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ENVIRONMENTAL SCIENCES

Black cockatoo breeding activity census 2019-20 for Muchea North

Great Northern Highway, Muchea to Wubin Upgrade Stage 2 Project

Prepared for Main Roads WA

April 2020

Final

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Version history				
Author	**Version**	**Version number**	**Date**	**Submitted to**
A. Jacks	Draft issued for client review	0.1	27-Mar-2020	M. Baetge
A. Jacks	Final, client comments addressed	1.0	01-Apr-2020	M. Baetge

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Project code: 1272-SR159-MR-VER

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1 INTRODUCTION

Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Main Roads WA, to undertake a Carnaby's Cockatoo breeding activity census over the 2019-20 breeding season within and surrounding the disturbance footprint for the Muchea North project area (Figure 1). This report presents the results of the census.

1.1 BACKGROUND

Main Roads is currently upgrading the Great Northern Highway (GNH) between Straight Line Kilometre (SLK) 38.60 and 51.40 (referred to as Muchea North Upgrade). The Muchea North Upgrade 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.

Muchea North Upgrade resulted in the loss of 13 Carnaby's Black 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:

- EPBC 2016/7656 condition f(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
- EPBC 2016/7656 condition f(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.

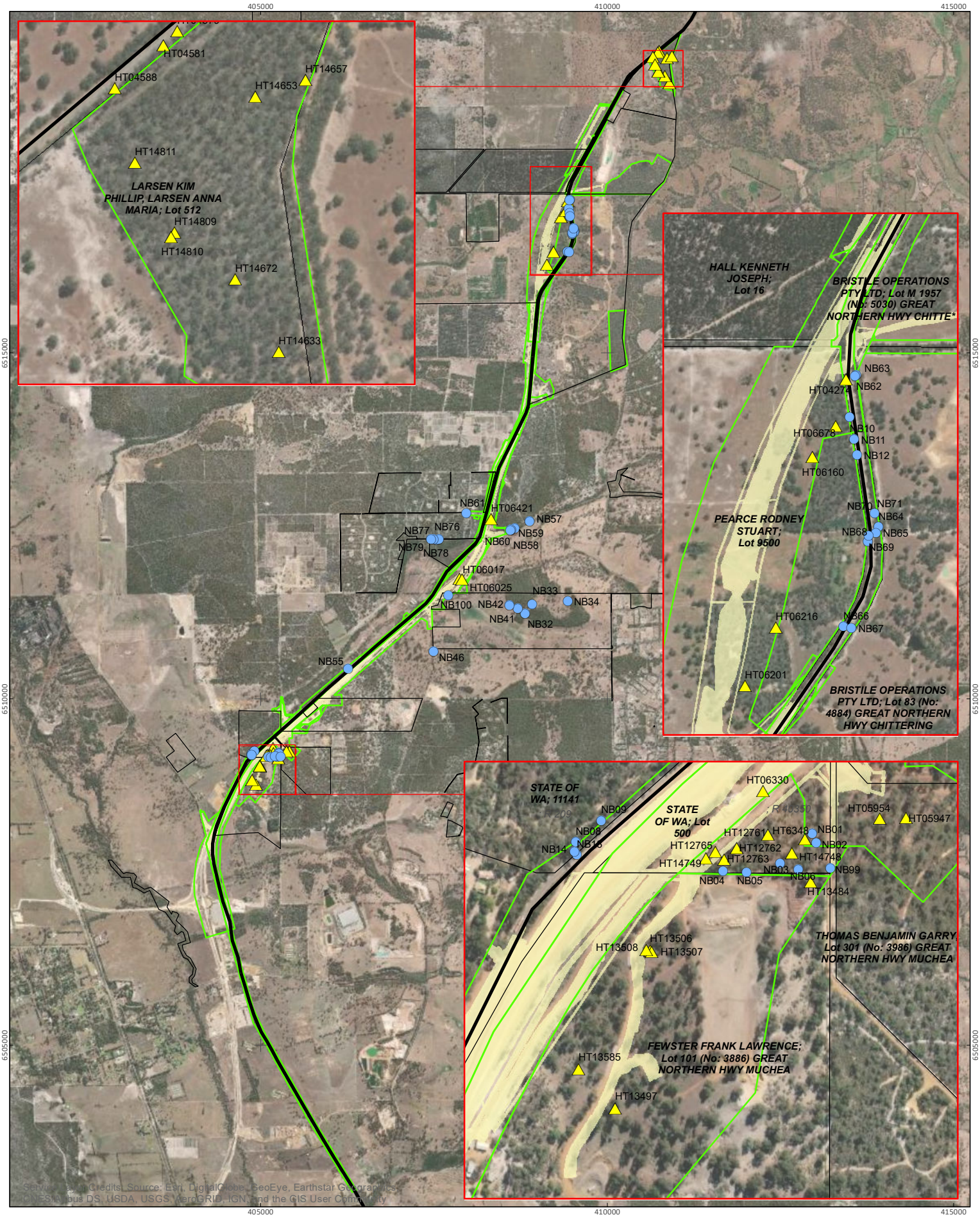
The monitoring campaign will also require monitoring of previously recorded natural hollows suitable for Carnaby's Cockatoo (Figure 1). Monitoring of artificial and natural hollows shall be monitored in accordance with How to Monitor and Maintain Artificial Hollows for Carnaby's Cockatoo (DPaW 2015).

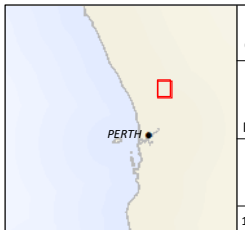
Detailed black cockatoo habitat assessments conducted as part of the baseline assessments for the Muchea North project (Phoenix 2015, 2017a) recorded all potential breeding trees of species known to support black cockatoo breeding and identifed suitable nesting hollows and hollows with evidence of use.

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 Muchea North EPBC Act Approval Boundary and wider baseline survey area (Phoenix 2015, 2017a) (the study area; Figure 1). The initial baseline monitoring program was conducted in the 2017-18 breeding season (August 2017 – February 2018) and assessed hollow usage of suitable nesting hollows and hollows with evidence of use within the study area (Phoenix 2018). A second year of 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 two surveys collectively represent the pre-impact breeding density.

