EPBC Annual Compliance Report

EPBC 2016/7656

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Great Northern Highway Upgrade:
Muchea to Wubin – Muchea North
D24#1330778

Reporting period: 21 September 2023 to 20 September 2024

Document Control

Report Compilation & Review	Position	Document Revision	Date
Author:	Senior Environment Officer	Rev A	15/11/2024
Reviewer:	Principal Environment Officer	Rev A	17/12/2024
Author:	Senior Environment Officer	Rev 0	19/12/2024

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Declaration of accuracy

In making this declaration, I am aware that sections 490 and 491 of the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) make it an offence in certain circumstances to knowingly provide false or misleading information or documents. The offence is punishable on conviction by imprisonment or a fine, or both. I declare that all the information and documentation supporting this compliance report is true and correct in every particular. I am authorised to bind the approval holder to this declaration and that I have no knowledge of that authorisation being revoked at the time of making this declaration.

Signed Martine Scheltema (approval holder)

Full name (please print) Martine Scheltema

Position (please print) Director Environment and Heritage

Organisation (please print including ABN/ACN if applicable) Main Roads Western Australia
ACN 50 860 676 021

Date 19/12/24

1 Introduction

1.1 Project Background, Location and Status

Great Northern Highway forms part of the National Highway Network and provides a strategic freight link between Perth and the State's north, as well as Darwin and the Northern Territory. Between 2000 and 2009, Stage One of the Great Northern Highway Muchea to Wubin Upgrade project was completed, which saw 76 km of the highway upgraded to National Highway standard.

In 2014, a comprehensive planning review was undertaken of the full Muchea to Wubin link along the highway. A series of construction packages were prioritised following the review, which included upgrading the existing Great Northern Highway between the Old Gingin Road to Chittering Roadhouse, known as the Muchea North section (the Project). The upgrades included town bypasses, wider roads, more passing lanes, flattening crests and easing curves, safer roadsides, more rest stops and additional facilities for heavy vehicles.

Construction of the Project was completed in 2020. As such, no construction or clearing activities were undertaken during the reporting period (21 September 2023 to 20 September 2024).

1.2 Approval under the *Environment Protection and Biodiversity Conservation Act 1999*

The Project was referred to the then Department of the Environment and Energy (DoEE; 'the Department') now the Department of Climate Change, Energy, the Environment and Water (DCCEEW) for assessment under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). The Project was determined to be a Controlled Action due to potential impacts on listed threatened species and communities. The Department issued conditional approval for these works to proceed on 10 August 2018 (EPBC2016/7656).

1.3 Purpose of this Report

Construction of the Project commenced on 21 September 2018. This annual compliance report has been produced to satisfy Condition 12 of approval EPBC2016/7656.

2 Summary of Compliance

The Project was found to be fully compliant with the requirements of the EPBC2016/7656. Table 1 of this report details the project's compliance with regard to each approval condition over the 12-month reporting period: 21 September 2023 to 20 September 2024. Conditions deemed completed are shaded grey.

Construction of the Project has been completed, however completion criteria for revegetation has not yet been achieved. Reporting will continue annually under Condition 12 of EPBC 2016/7656.

2.1 New Environmental Risks

No new environmental risks for the project have become apparent during the reporting period.

Table 1: Compliance with Conditions of EPBC Approval EPBC2016/7656

Condition Number	Condition	Status	Evidence/Comments
1	The approval holder must not clear more than 52.5 hectares of Carnaby's Black Cockatoo habitat within the project area and can only clear up to six of the hollows identified as 'hollow with evidence of use' and up to eight of the hollows identified as 'suitable hollows', in Attachment 1.	Compliant	No clearing was undertaken during the reporting period. Clearing during previous reporting periods has not exceeded 52.5 hectares of Carnaby's Black Cockatoo habitat.
2	To mitigate impacts to the Carnaby's Black Cockatoo, the approval holder must undertake all efforts to avoid clearing the known nesting hollow and suitable nesting hollow identified in Attachment 2. Within one month of the completion of clearing, the approval holder must provide the Department with evidence that these hollows have not been cleared or a detailed assessment of why clearing of these hollows could not be avoided.	Compliant	The suitable nesting hollows and known nesting hollows identified in Attachment 2 of EPBC2016-7656 have not been cleared, as confirmed to the Department in an email on 11 April 2019.
3	Within 7 days prior to clearing of any area of Carnaby's Black Cockatoo habitat, the approval holder must investigate and document all potential nesting trees within the area to be cleared to determine if there are any hollows that are being utilised, or are capable of being utilised, by the Carnaby's Black Cockatoos for nesting. The investigation must be undertaken by a suitably qualified person. a. If any Carnaby's Black Cockatoo(s) is detected utilising any hollow in any tree, the approval holder must: i. clearly identify and mark the identified nesting tree	Compliant	No clearing was undertaken during the reporting period.

Condition Number	Condition	Status	Evidence/Comments
	ii. maintain a register of nesting trees iii. only clear the identified nesting tree and vegetation within a 10 metre radius of the tree, if a suitably qualified person has verified that the hollow in the tree are no longer being used by the Carnaby's Black Cockatoo record the location of any known nesting hollow or suitable nesting hollow, identified during the investigations, that are additional to the nesting hollows identified in Attachment 1.		
4	To mitigate and offset the loss of known nesting hollows and suitable nesting hollow the approval holder must: a. install at least three artificial nesting hollows for each known nesting hollow and suitable nesting hollow cleared b. install at least ten of the artificial nesting hollows required by Condition 4.a prior to the clearing of any known nesting hollow or suitable nesting hollow with all remaining hollows to be installed prior to the beginning of the next breeding season following the commencement of the action. c. maintain the pre-impact breeding density of the Carnaby's Black Cockatoo within the project area by undertaking adaptive management of the artificial nesting hollows to maximise the likelihood that the installed artificial nesting hollows are used by the Carnaby's Black Cockatoo	Compliant	a. No known or suitable nesting hollows were cleared in the reporting period. b. As above c. No adaptive management actions were required in this reporting period. d. A total of 15 artificial hollows showed evidence of use in the 2019-2020 breeding season with 19 artificial hollows showing evidence of use in the 2020-21 breeding season and 25 artificial hollows showing evidence of use in the 2021-22 breeding season. The number of natural hollows impacted by the proposal was 13. This condition has therefore been met and adaptive management is no longer required. e. The outcome of Condition 4.d has been met. No further actions in relation to this condition are required. f. Main Roads commissioned Phoenix Environmental Sciences to undertake the required monitoring as provided in **Appendix 1**. All artificial nesting hollows

Condition Number	Condition	Status	Evidence/Comments
	d. adaptive management may cease when at least one artificial nesting hollow for each known nesting hollow cleared has shown evidence of use by the Carnaby's Black Cockatoo, as verified by the suitable qualified person, for three consecutive years; the artificial nesting hollow in use for three consecutive years need not be the same artificial nesting hollow each year e. if after nine years from commencement of the action the outcome identified in Condition 4.d is not met, the approval holder must i. submit to the Minister for approval the details of an offset that meets the requirements of the EPBC Environmental Offsets Policy and will compensate for the permanent loss of known Carnaby's Black Cockatoo breeding hollows ii. submit to the Department a detailed assessment of the factors that cause the failure to achieve the outcome identified in Condition 4.d f. Each artificial nesting hollow installed must: i. be inspected at least twice a year by a suitably qualified person during the peak breeding season to record any evidence of use by the Carnaby's Black Cockatoo and to identify any maintenance requirements ii. be monitored and maintained in accordance with relevant artificial hollow guidance for the life of the approval, with		were considered to be in good condition, with 10 requiring minor maintenance actions. Main Roads commissioned Australian Black Cockatoo Specialists to undertake the required maintenance actions on the hollows, which included additional maintenance actions for five hollows (15 in total). The maintenance activities were undertaken in June 2024, outside of the 2024 breeding season. A summary report of the maintenance actions is provided in **Appendix 2**.

Condition Number	Condition	Status	Evidence/Comments
	maintenance actions, if required, undertaken outside of the breeding season and before the commencement of the next breeding season iii. not be installed in a manner that requires additional clearing of Carnaby's Black Cockatoo habitat or within 10 metres of the edge of the road seal to reduce the risk of vehicle strike.		
5	For the purposes of Condition 4, the maximum number of hollows to be cleared that are additional to the hollows identified in Attachment 1 must not exceed four and at least half of all artificial nesting hollows installed must be installed within 500 m of the project area.	Compliant	No clearing or installation of artificial nesting hollows was undertaken during the reporting period.
6	All data, enquiries and findings of the monitoring required by Condition 4 must be provided to the Department, DBCA and published on the approval holder's website to contribute to broader research into the use of artificial nesting hollows by the Carnaby's Black Cockatoo. Publication must occur within one year of the environmental outcome identified in Condition 4.d being achieved or after nine years from the commencement of the action if the environment outcome is not met by that time.	Compliant	Condition 4.d was achieved in the 2021-22 reporting year. The information referenced in this condition has been published on the Main Roads website (Construction Project Compliance Reports | Main Roads Western Australia) and provided to DBCA on 10 November 2022 (evidence provided in the 2021-2022 Annual Compliance Report).
7	To mitigate impacts to the Carnaby's Black Cockatoo, the approval holder must revegetate at least 19.69 hectares of land with species that are known to provide foraging and breeding habitat for the Carnaby's Black Cockatoo, in the area identified in Attachment 3. The objective of	Compliant	a. Initial revegetation planting for the proposal was completed prior to this reporting period. Initial revegetation activities commenced on 20 August 2019, approximately 11 months after commencement of the action and all areas identified for revegetation were

Condition Number	Condition	Status	Evidence/Comments
	revegetation works is to re-establish a self-sustaining vegetation cover, integrate with the surrounding ecosystem, which provides Carnaby's Black Cockatoo habitat. The approval holder must adhere to the following during all revegetation works: a. revegetation must begin within one year of commencement of the action and must have commenced within all the areas identified for revegetation in Attachment 3, within one year of the completion of construction b. flora species identified as Carnaby's Black Cockatoo habitat must not be planted within 10 metres of the edge of the road seal to reduce the risk of vehicle strike c. revegetation works may cease once a suitably qualified person has verified that the revegetated areas meet the completion criteria d. once the completion criteria have been achieved, all areas of revegetation must be inspected once every 2 years, during Spring, for at least a further 20 years to ensure the completion criteria are being maintained e. undertaken corrective actions to improve vegetation quality within the revegetated areas, within 3 months of becoming aware that an area of revegetation no longer meets the completion		completed in July 2020, one month after construction works were completed. Revegetation maintenance works are ongoing. b. No flora species identified as Carnaby's Black Cockatoo habitat have been planted within 10 metres of the edge of the road seal. c. Revegetation has not yet been verified to meet the completion criteria. Main Roads commissioned Gambara to monitor and assess the revegetation against the completion criteria in July 2024. Gambara confirmed that the revegetation meets three of the five completion criteria targets. The status of the remaining two completion criteria targets is considered not yet achieved (See **Appendix 3**). Main Roads will undertake infill planting in 2025. d. This condition is not yet relevant. Revegetation has not yet been verified to meet the completion criteria. e. This condition is not yet relevant. Revegetation has not yet been verified to meet the completion criteria.

Condition Number	Condition	Status	Evidence/Comments
	criteria; corrective actions may cease once the completion criteria have again been achieved.		
8	To mitigate impacts to the Carnaby's Black Cockatoo, the approval holder must prepare and submit a *Construction Environmental Management Plan* (CEMP) for the approval of the Minister. The approval holder must not commence the action unless the Minister has approved the CEMP. The approved CEMP must be implemented. The CEMP must be prepared in accordance with the Department's Environmental Management Plan Guidelines and include, but not be limited to: a. design principles and practices to minimise clearing of Carnaby's Black Cockatoo habitat – for example, road micro-alignment, traffic management alternatives to side roads b. measures to prevent impacts to Carnaby's Black Cockatoo habitat during construction, including to: i. prevent and/or control site access, weeds, *Phytophthora* dieback, erosion, dust and fire ii. delineate vegetation to be retained through, for example, the erection of temporary fencing or signage to avoid accidental clearing or disturbance outside of the impact area c. management measures, including in relation to fencing and access controls, to permanently restrict access to adjacent road reserves	Complete	The Minister approved the CEMP on 5 September 2018 and the action commenced on 21 September 2019. Main Roads implemented the approved CEMP.

Condition Number	Condition	Status	Evidence/Comments
	d. objectives, targets and completion criteria for post construction rehabilitation measures such as site clean-up and weed management, including information on the mapping, monitoring and removal of noxious weeds e. objectives and targets for landscaping and revegetation works required by Condition 7, including details on site preparation works, seeding planting programs, success rates, ongoing management post establishment and details of replanting requirements if success rates are not achieved f. clear objectives and performance indicators for all management actions, mitigation measures and practices prescribed by the CEMP including details of the monitoring to be undertaken to demonstrate the effectiveness of the measures g. corrective actions for circumstances where an action, mitigation measure or practice prescribed by the CEMP fails to meet, or is unlikely to meet, its prescribed objectives, and trigger action points at which these corrective actions will be implemented h. timeframes for implementing the above measures.		
9	To compensate for the loss of up to 52.5 hectares of foraging habitat, and 744 potential breeding trees for the Carnaby's Black Cockatoo the approval holder must, within one year after the commencement of the action, provide the Department with the offset attributes, shapefiles and textual descriptions and maps to clearly	Complete	Main Roads provided a letter and information to the Department on 12 November 2018 to satisfy the requirements of this Condition.

Condition Number	Condition	Status	Evidence/Comments
	define the location and boundaries of the Ioppolo Road Offset and Banovich Road Offset, that the approval holder has transferred to the DBCA.		
10	Within 30 days after the commencement of the action, the approval holder must advise the Department in writing of the actual date of commencement.	Complete	The action commenced on 21 September 2018, with written notification provided to the Department by email on 27 September 2018.
11	The approval holder must maintain accurate records substantiating all activities associated with or relevant to the conditions of approval, including measures taken to implement the plan required by this approval (Condition 8), and make them available upon request to the Department. Such records may be subject to audit by the Department of an independent auditor in accordance with section 458 of the EPBC Act or used to verify compliance with the conditions of this approval. Summaries of audits will be posted on the Department's website. The results of audits may also be publicised through the general media.	Compliant	Main Roads has maintained records in accordance with this condition and their legal obligations under the Western Australian *State Records Act 2000*.
12	Within three months of every 12 month anniversary of the commencement of the action, the approval holder must publish a report on their website addressing compliance with each of the conditions of this approval, including implementation of any management plans as specified in the conditions. Documentary evidence providing proof of the date of publication and non-compliance with any of the conditions of this approval must be provided to the Department at the same time as the compliance report is published. Reports must remain on the website for the life of this approval. The approval	Compliant	This 2023-24 Annual Compliance Report will be published on the Main Roads website at the same time as the provision of this report to the Department. The report is available here: Construction Project Compliance Reports | Main Roads Western Australia

Condition Number	Condition	Status	Evidence/Comments
	holder must continue to comply with this condition until such time as agreed to in writing by the Minister.		
13	Upon the direction of the Minister, the approval holder must ensure that an independent audit of compliance with the conditions of approval is conducted and a report submitted to the Minister. The independent auditor must be approved by the Minister prior to the commencement of the audit. Audit criteria must be agreed to by the Minister and the audit report must address the criteria to the satisfaction of the Minister.	Not applicable	The Minister has not yet directed Main Roads to conduct an independent audit of compliance with EPBC 2016/7656 conditions of approval.
14	The approval holder may choose to revise a management plan approved by the Minister under Condition 8 without submitting it for approval under section 143A of the EPBC Act, if the taking of the action in accordance with the revised plan would not be likely to have a new or increased impact. If the approval holder makes this choice they must notify the Department in writing that the approved plan has been revised and provide the Department, at least four weeks before implementing the revised plan, with: a. an electronic copy of the revised plan; b. an explanation of the differences between the revised plan and the approved plan; and the reasons the approval holder considers that taking the action in accordance with the revised plan would not be likely to have a new or increased impact.	Not applicable	The approved CEMP has not been revised during this reporting period.
15	The approval holder may revoke their choice under Condition 14 at any time by notice to the Department. If the approval holder revokes the choice to implement a	Not applicable	Main Roads has not elected to revoke their choice under Condition 14.

