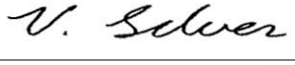
Microbat Management Plan Sections 3 to 11

Woolgoolga to Ballina Pacific Highway upgrade

April 2015

Certification

	Name	***Signature***	***Date***
Prepared by	Veronica Silver		23/03/2015
Reviewed by	Adam Greenhalgh		23/03/2015

UPR	***Description***	***Date Issued***	***Issued By***
2373-1010	Version 1	23/03/2015	VJS
2373-1019	Version 2	21/04/2015	VJS

Table of Contents

Illustrations

Tables

Plates

Appendices

1. Introduction

1.1 Project Overview and Background to the Plan

The Pacific Highway Upgrade Program is a joint commitment by the Australian and New South Wales governments to improve the standard and safety of the Pacific Highway between Hexham and the Queensland border.

An Environmental Impact Statement (EIS) has been prepared (NSW Roads and Maritime Services, 2012) for the Woolgoolga to Ballina Pacific (W2B) Highway upgrade project (referred to hereafter as W2B or the Project). The Project was approved under the NSW *Environmental Planning and Assessment Act 1979* on 24 June 2014 and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* on 14 August 2014.

W2B extends over approximately 155 km from the northern end of the Sapphire to Woolgoolga Pacific Highway upgrade (S2W) (approximately 6 km north of Woolgoolga to the Ballina Bypass (approximately 6 km south of Ballina). It is broken up into eleven sections as outlined in **Table 1.1**.

Table 1.1 Woolgoolga to Ballina Sections

Section Number	*Location Description*	*Stations*	*Length (km)*
1	Woolgoolga to Halfway Creek	0-16.5	16.5
2	Halfway Creek to Glenugie Upgrade	16.5-31.4	14.9
3	Glenugie Upgrade to Tyndale	33.8-68.8	35
4	Tyndale to Maclean	68.8-82	13.2
5	Maclean to Illuka Road, Woombah	82-96.4	14.4
6	Illuka Road to Devils Pulpit	96.4-105.4	9
	Devils Pulpit	105.4-111.1	5.7
7	Devils Pulpit Upgrade to Trustums Hill	111.1-126.4	15.3
8	Trustums Hill to Broadwater National Park	126.4-137.6	11.2
9	Broadwater National Park to Richmond River	137.6-145.1	7.5
10	Richmond River to Coolgardie Road, Wardell	145.1-158.6	13.5
11	Coolgardie Road to Ballina Bypass	158.6-164	5.4

This Microbat Management Plan relates to Sections 3 to 11.

GeoLINK was engaged by NSW Roads and Maritime Services (RMS) to undertake targeted microbat surveys of existing drainage structures (culverts and bridges) associated with the Project. As such, in accordance with Section 5.3.5 of the Threatened Mammal Management Plan (TMMP) (RMS, 2013), the survey results have triggered the requirement for a Project Specific Bat Management Plan which provides details regarding provision of artificial roosting structures, exclusion procedures prior to demolition works and monitoring procedures. Artificial roosting structures are only considered necessary for high or medium conservation/ habitat value drainage structures that require removal or disturbance as part of the Project. Low conservation/ habitat value drainage structures of similar value to those requiring demolition are locally common and/ or would be duplicated by culverts and bridges on the new highway upgrade. The categorisation of conservation/ habitat values was based on survey

results in relation to potential microbat roosting habitat, species presence and evidence of usage present as well as representativeness of each drainage structure.

1.2 Pre-construction Surveys

Microbat surveys were undertaken by GeoLINK within Sections 3-11 in July 2014 (winter), October-November 2014 (spring) and February 2015 (summer). In addition to this, microbat surveys were also undertaken within Sections 4 and 5 soft soil treatment sites (SSTS) by GeoLINK in November 2013 and February 2014.