Phoenix was subsequently commissioned to undertake a third year of monitoring for hollow usage within the study area in the 2019-2020 breeding season. This report incorporates the results of the third monitoring season into the nesting hollow usage dataset for Muchea North.





Main Roads WA
Great Northern Highway, M2W Upgrade Project

Project No	1272
Date	26-Mar-20
Drawn by	AJ
Map author	AJ

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Kilometers

1:70,000 (at A4) GDA 1994 MGA Zone 50

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Study area
Disturbance footprint
Road

Monitored hollows

Artificial nesting hollow
Natural nesting hollow

Figure 1

Study area and sampling sites

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1.2 SCOPE OF WORK

The scope of work was as follows:

Six rounds of monitoring of artificial and natural nest hollows to be undertaken between August 2019 and January 2020.

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 Black Cockatoo.

Provide a report that summarises all records required by Conditions 4f(i) and (ii) of EPBC 2016/7656 for all artificial and natural hollows inspected. The draft report shall be provided to Main Roads in electronic PDF and Word version copy format.

2 CENSUS METHODOLOGY

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

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. Other observational methods were also employed, i.e. pole camera inspections of hollows where possible, listening for nest activity, flock and individual bird behaviour.

Consistent with previous methodology the following activities were undertaken:

- 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 will assess the following as a minimum:

- 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 surveys, site visits were undertaken every 4-5 weeks between August 2019 and January 2020: 15 August, 17 September, 22 October, 22 November, 21 December and 20 January.

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 survey 37 of these were monitored as the remaining 20 were unable to be assessed due to access constraints.

In the 2018-19 season, 47 natural nesting hollows and 36 artifical nesting hollows were monitored. This included two new natural hollows added to the census in the current season and 14 trees that were not accessible in the 2017-18 season. Twelve further natural nesting hollows were not monitored; five of these were not able to be accessed, three were not relocated and four hollows were removed from monitoring in the 2017-18 season due to collapse, cracks forming or tree death.

In the current survey a total of 73 hollows were monitored, of which 33 were natural nesting hollows and 40 were artifical nesting hollows (Table 1). Prior to the survey, 13 trees which contained suitable nesting hollows were removed as part of the GNH road upgrades (HT05911, HT05923, HT06020, HT06046, HT06261, HT06278, HT06655, HT08752, HT08753, HT08754, HT13533, HT13534 and HT13535), 12 of these were monitored in the previous two monitoring programs and one was not accessible. These 13 trees were offset by the installation of the 39 artificial nesting hollows of which all were able to be monitored this season. 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 two years were this year able to be surveyed because landowner access had been granted. Four trees with natural nesting hollows were not surveyed this year because the tree or hollow was no longer considered suitable.

In this report:

- *confirmed breeding event* – means eggs were seen in hollow and/or other clear evidence observed that chick was present (i.e. female seen at hollow entrance when brooding eggs and/or parents seen preparing to feed chick in the hollow)
- *evidence of nesting activity* – means chewing around the hollow entrance and/or bird seen prospecting hollows. It does not necessarily mean that a breeding event took place that year; however, it is evidence that the hollow is suitable and was considered and may have been used in previous years.

Table 1 Monitored hollows

HT ID*	Baseline records (pre-2017)	Species	2017-18	2018-19	2019-20
HT04059	Evidence of nesting activity, artificial hollow	*Eucalyptus wandoo*	Yes	Yes	No (tree cleared)
HT04274	Suitable, no evidence of breeding	*Eucalyptus wandoo*	Yes	Yes	Yes
HT04579	Suitable, artificial hollow, no evidence of breeding	*Eucalyptus wandoo*	Yes	Yes	Yes
HT04581	Suitable, artificial hollow, no evidence of breeding	*Eucalyptus wandoo*	Yes	Yes	Yes
HT04588	Suitable, artificial hollow, no evidence of breeding	*Eucalyptus accedens*	Yes	Yes	Yes
HT05911	Suitable, artificial hollow, no evidence of breeding	*Eucalyptus accedens*	No access	No access	No (tree cleared)
HT05923	Suitable, no evidence of breeding	*Eucalyptus wandoo*	Yes	Yes	No (tree cleared)
HT05938	Suitable, no evidence of breeding	*Eucalyptus wandoo*	Yes	No	No (not suitable – hollow has cracked or degraded)
HT05947	Suitable, no evidence of breeding	*Eucalyptus wandoo*	Yes	No	Yes
HT05954	Evidence of nesting activity	*Eucalyptus wandoo*	Yes	Yes	Yes
HT06017	Evidence of nesting activity	*Eucalyptus wandoo*	No access	Yes	Yes
HT06020	Suitable, no evidence of breeding	*Corymbia calophylla*	No access	Yes	No (tree cleared)
HT06025	Suitable, no evidence of breeding	*Eucalyptus wandoo*	No access	Yes	Yes
HT06046	Suitable, no evidence of breeding	*Eucalyptus wandoo*	No access	Yes	No (tree cleared)
HT06148	Suitable, no evidence of breeding	*Corymbia calophylla*	Yes	No	No (not suitable – hollow has cracked or degraded)
HT06160	Suitable, no evidence of breeding	*Eucalyptus wandoo*	Yes	Yes	Yes
HT06201	Suitable, no evidence of breeding	*Eucalyptus wandoo*	Yes	Yes	Yes
HT06216	Suitable, no evidence of breeding	*Eucalyptus marginata*	Yes	Yes	Yes
HT06261	Suitable, no evidence of breeding	*Eucalyptus wandoo*	Yes	Yes	No (tree cleared)
HT06278	Evidence of nesting activity	*Eucalyptus wandoo*	Yes	Yes	No (tree cleared)
HT06330	Not suitable	*Eucalyptus wandoo*	No	Yes	Yes
HT06348	Evidence of nesting activity	*Eucalyptus wandoo*	Yes	Yes	Yes
HT06421	Evidence of nesting activity	*Corymbia calophylla*	No access	No access	No (no access)

