,451	Fauna Corridor	12.9-10.17 / 12.9-10.2	Fine grained sedimentary rocks - undulating country on fine grained sedimentary rocks
ORU4	269,317	Fauna Corridor	12.3.11 / 12.3.6 / 12.3.7 12.9-10.17 / 12.9-10.2	Recent quaternary alluvial systems – alluvial river and creek flats and Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU5	201,530	Fauna Corridor	12.3.11 / 12.3.6 / 12.3.7	Recent quaternary alluvial systems – alluvial river and creek flats
ORU6	10,205	Fauna Corridor	12.3.11 / 12.3.7	Recent quaternary alluvial systems – alluvial river and creek flats
ORU7	7,264	Fauna Corridor	12.3.11 / 12.3.6 / 12.3.7	Recent quaternary alluvial systems – alluvial river and creek flats
ORU8	46,711	Fauna Corridor	12.9-10.17 / 12.9-10.2	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU9	513,080	Environmental Protection / Fauna Corridor	12.9-10.17 / 12.9-10.19	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU10	8, 777	Environmental Protection	12.9-10.17	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU11	8,324	Environmental Protection	12.9-10.17	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU12	46,711	Environmental Protection	12.9-10.17 / 12.9-10.2	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU13	49,644	Environmental Protection	12.9-10.17 / 12.9-10.19 / 12.9-10.2	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU14	4,286	Environmental Protection	12.9-10.17 / 12.9-10.19 / 12.9-10.2	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU15	80,800	Environmental Protection	12.9-10.17 / 12.9-10.2	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks

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Rehab. Unit	Area (m^2)	Corridor Type	RE Code(s)	Landzone / Geology
ORU16	4,708	Environmental Protection	12.9-10.17 / 12.9-10.19	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU17	47,475	Environmental Protection	12.9-10.17 / 12.9-10.2	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU18	24,352	Environmental Protection	12.9-10.17	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
ORU19	59,917	Environmental Protection	12.11.5 / 12.11.3	Recent quaternary alluvial systems – alluvial river and creek flats
ORU20	3,154	Environmental Protection	12.9-10.17 / 12.9-10.2	Fine grained sedimentary rocks - undulating country on fine grained sedimentary rocks
ORU21	13,374	Environmental Protection	12.11.5 / 12.11.3	Recent quaternary alluvial systems – alluvial river and creek flats
ORU22	118,260	Environmental Protection	12.11.5 / 12.11.3	Recent quaternary alluvial systems – alluvial river and creek flats
ORU23	6,201	Environmental Protection	12.11.5	Recent quaternary alluvial systems – alluvial river and creek flats
Area	**1,981,771**			

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Table 2 Road and infrastructure crossing rehabilitation units (CRU) traversing offset rehabilitation units (ORU)

Crossing Rehab. Unit	Area (m^2)	Traversing ORU	Corridor Type	RE Code(s)	Landzone / Geology
CRU3	12,578	ORU5, ORU6, ORU7, ORU9	Fauna Corridor	12.3.11 / 12.3.6 / 12.3.7	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
CRU11	31,324	ORU2	Fauna Corridor	12.3.11 / 12.3.7	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
CRU15	22,138	ORU5	Greenspace Corridor / Fauna Corridor	12.3.11 / 12.3.6 / 12.3.7	Fine grained sedimentary rocks – undulating country on fine grained sedimentary rocks
Area	**66,040**				

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3.4 Pre-clearing Regional Ecosystems rehabilitation units

A short description of the pre-clearing Regional Ecosystems (RE) identified in the offset rehabilitation units and crossing rehabilitation units is provided in Table 3.

Table 3 Summary of pre-clearing Regional Ecosystems (RE) within offset rehabilitation units and crossing rehabilitation units

RE Code	RE short description (extract from Qld Herbarium RE Description Database)	*Vegetation Management Act* Class	Biodiversity Status
12.3.6	*Eucalyptus tereticornis, Casuarina cunninghamiana* subsp. *cunninghamiana* +/- *Melaleuca* spp. fringing woodland	Least concern	No concern at present
12.3.7	*Melaleuca quinquenervia* +/- *Eucalyptus tereticornis, Lophostemon suaveolens* open forest on coastal alluvial plains	Least concern	No concern at present
12.3.11	*Eucalyptus tereticornis* +/- *Eucalyptus siderophloia, Corymbia intermedia* open forest on alluvial plains	Of concern	Of concern
12.9-10.2	*Corymbia citriodora* subsp. *variegata* +/- *Eucalyptus crebra* open forest on sedimentary rocks	Least concern	No concern at present
12.9-10.4	*Eucalyptus racemosa* subsp. *racemosa* woodland on sedimentary rocks	Least concern	No concern at present
12.9-10.12	*Eucalyptus seeana, Corymbia intermedia, Angophora leiocarpa* woodland on sedimentary rocks	Endangered	Endangered
12.9-10.17	*Eucalyptus acmenoides, E. major, E. siderophloia* +/- *Corymbia citriodora* subsp. *variegata* woodland on sedimentary rocks	Least concern	No concern at present
12.9-10.19	*Eucalyptus fibrosa* subsp. *fibrosa* woodland on sedimentary rocks	Least concern	No concern at present
12.11.3	*Eucalyptus siderophloia, E. propinqua* +/- *E. microcorys, Lophostemon confertus, Corymbia intermedia, E. acmenoides* open forest on metamorphics +/- interbedded volcanics	Least concern	No concern at present
12.11.5	*Corymbia citriodora* subsp. *variegata, Eucalyptus siderophloia, E. major* open forest on metamorphics +/- interbedded volcanics	Least concern	No concern at present

(Source: QLD Government 2015a)

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4 Rehabilitation performance indicators

In accordance with the *EPBC Act 1999* decision notice, the Koala Habitat Rehabilitation Management Plan (Natura Consulting 2015) has been formulated reflecting the onsite rehabilitation requirements of Fauna and Green Space Corridors, Regional Ecosystems, drainage lines and post development fauna movement pathways within Offset Areas on the site. This plan identifies Koala habitat rehabilitation benchmarks and determines restoration actions to meet these benchmarks.

Each rehabilitation unit is to be rehabilitated to a vegetation structure and species composition that is in line with that of the appropriate pre-clearing RE (Table 4). The reference benchmark for rehabilitation of each rehabilitation unit is derived from the vegetation structure and species composition of the appropriate pre-clearing Regional Ecosystem (RE) (Table 4). These benchmarks quantify average canopy cover, shrub cover, ground cover, species richness and average height of the canopy and have been sourced from the Queensland Herbarium (Queensland Government 2015a). These technical descriptions are a compilation of data from multiple sites for canopy cover, shrub cover, and average stem density for each strata, groundcover and average species richness (Queensland Government 2015a). Through establishing these benchmarks, a reasonable comparison can be made between the floristic composition and vegetation structure of a given rehabilitation unit and the appropriate pre-clearing RE.

4.1 Performance indicators

The final benchmark for rehabilitation is derived from the definition of remnant vegetation under the *Vegetation Management Act 1999.* Vegetation can be mapped as remnant vegetation and associated essential habitat for Koalas if the canopy is 70% of the height, 50% of the cover and similar species composition of the appropriate pre-clearing RE (Queensland Government 2015a). Therefore, the final benchmark for rehabilitation is 70% of the reference benchmark cover (for canopy, shrub and ground-layer) and 50% of the reference benchmark height (for canopy and shrub layer) of the appropriate RE.

Six rehabilitation performance indicators were selected:

1 average canopy cover
2 average height of canopy
3 dominant canopy species
4 average shrub cover
5 average groundcover
6 species richness
7 weed cover

Weed cover needs to be considered for rehabilitation benchmarks for this site, particularly in the canopy where numerous exotic pine trees exist. Throughout the life of the development a weed cover of ≤5% is to be reached, and then maintained.

The reference and final benchmark vegetation structure and species composition for each of the pre-clearing RE's identified within the mapped rehabilitation units is identified in Table 4. Note that exotic species identified in Table 4 are to assist with identification purposes only and are to be controlled and managed, not planted or assisted.

Rehabilitation units are to be managed and restored until they reach the final benchmark condition as identified in Table 4 and objectives of the Habitat Rehabilitation and Management Plan. The objectives of this plan are long term and are likely to require more than 15 years to be achieved, within each rehabilitation unit, after commencement of implementation.

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Interim benchmarks are also provided whereby an assessment at regular intervals can be made on the progress of the rehabilitation / revegetation efforts towards achieving this plan's outcomes. Given this, adaptive management approaches can also be employed to redirect restoration approaches, in the event that interim benchmarks are not being met. Table 4 provides a summary of the timeframe to achieve the interim and final benchmarks.

For Interim Benchmark years 1 to 10, vegetation structure has been quantified from a cumulative growth curve (CGC), which for biological organisms including trees and shrubs, is sigmoidal. As the reference benchmarks applied for this report are at the Regional Ecosystem level and site data and long term tree and shrub growth curves are not available for Yarrabilba, we have derived general growth curves for each Regional Ecosystem. This is based on a sigmoidal growth curve, the average reference benchmark height of the stratum, the minimum height at which regrowth vegetation is considered to be of equivalent height as the RE (50% of reference benchmark height), and the average height of tubestock (20 cm) that is predominately used for revegetation in southeast Queensland.

The final benchmark at year 15 is 70% of the reference benchmark cover (for canopy, shrub and ground-layer) and 50% of the reference benchmark height (for canopy and shrub layer) of the appropriate pre-clearing RE.

4.2 Contingency measures and corrective actions

4.2.1 Meeting benchmarks

During the course of monitoring, if interim benchmarks are not being met, the timeframes to achieve the final benchmarks will be reviewed and extended, whereby Lendlease will continue to undertake rehabilitation works with continued monitoring until the final benchmarks are met. The review of the success of meeting interim benchmarks will be undertaken at each monitoring event and reported on. Where the extension of rehabilitation works is required for particular rehabilitation units, discussions will be undertaken with the Department of Environment, to ensure that any additional requirements are also highlighted and addressed.

4.2.2 As constructed data

Constructed data and surveyed boundaries will be provided for each rehabilitation unit, within three months of completion of earthworks. This will be undertaken to test and demonstrate compliance within the offset area (195 ha) requirement.