Condition Number	Condition	Status	Evidence/Comments
	revised plan, without approval under section 143A of the Act, the plan approved by the Minister must be implemented.		
16	If the Minister gives a notice to the approval holder that the Minister is satisfied that the taking of the action in accordance with the revised plan would be likely to have a new or increased impact, then: a. Condition 14 does not apply, or ceases to apply, in relation to the revised plan; and b. The approval holder must implement the plan approved by the Minister. To avoid any doubt, this condition does not affect any operation of Conditions 14 and 15 in the period before the day the notice is given.	Not applicable	The approved CEMP has not been revised during this reporting period.
17	Conditions 14, 15 and 16 are not intended to limit the operation of section 143A of the EPBC Act which allows the approval holder to submit a revised plan to the Minister for approval.	Not applicable	The approved CEMP has not been revised during this reporting period.
18	Unless otherwise agreed to in writing by the Minister, the approval holder must publish all management plans referred to in these conditions of approval on their website for the duration of this approval. Each management plan must be published on the website within 1 month of being approved by the Minister or being submitted under Condition 12 and must remain on the website for the life of this approval.	Compliant	The approved CEMP was first published on Main Roads' website on 2 October 2018. The plan is available here: Construction Project Compliance Reports | Main Roads Western Australia

3 Appendices

Appendix	Title
Appendix 1	Phoenix Environmental 2023-24 Artificial Nest Box Monitoring Report
Appendix 2	Australian Black Cockatoo Specialists 2024 Artificial Next Box Maintenance
Appendix 3	Gambara 2024 Muchea North Revegetation Monitoring Report

Appendix 1: Phoenix Environmental 2023-24 Artificial Nest Box Monitoring Report

PHOENIX
ENVIRONMENTAL SCIENCES

Black cockatoo breeding activity census 2023-24 for Muchea North

Great Northern Highway, Muchea to Wubin Upgrade Stage 2 Project

Prepared for Main Roads WA

March 2024

Final

Black cockatoo breeding activity census 2023-24 for Muchea North.

Great Northern Highway, Muchea to Wubin Upgrade Stage 2 Project.

Prepared for Main Roads WA

Author	Version	Version number	Date submitted	Submitted to
A. Jacks	Draft for client comments	0.1	08-Mar-24	A. Dalton
A. Jacks	Final, client comments addressed	1.0	26-Mar-24	A. Dalton

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1 INTRODUCTION

Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Main Roads WA, to undertake a Carnaby's Cockatoo (*Zanda latirostris*) breeding activity census over the 2023-24 breeding season within and surrounding the disturbance footprint for the Muchea North Upgrade project area (Figure 1). This report presents the results of the census.

1.1 BACKGROUND

Main Roads has recently upgraded the Great Northern Highway (GNH) between Straight Line Kilometre (SLK) 38.60 and 51.40, referred to as Muchea North Upgrade (Muchea North in this report). The Muchea North proposal was referred under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 1 March 2016 (EPBC 2016/7656), assessed as a controlled action and granted conditional approval in August 2018 (DotEE 2018).

Muchea North resulted in the loss of 13 Carnaby's Cockatoo nesting hollows. To mitigate and offset the loss of these, Main Roads was required to install 39 artificial nest boxes (Figure 1). In accordance with EPBC 2016/7656 Conditions 4f(i) and (ii) each artificial nesting hollow installed must:

- (i): be inspected at least twice a year by a suitably qualified person during the peak breeding season to record any evidence of use by the Carnaby's Black Cockatoo and to identify any maintenance requirements.
- (ii): be monitored and maintained in accordance with relevant artificial hollow guidance for the life of the approval, with maintenance actions, if required, undertaken outside of the breeding season and before the commencement of the next breeding season.

The monitoring program also required monitoring of previously recorded natural hollows suitable for Carnaby's Cockatoo (Figure 1). Monitoring of artificial and natural hollows is required in accordance with How to Monitor and Maintain Artificial Hollows for Carnaby's Cockatoo (DPaW 2015).

Detailed black cockatoo habitat assessments conducted as part of the baseline assessments for the Muchea North (Phoenix 2015, 2017a) recorded all potential breeding trees of species known to support black cockatoo breeding and identified suitable nesting hollows and hollows with evidence of use.

A native vegetation clearing permit (NVCP) for Muchea North (Permit no. 7563/2) has been approved by the WA Department of Water and Environmental Regulation (DWER) under the *Environmental Protection Act 1986* (EP Act).

To support Condition 4c of EPBC 2016/7656, Main Roads commissioned Phoenix to undertake monitoring of confirmed and suitable nesting hollows recorded within the EPBC Act Approval Boundary and wider baseline survey area (Phoenix 2015, 2017a) (the study area; Figure 1). A series of monitoring events have taken place to support this condition (Table 1). The initial baseline monitoring program was conducted in the 2017-18 breeding season (August 2017 – February 2018) which assessed hollow usage of suitable nesting hollows and hollows with evidence of use within the study area (Phoenix 2018). A second year of baseline monitoring for hollow usage within the study area in the 2018-19 breeding season was undertaken by Phoenix from August 2018 to February 2019 (Phoenix 2019). The artificial nesting hollows were installed during the 2018-2019 breeding season, therefore the results of these first 2 surveys collectively represent the pre-impact breeding density.

Impact monitoring was subsequently conducted each breeding season since 2019 (Phoenix 2020), (Phoenix 2021) (Phoenix 2022) (Phoenix 2023) breeding season. This report incorporates the results of the 2023-2024 monitoring season into the nesting hollow usage dataset for Muchea North.

Table 1 Summary of black cockatoo monitoring activity

Year	Activity
2014-2016 Various times	Habitat assessment including recording all potential breeding trees and suitability for nesting.
2017-2018 August to January	Baseline assessment: Assessment of nest hollows for evidence of breeding.
2018-2019 August to February	Baseline assessment: Assessment of nest hollows for evidence of breeding. *Road works commenced and artificial nesting hollows were installed during this breeding season.*
2019-2020 August to January	Post-impact assessment of both natural nest hollows and artificial nesting hollows for evidence of breeding.
2020-2021 August to February	
2021-2022 August to February	
2022-2023 August to February	
2023-2024 August to February	

1.2 SCOPE OF WORK

The scope of work was as follows:

- Between August 2023 and February 2024, inspect the 40 artificial nest boxes installed in the Muchea North area. These inspections must be in accordance with DPaW (2015).
- The inspection of the artificial nest boxes on Nesci Estate must be in accordance with the land access agreement.
- Between August 2023 and February 2024, survey the previously recorded natural hollows suitable for Carnaby's Cockatoo to allow for a comprehensive view of Carnaby's Black Cockatoo breeding activity. Access to trees on private property will be contingent on prior landowner consent, to be negotiated by the consultant (Main Roads to provide landowner contact details).
- During inspections of artificial and natural hollows, record evidence of use by Carnaby's Cockatoos at each artificial and natural hollow in accordance with DPaW (2015).
- During inspections, identify any artificial nest box maintenance needs in accordance with DPaW (2015), and whether natural hollows remain suitable for use by Carnaby's Cockatoo.
- Within six weeks of completion of the final monitoring campaign provide to Main Roads a draft report that provides all records required by Conditions 4f(i) and (ii) of EPBC 2016/7656 for all artificial and natural hollows inspected. This report must be suitable for publication on the Main Roads website for public accessibility, and provision to the WA Department of Biodiversity, Conservation and Attractions (DBCA) and the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW).

2 CENSUS METHODOLOGY (DPAW 2015)

Methods were consistent with the approach undertaken in previous monitoring events for Muchea North (Phoenix 2018, 2019, 2020, 2021, 2022, 2023).

Prior to the surveys, site locations (artificial and natural nest hollows) were loaded onto field tablets. Data was collected electronically using a customised data collection template and included:

- site code
- signs of use – birds prospecting hollows, fresh chewings, birds perching, birds entering/existing hollows, birds flushed from hollows, gender of observed birds, chick calls, eggs observed (inc. status if possible – incubated or abandoned), chick/s observed, chick/s fledged
- other indicators, e.g. gender mix of flocks, evidence of nesting at base of trees
- condition of hollow, current suitability for use (natural hollows), maintenance requirements (artificial hollows).

The knocking and scraping method was conducted at the base of trees for all monitored hollows during the first half of the monitoring period when birds are typically prospecting for suitable hollows and females are incubating eggs. Pole camera inspections were carried out at each hollow towards the latter half of the survey so as to not disturb females incubating eggs during the first half of the monitoring period. The pole camera is used to check to see if eggs or chicks are in nest hollows and their condition (i.e. abandoned eggs, dead or alive chicks). Some hollows could not be accessed by pole camera due to the hollow being too high, blocked by branches, the hollow entrance at an unsuitable angle to allow a clear picture, or the hollow being located close to powerlines. These hollows rely on visual observations of parent birds' activity.

Other observational methods were also employed, i.e. listening for nest activity, flock and individual bird behaviour.

Consistent with previous methodology, the following activities were recorded:

- evidence of nesting activity was noted where fresh chewing is around the hollow entrance and/or birds are seen prospecting hollows
- a confirmed breeding event was noted where eggs are seen in hollow and/or other clear evidence observed that a chick is present (i.e. female seen at hollow entrance when during brooding eggs, and/or parents seen preparing to feed chick in the hollow).

Maintenance checks of artificial hollows assessed the following:

- condition of chewing posts
- condition of attachment points
- condition of hollow bases
- stability of tree or pole used to mount the artificial hollow.

As per previous monitoring surveys, site visits were undertaken every 4-6 weeks between August 2023 and February 2024: 25 August, 29 September, 28 October, 6 December, 5 January, and 13 February. Due to the late breeding season, the final survey was delayed to confirm the fate of chicks.

The baseline surveys for Muchea North identified a total of 57 trees in the study area containing suitable nesting hollows for black cockatoos, of which 25 had evidence of nesting activity.

In the initial baseline survey (2017-18 season), 36 of these were monitored as the remaining 21 were unable to be assessed due to access constraints.

In the second baseline season (2018-19), a total of 86 hollows were monitored; 47 natural nesting hollows and 39 newly installed artificial nesting hollows were monitored (Appendix 1). This included 2 new natural hollows added to the census in the current season (HT6330 and HT13585) and 14 trees with natural nesting hollows that were not accessible in the 2017-18 season. A further 5 natural nesting hollows were not monitored due to 2 trees no longer being accessible, and 3 tree hollows no longer being suitable (i.e. Tree or hollow collapse (Appendix 1)).

In the 2019-2020 season, 73 hollows were monitored, of which 33 were natural nesting hollows and 40 were artificial nesting hollows (Appendix 1). Prior to the survey, 13 trees that contained suitable nesting hollows were removed as part of the GNH road upgrades (HT05911, HT05923, HT06020, HT06046, HT06261, HT06278, HT6330, HT06655, HT08752, HT08753, HT08754, HT13533, HT13534 and HT13535), 12 of these were monitored in the previous 2 monitoring programs and one was not accessible. These 13 trees were offset by the installation of the 39 artificial nesting hollows (which were installed the previous year) of which all were able to be monitored. An additional artificial nesting hollow (NB100) was included in the survey which was erected to replace HT04059. Four natural nesting hollows from the baseline dataset that had not been monitored in the previous 2 years were able to be surveyed in the 2019-2020 season as landowner access had been granted. Four trees with natural nesting hollows were not surveyed in the 2019-2020 season because the tree or hollow was no longer considered suitable.

In the 2020-2021 and 2021-2022 surveys, 71 hollows were monitored. These were the same trees and artificial nesting hollows from the 2019-2020 season however 2 of the 73 trees from the 2019-2020 season were not able to be surveyed due to the hollow becoming unsuitable (HT12761) or the tree had been removed (HT13533) (Appendix 1).

In the 2022-2023 and current survey, 72 hollows, comprising of the 71 suitable hollows from the 2021-2022 breeding season and an additional natural hollow (Dylan) located 75 m south of NB34.

3 RESULTS AND DISCUSSION

3.1 CENSUS RESULTS 2023-24 BREEDING SEASON

A total of 25 natural or artificial hollows recorded evidence of nesting activity or a confirmed breeding event during the 2023-24 breeding season. Of these, confirmed breeding events were recorded in 15 artificial nesting hollows and no confirmed breeding events occurred in natural nest hollows (Table 2; Figure 2).

Of the confirmed breeding events:

- 7 were presumed to have resulted in the successful fledging of a chick (NB01, NB04, NB06, NB12, NB32, NB062, NB99)
- 8 nests resulted in unsuccessful breeding attempts:
    - 2 nests recorded dead chicks (NB08 and NB69)
    - 6 nests recorded old, broken or abandoned eggs (NB60, NB64, NB65, NB68, NB76 and NB79)

Evidence of nesting activity was observed in 4 artificial nesting hollows and in 6 natural nesting hollows (Table 2; Figure 2). Of these, 8 were instances where females were flushed but a later inspection saw no chicks or eggs and the bird was likely to be prospecting, and 2 were fresh chewing around the hollow entrance.