HT ID*	Baseline records (pre-2017)	Species	2017-18	2018-19	2019-20
HT06655	Suitable, no evidence of breeding	*Corymbia calophylla*	Yes	No	No (tree cleared)
HT06678	Suitable, no evidence of breeding	*Eucalyptus wandoo*	Yes	Yes	Yes
HT08752	Evidence of nesting activity	*Eucalyptus wandoo*	Yes	Yes	No (tree cleared)
HT08753	Evidence of nesting activity	*Eucalyptus wandoo*	Yes	Yes	No (tree cleared)
HT08754	Evidence of nesting activity	*Eucalyptus wandoo*	No access	~~Yes~~	No (tree cleared)
HT12761	Evidence of nesting activity	*Eucalyptus wandoo*	No	No	Yes
HT12762	Evidence of nesting activity	*Eucalyptus wandoo*	Yes	Yes	Yes
HT12763	Evidence of nesting activity (FRTBC)	*Eucalyptus wandoo*	Yes	Yes	Yes
HT12765	Evidence of nesting activity	*Eucalyptus wandoo*	Yes	Yes	Yes
HT13484	Suitable, no evidence of breeding	*Eucalyptus wandoo*	No access	Yes	Yes
HT13497	Suitable, no evidence of breeding	*Eucalyptus marginata*	No access	Yes	Yes
HT13503	Suitable, no evidence of breeding	*Eucalyptus marginata*	No access	Yes	No (not suitable – hollow has cracked or degraded)
HT13505	Suitable, no evidence of breeding	*Eucalyptus sp.*	No access	Yes	No (not suitable – hollow has cracked or degraded)
HT13506	Suitable, no evidence of breeding	*Eucalyptus wandoo*	No access	Yes	Yes
HT13507	Suitable, no evidence of breeding	*Eucalyptus wandoo*	No access	Yes	Yes
HT13508	Suitable, no evidence of breeding	*Eucalyptus wandoo*	No access	Yes	Yes
HT13511	Suitable, no evidence of breeding	*Corymbia calophylla*	No access	Yes	No (not suitable – hollow has cracked or degraded)
HT13523	Suitable, no evidence of breeding	*Eucalyptus wandoo*	No access	Yes	No (not suitable – hollow has cracked or degraded)
HT13533	Suitable, no evidence of breeding	*Eucalyptus wandoo*	Yes	Yes	No (tree cleared)
HT13534	Suitable, no evidence of breeding	*Eucalyptus wandoo*	Yes	Yes	No (tree cleared)

HT ID*	Baseline records (pre-2017)	Species	2017-18	2018-19	2019-20
HT13535	Suitable, no evidence of breeding	*Eucalyptus wandoo*	Yes	Yes	No (tree cleared)
HT13585	Not suitable	*Corymbia calophylla*	No	Yes	Yes
HT14633	Suitable, no evidence of breeding	*Eucalyptus wandoo*	Yes	Yes	Yes
HT14653	Evidence of nesting activity	*Eucalyptus wandoo*	Yes	Yes	Yes
HT14657	Evidence of nesting activity	*Eucalyptus wandoo*	Yes	Yes	Yes
HT14670	Evidence of nesting activity	*Eucalyptus wandoo*	Yes	No	No (not suitable – hollow collapsed)
HT14672	Evidence of nesting activity	*Eucalyptus wandoo*	Yes	Yes	Yes
HT14748	Evidence of nesting activity	*Eucalyptus wandoo*	Yes	Yes	Yes
HT14749	Evidence of nesting activity	*Eucalyptus wandoo*	Yes	Yes	Yes
HT14805	Evidence of nesting activity	*Eucalyptus wandoo*	No access	No access	No (not suitable – hollow has cracked or degraded)
HT14806	Evidence of nesting activity	*Eucalyptus wandoo*	No access	No access	No (not suitable – hollow has cracked or degraded)
HT14807	Suitable, no evidence of breeding	*Eucalyptus wandoo*	No access	No access	No (not suitable – hollow has cracked or degraded)
HT14808	Suitable, no evidence of breeding	*Eucalyptus wandoo*	No access	No access	No (not suitable – hollow has cracked or degraded)
HT14809	Evidence of nesting activity	*Eucalyptus wandoo*	Yes	Yes	Yes
HT14810	Evidence of nesting activity	*Eucalyptus wandoo*	Yes	Yes	Yes
HT14811	Evidence of nesting activity	*Eucalyptus wandoo*	Yes	Yes	Yes
NB01	n/a	n/a	n/a	Yes	Yes
NB02	n/a	n/a	n/a	Yes	Yes
NB03	n/a	n/a	n/a	Yes	Yes
NB04	n/a	n/a	n/a	Yes	Yes
NB05	n/a	n/a	n/a	Yes	Yes
NB06	n/a	n/a	n/a	Yes	Yes
NB08	n/a	n/a	n/a	Yes	Yes
NB09	n/a	n/a	n/a	Yes	Yes
NB10	n/a	n/a	n/a	Yes	Yes

HT ID*	Baseline records (pre-2017)	Species	2017-18	2018-19	2019-20
NB11	n/a	n/a	n/a	Yes	Yes
NB12	n/a	n/a	n/a	Yes	Yes
NB13	n/a	n/a	n/a	Yes	Yes
NB14	n/a	n/a	n/a	Yes	Yes
NB32	n/a	n/a	n/a	Yes	Yes
NB33	n/a	n/a	n/a	Yes	Yes
NB34	n/a	n/a	n/a	n/a	Yes
NB41	n/a	n/a	n/a	n/a	Yes
NB42	n/a	n/a	n/a	n/a	Yes
NB46	n/a	n/a	n/a	Yes	Yes
NB55	n/a	n/a	n/a	Yes	Yes
NB57	n/a	n/a	n/a	Yes	Yes
NB58	n/a	n/a	n/a	Yes	Yes
NB59	n/a	n/a	n/a	Yes	Yes
NB60	n/a	n/a	n/a	Yes	Yes
NB61	n/a	n/a	n/a	Yes	Yes
NB62	n/a	n/a	n/a	Yes	Yes
NB63	n/a	n/a	n/a	Yes	Yes
NB64	n/a	n/a	n/a	Yes	Yes
NB65	n/a	n/a	n/a	Yes	Yes
NB66	n/a	n/a	n/a	Yes	Yes
NB67	n/a	n/a	n/a	Yes	Yes
NB68	n/a	n/a	n/a	Yes	Yes
NB69	n/a	n/a	n/a	Yes	Yes
NB71	n/a	n/a	n/a	Yes	Yes
NB76	n/a	n/a	n/a	Yes	Yes
NB77	n/a	n/a	n/a	Yes	Yes
NB78	n/a	n/a	n/a	Yes	Yes
NB79	n/a	n/a	n/a	Yes	Yes
NB99	n/a	n/a	n/a	Yes	Yes
NB100	HT04059 was cleared and this nestbox was installed to replace it in 2019	n/a	n/a	n/a	Yes