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Table 4 Reference, interim and final benchmark vegetation structure for each pre-clearing RE detailed for rehabilitation units (ORU and HRU) and crossing rehabilitation units (CRU)

Benchmark Condition (where rehabilitation units are treated individually, at least 70% of height and 50% of cover values to be attained within first 15 years of commencement of rehabilitation works)											
RE Code	**Name**	**Status (VMA)**	**Biodiversity Status**	**Offset Rehabilitation Unit**				**Crossing Rehabilitation Unit**			
12.3.6	***Melaleuca quinquenervia* +/- *Eucalyptus tereticornis, Lophostemon suaveolens* open forest on coastal alluvial plains**	Least concern	No concern at present	ORU2, ORU4, ORU5, ORU7				CRU3, CRU15			
				Average Canopy Cover (%)	**Average Canopy Height (m)**	**Average T2-T3 Canopy Cover (%)**	**Average T2-T3 Canopy Height (m)**	**Average Shrub Cover (%)**	**Average Shrub Height (m)**	**Average Ground cover (%)**	**Species Richness (av. +/- SD)**
Interim Benchmark by 1 year				10.0	1.5			1.5	0.5	6.0	
Interim Benchmark by 2 years				14.0	3.0			2.0	0.8	10.0	
Interim Benchmark by 3 years				16.0	4.0			2.5	1.2	15.0	
Interim Benchmark by 5 years				22.0	6.0			3.0	1.4	20.0	
Interim Benchmark by 10 years				28.0	9.2			4.0	1.5	25.0	
Final Benchmark by 15 years				**30.5**	**10.7**			**4.5**	**1.6**	**29.2**	**-**
Reference Benchmark (Pre-Clearing RE)				**60.9**	**15.3**			**8.9**	**2.3**	**58.4**	**33.3 +/- 10.5**
12.3.7	***Eucalyptus tereticornis*, *Casuarina cunninghamiana* subsp. *cunninghamiana* +/- *Melaleuca* spp. fringing woodland**	Least concern	No concern at present	ORU2, ORU4, ORU5, ORU6, ORU7				CRU3, CRU11, CRU15			
				Average Canopy Cover (%)	**Average Canopy Height (m)**	**Average T2-T3 Canopy Cover (%)**	**Average T2-T3 Canopy Height (m)**	**Average Shrub Cover (%)**	**Average Shrub Height (m)**	**Average Ground cover (%)**	**Species Richness (av. +/- SD)**
Interim Benchmark by 1 year				5.5	1.6	2.0	0.8	2.5	0.5	6.0	
Interim Benchmark by 2 years				6.0	2.9	3.0	2.7	3.0	0.8	7.0	
Interim Benchmark by 3 years				7.0	4.1	4.0	3.7	3.5	1.2	8.0	
Interim Benchmark by 5 years				9.0	6.2	5.9	5.2	4.0	1.4	10.0	
Interim Benchmark by 10 years				12.0	10.1	9.3	7.3	6.0	1.5	12.0	
Final Benchmark by 15 years				**13.3**	**13.6**	**11.5**	**8.2**	**6.6**	**1.6**	**14.4**	**-**
Reference Benchmark (Pre-Clearing RE)				**26.6**	**19.4**	**15.3**	**9.0**	**13.2**	**2.3**	**28.7**	**52.8 +/- 7.5**

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Benchmark Condition (where rehabilitation units are treated individually, at least 70% of height and 50% of cover values to be attained within first 15 years of commencement of rehabilitation works)											
RE Code	**Name**	**Status (VMA)**	**Biodiversity Status**	**Offset Rehabilitation Unit**				**Crossing Rehabilitation Unit**			
12.3.11	***Eucalyptus tereticornis* +/- *Eucalyptus siderophloia*, *Corymbia intermedia* open-forest on alluvial plains**	Of concern	Of concern	ORU2, ORU4, ORU5, ORU6, ORU7				CRU3, CRU11, CRU15			
				Average Canopy Cover (%)	**Average Canopy Height (m)**	**Average T2-T3 Canopy Cover (%)**	**Average T2-T3 Canopy Height (m)**	**Average Shrub Cover (%)**	**Average Shrub Height (m)**	**Average Ground cover (%)**	**Species Richness (av. +/- SD)**
Interim Benchmark by 1 year				7.0	1.6	2.0	0.8	2.0	0.4	1.5	
Interim Benchmark by 2 years				10.0	3.0	3.0	2.8	4.0	0.7	2.0	
Interim Benchmark by 3 years				12.0	4.2	4.2	3.8	5.0	1.1	3.0	
Interim Benchmark by 5 years				18.0	6.4	6.4	5.5	7.0	1.3	4.5	
Interim Benchmark by 10 years				22.0	10.7	10.7	8.2	9.0	1.5	7.0	
Final Benchmark by 15 years				**25.6**	**16.7**	**13.9**	**9.6**	**10.9**	**1.9**	**8.5**	**-**
Reference Benchmark (Pre-Clearing RE)				**51.1**	**23.8**	**23.9**	**11.3**	**21.7**	**2.7**	**17**	**40.6 +/- 8.5**

12.9-10.2	***Corymbia citriodora* subsp. *variegata* +/- *Eucalyptus crebra* open forest on sedimentary rocks**	Least concern	No concern at present	ORU1, ORU3, ORU4, ORU8, ORU12, ORU13, ORU14, ORU15, ORU17, ORU20							
				Average Canopy Cover (%)	**Average Canopy Height (m)**	**Average T2-T3 Canopy Cover (%)**	**Average T2-T3 Canopy Height (m)**	**Average Shrub Cover (%)**	**Average Shrub Height (m)**	**Average Ground cover (%)**	**Species Richness (av. +/- SD)**
Interim Benchmark by 1 year				6.0	1.6	2.0	0.8	6.0	0.4	6.0	3.0
Interim Benchmark by 2 years				10.0	2.9	2.9	2.8	6.5	0.7	7.0	4.0
Interim Benchmark by 3 years				12.0	4.2	4.0	3.8	7.0	1.1	12.0	5.0
Interim Benchmark by 5 years				18.0	6.3	6.0	5.3	8.5	1.3	18.0	7.0
Interim Benchmark by 10 years				22.0	10.5	9.6	7.7	11.4	1.5	22.0	9.0
Final Benchmark by 15 years				**26.8**	**15.5**	**11.9**	**8.9**	**15.1**	**1.8**	**23.6**	**10.8**
Reference Benchmark (Pre-Clearing RE)				**53.5**	**22.2**	**16.5**	**10.1**	**21.6**	**2.5**	**47.2**	**21.6**

12.9-10.17	***Eucalyptus acmenoides*,**	Least	No concern	ORU1, ORU3, ORU4, ORU8, ORU9, ORU10, ORU11,	

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Benchmark Condition (where rehabilitation units are treated individually, at least 70% of height and 50% of cover values to be attained within first 15 years of commencement of rehabilitation works)												
RE Code	**Name**	**Status (VMA)**	**Biodiversity Status**	**Offset Rehabilitation Unit**				**Crossing Rehabilitation Unit**			
	***Eucalyptus major, Eucalyptus siderophloia* +/- *Corymbia citriodora subsp. variegata* woodland on sedimentary rocks**	concern	at present	ORU12, ORU13, ORU14, ORU15, ORU16, ORU17, ORU18, ORU20							
				Average Canopy Cover (%)	**Average Canopy Height (m)**	**Average T2-T3 Canopy Cover (%)**	**Average T2-T3 Canopy Height (m)**	**Average Shrub Cover (%)**	**Average Shrub Height (m)**	**Average Ground cover (%)**	**Species Richness (av. +/- SD)**
Interim Benchmark by 1 year				6.0	1.6	2.0	0.8	6.0	0.6	10.0	
Interim Benchmark by 2 years				10.0	3.0	3.0	2.8	7.0	1.0	20.0	
Interim Benchmark by 3 years				12.0	4.2	4.3	3.9	10.0	1.5	25.0	
Interim Benchmark by 5 years				18.0	6.4	6.5	5.7	14.0	1.8	30.0	
Interim Benchmark by 10 years				22.0	10.9	11.3	8.9	16.0	2.2	35.0	
Final Benchmark by 15 years				**27.2**	**18.2**	**15.0**	**10.4**	**20.0**	**2.8**	**43.9**	-
Reference Benchmark (Pre-Clearing RE)				**54.3**	**26.0**	**30.5**	**12.9**	**40.0**	**4.0**	**87.8**	**36.5 +/- 15.1**

12.9-10.19	***Eucalyptus fibrosa subsp. fibrosa* woodland on sedimentary rocks**	Least concern	No concern at present	ORU9, ORU14, ORU16							
				Average Canopy Cover (%)	**Average Canopy Height (m)**	**Average T2-T3 Canopy Cover (%)**	**Average T2-T3 Canopy Height (m)**	**Average Shrub Cover (%)**	**Average Shrub Height (m)**	**Average Ground cover (%)**	**Species Richness (av. +/- SD)**
Interim Benchmark by 1 year				6.0	1.6	2.0	0.8	2.5	0.4	2.5	
Interim Benchmark by 2 years				7.0	3.0	2.9	2.7	4.0	0.7	3.0	
Interim Benchmark by 3 years				9.0	4.2	4.0	3.7	5.0	1.1	4.0	
Interim Benchmark by 5 years				12.0	6.3	6.0	5.2	7.0	1.3	6.0	
Interim Benchmark by 10 years				15.0	10.5	9.6	7.3	9.0	1.5	8.0	
Final Benchmark by 15 years				**20.9**	**15.8**	**11.9**	**8.2**	**9.6**	**1.7**	**8.2**	-
Reference Benchmark (Pre-Clearing RE)				**41.8**	**22.5**	**16.4**	**9.0**	**19.1**	**2.4**	**16.4**	**30.1 +/- 4.6**

12.11.3	***Eucalyptus siderophloia,***	Least	No concern	ORU19, ORU21, ORU22							

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Benchmark Condition (where rehabilitation units are treated individually, at least 70% of height and 50% of cover values to be attained within first 15 years of commencement of rehabilitation works)											
RE Code	**Name**	**Status (VMA)**	**Biodiversity Status**	**Offset Rehabilitation Unit**				**Crossing Rehabilitation Unit**			
	***E. propinqua* +/- *E. microcorys, Lophostemon confertus, Corymbia intermedia, E. acmenoides* open forest on metamorphics +/- interbedded volcanics**	concern	at present	**Average T1 Canopy Cover (%)**	**Average T1 Canopy Height (m)**	**Average T2-T3 Canopy Cover (%)**	**Average T2-T3 Canopy Height (m)**	**Average Shrub Cover (%)**	**Average Shrub Height (m)**	**Average Ground cover (%)**	**Species Richness (av. +/- SD)**
Interim Benchmark by 1 year				6.0	1.6	1.6	1.0	1.5	0.4	3.0	
Interim Benchmark by 2 years				10.0	3.0	3.0	2.7	2.0	0.7	5.0	
Interim Benchmark by 3 years				14.0	4.2	4.2	3.6	2.5	1.1	7.0	
Interim Benchmark by 5 years				20.0	6.4	6.5	4.9	4.0	1.3	10.0	
Interim Benchmark by 10 years				25.0	10.8	11.2	6.8	4.5	1.5	12.0	
Final Benchmark by 15 years				**31.1**	**17.6**	**14.9**	**7.5**	**5.3**	**1.7**	**15.4**	-
Reference Benchmark (Pre-Clearing RE)				**62.1**	**25.2**	**30.0**	**8.0**	**10.5**	**2.4**	**30.8**	**55.1 +/ 15.4**

12.11.5	***Corymbia citriodora* subsp. *variegata, Eucalyptus siderophloia, E. major* open forest on metamorphics +/- interbedded volcanics**	Least concern	No concern at present	ORU19, ORU21, ORU22, ORU23							
				Average T1 Canopy Cover (%)	**Average T1 Canopy Height (m)**	**Average T2-T3 Canopy Cover (%)**	**Average T2-T3 Canopy Height (m)**	**Average Shrub Cover (%)**	**Average Shrub Height (m)**	**Average Ground cover (%)**	**Species Richness (av. +/- SD)**
Interim Benchmark by 1 year				6.0	1.6	1.6	1.0	0.5	0.4	8.0	
Interim Benchmark by 2 years				9.0	3.0	2.8	2.7	1	0.7	10.0	
Interim Benchmark by 3 years				12.0	4.2	3.8	3.7	1.5	1.1	14.0	
Interim Benchmark by 5 years				15.0	6.4	5.4	5.3	2	1.3	18.0	
Interim Benchmark by 10 years				18.0	10.8	7.9	7.7	2.5	1.5	20.0	
Final Benchmark by 15 years				**21.8**	**15.8**	**9.2**	**8.7**	**2.9**	**1.6**	**23.0**	-
Reference Benchmark (Pre-Clearing RE)				**43.5**	**22.5**	**10.6**	**9.9**	**5.8**	**2.3**	**46.0**	**48.0 +/ 12.3**

Adapted from Queensland Government (2015a).* No pre-defined benchmarks for this RE are provided within the RE technical descriptions (Queensland Government 2015) and therefore, these numbers have been based on data collected in the field from previous assessments and reference sites within this RE type.