Four target threatened species were identified in the TMMP. One target species, Large-footed Myotis (*Myotis macropus*), listed as Vulnerable under the NSW TSC Act, has two breeding events per season in Northern NSW (Lloyd et al., 1999; Van Dyck and Strahan, 2008; Churchill, 2008). November was chosen to maximise detection of breeding activity as it coincides with the first breeding event of the season (Lloyd et al., 1999; Van Dyck and Strahan, 2008). Pre-construction winter surveys were recommended by Schulz (2013) as part of the TMMP peer review. These surveys aim to address seasonal variations in microbat roost behaviour and in particular, identify important winter roost sites (e.g. for threatened bentwing-bats). Surveys were therefore undertaken within each season including two in the breeding season.

A total of 119 structures were surveyed during the winter survey period in July 2014. On completion of these surveys 62 structures were assigned to the High, Medium or Low categories were surveyed again during the spring survey period in October – November 2014. Upon completion of the spring surveys a total of 39 drainage structures (26 culverts and 13 bridges) that were assigned to the High, Medium or Low categories were surveyed again in the summer survey period on the 3, 5 and 11 February 2015, coinciding approximately with the second Large-footed Myotis birthing event of the breeding season. A summary of the total number of drainage structures surveyed over current and previous survey periods is shown in **Table 1.2**.

Table 1.2 Summary of Numbers of Drainage Structures Surveyed

Section	*Number of Drainage Structures Surveyed in July 2014*	*Number of Drainage Structures Surveyed in October-November 2014*	*Number of Drainage Structures Surveyed in February 2015*
3	6	2	0
4	4	4	3
5	23	18	11
6	16	12	9
Devils Pulpit	12	2	2
7	38	15	10
8	7	2	2
9	4	1	0
10	4	2	2
11	5	4	0
TOTAL	**119**	**62**	**39**

Characteristics of the high, medium and low conservation/ habitat value categories are provided in **Table 1.3**.

Table 1.3 Drainage Structure Conservation/ Habitat Value Categories

Conservation/ Habitat Value Category	***Criteria***
High	Known to provide breeding habitat for threatened species (i.e. Large-footed Myotis); or Known to provide non-breeding roosting habitat for large numbers (ie. >50) of threatened species (e.g. known to support large numbers of bentwing-bats over winter); or Supports one or more of the federally listed Large-eared Pied Bat.
Medium	Does not satisfy high conservation/ habitat value category; Provides non-breeding roosting habitat for small numbers (ie. <50) of threatened species; or Medium to large guano accumulations and/ or stains present indicative of the occurrence of moderate numbers of microbats or medium to long-term usage (threatened/ non-threatened status unknown); or Potentially suitable for breeding Large-footed Myotis. For example, access under bridge/ into culvert >500 mm diameter, presence of large cavities (e.g. >20 mm wide and >100 mm deep), directly adjacent to/ over open water, low inundation susceptibility; or Supports protected cavities providing good potential long term roosting habitat; however, no bats or evidence of roosting bats present; and/or In proximity to open surface water, however provides mainly exposed roosting opportunities (e.g. cavities <50 mm deep, or rough concrete), offering limited potential for breeding roosting; and/or Supports a breeding colony of non-threatened microbats.
Low	Does not satisfy high or medium conservation/ habitat value categories; and Individual microbats or very small numbers of non-breeding microbats (e.g. <5) present; or Small guano accumulations and/ or stains present indicative of the occurrence of small numbers of microbats or short-term usage; or Provides mainly exposed roosting opportunities (e.g. cavities <50 mm deep, or rough concrete) offering limited potential for use as breeding habitat; or Not in proximity to open water. Roosting habitat of similar value locally is common and would be duplicated by culverts and bridges on the new highway upgrade.

1.3 Purpose and Objectives

This management plan outlines the proposed management measures to be implemented for the subject microbats and their habitat and provides a program for monitoring of the effectiveness of these measures. The objective of the management plan is to provide measures that minimise impacts to microbats associated with the Project. More specifically, the management plan aims to:

- reduce the potential for injury or death to microbats as a consequence of the proposed works by discouraging microbats from occupying the subject drainage structures at the time of the construction works;
- provide temporary alternative habitat for excluded microbats during the proposed works; and
- provide permanent replacement habitat within the drainage structures for microbats.