* HT = habitat tree (natural); NB = nest box (artificial)

3 RESULTS

3.1 CENSUS RESULTS 2019-20 BREEDING SEASON

Confirmed breeding events were recorded in three artificial nesting hollows and three natural nesting hollows by Phoenix, (Table 2; Figure 2). Evidence of nesting activity was observed in a further ten artificial nesting hollows and four natural nesting hollows (Table 2; Figure 2).

Of the confirmed breeding events:

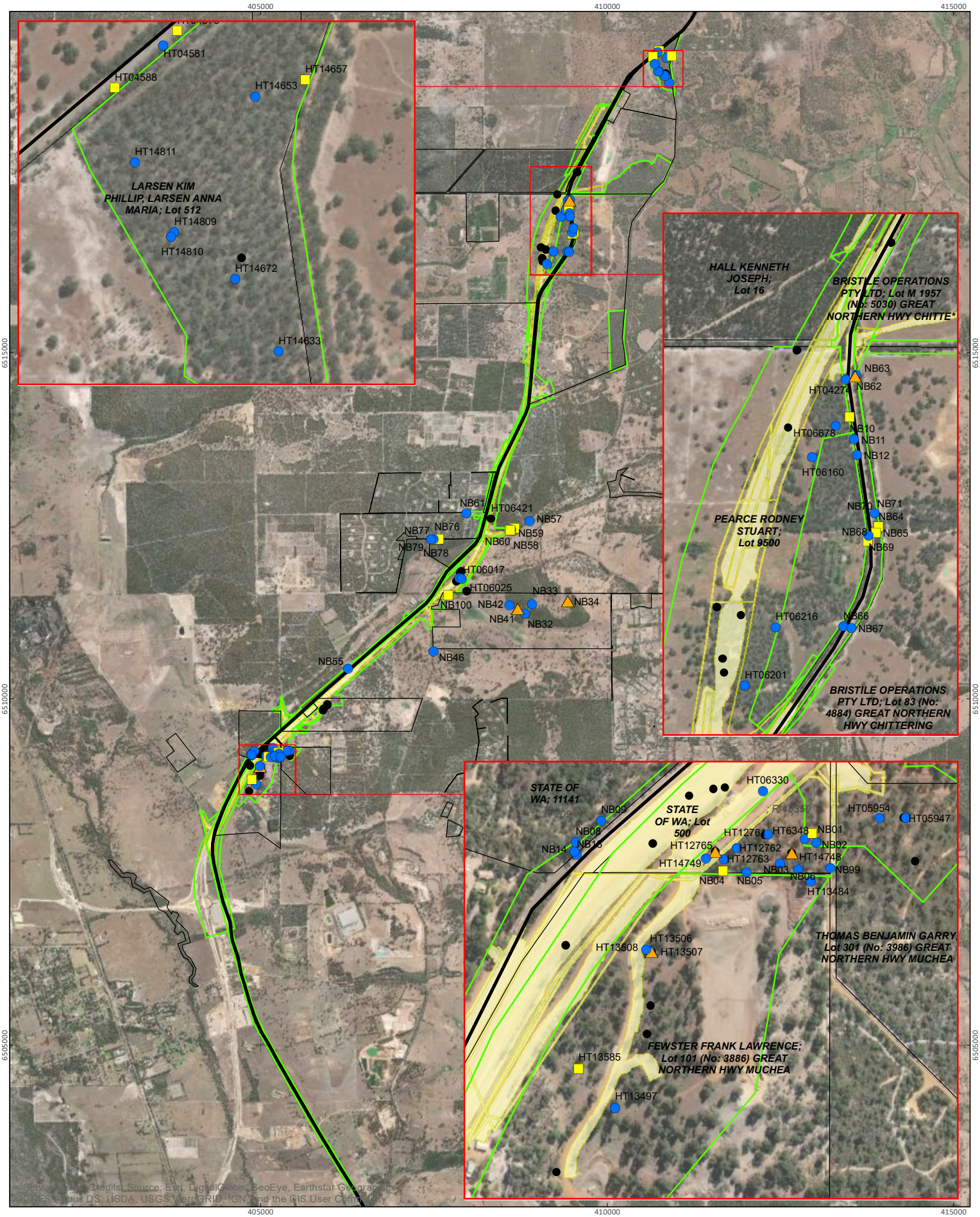
- NB34, NB41 and NB63 – are presumed to have resulted in successful fledging of a chick. Images of large chicks were seen with a camera in all three artificial nest hollows in December 2019 (Figure 3).
- HT12765 and HT13507 – female was flushed from hollow, presumed to be sitting on eggs.
- HT06348 – two eggs were observed with a camera in the hollow in October 2019, however these had been predated by November 2019.

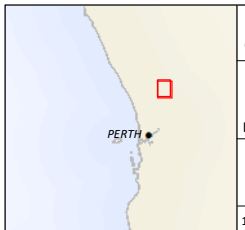
There were several instances where females were flushed from a hollow but a later inspection saw no chicks or eggs and the bird was likely to be prospecting. No evidence of nesting activities were observed in the remaining 27 natural nesting hollows or 26 artificial nesting hollows (Appendix 1).