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5 Monitoring methodology

The following monitoring program was implemented to capture baseline data prior to rehabilitation treatments being applied. Adaptive management strategies will be used where a rehabilitation treatment does not produce the desired result. When this occurs, the treatment will be identified and/or modified.

For this monitoring program, a minimum of two monitoring sites per rehabilitation unit is sufficient to identify any major changes and to provide a 'snap shot' of ecological conditions. Monitoring in this way will allow the ongoing collection of information to demonstrate the effectiveness of habitat rehabilitation efforts, and the frequency of monitoring activities will enable management prescriptions to be adjusted to bring about any necessary changes and corrective actions (adaptive management).

5.1 Sites

Vegetation monitoring for the 5th monitoring period occurred in a network of 59 monitoring sites (refer to Tables 1 and 2). The final location of each monitoring site within its representative rehabilitation unit was identified by GPS coordinates and direction (compass bearing). Monitoring site locations are identified in Figure 3.

Site locations have been permanently marked by two steel pickets with yellow safety caps placed approximately 50 m apart. Each picket is clearly labelled identifying the site number.

The following methodology will be applied to monitor at each site.

5.2 Photo point monitoring

For each site, a permanently marked photo point has been established at the first marker picket and photographing towards a second marker picket at 10 m along the relevant compass bearing. A yellow plastic picket cap was installed on starting point (0 m) star pickets, with the site number written in black permanent marker, to identify the site. All photos were taken such that the 0 m picket was located in the bottom left hand corner of the photo with the site number visible.

The photos were saved with the following information recorded for each file:

- site number
- survey (i.e. 5th mon.)
- date

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Figure 3 Offset Area monitoring locations

5.3 Transect and quadrat monitoring

Quantitative site data, including the attributes of species richness, percentage foliage cover for the ground layer, shrub and canopy layers, canopy height, and weed cover are to be collected from field transects and quadrats established at each of the monitoring sites:

- A 50 m transect was placed between the 0 m and 50 m metal pickets. Ten metre intervals were marked permanently with wooden stakes that had flagging tape attached for high visibility.

- Quadrats were placed along the transect:
  - 50 x 10 m plot positioned at the transect starting at 0 m on the right hand side of the transect
  - 1 x 1 m subplots positioned at staked intervals 0 m, 10 m, 20 m, 30 m and 40 m. Adjustments were made for each subplot if its positioning was placed over a trunk, fallen tree or roots. Installation of permanent stakes ensures consistent sampling and adequate replicaton for data collection in future monitoring periods.

Given the above, each monitoring site had the information collected, as detailed in (Table 5). This benchmark monitoring process has also been undertaken at 1 year, 18 months, 2 years (current monitoring period) and will continue at 2.5 years, 3 years, 4 years, 5 years, 10 years and 15 years. Reporting from each of the monitoring events shall be provided to the Department of Environment within 4 weeks of completion of monitoring.

Table 5 Data collected at monitoring sites

Method of collection	Data collected
50 m x 10 m quadrat (plot)	Species richness, tubestock survival, height of each canopy species
50 m transect	Canopy species cover and height, shrub cover
Five 1 x 1 m quadrats (subplot)	Percentage cover in ground layer (including regenerating native canopy cohorts)

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6 Results

6.1 Photo-point monitoring

Photo monitoring results for all surveyed sites, are reported in Table 6, indicating the variety of vegetation types and condition. This photo sample was considered representative of the entire transect in most cases, with the vegetation type and structure remaining fairly consistent throughout individual sites. In congruence with previous monitoring periods, the vegetation varies from mixed native grasses such as *Imperata cylindrica* and Bracken Fern (*Pteridium esculentum),* mixed with exotic grass pasture in the understorey with sparse regenerating shrubs and trees to established woodland eucalypt forest with intact structure and species composition. Note that a number of sites (e.g. sites 18, 132, 137 and 138) continue to show evidence of dense *Lantana camara* infestations, these sites are typically at an advanced state of natural regeneration with common canopy tree sized eucalypts and mixed Acacia species. Felled and fallen trees can also be seen within many of the photo monitoring points. A number of these are exotic pine (*Pinus elliottii*) which have been hand felled as part of the ongoing weed management process. There are several sites also containing immature *Pinus elliottii* in the understorey and shrub layers, which have advanced since the 4th monitoring period (e.g. sites 23, 24, 26, 47 and 56). In addition, a number of sites are heavily vegetated with regrowth of mixed Acacia species, predominantly *Acacia leiocalyx* and *A. disparrima* (e.g. sites 30, 44, 47 and 56).

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Table 6 Photo monitoring images

Site 18 – 01/05/2019

Site 19 – 02/05/2019

Site 23 – 01/05/2019

Site 24 – 02/04/2019

Site 25 – 01/05/2019

Site 26 – 02/04/2019

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Site 27 – 02/04/2019

Site 28 – 01/05/2019

Site 29 – 07/11/2018

Site 30 – 02/04/2019

Site 31 – 29/03/2019

Site 32 – 29/03/2019

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Site 33 – 29/03/2019

Site 44 – 19/03/2019

Site 45 – 19/03/2019

Site 46 – 22/03/2019

Site 47 – 21/03/2019

Site 49 – 10/03/2019

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Site 54 – 22/03/2019

Site 55 – 26/03/2019

Site 56 – 26/03/2019

Site 57 – 26/03/2019

Site 58 – 26/03/2019

Site 59 – 22/03/2019

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Site 60 – 26/03/2019

Site 61 – 26/03/2019

Site 62 – PHOTO ABSENT

Site 63 – 20/03/2019

Site 64 – 20/03/2019

Site 65 – 20/03/2019

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Site 66 – 26/03/2019

Site 67 – 20/03/2019

Site 68 – 20/03/2019

Site 69 – 03/04/2019

Site 102 – 03/04/2019

Site 103 – 03/04/2019

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Site 104 – 03/04/2019

Site 109 – 04/04/2019

Site 110 – 05/04/2019

Site 111 – 05/04/2019

Site 112 – 05/04/2019

Site 113 – 04/04/2019

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Site 115 – 05/04/2019

Site 123 – 26/04/2019

Site 124 – 26/04/2019

Site 127 – 26/04/2019

Site 128 – 26/04/2019

Site 129 – PHOTO ABSENT

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Site 131 – 26/04/2019

Site 132 – 17/04/2019

Site 133 – 26/04/2019

Site 134 – 17/04/2019

Site 135 – 17/04/2019

Site 136 – 27/03/2019

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Site 137 – 27/03/2019

Site 138 – 27/03/2019

Site 143 – 17/04/2019

Site 144 – 17/04/2019

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6.2 Transect and quadrat monitoring

6.2.1 Species richness

During the 5th monitoring period in March-May 2019, a total of 322 species were recorded within different strata at the 59 monitoring sites in the Offset Area. This is a decrease of 22 species from the 4th monitoring period.

Species richness within sites ranged from 13 to 41 native species (minus weeds), with 27.2 species per site observed on average. This is a 1.6% decrease in average native species richness since the 4th monitoring period.

Canopy tree species (T1 stratum) totalled 22 species (4 species more than 4th monitoring period). Those most common across the offset area remained mostly consistent 4th monitoring period and included *Corymbia trachyphloia* (11 sites), *C. citriodora* (8 sites), *Eucalyptus siderophloia* (7 sites) and *E. acmenoides* (6 sites).

Small tree species (T2-T3) totalled 34 species (1 species more than 4th monitoring period). Those common across the offset area were consistent with the 3rd monitoring period, with the addition of *Acacia disparrima,* and included *Lophostemon suaveolens, Eucalyptus siderophloia, L. confertus, A. disparrima, E. tereticornis* and *E. acmenoides* (from highest to lower abundance).

Shrub species (S1 stratum) totalled 56 species (1 species less than 4th monitoring period). Those that were commonly observed across the offset area included *Acacia leiocalyx, Acacia disparrima, Alphitonia excels, Leptospermum polygalifolium, Melaleuca linarifolia* and *Ozothamnus diosmifolius* (from highest to lower abundance).

Of all the species recorded, 58 were exotic (18.0% of total and five more species than 4th Monitoring period). This included one T1 species (*Pinus elliotti),* two T2 species (*Cinnamomum camphora* and *Pinus elliottii*), and four shrub species including *Pinus elliotii* (recruiting), *Lantana camara, Cinnamomum camphora* (recruiting), *and Triumfetta rhomboidea* (from highest to lowest number of sites). The ground layer contained 51 species (87.9% of weed species recorded across sites), with 30 herbaceous species (2 less than 4th monitoring period) and 14 graminoids (3 more than 4th monitoring period). Eight of these were present at greater than 10 monitoring sites (two less then 4th monitoring period). This includes *Lantana camara* (36 sites, 12 less than 4th monitoring period), *Passiflora suberosa* (28 sites, 4 more than 4th monitoring period), *Andropogon virginicus* (23 sites, 2 more sites than 4th monitoring period), *Lantana montevidensis* (18 sites, 1 more than 4th monitoring period), *Richardia brasiliensis* (15 sites, increased since 4th monitoring period), *Digitaria didactyla* (14 sites, 3 less than 4th monitoring period), *Ageratum houstonianum* (13 sites, 5 less than 4th monitoring period) and *Megathyrsus maximus* (10 sites, increased since 4th monitoring period).

Significant decreases were observed in a number of weed species, including *Pinus elliotti* (8 sites, compared to 16 sites in 4th monitoring period), *Senecio madagascariensis* (5 sites, compared to 15 sites in 4th monitoring period), *Conyza bonariensis* (9 sites compared to 12 sites in 4th monitoring period) and *Emilia sonchifolia* (8 sites compared to 12 sites in 4th monitoring period). This may be attributed to proactive weed management and seasonal variation, with the drier climate providing unfavourable conditions for some of the exotic herb species.