Table 2 2023-2024 breeding season nest activity

HT ID[1]	Inspection date						Result
	25/08/2023	29/092/2023	28/10/2023	06/12/2023	05/01/2024	13/02/2024	
HT06216	No flush	Female flushed	No flush	No flush	No flush	No flush	Evidence of nesting activity
HT14653	No flush	No flush	Chewed	No flush	No flush	No flush	Evidence of nesting activity
HT14657	No flush	Female in nest. 5 in tree	No flush	No flush	No flush	No flush	Evidence of nesting activity
HT14749	Pair Carnaby's prospecting hollows	Female flushed	No flush	No flush	No flush	No flush	Evidence of nesting activity
HT14809	No flush	No flush	Female flushed	No flush	No flush	No flush	Evidence of nesting activity
HT14811	No flush	No flush	Chewed	No flush	No flush	No flush	Evidence of nesting activity
NB01	No flush	Female flushed	Hatchling in nest	Chick in nest	No flush	Chick fledged	Confirmed breeding event: assumed successful fledge
NB02	Female flushed	Female flushed	No flush	No flush	No flush	No flush	Evidence of nesting activity
NB04	No flush	Female flushed	Hatchling in nest	Large chick in nest	Chick fledged	No flush	Confirmed breeding event: assumed successful fledge
NB06	Pair at nestbox	No flush	Hatchling in nest	Large chick in nest	Chick fledged	No flush	Confirmed breeding event: assumed successful fledge
NB08	No flush	Female flushed	Female flushed	Dead chick	No flush	No flush	Confirmed breeding event: unsuccessful fledge
NB12	No flush	No flush	Female incubating but wouldn't flush	No flush	Large chick	Chick fledged	Confirmed breeding event: assumed successful fledge
NB32	Female flushed	Female flushed	Pin feathered chick in nest	Large chick in nest	Chick fledged	No flush	Confirmed breeding event: assumed successful fledge

HT ID[1]	Inspection date						Result
	25/08/2023	29/092/2023	28/10/2023	06/12/2023	05/01/2024	13/02/2024	
NB34	No flush	Female flushed	Little Corella sat on nest post	Empty	No flush	No flush	Evidence of nesting activity
NB41	Female flushed	Female flushed	No flush	No flush	No flush	No flush	Evidence of nesting activity
NB58	No flush	Female flushed	No flush	No flush	No flush	No flush	Evidence of nesting activity
NB60	No flush	No flush	No flush	Old egg in nest	No flush	No flush	Confirmed breeding event: unsuccessful fledge
NB62	No flush	Female flushed	Pin feathered chick in nest	Large chick in nest. Parents nearby	Chick fledged	No flush	Confirmed breeding event: assumed successful fledge
NB64	No flush	No flush	Single egg in nest	Old egg in nest	No flush	No flush	Confirmed breeding event: unsuccessful fledge
NB65	No flush	Female flushed	No flush	Old egg in nest	No flush	No flush	Confirmed breeding event: unsuccessful fledge
NB68	No flush	No flush	2 deserted eggs	No flush	No flush	No flush	Confirmed breeding event: unsuccessful fledge
NB69	No flush	No flush	Dead chick	No flush	No flush	No flush	Confirmed breeding event: unsuccessful fledge
NB76	No flush	Female flushed	Female flushed	No flush	Hatched and deserted egg	No flush	Confirmed breeding event: unsuccessful fledge
NB79	No flush	No flush	No flush	Old egg in nest	No flush	No flush	Confirmed breeding event: unsuccessful fledge
NB99	No flush	Pair near nest	No flush	Female flushed. Hatchling in nest	Chick in nest	Chick fledged	Confirmed breeding event: assumed successful fledge

[1] HT = natural nesting tree hollow, NB = artificial nest box

Figure 3 **Pin feathered chick in nest box (NB63) (October 2023) (Photograph by T. Kirkby)**

Figure 4 **Large, feathered chick a nest box NB12 (October 2023) (Photograph by T. Kirkby)**

3.2 POST-IMPACT ASSESSMENT

The number of hollows which had confirmed Carnaby's Cockatoo breeding events in the 2023-24 breeding season is significantly higher than the pre-impact average and is on par with the post-impact 5-year average, however is lower than the previous 2 breeding seasons (Table 3).

The rate of successful breeding events in the 2023-24 breeding season (47%) is considerably lower than the pre-impact average and slightly lower than than the lowest pre-impact success rate (50%). The average post-impact success rate is 65%. The post-impact average breeding success rate is similar to historic data from a survey undertaken at Coomallo Creek (100 km north of the study area near Jurien Bay) between 1970 and 1976 where the breeding success rate from 482 nests was 64.7% (Saunders 1982). Breeding success rate is thought to be highly dependent on food availability (DCCEEW 2024).

All successful breeding attempts have produced one chick, with the exception of a single bird in 2022-2023 which fledged 2 chicks (2022-2023), and this is usually indicative of older, more experienced females but also relies on food resources and availability (Saunders *et al.* 2014).

Most significantly, the results of the monitoring program clearly show a trend towards increased usage of the artificial nesting hollows installed under the Muchea North offset. The nest boxes were installed during the 2018-2019 breeding season, so there were few records of use during that season, with only one confirmed breeding event and 2 records of evidence of nesting activity (Table 3). This increased in the 2019-2020 breeding season to 3 confirmed breeding events and 11 records of nesting activity in the artificial nesting hollows. In 2020-2021, the number of confirmed breeding events in the artificial nesting hollows increased to 12, with the majority assumed to have had a successful outcome i.e. a chick hatched and fledged (Table 3). In 2021-2022 and 2022-2023 breeding season, the number of confirmed breeding events increased further again to 21 and 20 respectively (Table 3), however in 2023-2024, this decreased to 15. For the 2021-2022 and the current breeding season, all confirmed breeding events occurred in artificial nesting hollows.

In contrast, the number of confirmed breeding events in natural nest hollows is showing a trend of declining use. A total of 3 in the 2019-2020 season, one in the 2020-2021 breeding season, none in the 2021-2022 breeding season, 3 in the 2022-2023 breeding season, and none again in the current breeding sesason. The results suggest the birds are preferentially choosing the artificial hollows over the natural hollows but will still willingly use natural nest hollows if available and suitable.

Given that Carnaby's Cockatoo display strong fidelity to traditional breeding areas and in some cases hollows, and it takes at least 4 years for Carnaby's Cockatoo to mature (DCCEEW 2024), it is apparent that older breeding pairs from the area choosing artificial nest hollows over previously used natural hollows from the surrounding area. New breeding pairs are also favouring artificial nesting hollows.

The number of nest hollows, both artificial and natural, with evidence of nesting (ie. prosecting, chewings) is the same as the pre-impact nesting average, however, as the number of trees monitored in the post-impact surveys is higher, this equates to a small decline. (ie. 19% pre-impact vs. 14% post-impact). However, variability was also noted in surveys conducted in the pre-impact years. The lower rate of evidence of nesting without breeding supports the higher uptake of confirmed breeding within the study area, with breeding pairs choosing to breed at more of the nesting hollows that are being monitored as part of this survey.

The number of natural breeding hollows with evidence of nesting was comparatively high in the first two pre-impact surveys (pre-2017-2018 and 2017-2018 breeding season), with 24 and 14 natural hollows recording evidence of nesting respectively. This reduced to an average 3.5 post-impact. Where the number of artificial nesting hollows with evidence of breeding post-impact breeding is

lower, appears to coincide with the increased number of confirmed breeding events, suggesting higher overall confirmed breeding rates are occurring in the artificial nesting boxes in those years.

Of the 72 hollows surveyed as part of the post-impact monitoring surveys, 56 have had at least one confirmed breeding event or displayed evidence of nesting activity. Of these, 45 have recorded at least one confirmed breeding event, including 31 of the 40 artificial nesting hollows and 14 natural nesting hollows (Figure 5).

Of the 15 nesting hollows which recorded a confirmed breeding event in the current breeding season, 9 also had a confirmed breeding activity in the previous (2022-2023) season, 7 of these also had a successful breeding event in the 2021-2022 season and 3 also had confirmed breeding activity in the 2020-2021 breeding season.

A total of 5 nesting hollows have had 4 confirmed breeding events since post-impact monitoring began, all artificial (Appendix 2). These are located in Nesci Estate (1), the road reserve adjacent to lot 9500 along the old GNH (2), and Reserve 40350/Lot 500 (2).

The nest locations can be separated in to 5 distinct areas. All areas have recorded confirmed breeding events and evidence of breeding activity (Figure 5):

- Nesci Estate – This was a location where several artificial nesting hollows were installed after it was observed that Carnaby's Cockatoos were present in higher numbers, indicating the area could be a favourable breeding area (Phoenix 2017b). Repeated use of artifical nesting hollows, including 1 which has been used for 4 out of 5 post-impact years, indicates this area is an important breeding site for Carnaby's Cockatoo.
- Reserve 40350/Lot 500 – This location was identified in the baseline surveys as having a relatively high number of nesting trees (Phoenix 2017b). As several potential breeding trees were removed from this area, a concentration of nest boxes were installed here. Monitoring surveys indicate a consistently high rate of use across the monitoring period, confirming this is an important breeding site for Carnaby's Cockatoo.
- Road reserve adjacent to lot 9500 – this location previously had suitable hollows; therefore artificial nesting hollows were installed. The prevalence of hollows with confirmed breeding events and/or evidence of breeding has increased substantially in both the 2021-2022 and 2022-2023 breeding seasons, with consistent use across the post-impact monitoring period, indicating this is a highly suitable site and Carnaby's Cockatoo are returning to this site to breed.
- Barraca Nature Reserve and Maddern Road – Artificial nesting hollows were installed here due to accessibility and availability of food resources. During the higher breeding seasons (2021-2022 and 2022-2023), an increased rate of confirmed breeding events were recorded in this area.
- Lot 512 in the northern part of the study area previously had a higher rate of hollows with evidence of nesting activity and/or confirmed breeding events; however, this has declined since monitoring began. No new artificial nest boxes were installed in this area; however, 3 of the 11 sites are previously installed artificial nesting hollows and the remainder are natural nest hollows. Even still, the existing artificial nesting hollows in this area have waned in use. The area is still used as a breeding site, with 4 hollows showing evidence of use this season and a confirmed breeding event occurring in a natural nest hollow in the 2022-2023 breeding season; however, the area now appears to be generally less favourable than other areas.

Table 3 Summary of results for each breeding season

	Baseline				Post-impact					
	pre-2017-2018[1, 2]	**2017-18**	**2018-19**[3, 4]	**Pre-impact average**	**2019-2020**[3]	**2020-2021**[3]	**2021-2022**[3]	**2022-2023**[3]	**2023-2024**[3]	**Post-impact average**
Confirmed breeding event	n/a	6	3 (2/1)	5	6 (3/3)	13 (1/12)	21 (0/21)	23 (3/20)	15 (0/15)	16
Successful breeding events	n/a	3 (50%)	3 (100%)	3	3 (75%) – 2 hollows unable to be checked	9 (69%)	13 (62%)	17 (74%)	7 (47%)	10 (65%)
Evidence of nesting activity	24	14	5 (3/2)	10	15 (4/11)	13 (6/7)	6 (2/4)	6 (1/5)	10 (6/4)	10
No evidence of breeding	35	13	63 (30/33)	38	53 (26/27)	45 (24/21)	44 (29/15)	43 (28/15)	47 (26/21)	46
Total no. hollows surveyed	59	33	71	53	73	71	71	72	72	72
% of trees with confirmed breeding	n/a	18%	4%	9%	8%	18%	30%	32%	21%	22%
% of trees with evidence of nesting	41%	42%	7%	19%	21%	18%	8%	8%	14%	14%

[1] Evidence of nesting activity recorded at some point. Not annual census data and cannot be compared with annual census results.
[2] Natural hollows and existing artificial hollows
[3] Parentheses indicate hollow type: (natural & existing artificial hollows/new artificial hollows)
[4] Does not include 12 hollows that were removed during survey period

3.3 CONDITION OF ARTIFICIAL NESTING HOLLOWS

All of the artificial nesting hollows surveyed were observed to be in good condition, however 10 artificial nesting hollows require a new sacrificial post installed (NB04, NB06, NB10, NB32, NB63, NB64, NB65, NB68, NB71, NB77).

4 CONCLUSION

The number of hollows with evidence or confirmed breeding recorded during the 2023-2024 breeding season is consistent with previous 2 years of monitoring, which is significantly higher than the pre-impact average. The success rate was lower during the most recent breeding season compared to the previous 2 sesasons, however, the success rate of the previous years monitoring is relativey high and the post-impact average is now similar to long-term studies of black cockatoo breeding success.

Given the evidence and confirmed breeding across the study area, Nesci Estate, Reserve 40350/Lot 500, and the surrounding road reserve of the Muchea North area is an important breeding area for Carnaby's Cockatoo. Due to the historic large-scale clearing of trees and continuing decline of suitable trees with hollows in the area, all remaining suitable nesting hollows in the study area should be considered of high value to Carnaby's Cockatoo.

The 2021-202 and, 2022-2023 breeding seasons were remarkably more successful than previous seasons, with a notably higher number of confirmed breeding events recorded compared with the other post-imapct breeding seasons and more than 3 times the pre-impact average. There is a clear trend towards confirmed breeding in the artificial nesting hollows which is promising for mitigating population decline, however sufficient food resource availability is also required for continuous population health.

The willingness of Carnaby's Cockatoo to utilise the artificial nesting hollows as an alternative to natural nest hollows is evident. Considering the artificial nesting hollows were installed during the 2018-2019 season, the uptake and consistent use of many of these for breeding and several more with evidence of nesting activity is encouraging. The repeated use of the same hollows suggests that Carnaby's Cockatoo have preferred locations, either in the landscape, breeding areas or within the tree itself.

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Appendix 2: Australian Black Cockatoo Specialists 2024 Artificial Next Box Maintenance

Australian Black Cockatoo Specialists

Report: Maintenance of Black Cockatoo artificial nesting hollows in the GNH 'Muchea North' area, WA

Main Roads
Western Australia

25 June 2024

CONTENTS

All images source: Rick Dawson

INTRODUCTION

Australian **B**lack **C**ockatoo **S**pecialists (ABCS) are pleased to submit this report to the Department of Main Roads Western Australia (MRWA) regarding the inspection and maintenance of fifteen (15) Artificial hollows (ANH) in GNH North Muchea project area, on Friday 21 June 2024.

REPAIR AND INSPECTION METHOD

The objective is to ensure that every hollow is in peak condition, and to establish if there has been any further Black Cockatoo 'prospecting' and/or nesting activity (fledging results) and inspect and repair the artificial hollows as requested. The scope of this project included:

- undertaking a close visual inspection of all ANH's via EWP or ladder, any activity detected was photographed.
- Inspect tree, fixings, and ANH condition.
- Place up to 30lts of wood chips in ANH's as required, posts replaced or reset, and obstruction(s) removed.

REPLENISHMENT AND RESULTS OF THE NINE ANH

The following observations, and maintenance was conducted:

- Although ABCS quoted to repair 10 ANH we took the opportunity to maintain five extra (at no cost) ANHs that were close by. This was achievable as we were able to pick up the EWP late the night before and make an early start.
- As a result of the 2023/24 nesting data provided by Phoenix and observations from ABCS ten (10) nesting attempts by Carnaby's Cockatoos (CC) with three failures recorded.
- As part of the normal compacting/decay up to 30lts of wood chips was placed in each hollow. as per Annex 1. Research has shown that if the substrate becomes too low and CC's have chewed the base which has resulted in eggs falling through (Pers Obs Rick Dawson and Dr Denis Saunders)
- There has been considerable rain in the area however it is likely that nestling(s) fledged in NB04, NB06, NB12, NB32, N62. Nestlings died in, NB69 and NB77, a CC egg failed in NB76.
- The sacrificial posts were replaced in NB04, NB06, NB10, NB71 and NB62.
- Sacrificial posts in NB32, NB65, NB68 and NB69.were able to be reused by relocating the brackets, so that post now reaches the substrate floor.
- All nineteen trees with ANH observed are in good condition and there is no need to relocate any hollows at this stage.
- All fixings and the hollows are in good condition.

RECOMMENDATIONS

- There should be no requirement to add any further substrate to the replenished ANH for at least two years unless compaction and/or decay from nesting attempts occurs.
- Research has indicated that after six years most ANH need to be replenished, or they are unlikely to be used, therefore ABCS recommends that the other ANH in the GNH North Muchea project be replenished with the next two years. **REF: Artificial nesting hollows for the conservation of Carnaby's cockatoo Calyptorhynchus latirostris: definitely not a case of erect and forget**. Denis A. Saunders (A), Rick Dawson (B) and Peter R. Mawson (C).)
- It is also recommended that in future nesting surveys, each ANH is not only assessed for its use but detailed requirements for maintenance are recorded, which will assist in planning and quoting. ABCS assess its ANH in two categories:

  Priority One: Sacrificial post and ladder do not reach substrate, requiring maintenance before the next breeding season.

  Priority Two: Ladder reaches the substrate however the post does not (ANH like this can be used by Black Cockatoos however non-target species may be unable to exit the

hollow as the post is not close enough to the substrate), maintenance should be done when possible.