This Project Specific Microbat Management Plan details:

- Alternative roosting habitat designs, locations and timing of installation;
- Methods and timing of monitoring pre, during and post construction;
- Exclusion techniques and management; and
- Provisions for an Ecologist experienced in microbat management to provide detailed input that is specific for each drainage structure at the time of works during construction phases.

The plan covers pre, during and post-construction (operational) phases of the Project and applies to the eleven drainage structures within Sections 4-7, Devil's Pulpit and Section 10 that have previously been categorised as high or medium conservation/ habitat value structures.

1.4 Management Structures and Plan Updates

This management plan has been presented using an adaptive management approach based on firstly identifying specific goals for management, implementation of management measures followed by monitoring of the performance of these measures against the goals and identified thresholds. As a final step the monitoring would evaluate the effectiveness of the management measures using identified thresholds for performance and implementing corrective actions to improve mitigation where required.

To ensure the success of this approach the management goals presented in the plan have been based on the following SMART principles:

- Specific
- Measurable
- Achievable
- Results-based
- Time-based

This Microbat Management Plan has been prepared in consultation with RMS and the NSW Environment Protection Authority (EPA). General responsibilities for environmental management would be outlined in the project specific Construction Environment Management Plan (CEMP) and CEMP sub plans including the Flora and Fauna Management Plan (FFMP). These management plans would be prepared prior to the commencement of construction. RMS and the Contractor for this Project would be responsible for implementing the measures in this Microbat Management Plan and this would include the engagement of suitably qualified specialists to undertake and oversee surveys and monitoring activities where necessary.

2. Subject Species and their Roosts

2.1 Subject Species

Four target threatened species were identified in the TMMP and are listed in **Table 2.1**. Of these, the Large-footed Myotis (*Myotis macropus*) is the only target species known to utilise drainage structures as maternity roosting habitat.

Table 2.1 Target Threatened Microbat Species

Scientific Name	*Common Name*	*Legal Status TSC Act*	*Legal Status EPBC Act*	*Roosting Habitat Requirement*	*Project Records*
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Typically requires sandstone escarpments (or occasionally volcanic rock types) to provide roosting habitat that is adjacent to higher fertility sites that are used for foraging. Roosting has also been observed in disused mine shafts, caves, overhangs and disused Fairy Martin (*Hirundo ariel*) nests. It also possibly roosts in the hollows of trees. The structure of primary nursery roosts appears to be very specific, ie. Arch caves with dome roofs with indentations (DoE 2014).	**Not recorded**. However, one record occurs within a 10 km radius of the Project footprint (RMS, 2012).
Miniopterus australis	Little Bentwing-bat	V	-	Caves, tunnels, tree hollows, abandoned mines, stormwater drains, culverts, bridges and sometimes buildings are the preferred roosting habitats (OEH 2012). Maternity colonies are restricted to specific maternity caves (predominantly limestone) (Van Dyck and Strahan, 2008). Only five nursery sites /maternity colonies are known in Australia (OEH 2012).	**Known**. One Little Bentwing-bat (*Miniopterus australis*) was observed roosting in a lifting point of drainage structure 506006 in Section 4 (SSTS) in July 2014. 262 *M. australis* were observed roosting in 17 groups between the jointing gaps of a RCPC in Section 4 in July 2014. 72 *M. australis* were also observed roosting between the jointing gaps of a RCPC in Section 5 in July 2014. 553 *M. australis* were observed roosting in 24 groups between the jointing gaps of the concrete planks of Tabbimoble Creek Bridge (BN7555) in July 2014. 166 *M. australis* were observed roosting in 11 groups between the jointing gaps of the