6.2.2 Tree canopy cover and height (T1)

Of the sites with canopy trees present (T1 stratum), tree canopy cover varied from 2% to 47% overlapping cover, with average total canopy cover of 19.3%, 3.6% less than 4th monitoring period

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(Table 7). Canopy species with high canopy cover were *Eucalyptus fibrosa, Corymbia intermedia, E. siderophloia, Eucalyptus planchoniana* and *Eucalyptus acmenoides* (in order of highest to lower).

Thirty two of the sites (54.2%, 8.5% more than the 4th monitoring period) did not have any canopy trees present, including sites 18, 23, 24, 25, 26, 27, 28, 29, 31, 32, 33, 44, 45, 47, 49, 54, 56, 57, 58, 59, 60, 61, 110, 112, 113, 124, 127, 130, 132, 133, 134, 135 and 144.

Of the sites with canopy trees present within the T1 stratum, tree height varied from 12.5 m to 22 m, with the average tree height 16.6 m, which was 0.5 m higher than average tree height during the 4th monitoring period (Table 7). Canopy species with high average canopy height were *Eucalyptus fibrosa, Corymbia citriodora, E. resinifera, E. acmenoides* and *C. intermedia* (in order of highest to lower).

Total weed crown cover (largely *Pinus elliottii* and *Cinnamomum camphora* in the 1st monitoring period) remained at 0% from 2nd monitoring period, following management activities. For successive monitoring periods including the current monitoring periods, this has remained at 0%.

6.2.3 Small tree cover and height (T2-T3)

Of the sites with small trees present (T2 – T3 stratum), cover varied from 0.2% to 66.7% overlapping cover, with average total canopy cover of 24.4%, which was 2.3% lower than in the 4th monitoring period. Small tree species with high average cover were mostly consistent with the 4th monitoring period and included *Acacia disparrima, Lophostemon confertus, L. suaveolens, E. siderophloia* and *C. trachyphloia* (from highest to lower).

Of the sites surveyed, six sites (10%) did not have any small trees (T2-T3 strata) present (5 more than 4th monitoring period). Sites which had previously no small trees recorded had improved in the area and a different cluster of sites were absent of small trees, including sites 25, 45, 49, 63, 115 and 144.

Of the sites with small trees present within the T2-T3 stratum, tree height varied from 5.9 m to 13.4 m, with the average tree height 9.1 m, which was 0.1 m higher than average tree height during the 4th monitoring period (Table 7). Canopy species with high average canopy height were *Eucalyptus siderophloia, E. acmenoides, L. confertus, Acacia disparrima* and *L. suaveolens* and (in order of highest to lower).

6.2.4 Shrub cover and height (S1)

Of the sites with shrubs present, shrub cover varied from 0.5% to 34.3% overlapping cover, with average total canopy cover of 10.4% (2.3% less average cover than 4th monitoring period). Average shrub height varied from 1.0 m to 3.8 m with an average height of 2.4 m, down by 0.3 m since the 4th monitoring period (not significantly different (<0.4% difference). Shrub species with high cover within sites were consistent with those recorded in the 4th monitoring period - *Acacia leiocalyx, Lantana camara, A. disparrima, Alphitonia excelsa* and *Lophostemon confertus* (in order of highest to lower average cover).

86% of sites (51 out of 59 sites) during this monitoring period contained shrub cover, a decrease of 12% since the 4th monitoring period. Sites that did not have any shrubs recorded in the transect included sites 18, 23, 45, 49, 112, 124, 137 and 144. Eight species were recorded in site 132, the only site that didn't have a shrub layer recorded in the 4th monitoring period.

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6.2.5 Ground cover (G1)

Consistent with the previous three monitoring periods as well as the baseline study, all sites had living ground cover layer. Ground-layer cover ranged from 3.6% to 81.2%, with an average of 32.3% (1.8% decrease since 4th monitoring period). The native grass species *Imperata cylindrica* had the highest amount of ground cover and was present at 39 sites (66% of sites), which was a positive change from the weed grass *Andropogon virginicus,* which had been dominant in the ground layer in the 3rd and 4th monitoring periods. Other ground cover species with high cover within sites included *A. virginicus,* the weed shrub *Lantana camara* and a diversity of other native species – *Entolasia stricta, Lomandra longifolia* and *Cymbopogon refractus* (in order of highest to lower average cover).

6.2.6 Weed incursion

Weeds in the ground layer were present at 49 sites (83%, a 4% increase since the 4th monitoring period), ranging from 0.4% (site 127) to 47.6% with an average weed cover of 12.6% (1.1% decrease in weed cover since the 4th monitoring period). Overall, weed cover in the ground layer had increased at 17 sites (28.8%, 6.7% less than 4th monitoring period) including sites 19, 25, 27, 28, 49, 59, 66, 103, 110, 124, 127, 128, 129, 131, 133, 137 and 138, and decreased at 31 sites (52.5%, 10.2% more than 4th monitoring period), including sites 18, 23, 24, 26, 29-47, 54-58, 60, 61, 67, 109, 111-115, 130, 135, 136, 143 and 144 . Sites with highest weed cover included sites 18 which also had highest cover in 4th monitoring period (27.2%, 4.4% more than 4th monitoring period), 24 (36.4%, 5.6% decrease since 4th monitoring period), 57 which also had high cover in 4th monitoring period (28.8%, 10.8% decrease since 4th monitoring period), 61 which also had high cover in 4th monitoring period (29.6%, 16% decrease since 4th monitoring period), 113 (25.6%, 0.8% decrease since 4th monitoring period) and 129 (37.2%, 16.8% increase since 4th monitoring period). These sites are located either within the Precinct 3 Fauna Corridor area (sites 57, 59, 61), P5 Fauna Corridor area (site 24) or within the Greenspace Corridors in Precinct 4 (site 18), Precinct 13 (site 113) and Precinct 17 (site 129).

Weed species in the ground layer with highest cover were consistent with the 4th monitoring period, with slight variation in the order of highest to lower abundance, comprising *Andropogon virginicus*, *Lantana camara*, *Setaria sphacelata, Passiflora suberosa* and immature *Pinus elliotti.*

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Table 7 5th monitoring period species richness, average canopy height within the canopy (T1), sub-canopy (T2-T3) and shrub layer (S1) and average total cover within the canopy (T1), sub-canopy (T2-T3), shrub layer (S1) and ground layer (G1)

Site	Species Richness (incl. weeds)					Height (m)			Overlapping Crown Cover (%)					Av. Ground Cover (%)	
	Canopy (T1)	*Sub - Canopy (T2 and T3)*	*Shrubs (S1)*	Ground Layer (G1)	Total (excl. weeds)	*Canopy (T1)*	*Sub - Canopy (T2 and T3)*	*Shrubs (S1)*	*Canopy (T1)*	*Sub - Canopy (T2 and T3)*	*Shrubs (S1)*	*Total Weed Crown Cover*	*Total Crown Cover*	*Total Ground Layer*	*Total Weed Ground Layer*
18	0	3	0	35	27	16.5	6.6	2.6	17	11	18.6	0	46.6	44.8	27.2
19	2	1	2	34	31	0.0	0.0	0.0	27	6.7	21.5	0	55.2	47.6	12.8
23	0	6	0	40	37	0.0	0.0	0.0	0	13.7	8.6	0	22.3	62.4	2.4
24	0	2	1	30	24	0.0	8.1	2.4	0	18.5	2	0	20.5	55.2	36.4
25	1	0	4	42	34	0.0	0.0	0.0	3	35.5	6.2	0	44.7	46	4
26	0	2	4	45	34	0.0	11.0	3.8	0	11	10	0	21.0	75.2	38
27	0	3	7	25	28	0.0	7.1	2.2	0	16.5	22.9	0	39.4	20.8	7.2
28	0	2	4	33	27	0.0	0.0	0.0	0	3	5.5	0	8.5	67.2	14.4
29	0	5	1	44	35	13.5	8.4	2.8	7.5	21	5.2	0	33.7	43.2	17.2
30	4	2	1	46	36	16.8	10.0	2.0	45	9.5	0.5	0	55.0	42.8	2
31	0	3	1	22	20	12.8	9.3	2.8	8	17	2	0	27.0	8.8	0.8
32	0	2	2	16	16	0.0	7.9	2.4	0	17.5	9	0	26.5	7.2	3.6
33	0	3	2	17	15	0.0	7.9	3.7	0	27.5	21	0	48.5	12.8	5.2
44	0	3	3	18	15	0.0	6.7	2.7	0	4.9	34.3	0	39.2	20.8	4.8
45	3	0	8	17	21	20.0	11.5	0.0	13	34.5	0	0	47.5	44	6.4
46	2	2	8	42	41	20.0	12.7	1.9	12	35	6.5	0	53.5	46	5.6
47	0	2	1	14	13	0.0	7.0	2.7	0	4.5	25.5	0	30.0	18.8	0.8
49	0	0	6	20	19	0.0	8.4	1.9	0	12	20.3	0	32.3	25.2	6
54	0	1	9	15	20	0.0	9.0	2.1	0	0.5	25.8	0	26.3	58.4	4.8
55	2	8	9	24	40	22.0	12.2	2.9	14	48	10.2	0	72.2	28.4	0.8
56	0	5	4	35	37	0.0	7.9	2.8	0	18.5	11.6	0	30.1	28	2
57	0	3	5	23	25	0.0	6.8	2.8	0	11	17.7	0	28.7	39.6	28.8
58	0	5	3	30	35	0.0	9.1	2.7	0	14.5	25.6	0	40.1	31.2	12.8
59	0	1	5	26	24	0.0	9.1	2.4	0	11	7.7	0	18.7	81.2	47.6
60	0	5	3	24	29	0.0	6.1	2.8	0	8.5	7.2	0	15.7	46	34
61	0	3	3	27	27	0.0	6.8	3.2	0	15	11	0	26.0	36.4	29.6
62	2	3	2	15	22	14.9	8.8	2.2	18	10.5	4.7	0	33.2	12.4	0
63	3	2	6	19	29	19.7	6.6	1.9	31	14	18.5	0	63.5	27.6	0
64	3	2	6	16	26	12.5	8.3	1.9	34	9	6.3	0	63.5	15.2	0
65	5	1	10	23	39	15.6	9.1	2.1	33.5	10	11.2	0	49.3	28.4	0
66	2	7	6	30	41	13.5	8.6	2.4	7	22	14.7	0	54.7	25.4	1.6
67	3	3	7	19	30	15.4	6.6	2.8	34.2	14	10	0	43.7	22.4	0.8
68	3	1	7	13	24	14.1	8.1	2.1	19.5	12.5	5.7	0	58.2	30	0
69	3	1	1	19	24	15.0	11.0	1.3	21.5	0.2	0.8	0	37.7	20.8	0
102	3	3	2	11	19	16.8	9.6	2.2	43.5	13.5	2.2	0	59.2	3.6	0
103	4	1	2	23	27	15.6	9.0	1.3	38	0	2.2	0	40.2	10.4	0.4
104	3	1	2	16	22	16.4	9.5	2.0	23	16.5	4	0	43.5	19.6	0
109	4	3	5	21	30	15.6	7.9	2.1	21	14.9	2	0	37.9	7.2	0.4
110	0	4	5	24	23	0.0	11.0	1.5	0	2.5	5	0	7.5	48.4	14.8
111	1	3	1	15	16	13.0	7.8	2.3	2	30.08	23.5	0	55.6	41.2	30
112	0	4	0	36	29	0.0	5.9	3.3	0	28.7	6.5	0	35.2	53.2	16.8