- Artificial hollows are relatively new to offsets and they are a work in progress, with us learning more each breeding season. It would appear that when the ANH were installed for this project, they were in placed in trees without consideration for future maintenance. ABCS found that a number of ANH's can only be accessed by ladder or arborist, others are too high for ladders. ABCS 'laser measured' two ANH that were close to 11m from the ground, this will require a 12m EWP. Consideration could be given to lowering some of the ANH to enable easier access for maintenance.

CONCULSIONS

All ANH repaired are now in peak condition and ready for this year's breeding season.

CONTACT INFORMATION

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Rick Dawson
Director
Australian Black Cockatoo Specialist
25 June 2024

APPENDIX 1 – LIST OF REPAIRS AND OBSERVATIONS.

ANH#	Lat	Long	Height Mts	Wood chips Lts	Post	Comments
NB04	[redacted]		8.975	10lts	New Post	Nesting Fledged (Old CC feather quills)
NB06			9.990	10lts	New Post	Nesting Fledged
NB10			7.690	15lts	New Post	
NB11			6.920	15lts	Not replaced	
NB12			93.30	15lts	Not replaced	
NB32			7.750	10lts	Bracket relocated	Nesting Fledged
NB33			9.950	Laser measured		Need 12m EWP to access
NB41			10.900			Need 12m EWP to access
NB42			10.300			Need 12m EWP to access
NB62			9.030	15lts	New Post	Nesting Fledged
NB63			8.420	15lts	Not replaced	
NB65			9.350	30lts	Bracket relocated	
NB64			8.600	15lts	Not replaced	
NB68			8.975	10lts	Bracket relocated	
NB69			8.200	20lts	Bracket relocated	1 x broken CC egg and 1 x dead CC nestling
NB71			7.500	15	New Post	
NB76			7.750	15lts	Not replaced	1 x broken CC egg
NB77			7.770	15lts	Not replaced	1 x old CC skeleton
NB78			10.900	Laser measured		Need 12m EWP to access

APPENDIX 2 – PHOTOGRAPS OF REPAIRS TO ANH's.

Replenishment of ANH NB68

ANH#	Latitude	Longitude	Height Mts	Wood chips Lts	Post	Comments
NB68	[redacted]		8.975	10lts	Bracket relocated	

Replenishment of ANH NB69

ANH#	Latitude	Longitude	Height Mts	Wood chips Lts	Post	Comments
NB69	[redacted]		8.200	20lts	Bracket relocated	1 x broken CC egg and 1 x dead CC nestling

Replenishment of ANH NB64

ANH#	Latitude	Longitude	Height Mts	Wood chips Lts	Post	Comments
NB64	[redacted]		8.600	15lts	Not replaced	

Replenishment of ANH NB65

ANH#	Latitude	Longitude	Height Mts	Wood chips Lts	Post	Comments
NB65	[redacted]		9.350	30lts	Bracket relocated	

Replenishment of ANH NB10

ANH#	Latitude	Longitude	Height Mts	Wood chips Lts	Post	Comments
NB10	[redacted]		7.690	15lts	New Post	

Replenishment of ANH NB62

ANH#	Latitude	Longitude	Height Mts	Wood chips Lts	Post	Comments
NB62	[redacted]		9.030	15lts	New Post	Nesting Fledged

Replenishment of ANH NB63

ANH#	Latitude	Longitude	Height Mts	Wood chips Lts	Post	Comments
NB63	[redacted]		8.420	15lts	Not replaced	

Replenishment of ANH NB12

ANH#	Latitude	Longitude	Height Mts	Wood chips Lts	Post	Comments
NB12	[redacted]		93.30	15lts	Not replaced	

Replenishment of ANH NB11

ANH#	Latitude	Longitude	Height Mts	Wood chips Lts	Post	Comments
NB11	[redacted]		6.920	15lts	Not replaced	

Replenishment of ANH NB77

ANH#	Latitude	Longitude	Height Mts	Wood chips Lts	Post	Comments
NB77	[redacted]		7.770	15lts	Not replaced	1 x CC old skeleton

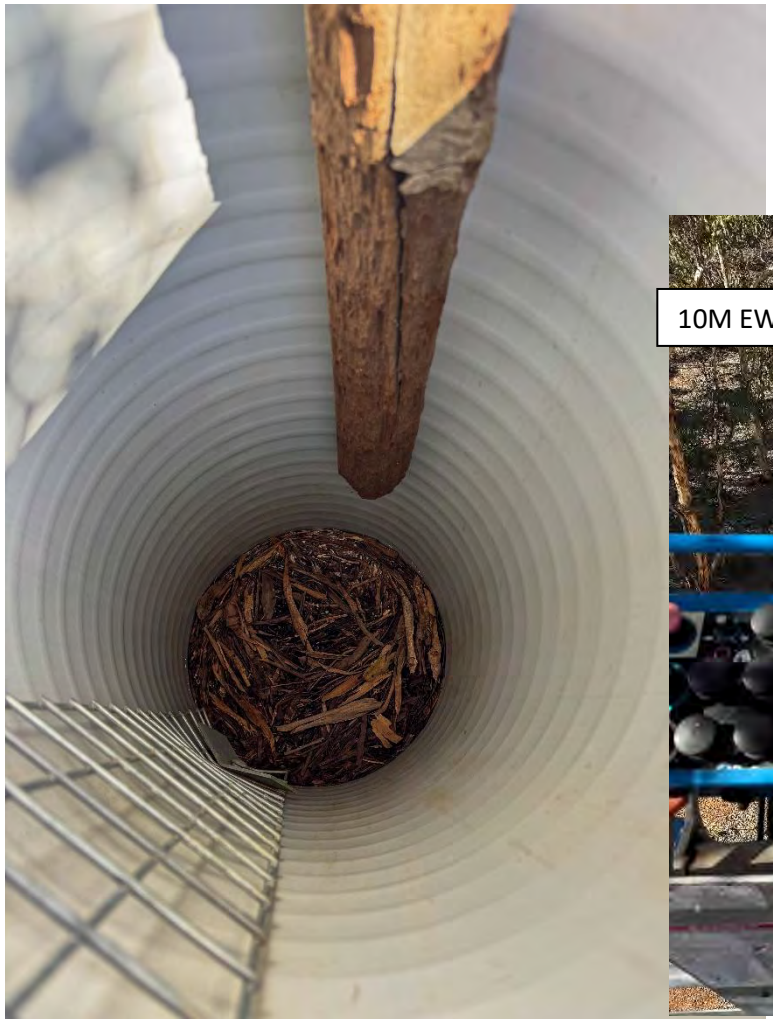
Replenishment of ANH NB76

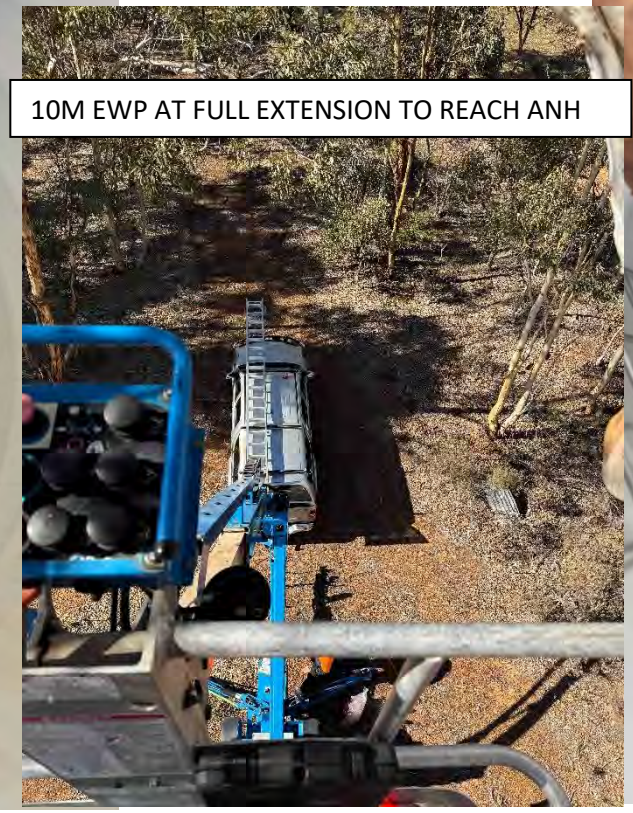
ANH#	Latitude	Longitude	Height Mts	Wood chips Lts	Post	Comments
NB76	[redacted]		7.750	15lts	Not replaced	1 x broken CC egg

Replenishment of ANH NB04

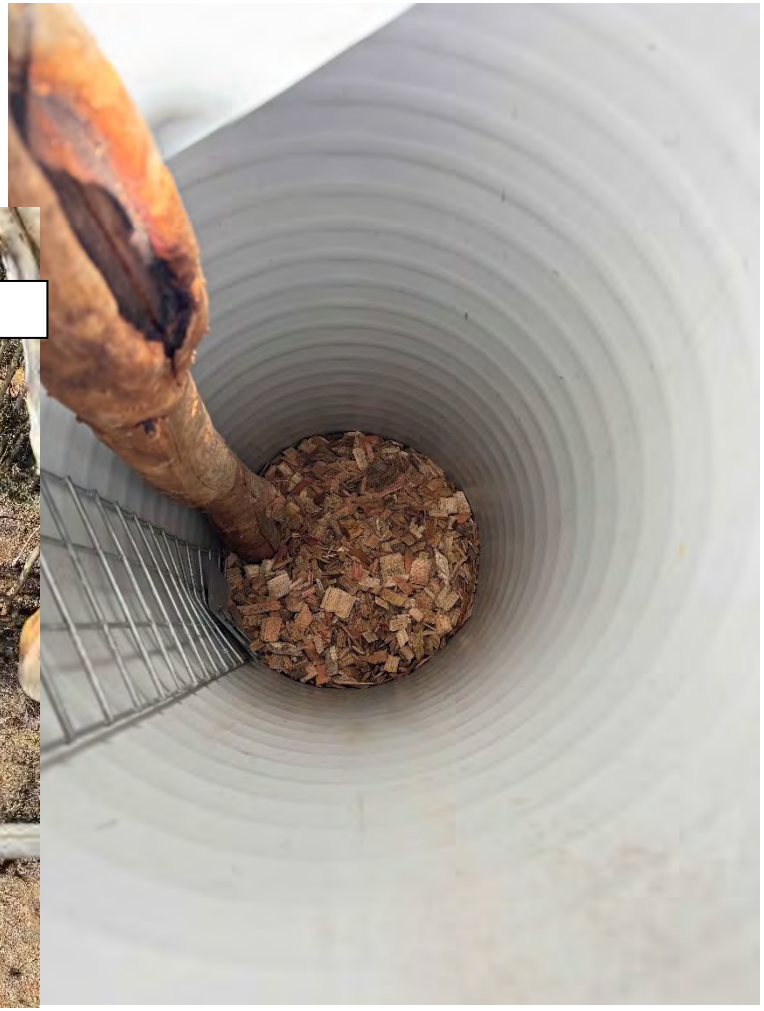
ANH#	Latitude	Longitude	Height Mts	Wood chips Lts	Post	Comments
NB04	[redacted]		8.975	10lts	New Post	Nesting Fledged (Old CC feather quills)

Replenishment of ANH NB06





10M EWP AT FULL EXTENSION TO REACH ANH



ANH#	Latitude	Longitude	Height Mts	Wood chips Lts	Post	Comments
NB06	[redacted]		9.990	10lts	New Post	Nesting Fledged

Replenishment of ANH NB32

ANH#	Latitude	Longitude	Height Mts	Wood chips Lts	Post	Comments
NB32	[redacted]		7.750	10lts	Bracket relocated	Nesting Fledged

Replenishment of ANH NB71

ANH#	Latitude	Longitude	Height Mts	Wood chips Lts	Post	Comments
NB71	[redacted]		7.500	15	New Post	

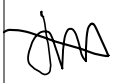
Appendix 3: Gambara 2024 Muchea North Revegetation Monitoring Report

Field Monitoring Report

Muchea North 2024 Monitoring Report

Client contract number:
Client project number:
Document number: GMB-609-ENV-MR
Revision date: 16/07/2024
Revision: 1

Document Approval

Rev.	Date	Prepared by	Reviewed by	Recommended by	Approved by	Remarks
1	16/07/2024	Steven Madamecila	Jye McLeish	Anton Kezic		
Signature:						

Details of Revision Amendments

Document Control

The Project Manager is responsible for ensuring that this report is reviewed and approved.

Amendments

Any revisions or amendments must be approved by the Project Manager and/or client before being distributed / implemented.

Revision Details

Revision	Details
A	Draft
1	Issued for Approval

TABLE OF CONTENTS

1 | SUMMARY

1.1 | OVERVIEW

Table1. Assessment against key completion criteria.

Completion Target	Target	Assessment Results for the 2024 Summer Monitoring
In compliance to EPBC 2016/7656 condition, Section 7.	Ensure that at least 2,436 *Eucalyptus wandoo* plants are alive across all areas of revegetation.	The average abundance of *Eucalyptus wandoo* on site is 6.4 per 100 m², which is approximately 12,601 native stems across the entire revegetation site. This meets the completion criteria.
	Achieve a minimum native foliage cover of 50 per cent.	The site has an average native foliage cover of 55%. - Compliant with the completion criteria target.
	Achieve an average density of 3 native vegetation stems per metre square. (300 stems / 100 m2)	The native stem density across the site is approximately 55.2 / 100 m2. – **Not yet** compliant with the completion criteria.
	Achieve weed coverage of less than 30 per cent.	The average weed cover across the site is 24.7%. This is below the completion target. The site is compliant with the completion criteria.
	The majority (greater than 50 per cent) of plant species are at least five years old	Revegetation works started in 2021 and no infill planting works were undertaken prior to the monitoring event. Hence the plants are approximately 3 years old. – **Not yet** compliant with the completion criteria.

1.2 | RECOMMENDED REMEDIAL AND MAINTENANCE WORKS

See **Map (Appendix 2)** for all locations.

Table 2. Recommended Remedial / Maintenance action for each plot.

Plot	Recommended Remedial / Maintenance Action
1	Conduct manual removal of dead grassy weeds through brush cutting, followed by targeted herbicide control using Glyphosate as a spot spray, taking care to avoid native plants. This process should be carried out in early spring and at the end of winter. Reassessment of the native plant density completion criteria. Infill planting is required to increase native plant density. A high infill of shrub species is recommended to increase diversity. Before infill, a site inspection is recommended to determine factors that have led to high plant mortality. As an example, soil and disease tests to ensure infill success.
2	Reassessment of the native plant density completion criteria. No infill actions are required.
3	Conduct manual removal of dead grassy weeds through brush cutting, followed by targeted herbicide control using Glyphosate as a spot spray, taking care to avoid native plants. This process should be carried out in early spring and at the end of winter. Reassessment of the native plant density completion criteria. Infill planting is required to increase native plant density. Before infill, a site inspection is recommended to determine factors that have led to high plant mortality. As an example, soil and disease tests to ensure infill success.
4	Conduct manual removal of dead grassy weeds through brush cutting, followed by targeted herbicide control using Glyphosate as a spot spray, taking care to avoid native plants. This process should be carried out in early spring and at the end of winter. Reassessment of the native plant density completion criteria. Infill planting is of shrub species is required to increase plant diversity and density.
5	Conduct manual removal of dead grassy weeds through brush cutting, followed by targeted herbicide control using Glyphosate as a spot spray, taking care to avoid native plants. This process should be carried out in early spring and at the end of winter. Reassessment of the native plant density completion criteria. Heavy infill planting within the plot is recommended. Shrub and other understory species are required to increase native plant density and overall diversity within the plot. Before infill, a site inspection is recommended to determine factors that have led to high plant mortality. As an example, soil and disease testings to ensure infill success.
6	Reassessment of the native plant density completion criteria. Infill planting is required to increase native plant density. Targeted herbicide control is undertaken using Glyphosate through spot spray avoiding native plants to be undertaken in early spring and end of winter. To maintain weed coverage compliance.
7	Reassessment of the native plant density completion criteria. No infill actions are required. Weed control is recommended to maintain compliance with weed load completion criteria.
8	Reassessment of the native plant density completion criteria. Weed control is recommended to maintain compliance with weed load completion criterion.
9	Conduct manual removal of dead grassy weeds through brush cutting, followed by targeted herbicide control using Glyphosate as a spot spray, taking care to avoid native plants. This process should be carried out in early spring and at the end of winter. Reassessment of the native plant density completion criteria. Heavy infill planting within the plot is recommended. Shrub and other understory species are required to increase native plant density and overall diversity within the plot.
10	Reassessment of the native plant density completion criteria. Infill planting is required to increase native plant density.