Table 2 Evidence of breeding records by Phoenix during the 2019-20 census

	Inspection date						
HT ID	**15/08/2019**	**17/09/2019**	**22/10/2019**	**22/11/2019**	**21/12/2019**	**20/01/2020**	**Result**
NB01	Fresh chewing at post	No flush	No flush	No flush	No flush	No flush	Evidence of nesting activity
NB04	No flush	No flush	No flush	Flushed female CBC, likely to be prospecting hollow	No flush, no eggs in hollow	No flush	Evidence of nesting activity
NB10	No flush	Prospecting pair in tree: female flushed from hollow , likely to be propsecting hollow	No flush, no eggs in hollow	No flush	No flush	No flush	Evidence of nesting activity
NB34	No flush	No flush	No flush	No access	Camera check: Large chick in nest	Chick fledged	Confirmed breeding event: assumed successful
NB41	No flush	No flush	No flush	No access	Camera check: Large chick in nest	Chick fledged	Confirmed breeding event: assumed successful
NB58	No flush	No flush	No flush	Flushed female CBC, possibly prospecting hollow	No flush, no eggs in hollow	No flush	Evidence of nesting activity
NB60	No flush	Chewing at post	No flush	No flush	No flush	No flush	Evidence of nesting activity
NB63	No flush	Flushed female CBC, likely to be incubating eggs	Flushed female CBC, likely to be incubating eggs	Camera check: small chick in nest	Camera check: Large chick in nest	Chick fledged	Confirmed breeding event: assumed successful
NB64	No flush	Chewing at post	No flush	No flush	No flush	No flush	Evidence of nesting activity

	Inspection date						
HT ID	**15/08/2019**	**17/09/2019**	**22/10/2019**	**22/11/2019**	**21/12/2019**	**20/01/2020**	**Result**
NB65	No flush	Chewing at post	No flush	No flush	No flush	No flush	Evidence of nesting activity
NB68	No flush	No flush	No flush	Flushed female CBC, likely to be propsecting hollow	No flush, no eggs in hollow	No flush	Evidence of nesting activity
NB76	No flush	No flush	No flush	Chewing at post	No flush	No flush	Evidence of nesting activity
NB77	No flush	No flush		Chewing at post	No flush	No flush	Evidence of nesting activity
HT04579	No flush	No flush	Chewing at hollow entrance	No flush	No flush	No flush	Evidence of nesting activity
HT04588	No flush	No flush	Chewing at hollow entrance	No flush	No flush	No flush	Evidence of nesting activity
HT06348	No flush	No flush	Flushed female CBC, camera check: 2 eggs in nest	Camera check: eggs predated	No flush	No flush	Confirmed breeding event: unsuccessful
HT12765	No flush	No flush	No flush	Flushed female CBC, likely to be incubating eggs	No flush, tree too close to powerlines to inspect with pole camera	No flush	Confirmed breeding event
HT13507	No flush	Flushed female CBC, likely to be incubating eggs	No flush, hollow too high to inspect with pole camera	No flush	No flush	No flush	Confirmed breeding event
HT13585	No flush	No flush	Chewing at hollow entrance	No flush	No flush	No flush	Evidence of nesting activity
HT14657	No flush	Flushed female CBC, likely to be propsecting hollow	No flush	No flush, no eggs or chicks seen in hollow	Prospecting pair in tree hollows	No flush	Evidence of nesting activity





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1:70,000 (at A4) GDA 1994 MGA Zone 50

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- Study area
- Disturbance footprint
- Road

Results

- Confirmed breeding event
- Evidence of nesting activity
- No evidence of breeding
- Not surveyed (no access/no longer suitable, cleared)

Figure 2

Monitoring results for 2018-19 breeding season

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Figure 3 Female flushed from a nest box (September 2019)

Figure 4 Chick in nest box (December 2019)

3.2 COMPARISON BETWEEN MONITORING SEASONS

The number of confirmed Carnaby's Cockatoo breeding events in the 2019-20 breeding season is about consistent with the pre-impact average, however the nesting activity was significantly higher than the pre-impact average, particularly the 2018-2019 breeding season which surveyed a comparable number of artificial and natural nesting hollows (Table 3).

Breeding events and evidence of nesting activity in the 2019-20 season were identified in the same general areas as in the previous seasons, including the two areas that were identified as having a higher rate of breeding activity, Reserve 40350 and Lot 512 (Figure 3). An additional cluster where there was evidence of nesting or breeding activity was on a property 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 (Nesci Estate and surrounding road reserve) (Phoenix 2017b).

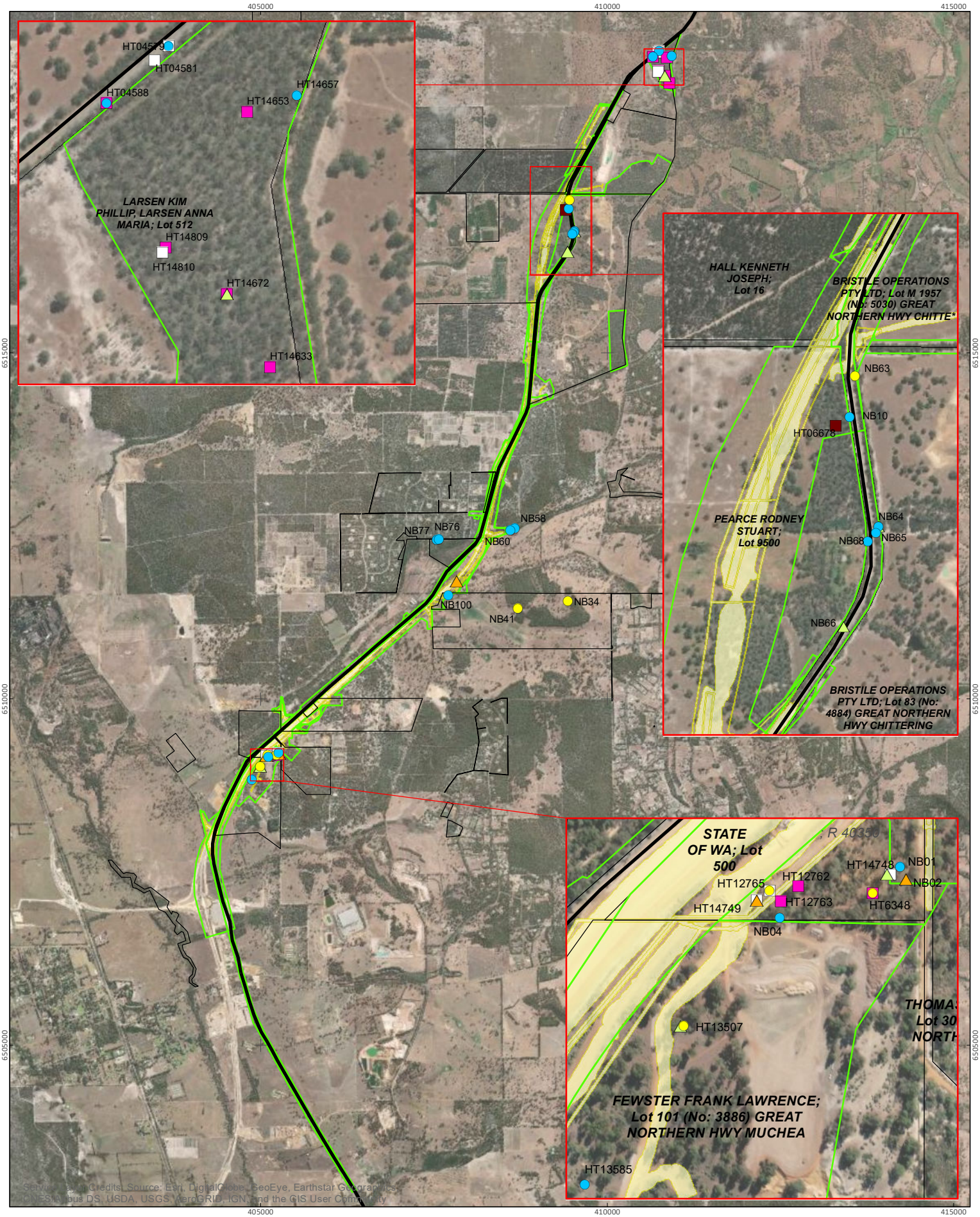
The natural nesting hollows which recorded a confirmed breeding event also had evidence of use in the previous breeding seasons, one had a successful breeding event in the 2017-2018 season. Of the four natural nesting hollows which recorded evidence of nesting activity, two had previous evidence, and of these, one had a confirmed breeding event.