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Site	Species Richness (incl. weeds)					Height (m)			Overlapping Crown Cover (%)					Av. Ground Cover (%)	
	Canopy (T1)	*Sub - Canopy (T2 and T3)*	*Shrubs (S1)*	Ground Layer (G1)	Total (excl. weeds)	*Canopy (T1)*	*Sub - Canopy (T2 and T3)*	*Shrubs (S1)*	*Canopy (T1)*	*Sub - Canopy (T2 and T3)*	*Shrubs (S1)*	*Total Weed Crown Cover*	*Total Crown Cover*	*Total Ground Layer*	*Total Weed Ground Layer*
113	0	1	5	20	20	0.0	7.5	3.1	0	3	8.6	0	11.6	49.2	25.6
115	3	0	4	17	19	14.0	0.0	2.3	3	0	10.5	0	13.5	34.8	8.4
123	1	3	7	12	22	17.5	9.5	1.9	6	56	2.4	0	64.4	17.6	0
124	0	5	0	23	27	0.0	10.6	2.6	0	63.5	6.2	0	69.7	18	0.4
127	0	4	7	29	32	15.5	9.3	1.0	12	35.2	0.5	0	47.7	17.6	1.2
128	5	3	2	31	35	16.7	9.5	2.3	47	23.5	4.7	0	75.2	34.4	9.2
129	1	1	11	29	35	17.0	8.6	2.7	12	20.5	28.1	0	60.6	49.6	37.2
130	0	7	4	22	30	0.0	12.1	2.7	0	65	3.7	0	68.7	19.2	6.8
131	3	7	6	13	29	20.5	11.1	2.4	15	40	5.2	0	60.2	16.4	1.2
132	0	8	8	24	32	0.0	11.8	2.3	0	48.7	4.7	0	53.4	18	4.4
133	0	8	2	19	26	19.4	9.6	2.3	31	36.5	9.9	0	77.4	19.2	6
134	0	5	1	16	21	0.0	6.2	2.5	0	66.7	5.9	0	72.6	16	0
135	0	8	1	29	32	0.0	10.4	2.5	0	59.7	10	0	69.7	34.4	14.4
136	4	4	1	22	27	20.0	10.7	2.9	12	60.5	11	0	83.5	10	0.4
137	1	7	0	30	31	20.0	13.1	1.7	11	35	13	0	59.0	43.6	31.6
138	1	6	1	27	28	20.0	13.4	2.3	9	45.5	17.8	0	72.3	39.2	16.4
143	0	3	3	23	26	0.0	12.2	1.6	0	60.5	4.8	0	65.3	25.6	8.8
144	1	5	3	17	23	15.0	10.1	1.9	6	49	4.7	0	59.7	38.8	1.6
*	**2.5 (0.1)****	**3.4 (-0.9)**	**3.9 (+0.9)**	**24.5 (-2.5)**	**27.2 (-1.6)**	**16.6 (-0.5)**	**9.1 (-0.1)****	**2.4 (-0.3)****	**19.3 (-3.6)**	**24.4 (-2.3)**	**10.4 (-2.4)**	**0 (0)****	**45.4 (-5.2)**	**32.3 (-1.8)**	**12.1 (-1.6)**

* Note: values in parentheses indicate the percent or actual change in averages since 4th monitoring period

** Within the margin of error (+/- 4%) for this type of assessment and is otherwise identified as 'no change' between two subsequent monitoring periods. Analysis of results from additional monitoring periods will provide a basis for more accurate conclusions.

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6.3 Normalised Difference Vegetation Index (NDVI) monitoring

During the 5th monitoring period an additional assessment was undertaken to determine the health and condition of native vegetation within “Existing Assessable Koala Habitat to be protected and managed” and “Offset Areas” within Fauna Corridors, Greenspace Corridors and Environmental Protection Zones. This assessment was called Normalised Difference Vegetation Index (NDVI) imaging and was conducted as part of aerial mapping of the offset areas using a DJI Phantom 4 remote-piloted aircraft (drone) with an affixed Parrot Sequoia multispectral NDVI camera. NDVI imagery determines percent foliar cover and photosynthetic health of the vegetation (Figure 4). This method calculates the ratio of ingoing absorbed visible light (wavelengths 0.4 – 0.7 µm) against reflected / outgoing near-infrared light to determine photosynthetic health of foliar cover. The higher the values of visible light / near-infrared light per point, the higher the NDVI value (scale -1 to 1), and therefore the healthier the foliage, and vice versa.

A series of 42 x 1 ha sampling tiles were assessed using the drone and NDVI camera out of the total 59 sites monitored (Figure 5). During the previous 4th monitoring period, only 9 sites divided up into 9 tiles across 3 series (Northern, Eastern and Southern) were included. The current 5th monitoring period includes all 9 of these previously assessed tiles as well an additional 33 tiles which cover all remaining sites except sites 69, 137 and 138 which could not be accessed with the RPA drone system during field-work and site 25 which could not be analysed using the software. All aerial imagery for all of the 42 sampled sites were 'stitched' together and uploaded to Pix4D for processing of NDVI-indexed images (Figure 4). Quantification of total percent foliar cover using NDVI, was carried out using ArcMap Version 10.5.1.

For calculating descriptive statistics of photosynthetic health, firstly a complete 'stitched' NDVI image of each sampling tile was uploaded to ArcMap as a .tiff file and geolocated to the site location. Within this area, the image was clipped to a 1 ha quadrangle for each site, in some cases 1 x 1 ha quadrangle covered up to 3 monitoring sites where sites were close together. These quadrangles are set in place for all future Koala Offset Area monitoring so as to provide accurate comparisons across time (see Table 8 for overlap between 4th monitoring period 9 x tile series and current 5th monitoring period 42 x tiles by site). Following this, the raster data set that comprises the NDVI image within the quadrangles, was converted into a grid of points (average total number circ. 1.8 million points per quadrangle) with each point bearing the NDVI value of the underlapping pixel. These points were then selected using the 'Select by Location' tool using selection method 'Intersect (3D) the source layer feature' to select only point data within each 1 ha quadrangle and then analysed for mean average (+/- standard deviation), minimum and maximum values (Table 8).

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Table 8 Results of NDVI imaging values for each sampling tile per series

Site #	Previous Sampling Series and Tile # (if applicable)	# NDVI sampling points	4th Monitoring Mean NDVI (µm) +/- SD	Trend	5th Monitoring Mean NDVI (µm) +/- SD	Minimum NDVI (µm)	Maximum NDVI (µm)	Overall NDVI health
18+19	Not evaluated	1,982,206	Not evaluated		0.68 +/-0.09	0.26	0.90	
23	Not evaluated	1,981,835	Not evaluated		0.67 +/- 0.14	-0.22	0.94	
24	Northern Series, Tile 3	1,982,205	0.59 +/- 0.12	▲	0.68 +/- 0.11	0.21	0.94	
26	Northern Series, Tile 1	1,912,071	0.63 +/- 0.11	▲	0.70 +/- 0.09	-0.07	0.93	
27	Not evaluated	1,982,176	Not evaluated		0.75 +/- 0.09	0.21	0.94	
28	Not evaluated	1,968,198	Not evaluated		0.75 +/- 0.10	0.27	0.95	
29	Northern Series, Tile 2	1,982,244	0.62 +/- 0.1	▲	0.65 +/- 0.10	0.16	0.93	
30	Not evaluated	1,982,275	Not evaluated		0.75 +/- 0.09	0.23	0.95	
31	Southern Series, Tile 3	1,982,218	0.6 +/- 0.12	▲	0.67 +/- 0.12	-0.08	0.95	
32	Southern Series, Tile 1	1,982,431	0.64 +/- 0.11	▲	0.72 +/- 0.09	0.10	0.92	
33	Southern Series, Tile 2	1,982,283	0.61 +/- 0.13	▲	0.68 +/- 0.12	0.17	0.91	
44	Not evaluated	1,968,273	Not evaluated		0.58 +/- 0.25	-0.32	0.92	
45	Not evaluated	1,982,033	Not evaluated		0.70 +/- 0.13	-0.55	0.97	
46	Not evaluated	1,982,176	Not evaluated		0.73 +/- 0.10	-0.26	0.96	
47	Not evaluated	1,982,175	Not evaluated		0.66 +/- 0.21	-0.29	0.96	
48+49	Not evaluated	1,982,176	Not evaluated		0.44 +/- 0.29	-0.30	0.91	
54+56+59	Not evaluated	1,982,174	Not evaluated		0.79 +/- 0.06	0.12	0.94	
55+58	Not evaluated	1,982,175	Not evaluated		0.79 +/- 0.06	0.10	0.95	
57	Not evaluated	1,982,176	Not evaluated		0.69 +/- 0.16	-0.29	0.92	
60	Not evaluated	1,982,178	Not evaluated		0.69 +/- 0.20	-0.07	0.98	
61	Eastern Series, Tile 2	1,969,735	0.4 +/- 0.23	▲	0.68 +/- 0.22	-0.05	0.97	
62+63+65	Not evaluated	1,982,174	Not evaluated		0.77 +/- 0.07	0.18	0.94	
64+68	Not evaluated	1,982,172	Not evaluated		0.74 +/- 0.10	-0.18	0.94	
66	Eastern Series, Tile 3	1,975,790	0.41 +/- 0.17	▲	0.71 +/- 0.11	-0.33	0.98	
67	Eastern Series, Tile 1	1,982,176	0.37 +/- 0.15	▲	0.76 +/- 0.08	0.09	0.95	
101	Not evaluated	1,980,265	Not evaluated		0.65 +/- 0.13	0.12	0.89	
102+109	Not evaluated	1,982,273	Not evaluated		0.63 +/- 0.17	0.07	0.89	
104	Not evaluated	1,982,277	Not evaluated		0.59 +/- 0.16	0.14	0.90	
110+112	Not evaluated	1,982,277	Not evaluated		0.71 +/- 0.12	0.12	0.91	
111	Not evaluated	1,982,275	Not evaluated		0.75 +/- 0.07	0.20	0.95	
113	Not evaluated	1,982,079	Not evaluated		0.61 +/- 0.19	-0.20	0.90	
115	Not evaluated	1,982,186	Not evaluated		0.61 +/- 0.17	0.10	0.94	
123	Not evaluated	1,982,276	Not evaluated		0.51 +/- 0.09	-0.08	0.77	
124+131	Not evaluated	1,982,277	Not evaluated		0.49 +/- 0.11	-0.16	0.79	
127	Not evaluated	1,218,523	Not evaluated		-0.11 +/- 0.25	-0.36	0.76	
129	Not evaluated	991,139	Not evaluated		-0.22 +/- 0.01	-0.22	-0.22	
130+132	Not evaluated	991,135	Not evaluated		-0.22 +/- 0.01	-0.22	-0.22	
133	Not evaluated	1,891,974	Not evaluated		0.77 +/- 0.12	-0.33	0.91	
134	Not evaluated	991,139	Not evaluated		-0.23 +/- 0.01	-0.23	-0.23	
135	Not evaluated	355,241	Not evaluated		-0.23 +/- 0.01	-0.23	-0.23	
136	Not evaluated	940,348	Not evaluated		0.76 +/- 0.08	0.18	0.92	
Overall Averages		1,820,864	0.54	▲	0.57	-0.04	0.81	