Plot	Recommended Remedial / Maintenance Action
11	Conduct manual removal of dead grassy weeds through brush cutting, followed by targeted herbicide control using Glyphosate as a spot spray, taking care to avoid native plants. This process should be carried out in early spring and at the end of winter. Reassessment of the native plant density completion criteria. Infill planting is required to increase native plant density and maintain completion criteria. Before infill, a site inspection is recommended to determine factors that have led to high plant mortality. As an example, soil and disease tests to ensure infill success.
12	Reassessment of the native plant density completion criteria. High native plant density was observed within the plot. No infill actions required.
13	Reassessment of the native plant density completion criteria. No infill actions is required.
14	Reassessment of the native plant density completion criteria. Targeted herbicide control undertaken through spot spray avoiding native plants to be undertaken in early spring and end of winter. Haloxyflop treatment for grassy weeds and Glyphosate for broadleaf weeds. To maintain weed coverage compliance.
15	Reassessment of the native plant density completion criteria. High native plant density was observed within the plot. No infill actions are required.
16	Conduct manual removal of dead grassy weeds through brush cutting, followed by targeted herbicide control using Glyphosate as a spot spray, taking care to avoid native plants. This process should be carried out in early spring and at the end of winter. Infill planting is required to increase native plant density and maintain completion criteria. Reassessment of the native plant density completion criteria Before infill, a site inspection is recommended to determine factors that have led to high plant mortality. As an example, soil and disease tests to ensure infill success.
17	Reassessment of the native plant density completion criteria. No infill actions required. Weed control is recommended to maintain compliance with weed load completion criteria.
18	Reassessment of the native plant density completion criteria. No infill actions are required.
19	Reassessment of the native plant density completion criteria. Infill planting is required to increase native plant density and overall diversity. Weed control is recommended to maintain compliance with the weed load completion criterion.
20	Reassessment of the native plant density completion criteria. No infill actions are required.

2 | INTRODUCTION

2.1 | SITE SUMMARY

The completion criteria for the Muchea North monitoring is described in EPBC 2016/7656 document and are presented in this report. The results of the autumn 2024 monitoring event are presented in this report and are considered against the final completion criteria.

2.1 | BACKGROUND & RECEIVING ENVIRONMENT

2.2.1 | BACKGROUND

In 2018, Main Roads Western Australia (MRWA) was granted approval for the Great Northern Highway Muchea to Wubin Upgrade Stage 2 - Muchea North, WA (EPBC 2016/7656). The project is comprised of the upgrade, rebuilding and relocating sections of the Great Northern Highway between Chittering Roadhouse and Old Gingin Road (SLK 38.6 to SLK 51.4), approximately 63 km Northeast of Perth.

Calyptorhynchus latirostris (Carnaby's Black Cockatoo) habitat was identified within the proposed project site. Carnaby's Black Cockatoo is listed as Endangered under the *Environmental Protection and Biodiversity Conservation (EPBC) Act 1999* and *Biodiversity Act 2016* in Western Australia. To mitigate the negative impacts on the Carnaby's Black Cockatoo, under the EPBC 2016/7656 section 7 condition, at least 19.69 Ha of land must be revegetated with native species that are known to provide both foraging and habitat for the Carnaby's Black Cockatoo.

In 2021, revegetation works were undertaken by Gambara Pty. Ltd. In 2023, Gambara was commissioned by MRWA to undertake the 2024 Muchea North monitoring program.

2.2.2 | SITE LOCATION & SIZE

The site is located along the Great Northern Highway, in the town of Muchea, approximately 50km north of Perth City. Refer to Appendix 1 for mapping.

2.2.3 | CLIMATE

The climate of the site is Mediterranean, with warm, dry summers and cool, wet winters. Summer occurs from December to February with mean maximum temperatures in 2023, ranged between 33.4°C to 34.2°C. The mean Maximum temperature recorded in 2023 is higher than the long-term average (Figure 1). Annual rainfall is 420.2 mm, with June being the wettest month with an average of 134.4 mm of rainfall recorded in 2023. In comparison to the long-term total rainfall, the 2023 rainfall data is significantly below the long-term average by 251.7mm (Table 1). Lower rainfall and hotter annual temperature can impact the survivability and overall success of the revegetation project. (data obtained from Bureau of Meteorology (BOM) website for weather station number 009053 – Pearce RAFF Base).

Table 3. Statistics for the Pearce RAFF Base - 009053.

Statistics	Months												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Long Term Mean maximum temperature (°C) 1940- 2024	33.6	33.4	30.6	26.5	22.1	19	18	18.5	20.2	23.6	27.5	30.6	25.3
Mean maximum temperature (°C) for 2023	34.8	34.2	31.6	24.8	23.1	17.6	18.6	20.4	22.6	27.9	32.4	33.4	26.8
Long Term Total rainfall (mm) 1940-2024	9.9	12.8	16.3	33.9	82.3	130.1	134	105.6	67.6	36.6	22	10.5	671.7
Rainfall (mm) for 2023	0	0	13.4	35.4	21.6	134.4	111.6	22.2	66.4	8.6	6.4	0	420

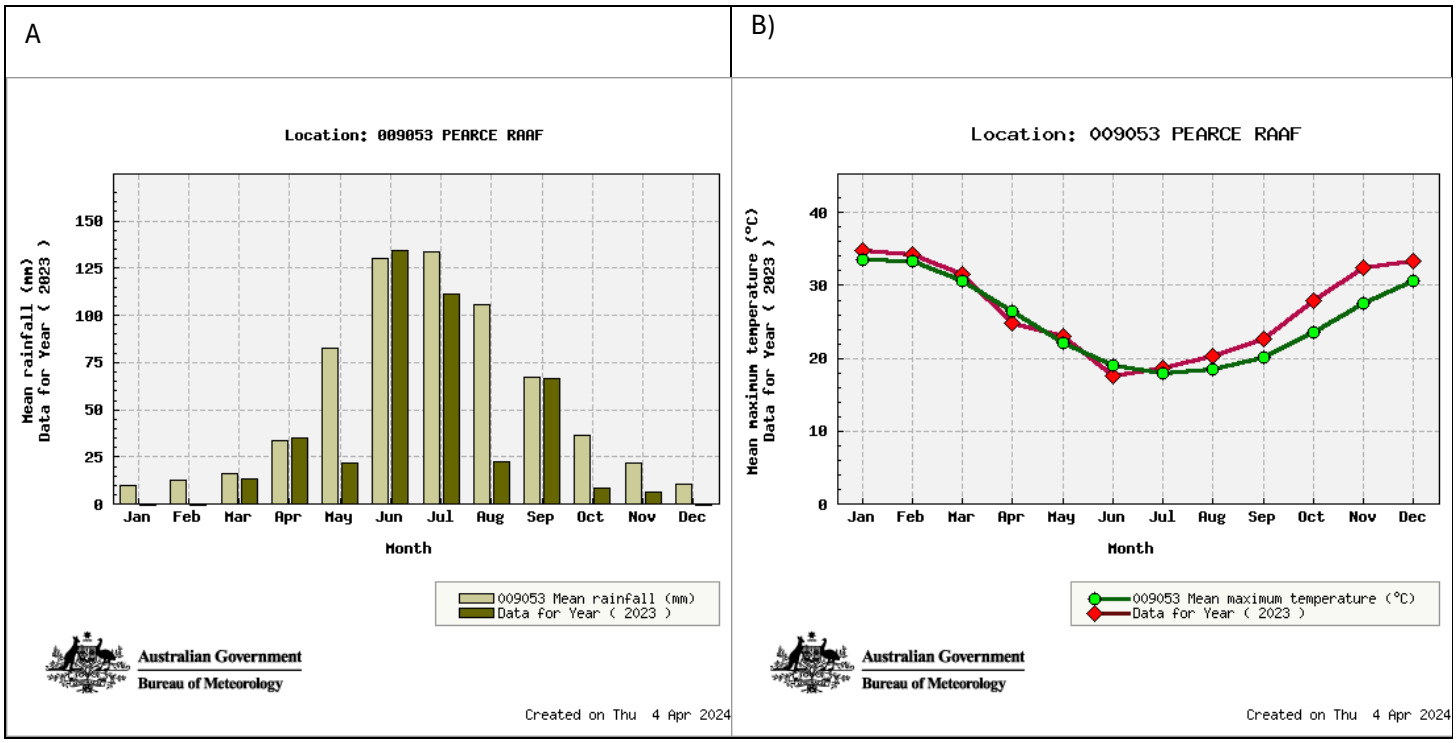


Figure 1. *Rainfall (mm) recorded for 2023 against the mean rainfall data (1940-2024) (A) and the maximum temperature in 2023 against the mean maximum temperature (1940-2024) (B).*

2.2.4 | VEGETATION

Four different types of vegetation complexes were identified across the site (Heddle et al., 1980).

- Mogumber Complex South, described as an open woodland dominated by *Corymbia calophylla* (Marri) and a mixture of *Eucalyptus marginata* (Jarrah)
- Moondah Complex, described as low closed to low open forest of *Banksia* species predominantly, *Banksia* attenuata, *Banksia menziesii* and *Banksia prionotes* furthermore, an open woodland of *Corymbia calophylla* (Marri)
- Reagan complex, described as a range of vegetation from low open *Banksia* woodland species and *Banksia todtiana* to heath dependent on soil depth.
- Coonambidgee Complex, described as a range of vegetation encompassing low open forest and low woodland predominantly, *Banksia* attenuata, *Banksia menziesii* and *Banksia ilicifolia*; to an open woodland of *Corymbia calophylla* (Marri) (Heddle et al., 1980)

2.3 | MONITORING PROGRAM

The monitoring program includes.

1. Establishment of twenty permanently marked monitoring plots, each measuring 20 m by 5 m. Ten of these plots were established as part of the 2024 Eucalyptus wandoo monitoring, in accordance with the Clearing Permit 7463/2 conditions. The remaining ten plots were placed within the Carnaby Black Cockatoo revegetation sites.
2. At each monitoring plot, the following was recorded:
   - Native species abundance.
   - Dominant weed species and weed coverage.
   - *Eucalyptus wandoo* abundance.
   - Native foliage cover.
   - Pest and disease.
   - All other general factors that may be affecting or contributing to the progress.
3. The delivery of a report outlining progress towards completion criteria and recommended actions (this report).

2.4 | COMPLETION CRITERIA

Table 4. Assessment against key completion criteria.

Target	Completion Target
In compliance to EPBC 2016/7656 condition, Section 7.	• Establish and maintain at least 2,436 alive Eucalyptus wandoo plants across all areas of revegetation. • Achieve a minimum foliage cover of native species of 50%. • Achieve an average density of 3 native vegetation stems density per m² or 300 native stems per plot (100 m²). • Achieve weed coverage of less than 30%. • Ensure that more than 50% of plant species are at least five years old.

This completion criteria have been developed taking into consideration the decision made under sections130(1) and 133 of the *Environmental Protection and Biodiversity Act 1999.*

3 | METHODOLOGY

3.1 | SURVEY TIMING

The autumn 2024 monitoring event was undertaken by Gambara Environmental Officer Steven Madamecila, Gambara Field Technician Litia Cameron Pearson and Gambara Field Technician Julia Ehrt on the 20th of March 2024 and on the 3rd of April 2024.

3.2 | MONITORING PLOTS

Permanently marked monitoring plots were established in 20 locations across the rehabilitated site.

Each monitoring plot measures 20 meters by 5 meters, covering a total area of 100 m^2. The plots were established in locations that best represent the overall population of the revegetated site. These locations were approved by MRWA and are detailed in Appendix 2.

Each monitoring plot was established in the following manner:

- Installation of a wooden post at each corner of the plot
- Attachment of permanent metal tagging to one corner post as plot labelling.
- Photos were taken from two opposite sides of each plot. Facing orientations are recorded within the monitoring sheets.
- Recording of each post location with 64sx GPS for mapping purposes.

Monitoring Plots section of this report outlines data collected at each plot.

4 | RESULTS

Results from the 2024 autumn monitoring event are summarised below. These are compared against completion criteria where applicable. Full data tables are provided for each plot number in Table 5.

4.1 | ABUNDANCE

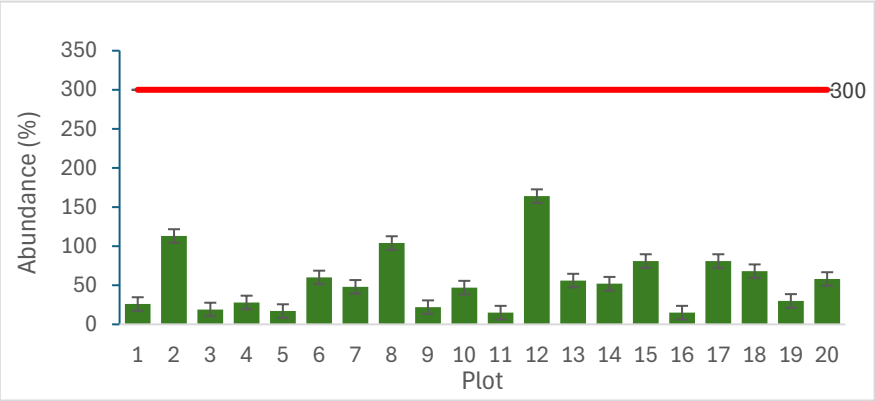


Figure 2. The abundance of native species within each monitoring plot, compared against the completion target (red line).

The average native plant abundance per plot is 55.2 ± 8.67. Plot 12 recorded the highest number of native plants, with 163 stems observed. In contrast, Plots 1, 3, 11, and 16 had the lowest abundance, each with fewer than 16 stems. The site does not meet the completion criterion of 300 native stems per plot (100 m²) or 3 stems per m2. Significant variation between monitoring plots is noted, primarily due to a range of biotic and abiotic factors, including soil conditions, water availability, weed cover, and predation, which have affected mortality and success rates.

Shrubs and understory species exhibit the highest mortality rates and are the least successful. Most of the shrub species did not survive. *Calothamnus, Acacia, Eucalyptus,* and *Melaleuca* are the most successful native genera on the site, as indicated by their high abundance (see Appendix 1). Among these, *Calothamnus quadrifidus* is the most successful native plant species on site.

The completion criterion of achieving a density of 3 stems per square meter is not feasible given the size of the established species. Most of the native species present are tall and medium-sized trees, such as *Eucalyptus, Melaleuca, Corymbia*, and *Acacia*. Therefore, establishing and maintaining 3 plants per square meter within such a small area over a 50-year period is impractical. The native plant density criterion should be updated to reflect a more feasible and representative target. Additionally, Wandoo woodlands are typically characterised as open stands of widely spaced trees over a sparse understorey of shrubs, grasses and herbs. The Wandoo woodland vegetation types mapped previously at the site from the Phoenix (2015) biological survey, were characterised as mostly open woodlands with sparse and open understory. Therefore, the requirement with three stems per m2 may not be consistent with the original vegetation communities at the site.