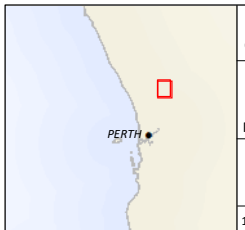
The artificial nesting hollows were installed during the 2018-2019 breeding season so there are a few records of use by Carnaby's Cockatoo. However, the 2019-2020 breeding season recorded a higher number of artificial nesting hollows with both confirmed breeding events and evidence of nesting activity other than in the natural nesting hollows. Three of the four confirmed breeding events were observed in the artificial nesting hollows, and these were also the three that had successful outcome (a chick that hatched and had fledged). An additional 10 artificial nesting hollows had evidence of nesting which was also higher than the natural nesting hollows of which six hollows had evidence of nesting activities. This is a good indication that the artificial nesting hollows are providing a suitable alternative to natural nesting hollows in the Muchea area.

Table 3 Summary of results for 2017-18 and 2018-19 breeding seasons

Result type	**Baseline records pre 2017-18**[1] Natural hollows and existing aritificial hollows	**2017-18 breeding season** Natural hollows and existing aritificial hollows	**2018-19 breeding season** All hollows (natural & existing artificial hollows/new artificial hollows)	**Pre-impact average (2017-18 and 2018-19)** All hollows	**2019-20 breeding season** All hollows (natural & existing artificial hollows/new artificial hollows)
Confirmed breeding event	n/a	6	3 (2/1)	5	6 (3/3)
Evidence of nesting activity	24	14	5 (3/2)	10	15 (4/11)
No evidence of breeding	35	13	63 (30/33)	38	52 (26/26)
No longer suitable, not accessible, cleared	n/a	26	25 (24/1)	23	17 (17/0)

[1] Evidence of nesting activity recorded at some point. Not annual census data and cannot be compared with annual census results.





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Study area
Disturbance footprint
Road

2019-2020 breeding season
- Confirmed breeding event
- Evidence of nesting activity

2018-2019 breeding season
- Confirmed breeding event
- Evidence of nesting activity

2017-2018 breeding season
- Confirmed breeding event
- Evidence of nesting activity
- Evidence of nesting activity (FRTBC)

Figure 5

Confirmed breeding events and Evidence of nesting activity across breeding seasons

PHOENIX ENVIRONMENTAL SCIENCES

4 CONCLUSION

Four confirmed Carnaby's Cockatoo breeding events were observed in the 2019-20 season and evidence of nesting was observed in a further 16 hollows, with both natural and artificial nesting hollows showing activity.

The difference in nesting activity recorded between the breeding seasons is not unexpected as the sample size for this monitoring program is small and breeding activity can be highly variable between years.

The 2019-2020 census results indicate that breeding activity is occurring throughout the Muchea North area. 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.

Considering the artificial nesting hollows were installed during the previous season, the uptake of many of these for breeding events and several more with evidence of nesting activity indicate the willingness of Carnaby's Cockatoo to utilise these as an alternative to natural nest hollows.

All of the artificial nesting hollows were in good condition and none required any maintenance.

For future monitoring of the nesting hollows, consistent methodology should be employed to that used in the 2019-2020 breeding census. Where possible, pole cameras should be used to inspect suspected breeding events.

5 REFERENCES

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Appendix 1 Results for all hollows in in the 2019-20 breeding season

HT ID	15-Aug-19	17-Sep-19	22-Oct-19	22-Nov-19	21-Dec-19	20-01-2020
HT04274	No flush	No flush	No flush	No flush	No flush	no flush
HT04579	No flush	No flush	Chewing at entrance	No flush	No flush	no flush
HT04581	No flush	No flush	No flush	No flush	No flush	no flush
HT04588	No flush	No flush	Slight chewing at entrance	No flush	No flush	no flush
HT05947	No flush	No flush	No flush	No flush	No flush	no flush
HT05954	No flush	No flush	No flush	No flush	No flush	no flush
HT06017	No flush	No flush	No flush	No flush	No flush	no flush
HT06025	No flush	No flush	No flush	No flush	No flush	no flush
HT06160	No flush	No flush	No flush	No flush	No flush	no flush
HT06201	No flush	No flush	No flush	No flush	No flush	no flush
HT06216	No flush	No flush	No flush	No flush	No flush	no flush
HT06330	No flush	No flush	No flush	No flush	No flush	no flush
HT06348	No flush	No flush	Carnaby flushed. 2 eggs	Eggs predated	No flush	no flush
HT06678	No flush	No flush	No flush	No flush	No flush	no flush
HT12761	No flush	No flush	No flush	No flush	No flush	no flush
HT12762	No flush	No flush	No flush	No flush	No flush	no flush
HT12763	No flush	No flush	No flush	No flush	No flush	no flush
HT12765	No flush	No flush	No flush	Carnaby's flushed	No flush	no flush
HT13484	No flush	No flush	No flush	No flush	No flush	no flush