Key:

NDVI values 0.8 - 1	Excellent health with high photosynthetic activity/chlorophyll content
NDVI values 0.3 – 0.79	Moderate health with moderate photosynthetic activity/chlorophyll content
NDVI values 0.1 – 0.29	Poor health with low photosynthetic activity/chlorophyll content
NDVI values -1 – 0	Dead/no photosynthetic activity/chlorophyll content

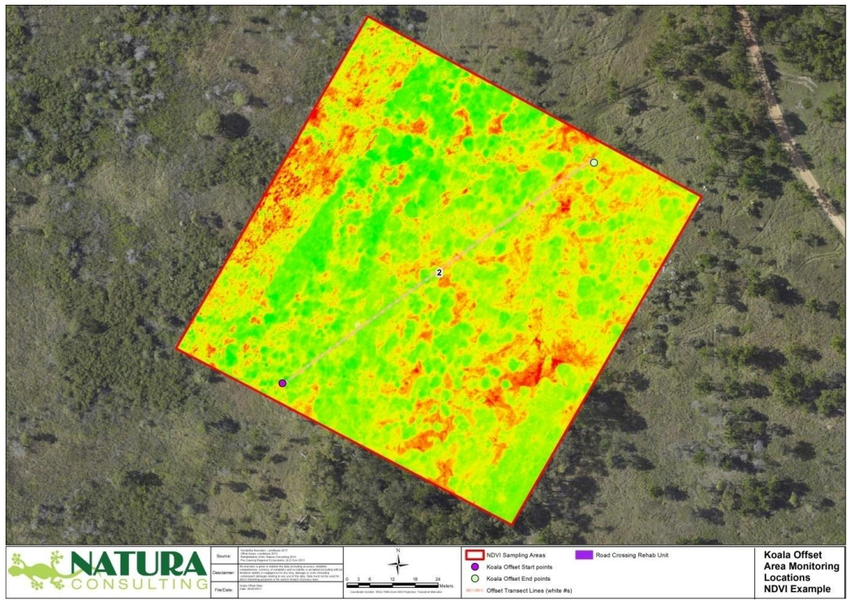

Figure 4 Example of an NDVI image

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Figure 5 Locations of NDVI imaging across the 42 x 1 ha sampling tiles across the total Koala offset management area sites

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7 Discussion

An assessment of site species richness and structure was undertaken to determine the 5th monitoring period condition against the 4th monitoring period and to measure against target benchmark parameters (Table 9). An increasing number of sites (50 sites, 84.7%) already meet the final benchmark for at least one of the benchmark parameters. This is a good result, indicating that a number of sites are already close to or approaching the goal of reaching their original RE conditions and are recovering naturally, or with some assisted natural regeneration. The 5th offset monitoring period represents the start of the 3rd year of monitoring. Therefore, sites will ideally have attained a minimum of IMO-3 for the benchmark variables. Due to the varied complexity and condition of sites, however, this is not consistent across all variables at every site and it can be seen that individual sites are at different stages of recovery, but generally trending towards improvement.

When compared to the 4th monitoring period, there was an overall trend of increase or no change in benchmark values for species richness, cover and height in most strata, with the exception of height in the shrub (S1) layer, which saw an overall trend of decrease (6 less sites meeting a benchmark and 18 sites decreasing in benchmark condition and only 7 improving). For individual sites, the trend of increase or no change remained consistent across all parameters at 15 sites (25.4%, 5.1% increase since 4th monitoring period), including site 26 (ORU2), 31 and 33 (ORU4), 47 (ORU5), 54 and 55 (ORU6), 56 and 57 (CRU3), 60 (ORU8), 113 (ORU16), 129 (ORU21), 135 and 136 (ORU22), and 138 (ORU23). Despite an overall trend of increase, 44 sites (74% of sites) saw a decrease in at least one of the benchmark variables (excluding weed cover), consistent with the 4th monitoring period. The variable that had decreased at the least number of sites was canopy height, with 5 sites decreasing. The variable that had decreased at the greatest number of sites was shrub height, with 18 sites decreasing. Some sites (29 sites) saw a decrease in two or more benchmark variables, including sites 18, 19, 30, 32, , 62-69, 102, 102, 109, 111, 112, 124 and 127 in RE12.9-10.17; sites 23, 25, 27, 28 and 45 in RE12.11.5 and sites 131, 133, 134, 143, 144 in RE12.11.5. In general, there was a trend of decrease within and between variables, consistent with the 4th monitoring period, with a lower number of sites improving in benchmark variables canopy height, small tree cover, small tree height, shrub height and ground cover. This may represent seasonal fluctuations in growth due to extended dry periods.

Regarding weed cover, the overall trend was of no change, with 51 sites remaining the same in both the 4th and 5th monitoring periods. A total of 30 sites met a benchmark for weedcover compared to 28 in the 4th monitoring period, with two sites improving. It is recommended to **continue investigating sites that have not met the benchmark or made improvements and prioritise weed management tasks within these ORU's, ORU1 (site 18 and 19), CRU11 (site 24), ORU2 (sites 26, 27 and 28), ORU4 (site 29 and 33), ORU5 (sites 45-46), CRU15 (site 49), CRU3 (site 57), ORU7 (sites 58-59), ORU8 (sites 60-61), ORU15 (sites 110-111), ORU16 (sites 112-113), ORU17 (site 115), ORU20 (site 128), ORU21 (sites 129-130), ORU19 (site 133), ORU22 (site 135), ORU23 (sites 137 and 138) and CRU8 (site 143).**

Table 7 contains the average results for variables within each site and also the overall average for each variable, indicating the variation since the previous (4th) monitoring period. The site with the lowest species richness recorded in the current monitoring period was site 47 (consistent with the 3rd and 4th monitoring periods), with 13 species recorded (2 more than the 4th monitoring period, excluding weeds), which were predominantly ground cover species. Again, there were no canopy (T1) species recorded within the site. **To improve species richness at site 47, strategic removal of acacia trees in the shrub layer is recommended, with in-fill planting of a variety of local native plants in alignment with recommended native species typical of RE12.3.11.**

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The site with the highest species richness in this monitoring period was site 46, with 41 species recorded (excluding weeds). Over 77% of the species recorded at site 46 were ground cover species. The high native species richness recorded at site 30 in the 4th monitoring period had decreased significantly from 50 species to 36 species during the 5th monitoring period. A total of 29 sites meet a benchmark for species richness, consistent witht he 4th monitoring period.

Where T1 canopy trees were present in the 5th monitoring period they are on average slightly taller than during the 4th monitoring period, (0.7% increase). Weed canopy cover remained at 0% cover across all sites. A total of 29 sites meet a benchmark for T1 canopy cover (49.1%, 8.5% increase since 4th monitoring period), whilst 27 sites (45.7%, 5.1% decrease since 4th monitoring period) meet the benchmark for T1 canopy height.

T2-T3 small tree cover decreased to 24.4% (-2.3% since 4th monitoring period) across sites. Where T2-T3 small trees do occur at sites, they are 9.1 metres high on average (0.1% increase since the 4th monitoring period, not significant (<0.4% difference). In slight variation to to the 4th monitoring period, where the T1 or T2 layer or both was present at all sites - site 49 was missing both T1 and T2 layers in the current monitoring period.

Shrub cover has decreased slightly to 10.4% (-2.4%). Despite the decrease in average cover, the total number of sites meeting a benchmark has increased slightly since the 4th monitoring period, with 44 sites (74.5% of sites) meeting a benchmark (compared to 42 sites or 71% in the 4th monitoring period). A total of 53 sites meet the benchmark for for shrub height which is a decrease since the 4th monitoring period (6.8% decrease). This decrease may be attributed to migration of plants in the shrub layer to successive layers of strata, or potentially also variation or error between different field staff.

The abundance of weed ground cover has continued to decline, with a decrease of 1.9% since the 4th monitoring period, likely attributable to ongoing weed control efforts in offset management areas, such as exotic pine removal from the ground and shrub layers to allow natural emergence of native species, off target herbicide application during weed control and also continuing to limit stock access. Successful implementation of management actions following the 2nd 3rd and 4th monitoring periods may explain the continued overall decline in weed cover.

Overall, the number of variables meeting benchmarks within sites continued to improve since the 4th monitoring period, with all sites meeting at least 4 benchmarks across variables and all sites reaching a minimum of two IMO-3 benchmarks. Furthermore, 48 sites (81.3% of sites) reaching the new benchmark IMO-3 or greater for at least 5 benchmark variables. **A number of sites (24 sites, 40.6% of sites) were still at IMO-1 or IMO-2 benchmark level for one or more variables**, such as canopy cover (site 29 and 31, (ORU4); site 66 (ORU9); site 123 (ORU18); sites 137 and 138 (ORU23), small tree cover (site 28, (ORU2); 110 (ORU15) and site 113 (ORU16), shrub cover (sites 24 (CRU11), 32 (ORU4), 46 (ORU5), 60 (ORU8), 64 (ORU11), 112 AND 113 (ORU16) and 124 (ORU18)), shrub height (site 69 (ORU9), 103 (ORU13) and 127 (ORU20)) and ground cover (site 33 (ORU4), 62 (ORU9), 64 (ORU11), 67 (ORU9), 69 (ORU9), 103 and 104 (ORU 13), 123 and 124 (ORU18), 127 (ORU20) AND 136 (ORU22)). In addition, 11 of these sites also failed to meet the benchmark for weed cover (<5% weed cover), (45.8%, 4.2% less than last monitoring period), **which may help to guide selection of new areas for rehabilitation, focusing on weed control and planting of appropriate strata specific species to bring the site into alignment with the IMO-3 targets.**

Sites that had the **poorest conditions overall in the 5th monitoring period** (failing to meet at least 4 benchmarks across the parameters), included sites site 32 (ORU4), site 54 (ORU6), site 60 (ORU8), site 110 (ORU15), site 115 (ORU17) and site 132 (ORU19). These sites generally improved or stayed the same, having a higher number of variables meeting benchmark parameters in the current

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monitoring period, with the exception of site 110, which had only three parameters reaching the IMO-3 or greater benchmark and did not make any improvements for any of the benchmark parameters. The other sites made improvements in at least one parameter, predominantly shrub cover (sites 54, 60 and 115). Other areas that improved for these sites included weed cover (sites 32 and 34) and species richness (site 132). These sites are predominantly characterised by a dense ground cover or shrub layer comprised of *Imperata cylindrica* in association with *Pinus elliotti*, or *Pteridium esculentum* or the woody weed *Lantana camara,* with the exception of site 32 which has a sparse ground layer.