4.2 | *EUCALYPTUS WANDOO* ABUNDANCE

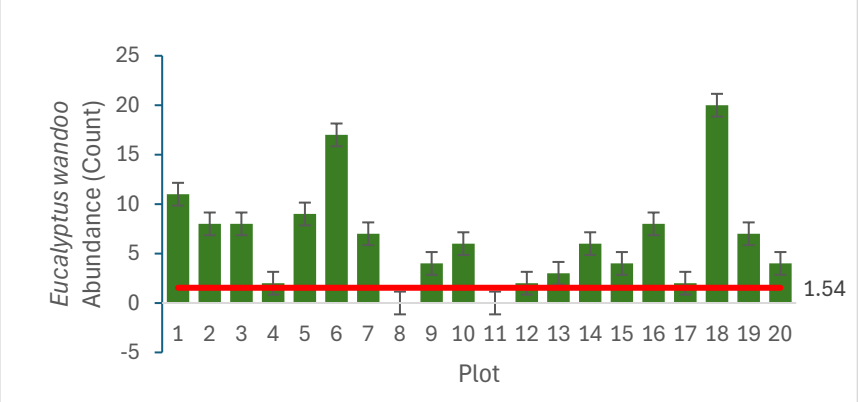


Figure 3. *Eucalyptus wandoo* (%) within each monitoring plot, compared against the completion target (red line).

The average abundance of *Eucalyptus wandoo* per plot is 6.4 ± 1.15, exceeding the completion criterion target of 1.54 native stems per plot (100 m²). Therefore, the site meets the completion criterion. Plots 18 and 6 recorded the highest abundance of *Eucalyptus wandoo,* with 20 and 17 native stems, respectively. In contrast, Plots 8 and 11 are the only plots where no *Eucalyptus wandoo* was observed. However, *Eucalyptus wandoo* was also observed outside the plots.

4.3 | WEEDS

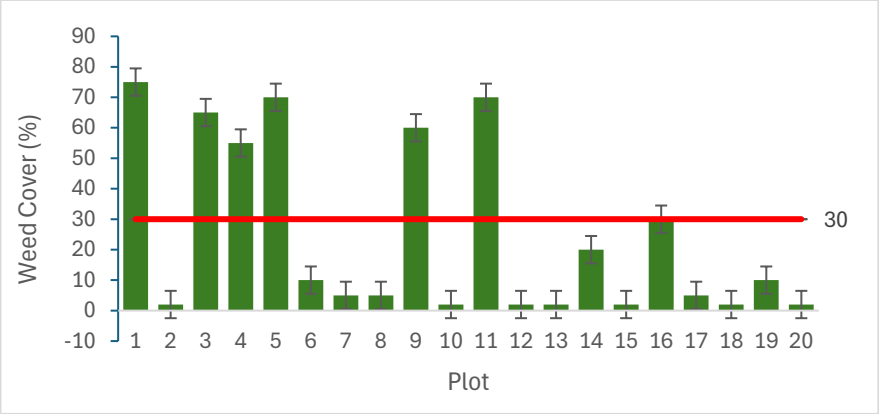


Figure 4. Weed coverage (%) within each monitoring plot, compared against the completion target (red line).

Weed cover across the site is relatively low, with an average weed cover of 24.7% ± 6.42. Most plots meet the completion criterion of less than 30% weed coverage, except for seven plots (see Figure 4). Plots 1, 5, and 11 exhibit the highest weed loads, with weed cover exceeding 70% in these plots. High native foliage cover was observed in plots with the lowest weed loads (see Figure 4 and Figure 5).

The site is dominated by both grassy and broadleaf weeds. The most dominant weed species observed are *Eragrostis curvula* (African Lovegrass), *Avena fatua* (Wild Oats), and *Sonchus oleraceus* (Sowthistle). Most of these weeds have already seeded and are now dead. High weed emergence is expected during the upcoming spring and winter.

4.4 | NATIVE FOLIAGE COVER

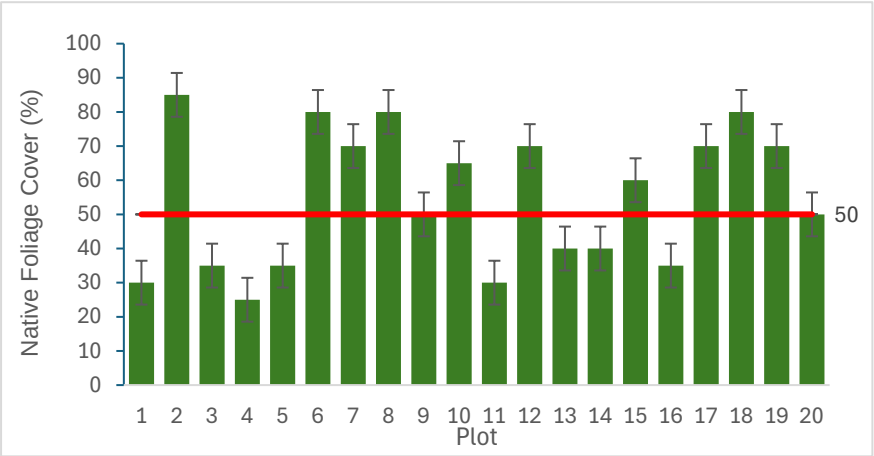


Figure 5. Native foliage coverage (%) within each monitoring plot.

The average native foliage cover on site is 55%. Only 6 out of 20 plots did not meet the compliance criterion target of 50%, but these plots are on track to achieve the target (see Figure 5). The lower foliage cover in some plots can be attributed to both lower native stem abundance and slower plant growth, which may be due to soil nutrient deficiencies. Plot 2 has the highest native foliage cover at 85%, while Plot 4 has the lowest at 25% (see Figure 5). *Eucalyptus* natives contribute significantly to native foliage cover, dependent on their size and health.

Native foliage cover varied across the site due to differences in plant growth, weed loads, and plant species present in each plot. Plots dominated by tree species, particularly *Eucalyptus*, exhibited higher native foliage cover compared to plots with smaller shrub species. *Eucalyptus* species provide significantly more native foliage cover compared to smaller shrubs.

4.5 | OBSERVATIONS

4.5.1 | PEST & DISEASE

During the survey, kangaroo droppings were observed on site. Minor predation by kangaroos and insects was noted, predominantly affecting young *Eucalyptus* natives. The frequency of predation among native plants is low, resulting in minimal impacts on plant health and survivability. No control measures are currently recommended. However, if insect or mammal predation increases, chemical treatments may be considered.

Disease and senescence on site are minimal. Wasp-induced gall disease was observed only in young *Eucalyptus* natives (see Figure 6). Leaf yellowing was also noted among several plants on site. Overall, the occurrence of disease among native plants is low, resulting in minimal impacts on plant health and survivability.

Figure 6. Wasp-induced gall disease present in *Eucalyptus wandoo* leaf. Photos taken by Steven Madamecila on the 3rd of April 2024.

5 | CONCLUSION & RECOMMENDATIONS

5.1 | CONCLUSIONS

Overall, the Muchea revegetation program is meeting the completion criteria specified in EPBC 2016/7656, with the exception of native vegetation density and the requirement that 50% of native vegetation be at least 5 years old criterion. Consequently, achieving a density of 3 stems per square meter criterion is not feasible due to the generally tall to medium-sized nature of the native plants chosen to be planted on site. Establishing and maintaining 3 stems per square meter over the long term is impractical. According to a previous survey by Phoenix (2015), the current stem density criterion does not accurately reflect the vegetation communities at the site. Therefore, the criterion needs to be updated to a better representative and feasible target.

The overall, *Eucalyptus wandoo* abundance criteria target has been met, the current average *Eucalyptus wandoo* stems observed on site is 6.4 per 100 m2, above the completion target of 1.54. This completion criteria is crucial to mitigating the negative impacts on Carnaby's Black Cockatoo, as *Eucalyptus wandoo* provide both nesting and food source for the Carnaby's Black Cockatoo. Plots 8 and 11 were the only plots with no *Eucalyptus wandoo* observed.

The overall weed cover on site is 24.7% on average. This is achieving the completion criteria target of below 30% weed cover. Certain areas of the site contain high weed loads, dominated by *Eragrostis curvula* (African lovegrass), *Avena fatua* (Wild oats) and *Sonchus oleraceus* (Sowthistle). Weed control is recommended to ensure the weed loads are maintained on site.

The native cover on site meets the completion criterion of 50%. The average native foliage cover is 55%, with 12 out of 20 plots showing native cover of 50% or more. Variations in native plant success, weed loads, and the types of native plant species contribute to differences in native foliage cover across the site.

5.2 | RECOMMENDATIONS

Native plant density on the site does not meet the completion criteria target; therefore, infill action is required. However, before proceeding with infill work, it is recommended that the current stem density target be reviewed and updated to a more representative and feasible goal. The existing target for native plant density is impractical, as it does not accurately reflect the vegetation communities of the site and is too restrictive for establishing tall and medium-sized native plants that are present in the revegetation site.

Weed control on site is advised. Weed control in areas with high weed load is recommended to reduce fire fuel load and nutrient competition with the natural regenerating and established natives. It should be noted that the weeds on site have already seeded hence, weed load emergence this winter will be high, predominantly grassy weeds. The following regime should be implemented. Careful application of chemical treatment near the native plants is required to avoid off-targeting.

1. Slashing of dead plant materials using a brush cutter or similar application, to reduce fuel load. This should occur in spring.

2. Follow-up chemical treatment post slashing of Glyphosate or grass-selective herbicide such as, Haloxyflop to eliminate emerging weeds. Spot spray application is recommended. This treatment should be undertaken in the following frequency: early spring, end of spring and end of winter.

3. Hand weeding is recommended in areas where weeds are within proximity to the native plants.

Monitoring is required in accordance with EPBC 2016/7656 to ensure that the completion criteria are being met.

Table 5. Completion criteria measurements per site.

Completion Criteria	Plots																				Average
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Native Plant Density (Count) per plot.	15	110	11	30	8	50	43	104	18	41	15	163	59	47	117	15	74	73	30	53	53.8 stems / plot (0.538 stem / m2)
Eucalyptus wandoo abundance per plot.	11	8	8	2	9	17	7	0	4	6	0	2	3	6	4	8	2	20	7	4	6.4 stems per plot
Weed Coverage (%).	75	2	65	55	70	10	5	5	60	2	70	2	2	20	2	30	5	2	10	2	24.7% weed cover
Native Foliage Coverage (%).	30	85	35	25	35	80	70	80	50	65	30	70	40	40	60	35	70	80	70	50	55% foliage cover
50% of the Native plants are at least 5 years old.	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No

*Note: The items highlighted in red represent a data point that is below the completion target

6 | REFERENCE

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SECTION 7

MONITORING PLOTS

Quadrat ID: **WP1**	Date: 24/01/2024	Recorders:	SM	LP	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude		Longitude		
	-31.55270202		115.994687		

Observation for rehabilitation area

Soil Profile type	Red soil, compact and contained gravel in topsoil.
Native foliage coverage	30%
Weed species coverage (assessed against total planting area)	75%
Major weed species	*Eragrostis curvula* (African lovegrass)
Native germination observed.	None
Seedlings and mature planting survival (general description)	Plants are generally healthy.
Bare ground cover	2%
Any other comments that may affect or contribute to progress.	*Eucalyptus wandoos* are observed to be healthy. High weed load predominantly grassy weeds.

Orientation: Southwest

Image: 1

Orientation: Northeast

Image:2

Observation for rehabilitation area

Quadrat ID: **WP2**	Date: 24/01/2024	Recorders:	SM	LP	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude			Longitude	
	-31.54760004			116.00102	
	-31.54761798			116.000987	
	-31.54770004			116.00092	
	-31.54772501			116.000931	

Observation for rehabilitation area

Soil Profile type	Red soil, compact and contained gravel in topsoil.
Native foliage coverage	85%
Weed species coverage (assessed against total planting area)	2%
Major weed species	*Eragrostis curvula* (African lovegrass)
Native germination observed.	None
Seedlings and mature planting survival (general description)	Plants are healthy. High native plant abundance within the plot.
Bare ground cover	20%
Any other comments that may affect or contribute to progress.	High native foliage cover within the plot. Hakea are observed to be well established in the plot together with *Eucalyptus wandoo.*

Orientation: Southwest

Image: 1

Orientation: Notheast

Image:2

Quadrat ID: **WP3**	Date: 24/01/2024	Recorders:	SM	LP	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude		Longitude		
	-31.54364898		116.006427		
	-31.54368703		116.006447		
	-31.54372903		116.006336		
	-31.54377102		116.006356		

Observation for rehabilitation area

Soil Profile type	Grey sandy soil, compact.
Native foliage coverage	35%
Weed species coverage (assessed against total planting area)	65%
Major weed species	*Eragrostis curvula* (African lovegrass), *Avena fatua* (Wild oats) and *Lupinus angustifolius* (Blue Lupin)
Native germination observed.	None
Seedlings and mature planting survival (general description)	High mortality of understory species.
Bare ground cover	5%
Any other comments that may affect or contribute to progress.	*Eucalyptus wandoo* are observed to be healthy. High dead weed load: *Eragrostis curvula* (African Lovegrass) and *Lupinus angustifolius* (Blue Lupin)

Orientation: Southwest
Image: 1

Orientation: Northeast
Image:2


Quadrat ID: **WP4**	Date: 24/01/2024	Recorders:	SM	LP	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude			Longitude	
	-31.53962097			116.009899	
	-31.53960002			116.009869	
	-31.53967797			116.009726	
	-31.53971502			116.00975	

Observation for rehabilitation area

Soil Profile type	Grey sandy soil, compact.
Native foliage coverage	35%
Weed species coverage (assessed against total planting area)	55%
Major weed species	*Eragrostis curvula* (African lovegrass), *Avena fatua* (Wild oats) and *Lupinus angustifolius* (Blue Lupin)
Native germination observed.	None
Seedlings and mature planting survival (general description)	Plant size within the plot is smaller in comparison to other plots.
Bare ground cover	10%
Any other comments that may affect or contribute to progress.	.

Orientation: Southwest

Image: 1

Orientation: Northeast

Image:2

Quadrat ID: **WP5**	Date: 24/01/2024	Recorders:	SM	LP	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude			Longitude	
	-31.536304			116.015362	
	-31.53633703			116.015391	
	-31.536218			116.015539	
	-31.53617601			116.015516	

Observation for rehabilitation area

Soil Profile type	Grey sandy soil, compact.
Native foliage coverage	35%
Weed species coverage (assessed against total planting area)	55%
Major weed species	*Eragrostis curvula* (African lovegrass) and *Sonchus oleraceus* (Sowthistle).
Native germination observed.	None
Seedlings and mature planting survival (general description)	Minor. Potential heat stress evident from leaf discolorations. *Eucalyptus wandoo* are observed to be healthy and dominant.
Bare ground cover	10%
Any other comments that may affect or contribute to progress.	Moderate weed load on site predominantly, *Eragrostis curvula* (African lovegrass) and *Sonchus oleraceus* (Sowthistle). Weeds already have seeded. Minor pest activity evident from the minor predation potentially from caterpillar

Orientation: Southwest

Image: 1

Orientation: Northeast

Image:2

Quadrat ID: **WP6**	Date: 24/01/2024	Recorders:	SM	LP	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude			Longitude	
	-31.52613399			116.027841	
	-31.52615997			116.02787	
	-31.52605			116.028068	
	-31.52602703			116.028032	

Observation for rehabilitation area

Soil Profile type	Compact, gravel in topsoil.
Native foliage coverage	80%
Weed species coverage (assessed against total planting area)	10%
Major weed species	*Eragrostis curvula* (African lovegrass) and *Avena fatua* (Wild oats)
Native germination observed.	None
Seedlings and mature planting survival (general description)	Several established natives appeared to be dying.
Bare ground cover	10%
Any other comments that may affect or contribute to progress.	Native vegetations are healthy and are abundant. Several *Eucalyptus wandoo* are observed to be healthy. Minor leaf predation potentially caterpillars.