Scientific Name	Common Name	Legal Status TSC Act	Legal Status EPBC Act	Roosting Habitat Requirement	Project Records
					concrete planks of Tabbimoble overflow (BN7532). No maternity roost sites are known or likely within the Project footprint. 221 records within a 10 km radius of the site (RMS, 2012).
Miniopterus schreibersii	Eastern Bentwing-bat	V	-	Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures (OEH, 2012; Van Dyck and Strahan, 2008).	**Known.** 131 Eastern Bentwing-bats (*Miniopterus schreibersii*) were observed roosting between the jointing gaps of the New Serpentine Creek Bridge in July 2014. 40 *M. schreibersii* were observed roosting on rough concrete and in the expansion joins of the Old Serpentine Creek Bridge in July 2014. Individual *M. schreibersii* were also observed at Tabbimoble Overflow (BN7532), Saltwater Creek Bridge (BN2167) and the adjacent RCPC on Saltwater Creek (506170) in Section 10 in July 2014. However, no maternity roost sites are known or likely within the Project footprint. 20 records within a 10 km radius of the site (RMS, 2012).
*Myotis macropus**	Large-footed Myotis	V	-	This species prefers caves, mines, tree hollows, aqueduct tunnels and under bridges/ culverts and in dense vegetation (the latter in the tropics) in the vicinity of bodies of slow-flowing or still water (Van Dyck and Strahan, 2008). Forages over streams and pools catching insects and small fish by raking their feet across the water surface (OEH 2014)	**Known** 29 records within a 10 km radius of the site (RMS, 2012). This species has been recorded from a number of locations within Sections 5, 6 and 7 only within the project footprint during GeoLINK surveys in 2014 and 2015. Maternal roost sites have been located within the project footprint.

Notes:

TSC Act = NSW Government *Threatened Species Conservation Act 1995*.

EPBC Act = Australian Government *Environment Protection and Biodiversity Conservation Act 1999*.

V: Vulnerable under Schedule 2 of the TSC Act

Project records are based on review of Roads and Maritime Services 2012 and GeoLINK surveys in 2014 and 2015.

2.2 Microbat Roosting Habitat Features

Culvert roost features within Sections 3-11 include:

- Culvert cell joins: Ranged in habitat value from minor hold points providing exposed roosting opportunities, to deep protected cavities. Cell joins were present in most drainage structures;
- Cavities above cell joins caused by cell dislodgment and subsequent erosion of road substrate above. Present in culverts 506051 in Section 6 and culverts 506073 and 506087 in Section 7;
- Culvert cell lift holes: Varied from minor hold points providing exposed roosting opportunities, to deep protected earth cavities. Culvert lift points ranged from being rectangular to circular in shape. Present mainly in the larger (>500 mm diameter) reinforced concrete pipe culverts (RCPC);
- Rough concrete on the culvert obvert: Provide exposed roosting opportunities and were common mainly in reinforced concrete box culvert (RCBC); and
- Presence of mud bird nests (Welcome Swallow *Hirundo neoxena,* and Fairy Martin *Petrochelidon ariel*).

Bridge roost features within Sections 3-11 include:

- Cavities between concrete planks/ segments: Present at Tabbimoble Overflow Bridges, Saltwater Creek Bridge and Serpentine north bound Bridge. Provide habitat ranging from protected (though somewhat shallow) cavities to exposed roost points. Some more modern structures also have a foam filling between the planks that may provide a secure hold point for roosting microbats.
- Cavities around piers/ headstocks: Present at Mororo Bridge and provide mainly exposed roosting opportunities.
- Rough concrete, concrete ledges and concrete angles: Present on Tabbimoble Overflow Bridges and provide exposed roosting opportunities.
- Cavities behind the approach and departure spans at Old Serpentine Creek Bridge: Provide culvert like roost features, with rough concrete ledges and angles providing roost points.
- Blocked scuppers: Present at Mororo and Old Serpentine Bridge may also provide suitable roosting habitat for microbats.

Bird nests (Welcome Swallow *Hirundo neoxena,* and Fairy Martin *Petrochelidon ariel*) and mud dauber wasp nest were observed at a number of locations within both bridges and larger drainage structures and provide mostly exposed (non-breeding) roosting opportunities.

The majority of drainage structures surveyed supported potential suitability for maternity roosting sites. These features are typical of road drainage structures and would be replicated through installation of drainage features as part of the Project.

2.3 Subject Drainage Structures

Subject drainage structures are those that have been assigned a conservation/ habitat value of medium or high (refer to **Table 1.2**). Details of the subject drainage structures are provided in **Table 2.2** and their locations are shown in **Illustration 2.1**.