In this monitoring period, there were three sites that failed to meet the IMO-3 benchmark or higher for at least four variables **(therefore considered to be in poorest condition).** They included site 28 (decreased in species richness, shrub height and T2 height), site 110 (decreased in shrub height) and site 113, which predominantly remained the same). **These three sites will need to be included amongst those prioritised for rehabilitation within the next 6 months, with focus on weed control to bring weed cover to <5%, potentially combined with thinning of *Imperata cylindrica* in the ground layer to give opportunity for the native seed bank to propagate - for increased species richness through assisted natural renegeration.** Overall, the low number of **poorest condition** sites (with less than four benchmark variables at IMO-3 or greater) is a positive result, considering this is the first monitoring period in the IMO-3 benchmark year.

The sites that were considered to have the **least improvement** were sites that had 4 or less IMO-3 benchmarks achieved across variables, with the lowest number of variables improving overall. The number of variables in which a particular site had declined was also taken into account. Of these low benchmark sites, there were five considered to have made the least improvement, as they had not improved in any of the benchmark variables since the 4th monitoring period and also had declined in more than one variable. In contrast to the 4th monitoring results, these sites were mostly different to those considered to be in the poorest condition overall, with the exception of site 110. Other **"least improvement"** sites included sites 103, 69, 112 and 24 (from lowest to highest improvement). All five sites consistently failed to meet the benchmark for native species richness, with all sites declining or remained the same for the other benchmark variables. The variable that had the greatest number of sites declining was shrub height. Areas to prioritise improvement include the T1 canopy layer (cover and height) for sites 24, 110 and 112; T2 cover for sites 69, 103 and 110; shrub cover for all five sites and weed cover <5% for sites 24, 110 and 112. **It is recommended that rehabilitation efforts within these sites are focussed on assisted natural regeneration of the ground and shrub layers and potential planting within appropriate strata where possible at all five sites, with weed management in the ground layer at sites 24, 110, 112.** The most common weeds within these sites include *Andropogon virginicus, Axonopus compressus, Lantana camara, Emilia sonchifolia, Pinus elliotti, Verbena bonariensis, Lantana montevidensis* (from highest to lower abundance) and a smaller number of other exotic herbs and grasses.

Overall condition of sites taken from the network of 42 x 1 ha NDVI sampling tiles showed that **photosynthetic health of the vegetation within these areas is currently 'moderate' and improving**. This is indicated by the middle-range NDVI values on the scale in Table 8 (overall average = 0.57) indicating overall moderate health. Generally, comparison of NDVI values of sampling tiles over time since the 4th monitoring period indicates, for those 9 tiles that had previously been mapped, an overall increase in NDVI values has taken place and therefore photosynthetic health has improved (from 0.54 in the 4th monitoring period to 0.57 in the current monitoring period). Individually, **5 sampling tiles showed 'poor' health for 6 sites** (sites 127, 129, 130, 132, 134 and 135) which sit in Yarrabilba's south-east, bordering Conservation Areas within the Yarrabilba-Wickham National Park interface. These latter sites had little to no photosynthetic activity indicated by an average NDVI value of circ. -0.2. This could be due to the fact that parts of these sites have experienced clearing in the adjacent Greenspace Corridor under the agricultural tenancy of the land, thus reducing vegetative cover significantly and increasing bare ground. Bare ground reflects very low

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NDVI values as it does not constitute photosynthetically-active tissues. Thus when a 1 ha sampling tile contains a large amount of bare ground, the overall NDVI value is inherently reduced. Further monitoring of regrowth in these areas is required to determine whether these areas can become viable, or are intended to be, areas of suitable koala offset.

Overall, this assessment reveals that rehabilitation efforts have continued to improve vegetation condition in many of the targeted offset rehabilitation areas, including areas ORU15, ORU16, CRU3, ORU19 and ORU17 and ORU7, which are no longer considered as top priority areas for management. The number of sites that fail to meet the ≤5% benchmark for total weed ground layer has decreased to 29 (49%, 4% less than 4th monitoring period) and there has been an increase in the number of sites meeting target benchmark parameters. Looking forward, it is recommended that **rehabilitation continues to prioritise weed control in areas that fail to meet the <5% weed cover benchmark, particularly those in sensitive areas, including Precincts 3 (ORU6 and ORU8), 5 (ORU15) and 17 (ORU19), with the addition of precinct 13 (ORU17)**, which are adjacent to the Plunkett Conservation Reserve, to minimise infiltration of weeds into the conservation area, where weed abundance is minimal or even absent in some areas. There are a total of 11 sites in these ORU's, 5 (45%) of which already meet the ≤5% benchmark for weed cover. **Rehabilitation efforts also need to continue prioritising ongoing maintenance of stock exclusion fencing, and planting of canopy species specific to the pre-clearing RE type,** as an integrated measure for reducing weed cover to below the 5% benchmark for all sites, in the shortest time frame possible. **Furthermore, continued strategic rehabilitation of the shrub layer may be required in these areas** to continue boosting the layer to meet or improve benchmarks, and also to help ensure that weeds are outcompeted and shaded out, thereby reducing the need for reactive management over time. **Thinning of the ground layer in sites that are dominated by *Imperata cylindrica, Pteridium esculentum* or exotic ground cover species is also recommended**, in order to provide opportunity for the natual seed bank to propagate and improve species richness.

In conclusion, according to results for benchmark indicators and weed cover**, there are 3 Rehabilitation Units to be considered highest priority action, including ORU2, ORU15 and ORU16,** which have a combination of ≤4 parameters meeting benchmarks and also a high weed prevalence of >5%. **An additional 3 Rehabilitation Units which need to be prioritised for benchmark improvements in one or more areas including species richness, T1 (height and cover), small tree cover and shrub cover with or without weed management include ORU13, ORU9 and CRU11 from highest to lowest priority.** This has been determined by cross assessment of highest % total ground weed cover, poorest conditions (sites which meet <4 IMO-3 benchmarks), and sites with the least improvement.

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Table 9 5th monitoring period species richness, canopy height within the canopy (T1), sub-canopy (T2-T3) and shrub layer (S1) and cover within the canopy (T1), sub-canopy (T2-T3), shrub layer (S1) and ground layer (G1)

Site	Rehab Unit	Pre-Clearing Regional Ecosystem	Species Richness (native)	Canopy Cover (T1)	Canopy Height (T1)	Small Tree Height (T2-T3)	Small Tree Cover (T2-T3)	Shrub Cover (S1)	Shrub Height (S1)	Ground Cover (G1)	Weed Cover (<5%?)
18	ORU1	12.9-10.17/12.9-10.2	FINAL (S)	IMO-3 (D)	IMO-10 (S)	IMO-5 (S)	IMO-5 (S)	IMO-10 (D)	IMO-10 (S)	FMO-15 (S)	X (S)
19	ORU1	12.9-10.17/12.9-10.2	FINAL (S)	IMO-10 (S)	X (D)	X (D)	IMO-5 (S)	FMO-15 (I)	X (D)	FMO-15 (I)	X (S)
23	CRU11	12.3.11/12.3.6/12.3.7	FINAL (S)	X (S)	X (S)	X (D)	IMO-10 (S)	IMO-5 (S)	X (D)	FINAL (S)	FINAL (S)
24	CRU11	12.3.11/12.3.6/12.3.7	X (S)	X (S)	X (S)	IMO-10 (S)	FMO-15 (S)	IMO-1 (S)	FMO-15 (D)	FINAL (S)	X (S)
25	ORU2	12.3.11/12.3.6/12.3.7	FINAL (I)	X (S)	X (S)	X (D)	FINAL (S)	IMO-3 (S)	X (D)	FINAL (S)	FINAL (S)
26	ORU2	12.3.11/12.3.6/12.3.7	FINAL (S)	X (S)	X (S)	FINAL (S)	IMO-10 (I)	IMO-10 (I)	FINAL (I)	FINAL (S)	X (S)
27	ORU2	12.3.11/12.3.6/12.3.7	X (S)	X (S)	X (S)	IMO-5 (S)	FMO-15 (S)	FINAL (S)	FMO-15 (D)	FINAL (D)	X (S)
28	ORU2	12.3.11/12.3.6/12.3.7	X (D)	X (S)	X (S)	X (D)	IMO-2 (S)	IMO-3 (I)	X (D)	FINAL (S)	X (S)
29	ORU4	12.9-10.17/12.9-10.2	FINAL (I)	IMO-1 (S)	IMO-10 (S)	IMO-5 (D)	FMO-15 (S)	X (S)	IMO-10 (I)	IMO-10 (S)	X (S)
30	ORU4	12.9-10.17/12.9-10.2	FINAL (S)	FMO-15 (S)	IMO-10 (S)	IMO-10 (D)	IMO-5 (D)	X (S)	IMO-5 (S)	IMO-10 (S)	FINAL (S)
31	ORU4	12.9-10.17/12.9-10.2	X (S)	IMO-1 (I)	IMO-10 (S)	IMO-10 (S)	FMO-15 (S)	X (S)	IMO-10 (S)	X (S)	FINAL (S)
32	ORU4	12.9-10.17/12.9-10.2	X (S)	X (S)	X (S)	IMO-5 (S)	FMO-15 (D)	IMO-2 (S)	IMO-10 (D)	X (S)	FINAL (I)
33	ORU4	12.9-10.17/12.9-10.2	X (S)	X (S)	X (S)	IMO-5 (S)	FMO-15 (S)	FMO-15 (S)	FMO-15 (S)	IMO-1 (S)	X (S)
44	ORU5	12.3.11/12.3.6/12.3.7	X (S)	X (S)	X (S)	IMO-5 (I)	IMO-3 (D)	FINAL (S)	FINAL (S)	FINAL (S)	FINAL (I)
45	ORU5	12.3.11/12.3.6/12.3.7	X (D)	IMO-3 (I)	FMO-15 (S)	FMO-15 (S)	FINAL (S)	X (S)	X (D)	FMO-15 (I)	X (S)
46	ORU5	12.3.11/12.3.6/12.3.7	FINAL (S)	IMO-3 (I)	FMO-15 (S)	FMO-15 (D)	FINAL (S)	IMO-1 (I)	FMO-15 (S)	FMO-15 (I)	X (S)
47	ORU5	12.3.11/12.3.6/12.3.7	X (S)	X (S)	X (S)	IMO-10 (S)	IMO-10 (I)	FMO-15 (S)	FMO-15 (S)	FINAL (S)	X (D)
49	CRU15	12.3.11/12.3.6/12.3.7	X (S)	X (S)	X (S)	IMO-10 (S)	X (S)	FINAL (I)	FMO-15 (S)	FINAL (S)	FINAL (I)
54	ORU6	12.3.11/12.3.7	FINAL (S)	IMO-3 (S)	FMO-15 (S)	FINAL (S)	FINAL (S)	IMO-10 (S)	FINAL (S)	FINAL (S)	FINAL (S)
55	ORU6	12.3.11/12.3.7	FINAL (S)	X (S)	X (S)	IMO-5 (S)	FMO-15 (S)	FMO-15 (I)	FINAL (I)	FINAL (I)	FINAL (S)
56	CRU3	12.3.11/12.3.7	FINAL (S)	X (S)	X (S)	IMO-5 (S)	IMO-10 (S)	FMO-15 (S)	FINAL (S)	FINAL (S)	X (S)
57	CRU3	12.3.11/12.3.6/12.3.7	FINAL (I)	X (S)	X (S)	IMO-10 (D)	FMO-15 (I)	FINAL (S)	FINAL (S)	FINAL (S)	X (S)
58	ORU7	12.3.11/12.3.6/12.3.7	X (S)	X (S)	X (S)	IMO-10 (S)	IMO-10 (I)	IMO-5 (I)	FMO-15 (D)	FINAL (S)	X (S)
59	ORU7	12.3.11/12.3.6/12.3.7	X (S)	X (S)	X (S)	IMO-5 (S)	IMO-5 (S)	IMO-2 (I)	FMO-15 (S)	FMO-15 (S)	X (S)
60	ORU8	12.9-10.17/12.9-10.2	X (S)	X (S)	X (S)	IMO-5 (S)	FMO-15 (S)	IMO-3 (S)	FMO-15 (S)	IMO-10 (D)	X (S)