Orientation: Southwest

Image: 1

Orientation: Northeast

Image:2

Quadrat ID: **WP7**	Date: 24/01/2024	Recorders:	SM	LP	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude			Longitude	
	-31.52603902			116.028033	
	-31.50953203			116.037133	
	-31.50933104			116.037209	
	-31.50936197			116.037257	

Observation for rehabilitation area

Soil Profile type	Compact, gravel in topsoil.
Native foliage coverage	70%
Weed species coverage (assessed against total planting area)	5%
Major weed species	*Eragrostis curvula* (African lovegrass) and *Avena fatua* (Wild oats)
Native germination observed.	None
Seedlings and mature planting survival (general description)	Several established natives appear to be suffering from heat stress.
Bare ground cover	20%
Any other comments that may affect or contribute to progress.	Native vegetations are healthy and are abundant. Several *Eucalyptus wandoo* are observed to be healthy. Minor leaf predation potentially caterpillars. Wasp induced galls observed.

Orientation: Southwest

Image: 1

Orientation: Northeast

Image:2

Quadrat ID: **WP8**	Date: 24/01/2024	Recorders:	SM	LP	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude			Longitude	
	-31.49142997			116.041888	
	-31.49142997			116.041924	
	-31.49162603			116.041867	
	-31.49162997			116.041916	

Observation for rehabilitation area

Soil Profile type	Compact soil, gravel in topsoil.
Native foliage coverage	80%
Weed species coverage (assessed against total planting area)	5%
Major weed species	*Eragrostis curvula* (African lovegrass) and *Avena fatua* (Wild oats)
Native germination observed.	none
Seedlings and mature planting survival (general description)	Dianella revolata and Pattersonia .. are pobserved to be successful in the plot.
Bare ground cover	15%
Any other comments that may affect or contribute to progress.	Minor predation among other native plants. Kangaroo droppings observed on site. High abundance of understory plants. High diversity within the plot.

Orientation: Southwest

Image: 1

Orientation: Northeast

Image:2

Quadrat ID: **WP9**	Date: 24/01/2024	Recorders:	SM	LP	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude			Longitude	
	-31.48129097			116.042608	

Observation for rehabilitation area

Soil Profile type	White sandy soil.
Native foliage coverage	50%
Weed species coverage (assessed against total planting area)	60%
Major weed species	*Eragrostis curvula* (African lovegrass) and *Avena fatua* (Wild oats)
Native germination observed.	Native germination observed outside the plot.
Seedlings and mature planting survival (general description)	*Eucalyptus wandoo* are observed to be healthy.
Bare ground cover	15%
Any other comments that may affect or contribute to progress.	

Orientation: Southwest

Image: 1

Orientation: Northeast

Image:2

Quadrat ID: **WP10**	Date: 24/01/2024	Recorders:	SM	LP	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude			Longitude	
	-31.46589702			116.051222	
	-31.46589903			116.051264	
	-31.46605401			116.051178	
	-31.46604597			116.051157	

Observation for rehabilitation area

Soil Profile type	Compact soil, gravel in topsoil.
Native foliage coverage	65%
Weed species coverage (assessed against total planting area)	2%
Major weed species	*Eragrostis curvula* (African lovegrass)
Native germination observed.	None
Seedlings and mature planting survival (general description)	*Melaleuca are observed to be dominant and successful within the plot.*
Bare ground cover	15%
Any other comments that may affect or contribute to progress.	Minor gall disease.

Orientation: Southwest

Image: 1

Orientation: Northeast

Image:2

Quadrat ID: **WP11**	Date: 03/04/2024	Recorders:	SM	JE	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude			Longitude	
	-31.55863297			115.991019	
	-31.55842099			115.990744	
	-31.55859601			115.990841	
	-31.55860498			115.990791	

Observation for rehabilitation area

Soil Profile type	Light grey, sandy soil.
Native foliage coverage	30%
Weed species coverage (assessed against total planting area)	80%
Major weed species	*Sonchus oleraceus* (Sowthistle), *Avena fatua* (Wild oats) and *Lupinus angustifolius* (Blue Lupin)
Native germination observed.	None
Seedlings and mature planting survival (general description)	Native plants are overburden with weeds. Several native mortalities observed.
Bare ground cover	0%
Any other comments that may affect or contribute to progress.	*Calothmanus quadrificus* are observed to be healthy and abundant.

Orientation: Southwest

Image: 1

Orientation: Northeast

Image:2

Quadrat ID: **WP12**	Date: 03/04/2024	Recorders:	SM	JE	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude			Longitude	
	-31.54308898			116.004996	
	-31.54305303			116.004966	
	-31.54321203			116.004817	
	-31.54316903			116.004801	

Observation for rehabilitation area

Soil Profile type	Compact brown soil with light gravel on top.
Native foliage coverage	70%
Weed species coverage (assessed against total planting area)	2%
Major weed species	*Sonchus oleraceus* (Sowthistle), *Avena fatua* (Wild oats).
Native germination observed.	None
Seedlings and mature planting survival (general description)	High diversity.
Bare ground cover	25%
Any other comments that may affect or contribute to progress.	*Calothmanus quadrificus* and *Acacia pulchella* are observed to be healthy and abundant.

Orientation: Southwest
Image: 1

Orientation: Northeast
Image:2


Quadrat ID: **WP13**	Date: 03/04/2024	Recorders:	SM	JE	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude			Longitude	
	-31.53851003			116.011294	
	-31.53854499			116.011312	
	-31.53861799			116.011115	
	-31.53865202			116.011153	

Observation for rehabilitation area

Soil Profile type	Yellow, sandy and dry soil.
Native foliage coverage	40%
Weed species coverage (assessed against total planting area)	2%
Major weed species	*Sonchus oleraceus* (Sowthistle)
Native germination observed.	None
Seedlings and mature planting survival (general description)	
Bare ground cover	5%
Any other comments that may affect or contribute to progress.	*Calothmanus quadrificus* and *Acacia pulchella* are observed to be healthy and abundant.

Orientation: Southwest

Image: 1

Orientation: Northeast

Image:2

Quadrat ID: **WP14**	Date: 03/04/2024	Recorders:	SM	JE	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude			Longitude	
	-31.5274			116.0263	
	-31.5274			116.0263	
	-31.5273			116.0265	
	-31.5272			116.0265	

Observation for rehabilitation area

Soil Profile type	Hard compact soil with gravel on top.
Native foliage coverage	40%
Weed species coverage (assessed against total planting area)	20%
Major weed species	High grassy weed load predominantly, *Avena fatua* (Wild oats) and *Eragrostis curvula* (African lovegrass).
Native germination observed.	None
Seedlings and mature planting survival (general description)	*Eucalyptus wandoo* are observed to be very healthy and successful.
Bare ground cover	0%
Any other comments that may affect or contribute to progress.	*Calothmanus quadrificus* and *Acacia pulchella* are observed to be healthy and abundant.

Orientation: Southwest

Image: 1

Orientation: Northeast

Image:2

Quadrat ID: **WP15**	Date: 03/04/2024	Recorders:	SM	JE	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude			Longitude	
	-31.5111			116.0357	
	-31.5111			116.0357	
	-31.5113			116.0356	
	-31.5113			116.0356	

Observation for rehabilitation area

Soil Profile type	Sandy grey soil.
Native foliage coverage	60%
Weed species coverage (assessed against total planting area)	2%
Major weed species	High grassy weed load predominantly, *Avena fatua* (Wild oats) and *Eragrostis curvula* (African lovegrass).
Native germination observed.	None
Seedlings and mature planting survival (general description)	
Bare ground cover	25%
Any other comments that may affect or contribute to progress.	*Acacia pulchella* are observed to be healthy and abundant.

Orientation: Southwest

Image: 1

Orientation: Northeast

Image:2

Quadrat ID: **WP16**	Date: 03/04/2024	Recorders:	SM	JE	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude			Longitude	
	-31.49385704			116.040995	
	-31.49384798			116.040938	
	-31.49406499			116.040969	
	-31.49405703			116.040922	

Observation for rehabilitation area

Soil Profile type	Sandy grey soil.
Native foliage coverage	35%
Weed species coverage (assessed against total planting area)	30%
Major weed species	High grassy weed load predominantly, *Avena fatua* (Wild oats) and *Eragrostis curvula* (African lovegrass).
Native germination observed.	None
Seedlings and mature planting survival (general description)	*Eucalyptus species* are very successful.
Bare ground cover	30%
Any other comments that may affect or contribute to progress.	Minor predation observed in *Eucalyptus.*

Orientation: Southwest

Image: 1

Orientation: Northeast

Image:2

Quadrat ID: **WP17**	Date: 03/04/2024	Recorders:	SM	JE	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude			Longitude	
	-31.47171699			116.048354	
	-31.47173904			116.048401	
	-31.47157903			116.048501	
	-31.471546			116.048464	

Observation for rehabilitation area

Soil Profile type	Gravel Compact Soil.
Native foliage coverage	70%
Weed species coverage (assessed against total planting area)	5%
Major weed species	*Avena fatua* (Wild oats) and *Eragrostis curvula* (African lovegrass).
Native germination observed.	None
Seedlings and mature planting survival (general description)	Native plants are healthy and thriving.
Bare ground cover	20%
Any other comments that may affect or contribute to progress.	*Acacia saligna* are observed to be healthy. Gall disease present in several *Eucalyptus* plants.

Orientation: Southwest

Image: 1

Quadrat ID: **WP18**	Date: 03/04/2024	Recorders:	SM	JE	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude			Longitude	
	-31.48439898			116.043082	
	-31.48437199			116.043029	
	-31.48421701			116.043146	
	-31.48420301			116.043081	

Observation for rehabilitation area

Soil Profile type	Sandy grey soil.
Native foliage coverage	80%
Weed species coverage (assessed against total planting area)	2%
Major weed species	*Avena fatua* (Wild oats) and *Eragrostis curvula* (African lovegrass).
Native germination observed.	None
Seedlings and mature planting survival (general description)	*Eucalyptus species* are very successful.
Bare ground cover	10%
Any other comments that may affect or contribute to progress.	*Eucalyptus* are observed to be abundant within the plot and surrounding environment.

Orientation: Southwest
Image: 1

Orientation: Northeast
Image:2


Quadrat ID: **WP19**	Date: 03/04/2024	Recorders:	SM	JE	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude			Longitude	
	-31.53864398			116.012326	
	-31.53860902			116.012307	
	-31.53874498			116.012177	
	-31.53872704			116.012148	

Observation for rehabilitation area

Soil Profile type	Sandy grey dry soil.
Native foliage coverage	70%
Weed species coverage (assessed against total planting area)	10%
Major weed species	*Avena fatua* (Wild oats) and *Eragrostis curvula* (African lovegrass).
Native germination observed.	None
Seedlings and mature planting survival (general description)	
Bare ground cover	10%
Any other comments that may affect or contribute to progress.	Light predations present in *Eucalyptus.*

Orientation: Southwest

Image: 1

Orientation: Northeast

Image:2

Quadrat ID: **WP20**	Date: 03/04/2024	Recorders:	SM	JE	
Quadrat size and orientation	5 m x 20 m				
Method of revegetation:	Full revegetation				
Date/s of infill planting (if any):					
Quadrat Co-ordinates (GDA 94)	Latitude			Longitude	
	-31.54698196			116.001194	
	-31.547017			116.001235	
	-31.54683997			116.001364	
	-31.54688498			116.00139	

Observation for rehabilitation area

Soil Profile type	Gravel dark grey soil.
Native foliage coverage	50%
Weed species coverage (assessed against total planting area)	20%
Major weed species	*Avena fatua* (Wild oats)
Native germination observed.	None
Seedlings and mature planting survival (general description)	Native plants are generally healthy.
Bare ground cover	25%
Any other comments that may affect or contribute to progress.	*Melaleuca* are observed to be successful and dominant.

Orientation: Southwest
Image: 1

Orientation: Northeast
Image:2


APPENDIX 1 | NATIVE PLANT OBSERVATION 2024

Native Species	Plots																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Acacia lasiocarpa					1	1				1			16							3
Acacia pulchella		8				6					3	33		19	47	1	5	7		19
Acacia saligna										1		5					19			6
Adenanthos cygnorum							2	8					1		1			3		
Allocasuarina humilis	1											12	8		7		10		1	
Billardiera fusiformis																		6		
Calothamnus hirsutus				1																
Calothamnus lateralis																				
Calothamnus quadrifidus		6	3	9	2	9					12	59	1	12	1				3	
Calothamnus sanguineus	2	1				4			1				3							2
Conostylis aculeata		6					7													
Corymbia ficifolia																				
Darwinia citriodora		40					2		1	5								4		
Darwinia citriodora 'Seaspray'		2																		
Daviesia divaricata																	5			
Dianella revoluta							8	23	2						1		5			1
Eucalyptus accedens						2						3				1				
Eucalyptus marginata				1			1		2					1		1	1			
Eucalyptus rudis				1		1	2								1		1	5		
Eucalyptus wandoo	11	8	8	2	9	17	7	0	4	6		2	3	6	4	8	2	20	7	4
Gompholobium tomentosum		7	1		1		3	30										12		
Hakea lissocarpha		11						1											1	
Hakea prostrata										1		2	4					1		
Hakea ruscifolia							1										1	4	1	
Hakea undulata						1										2			1	
Hakea varia					2															
Hardenbergia comptoniana																	12	5		
Hemiandra pungens				5		8			1	9				4					4	
Jacksonia calcicola													1		3			1		
Kennedia prostrata														3	6					
Melaleuca lateritia				2			1		1	1				2		2				
Melaleuca radula				3		1	2	8									20			
Melaleuca rhaphiophylla	6	16					6		7	7			19	2	7				12	
Melaleuca systena	4		7	3	1	2			3	16		38								23
Melaleuca viminea	2			1	1															
Myoporum caprarioides						8									1					
Nuytsia floribunda								3												
Patersonia occidentalis								31												
Spyridium globulosum		4					6					10		3	2					
Viminaria juncea		4																		
Total	**26**	**113**	**19**	**28**	**17**	**60**	**48**	**104**	**22**	**47**	**15**	**164**	**56**	**52**	**81**	**15**	**81**	**68**	**30**	**58**

APPENDIX 2 | MAPPING

403700 404700 405700 406700 407700 408700 409700 410700

6519000 6518000 6517000 6516000 6515000 6514000 6513000 6512000 6511000 6510000 6509000 6508000

LEGEND

MONITORING QUADRAT LOCATIONS

PROJECT BOUNDARY

QUADRAT 10
QUADRAT 17
FIG 06
QUADRAT 09
QUADRAT 18
QUADRAT 08
QUADRAT 16
FIG 05
QUADRAT 07
QUADRAT 15
FIG 04
QUADRAT 06
QUADRAT 14
FIG 03
QUADRAT 05
QUADRAT 13
QUADRAT 19
QUADRAT 04
QUADRAT 12
QUADRAT 03
QUADRAT 20
QUADRAT 02
FIG 02
QUADRAT 01
QUADRAT 11
FIG 01