Table 2.2 Subject Drainage Structures

Section	Chainage	Ref No.	No of Cells	Height or Dia (mm)	Feature Type	Action	Conservation/ Habitat Value
4	82020	506007	1	1,230	CPC	Extend or remove	High
5	82300	506008	1	1,500	CPC	Extend or remove	High
5	89370	A3	-	-	Concrete bridge cast in-situ	Likely retain	Medium
5	89400	A2	-	-	PPLNK	Retain	High
5	94090	2154	-	-	STRUS	Retain	High
5	94090	8297	-	-	PTROG	Retain	High
6	101610	7555	-	-	PPLNK	Likely retain	High
6	102900	7532	-	-	PPLNK	Likely retain	High
Devils's Pulpit	106190	9507	6	1,500	CPIPE	Retain	Medium
7	122280	2161	3	1,500 mm high x 2,740 mm wide + one cell 1,800 mm high	CCULV	Likely remove (could extend)	Medium
10	157400	2167	3	2,050 mm high x 2,740 mm wide.	CCULV	Retain	Medium

As indicated above, only three of the eleven structures that have been assessed as high or medium conservation/ habitat value would likely be directly impacted by the Project through extension or replacement. The eight drainage structures likely to be retained would be incorporated into the monitoring program to provide control sites. Detailed design has not been completed to date, therefore the distance of works to each drainage structure to be retained is unknown hence the control sites may vary in their significance.

2.4 Impacts to Microbats

The Project is anticipated to have the following potential impacts on microbats:

- Loss of roosting and breeding habitat;
- Loss of foraging habitat and reduced prey abundance;
- Reduced breeding output;
- Habitat fragmentation; and
- Injury/ mortality to individuals from construction works.

2.5 Goals for Management

The main goals for management are as follows:

- Low number of injuries/ mortality to roosting microbats from construction activities;
- Provide replacement roosting habitat within the newly constructed drainage structures; and
- Observe uptake, breeding and persistent use of replacement roosting habitat.

Illustration 2.1 Subject Drainage Structures

3. Management Measures

3.1 Overview

In general, management measures involve the following main components:

1. Temporary replacement habitat;
2. Exclusion of bats;
3. Creation of permanent cave-dwelling roost habitat within newly constructed drainage features;
4. Monitor; and
5. Implement corrective actions.

3.2 Temporary Replacement Habitat

3.2.1 Bat Box Installation

Bat boxes provide alternate roost habitat for microbats (specifically Large-footed Myotis) that are excluded from their current roost as a result of the Project and are regarded as a temporary measure provided prior to and during construction until roosts within their preferred habitat is replaced (ie. gaps in culverts and bat boxes beneath bridges/ in culverts etc). If microbats inhabit the bat boxes however, they would be left in place post-construction. Installation of bat boxes would be undertaken or supervised by an Ecologist with experience with microbats. Bat boxes that are attached to trees would be installed so as to not impede sap flow. Each bat box would be given a unique identification number and the location accurately recorded. The following attributes would be recorded when installing bat boxes and provided to RMS in an excel spreadsheet:

- Date installed;
- Identification code. This code is to be consistent with bat boxes installed within Sections 1 and 2, therefore this code would start with MMP and number consecutively from 36 (as MMP 1-28 have been installed within Sections 1 and 2 and MMP 30-35 have already been installed within Section 5).
- Easting and northing (GDA 94);
- Name of closest drainage line;
- Box type (eg. four-chambered, tree mounted, lattice, two-chambered etc.)
- Aspect of box on tree or structure;
- Tree species (if relevant);
- Tree health (if relevant);
- Diameter at breast height (DBH) of tree upon which box is mounted;
- Box height above ground;
- Distance to water (ie. directly above water, 10 m from creek etc).

3.2.2 Bat Box Design

Variation is required in the design of boxes being used at any one location. Boxes of different designs would increase the chances of uptake, address seasonality and thermoregulatory considerations and address the fact that bats are known to regularly change roost locations.

The following designs are recommended:

- Light weight concrete bat boxes;
- Large (four-chambered) hanging bat boxes;
- Lattice style bat boxes; and
- Tree mounted bat boxes (least preferred due to behaviour and habitat preferences of cave-dwelling microbats). If tree mounted bat boxes are installed, these must be in close proximity to water if not over hanging water.