HT13497	No flush	No flush	No flush	No flush	No flush	no flush
HT13506	No flush	No flush	No flush	No flush	No flush	no flush
HT13507	No flush	Carnaby flushed	No flush	No flush	No flush	no flush
HT13508	No flush	No flush	No flush	No flush	No flush	no flush
HT13585	No flush	No flush	Slight chewing at entrance	No flush	No flush	no flush
HT14633	No flush	No flush	No flush	No flush	No flush	no flush
HT14653	No flush	No flush	No flush	No flush	No flush	no flush
HT14657	No flush	Carnaby flushed	No flush	No flush	Pair prospecting hollows	no flush
HT14672	No flush	No flush	No flush	No flush	No flush	no flush
HT14748	No flush	No flush	No flush	No flush	No flush	no flush
HT14749	No flush	No flush	No flush	No flush	No flush	no flush
HT14809	No flush	No flush	No flush	No flush	No flush	no flush
HT14810	No flush	No flush	No flush	No flush	No flush	no flush
HT14811	No flush	No flush	No flush	No flush	No flush	no flush
NB01	Chewing at post	Chewing at post	No flush	No flush	No flush	no flush
NB02	No flush	No flush	No flush	No flush	No flush	no flush
NB03	No flush	No flush	No flush	No flush	No flush	no flush
NB04	No flush	No flush	No flush	Carnaby's flushed	No flush	no flush
NB05	No flush	No flush	No flush	No flush	No flush	no flush
NB06	No flush	No flush	No flush	No flush	No flush	no flush

NB08	No flush	No flush	No flush	No flush	No flush	no flush
NB09	No flush	No flush	No flush	No flush	No flush	no flush
NB10	No flush	Prospecting: female Carnaby flushed then leaves with male. Probably prospecting	No flush	No flush	No flush	no flush
NB11	No flush	No flush	No flush	No flush	No flush	no flush
NB12	No flush	No flush	No flush	No flush	No flush	no flush
NB13	No flush	No flush	No flush	No flush	No flush	no flush
NB14	No flush	No flush	No flush	No flush	No flush	no flush
NB32	No flush	No flush	No flush	No flush	No flush	no flush
NB33	No flush	No flush	No flush	No flush	No flush	no flush
NB34	no flush	no flush	no flush	No flush	Large chick in nest	Chick fledged
NB41	no flush	No flush	No flush	No flush	Large chick in nest - still has dowm on neck	Chick fledged
NB42	no flush	No flush	No flush	No flush	No flush	no flush
NB46	No flush	No flush	No flush	No flush	No flush	no flush
NB55	No flush	No flush	No flush	No flush	No flush	no flush
NB57	No flush	No flush	No flush	No flush	No flush	no flush
NB58	No flush	No flush	No flush	Carnaby's flushed	No flush	no flush
NB59	No flush	No flush	No flush	No flush	No flush	no flush
NB60	No flush	No flush	Post chewed	No flush	No flush	no flush
NB61	No flush	No flush	No flush	No flush	No flush	no flush

NB62	No flush	No flush	No flush	No flush	No flush	no flush
NB63	No flush	Carnaby's flushed	Carnaby's flushed	Pin feathered chick in nest	Large chick in nest	Chick fledged
NB64	No flush	Post chewed	No flush	No flush - empty	No flush	no flush
NB65	No flush	Post chewed	No flush	No flush	No flush	no flush
NB66	No flush	No flush	No flush	No flush	No flush	no flush
NB67	No flush	No flush	No flush	No flush	No flush	no flush
NB68	No flush	No flush	No flush	Carnaby flushed	No flush	no flush
NB69	No flush	No flush	No flush	No flush	No flush	no flush
NB71	No flush	No flush	No flush	No flush	No flush	no flush
NB76	No flush	No flush	No flush	Post chewed but nest empty	No flush	no flush
NB77	No flush	No flush	No flush	Post chewed but nest empty	No flush	no flush
NB78	no flush	No flush	No flush	No flush. Pair of Carnaby's nearby. Male making mating call	No flush	no flush
NB79	No flush	No flush	No flush	No flush	No flush	no flush
NB99	No flush	no flush	no flush	No flush	No flush	no flush
NB100	no flush	no flush	no flush	No flush	No flush - very old Carnaby's tail feather in nest	no flush

Appendix 2 Results for all hollows in 2017-18 and 2018-19 breeding season

HT ID	Result 2017-18	Result 2018-19	Result 2019-20
HT04059	No evidence of breeding	No evidence of breeding	Tree cleared. Further monitoring not required
HT04274	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT04579	Confirmed breeding event - failed	No evidence of breeding	No evidence of breeding
HT04581	Confirmed breeding event - failed	No evidence of breeding	No evidence of breeding
HT04588	Evidence of nesting activity	No evidence of breeding	Evidence of nesting activity
HT05911	No access	Hollow not located	Tree cleared. Further monitoring not required
HT05923	No evidence of breeding	Tree cleared. Further monitoring not required	n/a
HT05938	No longer suitable hollow. Further monitoring not required	n/a	n/a
HT05947	No evidence of breeding	Not located	No evidence of breeding
HT05954	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT06017	No access	No evidence of breeding	No evidence of breeding
HT06020	No access	Tree cleared. Further monitoring not required	n/a
HT06025	No access	No evidence of breeding	No evidence of breeding
HT06046	No access	Tree cleared. Further monitoring not required	n/a
HT06148	No longer suitable. Further monitoring not required	n/a	n/a
HT06160	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT06201	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT06216	No evidence of breeding	No evidence of breeding	No evidence of breeding
HT06261	No evidence of breeding	Tree cleared. Further monitoring not required.	n/a