Perth
Mandurah

LOCALITY MAP (NOT TO SCALE)

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
FALSE EASTING: 500,000.0000
FALSE NORTHING: 10,000,000.0000
CENTRAL MERIDIAN: 117.0000
SCALE FACTOR: 0.9996
LATITUDE OF ORIGIN: 0.0000
UNITS: METER

N
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SCALE

0 310 620 1,240 1,860 2,480 METERS

DRAWN	E TAN	REVISION	A
CHECKED	J. MCLEISH	DATE	21/04/2024

GAMBARA

PROJECT TITLE

GREAT NORTHERN HIGHWAY MUCHEA TO WUBIN UPGRADE STAGE 2

DRAWING TITLE

MUCHEA MONITORING 2024
PROJECT AREA OVERVIEW

DOCUMENT PATH: D:\ARCGIS\PROJECTS\28 - MUCHEA WANDOO\02 - GIS\02 - MXDS\LIVE WORKING.MXD

409700 410200

6519000 6519000

6518500 6518500

6518000 6518000

6517500 6517500

409700 410200

LEGEND

MONITORING QUADRAT LOCATIONS

PROJECT BOUNDARY

QUADRAT 10

QUADRAT 17

GREAT NORTHERN HWY

167 m

LOCALITY MAP (NOT TO SCALE)

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
FALSE EASTING: 500,000.0000
FALSE NORTHING: 10,000,000.0000
CENTRAL MERIDIAN: 117.0000
SCALE FACTOR: 0.9996
LATITUDE OF ORIGIN: 0.0000
UNITS: METER

N S

SCALE

0 45 90 180 270 360 METERS

DRAWN	E TAN	REVISION	A
CHECKED	J. MCLEISH	DATE	21/04/2024

GAMBARA

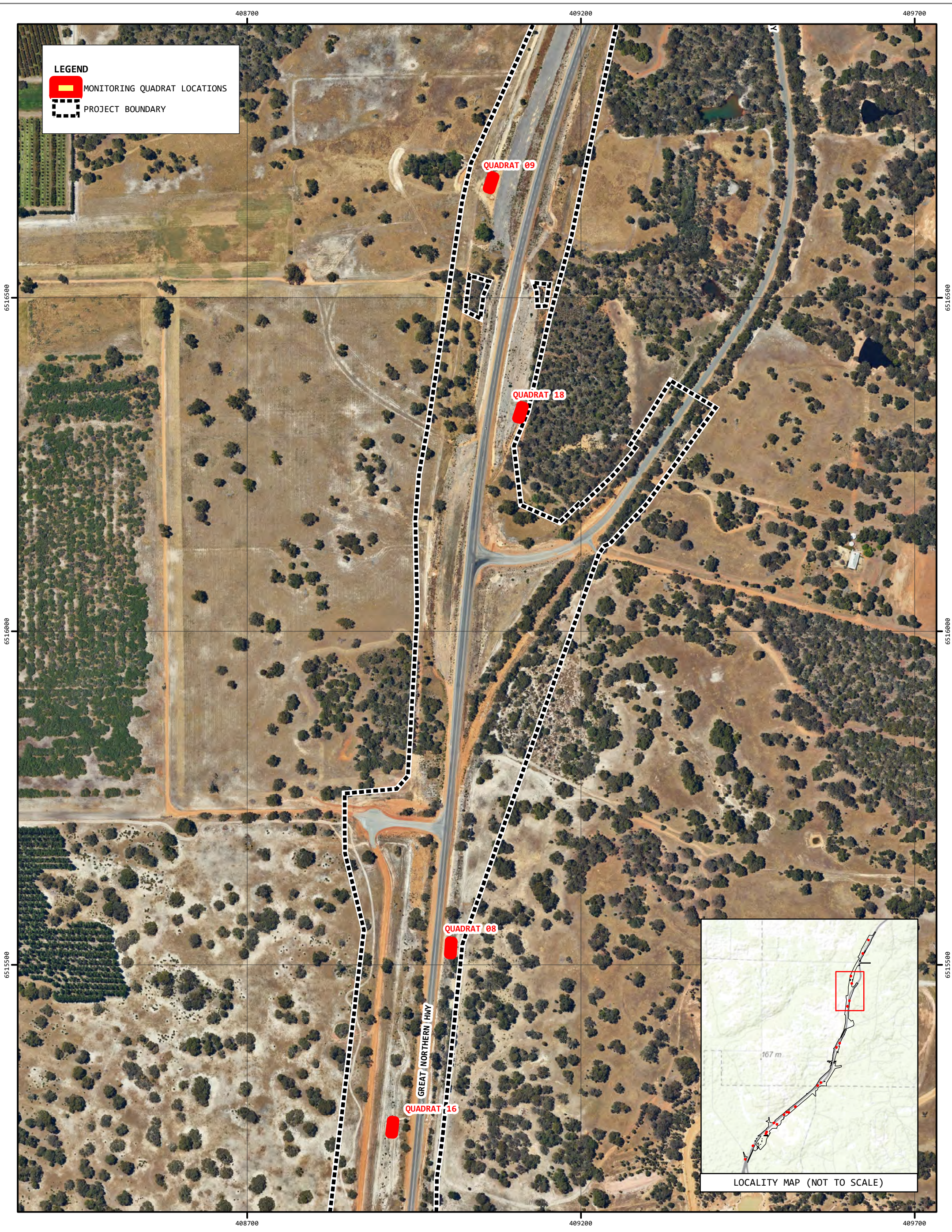
PROJECT TITLE

GREAT NORTHERN HIGHWAY MUCHEA TO WUBIN UPGRADE STAGE 2

DRAWING TITLE

MUCHEA MONITORING 2024
FIGUURE 01

DOCUMENT PATH: D:\ARCGIS\PROJECTS\28 - MUCHEA WANDOO\02 - GIS\02 - MXDS\DETAILED FIGURES.MXD



COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
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FALSE NORTHING: 10,000,000.0000
CENTRAL MERIDIAN: 117.0000
SCALE FACTOR: 0.9996
LATITUDE OF ORIGIN: 0.0000
UNITS: METER

SCALE

0 45 90 180 270 360 METERS

DRAWN	E TAN	REVISION	A
CHECKED	J. MCLEISH	DATE	21/04/2024

GAMBARA

PROJECT TITLE

GREAT NORTHERN HIGHWAY MUCHEA TO WUBIN UPGRADE STAGE 2

DRAWING TITLE

MUCHEA MONITORING 2024
FIGUURE 02

DOCUMENT PATH: D:\ARCGIS\PROJECTS\28 - MUCHEA WANDOO\02 - GIS\02 - MXDS\DETAILED FIGURES.MXD

408200 408700 409200

6514000

6513500

6513000

LEGEND

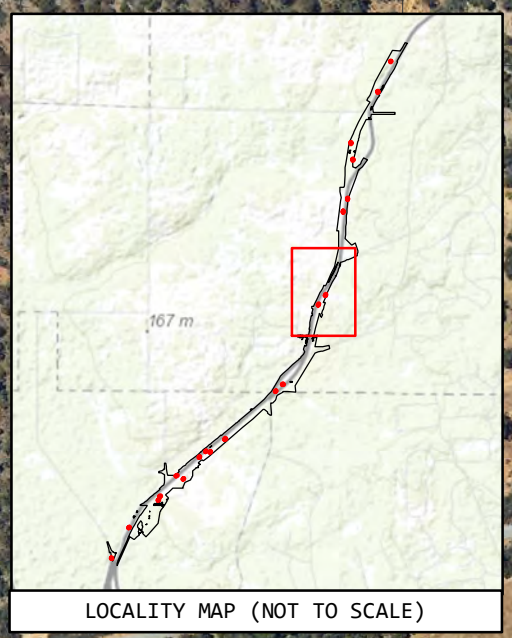
MONITORING QUADRAT LOCATIONS

PROJECT BOUNDARY

GREAT NORTHERN HWY

QUADRAT 07

QUADRAT 15



LOCALITY MAP (NOT TO SCALE)

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
FALSE EASTING: 500,000.0000
FALSE NORTHING: 10,000,000.0000
CENTRAL MERIDIAN: 117.0000
SCALE FACTOR: 0.9996
LATITUDE OF ORIGIN: 0.0000
UNITS: METER

N S

SCALE

0 45 90 180 270 360 METERS

DRAWN	E TAN	REVISION	A
CHECKED	J. MCLEISH	DATE	21/04/2024

GAMBARA

PROJECT TITLE

GREAT NORTHERN HIGHWAY MUCHEA TO WUBIN UPGRADE STAGE 2

DRAWING TITLE

MUCHEA MONITORING 2024
FIGUURE 03

DOCUMENT PATH: D:\ARCGIS\PROJECTS\28 - MUCHEA WANDOO\02 - GIS\02 - MXDS\DETAILED FIGURES.MXD

407200 407700 408200

6512500 6512000 6511500 6511000

LEGEND

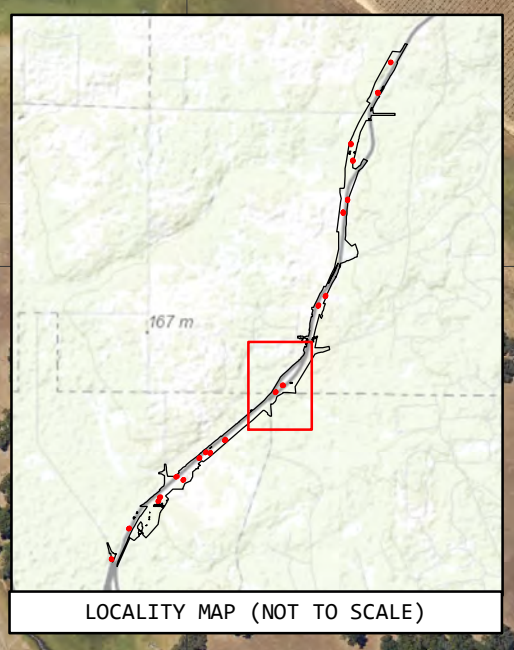
MONITORING QUADRAT LOCATIONS

PROJECT BOUNDARY

GREAT NORTHERN HWY

QUADRAT 06

QUADRAT 14



LOCALITY MAP (NOT TO SCALE)

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
FALSE EASTING: 500,000.0000
FALSE NORTHING: 10,000,000.0000
CENTRAL MERIDIAN: 117.0000
SCALE FACTOR: 0.9996
LATITUDE OF ORIGIN: 0.0000
UNITS: METER

N S

SCALE

0 45 90 180 270 360 METERS

DRAWN	E TAN	REVISION	A
CHECKED	J. MCLEISH	DATE	21/04/2024

GAMBARA

PROJECT TITLE

GREAT NORTHERN HIGHWAY MUCHEA TO WUBIN UPGRADE STAGE 2

DRAWING TITLE

MUCHEA MONITORING 2024
FIGUURE 04

DOCUMENT PATH: D:\ARCGIS\PROJECTS\28 - MUCHEA WANDOO\02 - GIS\02 - MXDS\DETAILED FIGURES.MXD

405700 406200 406700

6511000 6510500 6510000 6509500

LEGEND

MONITORING QUADRAT LOCATIONS

PROJECT BOUNDARY

GREAT NORTHERN HWY

QUADRAT 05

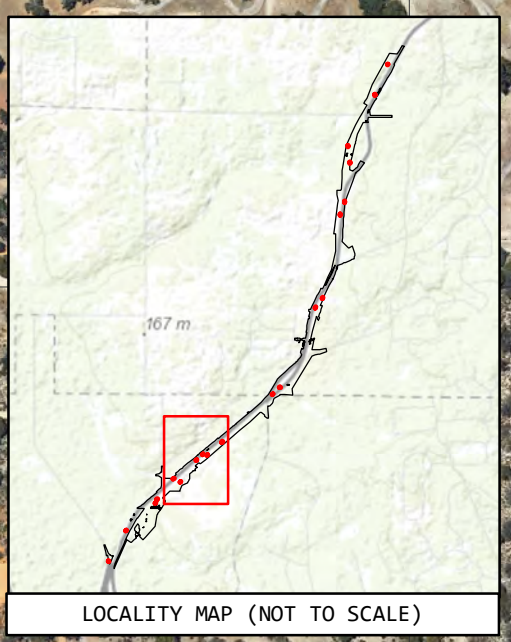
QUADRAT 19

QUADRAT 13

QUADRAT 04

QUADRAT 12

QUADRAT 03



LOCALITY MAP (NOT TO SCALE)

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
FALSE EASTING: 500,000.0000
FALSE NORTHING: 10,000,000.0000
CENTRAL MERIDIAN: 117.0000
SCALE FACTOR: 0.9996
LATITUDE OF ORIGIN: 0.0000
UNITS: METER

N S

SCALE

0 45 90 180 270 360 METERS

DRAWN	E TAN	REVISION	A
CHECKED	J. MCLEISH	DATE	21/04/2024

GAMBARA

PROJECT TITLE

GREAT NORTHERN HIGHWAY MUCHEA TO WUBIN UPGRADE STAGE 2

DRAWING TITLE

MUCHEA MONITORING 2024
FIGUURE 05

DOCUMENT PATH: D:\ARCGIS\PROJECTS\28 - MUCHEA WANDOO\02 - GIS\02 - MXDS\DETAILED FIGURES.MXD

404200 404700 405200

6509500 6509000 6508500 6508000

LEGEND

MONITORING QUADRAT LOCATIONS

PROJECT BOUNDARY

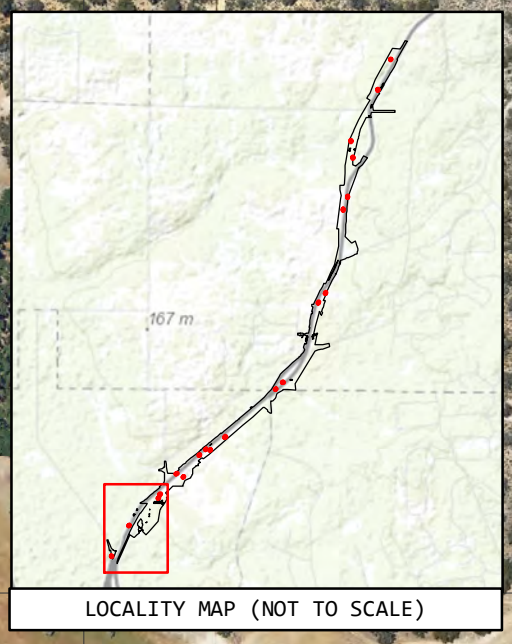
GREAT NORTHERN HWY

QUADRAT 20

QUADRAT 02

QUADRAT 01

QUADRAT 11



LOCALITY MAP (NOT TO SCALE)

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
FALSE EASTING: 500,000.0000
FALSE NORTHING: 10,000,000.0000
CENTRAL MERIDIAN: 117.0000
SCALE FACTOR: 0.9996
LATITUDE OF ORIGIN: 0.0000
UNITS: METER

N S

SCALE

0 45 90 180 270 360 METERS

DRAWN	E TAN	REVISION	A
CHECKED	J. MCLEISH	DATE	21/04/2024

GAMBARA

PROJECT TITLE

GREAT NORTHERN HIGHWAY MUCHEA TO WUBIN UPGRADE STAGE 2

DRAWING TITLE

MUCHEA MONITORING 2024
FIGUURE 06

DOCUMENT PATH: D:\ARCGIS\PROJECTS\28 - MUCHEA WANDOO\02 - GIS\02 - MXDS\DETAILED FIGURES.MXD