Bat boxes can be tailor made or sourced from Hollow Log Homes (http://www.hollowloghomes.com) or similar company that can ensure a robust structure.

If bat boxes are custom made they need to meet the following criteria:

- Constructed of hardwood or marine grade ply;
- Re-enforced with bracing;
- Variable width gaps (2-6 cm);
- Removable (able to be relocated to new drainage structures);
- Roughed/ grooved timber;
- Different length landing pads; and
- Gaps at the top of the wedges/ slats to allow microbats to move between the cavities.

Based on previous observations of microbat behaviour, lattice style boxes are recommended as they can allow for larger colonies and therefore increased ability to thermoregulate and breed.

3.2.3 Bat Box Placement

Placement of bat boxes is critical to their successful uptake. The most important feature is proximity to water. The bat boxes need to be above or as close to water as possible (refer to **Plate 3.1**). The location of bat boxes needs to satisfy the following criteria:

- Shaded location overhanging >100 mm of surface water;
- >2 m above ground (ideally 3-4 m unless directly over a deep, permanent water body);
- Recipient tree considered robust and in good health;
- On land outside the Project clearing limits (where possible); and
- Within RMS road reserve or adjacent private land with an agreement.

In the case where the drainage structure is to removed or extended, at least one temporary bat box would be installed in order to give bats the opportunity to familiarise themselves with the new bat box

structures thereby potentially enhancing uptake following exclusion. These bat boxes would then be moved to a predetermined location during exclusion.

3.2.4 Timing of Bat Box Installation

It is important that time is provided for microbats to recognise the presence of the bat boxes and the potential roosting opportunity they offer prior to microbat exclusion being implemented. Therefore, every attempt would be made to maximise the time between installation of bat boxes and exclusion of microbats from the subject drainage structures. It is preferable to install bat boxes up to 12 months in advance to give microbats time to locate and 'accept' the new structures as a viable roost.

Timing of bat box instalment relative to exclusion and demolition would be recorded. The duration of the lead time would be evaluated and communicated should this appear to be a factor influencing uptake of bat boxes.

3.2.5 Numbers of Bat Boxes

Based on surveys undertaken in July 2014 (winter), October-November 2014 (spring – birthing event 1) and February 2015 (summer – birthing event 2), numbers of bat boxes required at each of the subject drainage structures to be removed or extended are provided in **Table 3.1**. These calculations acknowledge that surveys have only been undertaken in three seasons over eight months therefore a 15% safety factor has been added. They also assume occupation by 20 microbats per wedge in a four-chambered bat box. One lattice style bat box (1 m x 0.3 m x 0.4 m – refer to **Section 3.4.2**) however is regarded as equivalent to three x four-chambered bat boxes.

Table 3.1 Number of Bat Boxes for Drainage Structures to be Directly Impacted

Section	Chainage	Reference No./ ID	Number of Bat Boxes
4	82020	506007	4#
5	82300	506008	2#
7	122280	2161	1

Miniopterus australis and *M. schreibersii* have been observed within concrete structures and are not known to occupy timber bat boxes. It is therefore proposed that concrete boxes/ concrete structures to the same carrying capacity be installed at these locations.

The number of bat boxes required for those structures proposed to be retained are also provided in **Table 3.3** as a precautionary measure if the proposed actions listed within **Table 2.2** change following the detailed design.

Table 3.2 Number of Bat Boxes Required IF Drainage Structures are Not Retained

Section	Chainage	Reference No./ ID	Number of Bat Boxes
5	89370	A3	2*
5	89400	A2	4^
5	94090	2154	4
5	94090	8297	4+
6	101610	7555	8#
6	102900	7532	3# and 1
Devils's Pulpit	106190	9507	1
10	157400	2167	1

* The following bat boxes were erected at drainage structure A3 (Old Serpentine Creek Bridge) on 4th March 2015:

MMP 31: wedge style box on mangrove east of Old Serpentine Creek Bridge.

MMP 35 part of lattice box installed under 1st span from the north, on Old Serpentine Creek Bridge, a large amount of guano in this location.