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Site	Rehab Unit	Pre-Clearing Regional Ecosystem	Species Richness (native)	Canopy Cover (T1)	Canopy Height (T1)	Small Tree Height (T2-T3)	Small Tree Cover (T2-T3)	Shrub Cover (S1)	Shrub Height (S1)	Ground Cover (G1)	Weed Cover (<5%?)
61	ORU8	12.9-10.17/12.9-10.2	X (S)	IMO-5 (S)	IMO-10 (S)	IMO-5 (S)	IMO-5 (D)	X (D)	IMO-10 (I)	IMO-1 (S)	FINAL (S)
62	ORU9	12.9-10.17/12.9-10.19	X (S)	FMO-15 (S)	FMO-15 (I)	IMO-5 (S)	IMO-10 (I)	IMO-10 (S)	IMO-5 (D)	IMO-3 (D)	FINAL (S)
63	ORU10	12.9-10.17	X (S)	FMO-15 (I)	IMO-10 (S)	IMO-5 (D)	IMO-5 (D)	IMO-1 (I)	IMO-5 (S)	IMO-1 (S)	FINAL (S)
64	ORU11	12.9-10.17	FINAL (S)	FMO-15 (S)	IMO-10 (S)	IMO-10 (D)	IMO-5 (D)	IMO-3 (S)	IMO-10 (D)	IMO-3 (D)	FINAL (S)
65	ORU10	12.9-10.17	FINAL (S)	IMO-1 (D)	IMO-10 (S)	IMO-5 (S)	FMO-15 (S)	IMO-5 (D)	IMO-10 (S)	IMO-3 (D)	FINAL (S)
66	ORU9	12.9-10.17/12.9-10.19	X (D)	FMO-15 (S)	IMO-10 (S)	IMO-5 (S)	IMO-10 (D)	IMO-3 (I)	IMO-10 (S)	IMO-2 (D)	FINAL (S)
67	ORU9	12.9-10.17/12.9-10.19	X (S)	IMO-5 (I)	IMO-10 (S)	IMO-5 (D)	IMO-10 (D)	X (S)	IMO-5 (D)	IMO-5 (D)	FINAL (S)
68	ORU9	12.9-10.17/12.9-10.19	X (S)	IMO-5 (S)	IMO-10 (S)	FMO-15 (S)	X (D)	X (S)	IMO-2 (D)	IMO-2 (D)	FINAL (S)
69	ORU9	12.9-10.17/12.9-10.19	X (S)	X (S)	X (S)	IMO-10 (S)	IMO-10 (I)	FMO-15 (S)	FMO-15 (S)	FINAL (S)	X (D)
102	ORU13	12.9-10.17/12.9-10.19	X (S)	FMO-15 (D)	IMO-10 (S)	IMO-10 (I)	IMO-10 (D)	X (S)	IMO-10 (S)	X (S)	FINAL (S)
103	ORU13	12.9-10.17/12.9-10.19	X (D)	FMO-15 (S)	IMO-10 (S)	IMO-10 (D)	X (D)	X (S)	IMO-2 (D)	IMO-1 (S)	FINAL (S)
104	ORU13	12.9-10.17/12.9-10.19	X (S)	IMO-10 (S)	IMO-10 (S)	IMO-10 (S)	FMO-15 (I)	X (S)	IMO-5 (I)	IMO-1 (D)	FINAL (S)
109	ORU15	12.9-10.17/12.9-10.2	X (S)	IMO-5 (D)	IMO-10 (S)	IMO-5 (S)	IMO-10 (S)	X (S)	IMO-5 (D)	X (S)	FINAL (S)
110	ORU15	12.9-10.17/12.9-10.2	X (S)	X (S)	X (S)	FMO-15 (S)	IMO-1 (S)	X (S)	IMO-3 (D)	FMO-15 (S)	X (S)
111	ORU15	12.9-10.17/12.9-10.2	X (S)	X (D)	IMO-10 (I)	IMO-5 (S)	FMO-15 (D)	FMO-15 (D)	IMO-10 (S)	IMO-10 (S)	X (S)
112	ORU16	12.9-10.17/12.9-10.19	X (D)	X (S)	X (S)	IMO-5 (S)	FMO-15 (S)	IMO-1 (D)	FMO-15 (S)	FMO-15 (S)	X (S)
113	ORU16	12.9-10.17/12.9-10.19	X (S)	X (S)	X (S)	IMO-5 (S)	IMO-2 (S)	IMO-2 (I)	FMO-15 (S)	FMO-15 (S)	X (S)
115	ORU17	12.9-10.17/12.9-10.2	X (S)	X (S)	IMO-10 (S)	X (S)	X (S)	IMO-3 (I)	IMO-10 (S)	IMO-5 (D)	X (S)
123	ORU18	12.9-10.17	FINAL (S)	IMO-1 (D)	IMO-10 (S)	IMO-10 (S)	FINAL (I)	X (S)	IMO-5 (S)	IMO-1 (S)	FINAL (S)
124	ORU18	12.9-10.17	FINAL (S)	X (D)	X (D)	FMO-15 (I)	FINAL (I)	IMO-1 (D)	IMO-10 (S)	IMO-1 (S)	FINAL (S)
127	ORU20	12.9-10.17/12.9-10.2	FINAL (S)	IMO-3 (D)	IMO-10 (S)	IMO-10 (S)	FINAL (I)	X (S)	IMO-2 (D)	IMO-1 (S)	FINAL (S)
128	ORU20	12.9-10.17/12.9-10.2	FINAL (S)	FMO-15 (S)	IMO-10 (S)	IMO-10 (S)	FMO-15 (S)	X (D)	IMO-10 (S)	IMO-5 (S)	X (S)
129	ORU21	12.11.5/12.11.3	FINAL (S)	IMO-3 (I)	X (S)	IMO-10 (I)	FINAL (S)	FINAL (S)	FINAL (S)	FINAL (I)	X (S)
130	ORU21	12.11.5/12.11.3	FINAL (S)	X (S)	X (S)	FINAL (S)	FINAL (S)	FMO-15 (D)	FINAL (S)	IMO-5 (I)	X (S)
131	ORU19	12.11.5/12.11.3	FINAL (S)	IMO-5 (I)	FMO-15 (D)	FINAL (S)	FINAL (S)	FMO-15 (D)	FINAL (S)	IMO-3 (D)	FINAL (S)
132	ORU19	12.11.5/12.11.3	FINAL (I)	X (S)	X (S)	FINAL (S)	FINAL (S)	FMO-15 (I)	X (S)	IMO-5 (S)	FINAL (S)
133	ORU19	12.11.5/12.11.3	FINAL (S)	FMO-15 (I)	FMO-15 (S)	FMO-15 (D)	FINAL (S)	FINAL (S)	FINAL (S)	IMO-5 (S)	X (D)

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Site	Rehab Unit	Pre-Clearing Regional Ecosystem	Species Richness (native)	Canopy Cover (T1)	Canopy Height (T1)	Small Tree Height (T2-T3)	Small Tree Cover (T2-T3)	Shrub Cover (S1)	Shrub Height (S1)	Ground Cover (G1)	Weed Cover (<5%?)
134	ORU22	12.11.5/12.11.3	X (D)	X (S)	X (S)	IMO-5 (D)	FINAL (S)	FINAL (I)	FINAL (S)	IMO-3 (S)	FINAL (S)
135	ORU22	12.11.5/12.11.3	FINAL (S)	X (S)	X (S)	FINAL (S)	FINAL (S)	FINAL (S)	FINAL (S)	FMO-15 (S)	X (S)
136	ORU22	12.11.5/12.11.3	FINAL (S)	IMO-3 (I)	X (S)	FINAL (S)	FINAL (S)	FINAL (S)	FINAL (S)	IMO-2 (S)	FINAL (S)
137	ORU23	12.11.5	FINAL (S)	IMO-2 (I)	X (S)	FINAL (S)	FINAL (S)	FINAL (S)	FMO-15 (D)	FMO-15 (S)	X (S)
138	ORU23	12.11.5	FINAL (S)	IMO-2 (I)	X (S)	FINAL (S)	FINAL (S)	FINAL (S)	FINAL (S)	FMO-15 (S)	X (S)
143	CRU8	12.11.5/12.11.3	FINAL (I)	X (D)	X (D)	FINAL (S)	FINAL (S)	FMO-15 (D)	IMO-10 (S)	FMO-15 (S)	X (S)
144	CRU8	12.11.5/12.11.3	FINAL (S)	X (S)	IMO-10 (D)	FINAL (S)	FINAL (S)	FMO-15 (D)	FMO-15 (I)	FMO-15 (S)	FINAL (S)
Total meeting a benchmark			**28**	**29**	**27**	**55**	**54**	**44**	**53**	**55**	**30**
Total meeting a benchmark (5th mon.)			**29**	**24**	**30**	**57**	**58**	**42**	**58**	**55**	**28**
Total improving (since 4th mon.)			**5**	**11**	**2**	**4**	**9**	**15**	**7**	**6**	**4**
Total declining (since 4th mon.)			**6**	**8**	**5**	**14**	**12**	**10**	**18**	**11**	**2**
Total same (since 4th mon.)			**46**	**38**	**51**	**40**	**37**	**33**	**33**	**41**	**51**
Overall trend			**=**	**≥**	**=**	**=**	**≤**	**≥**	**≤**	**=**	**=**
Total sites (excl. removed) = 59											

Note: the site meets the following benchmarks: IMO- 1 year; IMO- 2 year, IMO-3 year, IMO-5 year, IMO-10 year, FMO-15 year, FINAL Benchmark condition, and X – does not meet any benchmark.
* D = Decrease, S = Same, I = Increase in all values

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