HT ID	Result 2017-18	Result 2018-19	Result 2019-20
HT06278	Evidence of nesting activity	Tree cleared. Further monitoring not required.	n/a
HT06330	Not sampled	No evidence of breeding. Added to breeding census in 2018-19	No evidence of breeding
HT06348	Evidence of nesting activity	No evidence of breeding	Confirmed breeding event - failed
HT06421	No access. Evidence of nesting activity (from a distance)	No access	n/a
HT06655	No longer suitable. Further monitoring not required	Tree cleared. Further monitoring not required	n/a
HT06678	Evidence of nesting activity (FRTBC)	No evidence of breeding	No evidence of breeding
HT08752	No evidence of breeding	Tree cleared. Further monitoring not required	n/a
HT08753	Evidence of nesting activity	No evidence of breeding	Tree cleared. Further monitoring not required
HT08754	No access	Confirmed breeding event	Tree cleared. Further monitoring not required
HT12761	Hollow not located	Hollow not located	No evidence of breeding
HT12762	Evidence of nesting activity	No evidence of breeding	No evidence of breeding
HT12763	Evidence of nesting activity	No evidence of breeding	No evidence of breeding
HT12765	Confirmed breeding event - successful	No evidence of breeding	Confirmed breeding event
HT13484	No access	No evidence of breeding	No evidence of breeding
HT13497	No access	No evidence of breeding	No evidence of breeding
HT13503	No access	No longer suitable. Further monitoring not required	n/a
HT13505	No access	No longer suitable. Further monitoring not required	n/a
HT13506	No access	No evidence of breeding	No evidence of breeding
HT13507	No access	Evidence of nesting activity	

HT ID	Result 2017-18	Result 2018-19	Result 2019-20
HT13508	No access	No evidence of breeding	No evidence of breeding
HT13511	No access	No longer suitable. Further monitoring not required	n/a
HT13523	No access	No longer suitable. Further monitoring not required	n/a
HT13533	No evidence of breeding	No evidence of breeding	Tree cleared. Further monitoring not required
HT13534	Evidence of nesting activity	Tree cleared. Further monitoring not required	n/a
HT13535	Evidence of nesting activity	Tree cleared. Further monitoring not required	n/a
HT13585	Not sampled	No evidence of breeding. Added to breeding census in 2018-19, chewing observed at hollow	Evidence of nesting activity
HT14633	Evidence of nesting activity	No evidence of breeding	No evidence of breeding
HT14653	Evidence of nesting activity	No evidence of breeding	No evidence of breeding
HT14657	No evidence of breeding	No evidence of breeding	Evidence of nesting activity
HT14670	Collapsed, no longer suitable. Further monitoring not required	n/a	n/a
HT14672	Evidence of nesting activity	Evidence of nesting activity	No evidence of breeding
HT14748	Confirmed breeding event - successful	Evidence of nesting activity	No evidence of breeding
HT14749	Confirmed breeding event - successful	Confirmed breeding event	No evidence of breeding
HT14805	No access	No access	No longer suitable. Further monitoring not required
HT14806	No access	No access	No longer suitable. Further monitoring not required
HT14807	No access	No access	No longer suitable. Further monitoring not required
HT14808	No access	No access	No longer suitable. Further monitoring not required
HT14809	Evidence of nesting activity	No evidence of breeding	No evidence of breeding

HT ID	Result 2017-18	Result 2018-19	Result 2019-20
HT14810	Confirmed breeding event - failed	No evidence of breeding	No evidence of breeding
HT14811	No evidence of breeding	No evidence of breeding	No evidence of breeding
NB01	n/a	No evidence of breeding	Evidence of nesting activity
NB02	n/a	Confirmed breeding event	No evidence of breeding
NB03	n/a	No evidence of breeding	No evidence of breeding
NB04	n/a	No evidence of breeding	Evidence of nesting activity
NB05	n/a	No evidence of breeding	No evidence of breeding
NB06	n/a	No evidence of breeding	No evidence of breeding
NB08	n/a	No evidence of breeding	No evidence of breeding
NB09	n/a	No evidence of breeding	No evidence of breeding
NB10	n/a	No evidence of breeding	Evidence of nesting activity
NB11	n/a	No evidence of breeding	No evidence of breeding
NB12	n/a	No evidence of breeding	No evidence of breeding
NB13	n/a	No evidence of breeding	No evidence of breeding
NB14	n/a	No evidence of breeding	No evidence of breeding
NB32	n/a	No evidence of breeding/no access	No evidence of breeding
NB33	n/a	No evidence of breeding/no access	No evidence of breeding
NB34	n/a	n/a	Confirmed breeding event
NB41	n/a	n/a	Confirmed breeding event
NB42	n/a	n/a	No evidence of breeding
NB46	n/a	No evidence of breeding	No evidence of breeding

HT ID	Result 2017-18	Result 2018-19	Result 2019-20
NB55	n/a	No evidence of breeding	No evidence of breeding
NB57	n/a	No evidence of breeding	No evidence of breeding
NB58	n/a	No evidence of breeding	Evidence of nesting activity
NB59	n/a	No evidence of breeding	No evidence of breeding
NB60	n/a	No evidence of breeding	Evidence of nesting activity
NB61	n/a	No evidence of breeding	No evidence of breeding
NB62	n/a	No evidence of breeding	No evidence of breeding
NB63	n/a	No evidence of breeding	Confirmed breeding event
NB64	n/a	Evidence of nesting activity	Evidence of nesting activity
NB65	n/a	No evidence of breeding	Evidence of nesting activity
NB66	n/a	Evidence of nesting activity	No evidence of breeding
NB67	n/a	No evidence of breeding	No evidence of breeding
NB68	n/a	No evidence of breeding	Evidence of nesting activity
NB69	n/a	No evidence of breeding	No evidence of breeding
NB71	n/a	No evidence of breeding	No evidence of breeding
NB76	n/a	No evidence of breeding	Evidence of nesting activity
NB77	n/a	No evidence of breeding	Evidence of nesting activity
NB78	n/a	No evidence of breeding	No evidence of breeding
NB79	n/a	No evidence of breeding	No evidence of breeding
NB99	n/a	No evidence of breeding	No evidence of breeding
NB100	n/a	n/a	Evidence of nesting activity