^ The following bat boxes were erected at drainage structure A2 (New Serpentine Creek Bridge) on 4th March 2015:

MMP 30: four-chambered hollow log homes style box on a mangrove west of the new Serpentine Bridge.

MMP 32: wedge style box on mangrove in between 2 bridges.

MMP 33: larger part of lattice box installed under 2nd span from the north on New Serpentine Creek Bridge, box over water during high tide.

MMP 34: part of lattice box installed under 3rd span from the north on New Serpentine Creek Bridge, box over water during high tide.

\+ The structure of the south bound Mororo Bridge itself does not provide suitable microbat habitat (Super-T structure). The large numbers of microbats observed under this bridge have been recorded in four bat boxes which were installed in 2013 as part of a separate project.

3.2.6 Bat Boxes and Nest Box Management Plans

Bat boxes provided under this microbat management plan are regarded as additional items to the nest box management plans prepared for each section as follows:

- Section 1 by Biosis
- Section 2 by Ecosure
- Section 3, 4 and 5 by GeoLINK
- Section 6 by AECOM
- Section 7 by Biosis
- Section 8 & 9 by Melaleuca Group Pty Ltd
- Section 10 & 11 by Australian Museum Consulting

3.2.7 Blind Culvert

An experimental structure in the form of a blind culvert can be used to provide an alternate roost for Little Bent-wing Bats who prefer concrete structures (pers. obs). The blind culvert would comprise the following:

- 2.4 m long CPC;
- 1.2-1.5 m diameter;
- positioned horizontally;
- blocked at one end;
- covered with compacted soil for insulation and to avoid scouring;
- invert grooved to collect water;
- close to water source;
- entrance open to a south-westerly aspect (if possible) to reduce amount of light and wind entering;
- fitted out with concrete blocks or a recessed chamber (refer to **Section 3.4.5**).

This culvert would be installed pre-construction or in the early stages of construction to maximise compensation.

A 'bat cave' was installed as part of the Tintenbar to Ewingsdale Pacific Highway Upgrade (north of the subject sections) to provide compensatory microbat habitat. The 'blind culvert' recommends improvements from lessons learnt from the bat cave as it would more closely replicate existing habitat that microbats have been observed to inhabit. A pipe on its side within the earth would provide insulation as well as temperatures and humidity preferred by microbats rather than a vertical pipe or 'bat cave'.

3.3 Roost Exclusion

Exclusion of microbats from roost sites would only be necessary at the subject drainage structures requiring direct works (ie. removal or extension). As indicated in **Table 2.2**, these are drainage structures 506007 within Section 4, 506008 within Section 5 and 2161 in Section 7. As the detailed design has not been finalised however there is possibility that other drainage structures (listed within **Table 2.2**) may be removed or extended due to design modifications and therefore require exclusion,

provision of temporary replacement habitat as well as provision of permanent cave-dwelling roost habitat.

3.3.1 Timing of Exclusion

Exclusion of microbats from the subject drainage structures is required to enable construction works to be undertaken at any time of the year. If microbats were not excluded, works on the subject drainage structures would need to be undertaken outside the typical breeding period for the Large-footed Myotis (breeding between early October to mid-April) and also avoid over-wintering periods for Little and Eastern Bent-wing Bats. This would limits works to approximately September and May of each year which is impractical.

The exclusion component of this Microbat Management Plan must only occur the season before works at each subject drainage structure between late August and early October or between mid-April and end of May which would avoid the breeding season and overwintering periods for subject microbats. Furthermore, planned roost exclusion would not occur during forecast periods of heavy rain (>20 mm in 24 hours according to the Bureau of Meteorology).

Large-footed Myotis is the only target species known to utilise drainage structures as maternity roosting habitat. The potential for injury and death to Large-footed Myotis would be much higher during the breeding period due to the presence of dependant young and/ or juveniles. Dependant young are less likely to vacate the roost and there is a high risk that juveniles would be abandoned in the roost by adults.

Exclusion devices would need to be periodically monitored for effectiveness in excluding bats, especially following flood events. This could be undertaken by a works contractor who would check that there are no gaps or breakages in the exclusion device that could allow entry by microbats.

3.3.2 Exclusion Methodology for Culverts

Roost exclusion would involve the Project Ecologist inspecting the roost prior to the dusk fly-out to identify if microbats are present and where they are roosting. Exclusion devices would then be installed in culvert cells confidently identified as being bat free.

For culvert cells with small numbers of bats (<15) that are able to be captured, the Project Ecologist would capture and later release the microbats at dusk as detailed in **Section 3.6.1**, once the exclusion devices are installed.

Culvert cells with medium to large numbers of roosting bats (or that are unable to be confidently identified as bat free) would then be inspected one hour after the first bat emerges (to ensure the peak activity associated with emergence has passed), by an Ecologist with microbat experience to confirm that no microbats are present. Once this is confirmed, exclusion devices would be deployed. Exclusion structures would be deployed gradually (ie. one cell each night, or specific sections of bridges) to encourage bats to find roosting sites elsewhere, limiting the number of bats 'caught short' and potentially roosting in inappropriate locations. Exclusion structures that allow bats to exit but not re-enter would be used at roost sites where small numbers of bats that have not flown out and cannot be captured by the Ecologist remain or where it is not possible to confidently identify the roost site as bat free due to the roost cavity structure.

Exclusion devices comprise a combination of the following depending on the specific habitat features at each site:

- Plastic sheeting;
- Gap filler or expandable foam;
- Marine grade plywood secured with screws;
- One-way flap (for small cracks, fissures or lifting holes).

The plastic sheeting exclusion option comprises a thick, slippery plastic sheet attached to the headwall to exclude bats (refer to **Plate 3.2**). An example of suitable plastic sheeting previously been used for this purpose is 'Enviroguard' sourced from Burwell Technologies: http://www.burwell.com.au/catalogue/containmentscreen/Enviroguard. Care needs to be taken to ensure bats cannot land on the headwall and crawl along the concrete and under the exclusion device. One disadvantage of plastic sheeting is that it obstructs the fly-way however it is effective in excluding microbats from all crevices within the drainage structure.

Gap filler or expandable foam, would need to completely fill the gap therefore would only be suitable for gaps <5 cm deep and only in horizontal gaps (ie. the side walls of box culverts). Where the gap cannot be completely sealed (i.e. due to an obscure cavity), ply-wood secured with adhesive/ screws or one-way plastic flaps would be installed. One disadvantage of gap filler (or equivalent) is that microbats can still grip the foam and use it as an exposed hold point. Furthermore, it is messy and contact must be avoided by all fauna until it has dried.

Plywood screwed into the concrete is an effective way of excluding bats from large gaps or those that are along a straight surface such as within a RCBC or bridge (refer to **Plate 3.3**). Plywood needs to be marine grade or form ply which have smooth surfaces preventing microbats from holding on and do not warp following inundation by water. This method can be used in conjunction with gap filler and is best utilised in areas where the size of the gap exceeds the working limit of the gap filler (refer to **Plate 3.4**). Securing the plywood with adhesive (ie. liquid nails) has been found to be ineffective due to the weight of the plywood and the time needed for the adhesive to set.

Installation of the one-way flap involves attaching (screwed into concrete with timber support - refer to **Plate 3.5**) a plastic shield over the exit hole/ gap, extending at least 80 mm from the hole to ensure a non-grip surface (Temby 2012). Then hang a flap of plastic sheeting over the exit point, so that bats can leave but not re-enter. If there is to be a significant delay between exclusion and proposed works, re-inspect the one-way plastic flaps 48 hours after installation with torch and endoscope and decommission with expandable foam or equivalent. One-way plastic flaps would be used where a cavity cannot be fully inspected.

It should be noted that Shultz (2013) also recommends that all abandoned Fairy Martin nests should be destroyed if unoccupied at the time of planned exclusion.

There are advantages and disadvantages for each exclusion methodology therefore the Project Ecologist would recommend which of the above listed exclusion methodologies would be used at each site at the time of exclusion. If exclusion is not effective, a thermal imaging camera or night vision scope would be used to observe microbats to determine where the breach is occurring. Actions would be undertaken to remedy any breaches or improve the methodology (eg. temporary installation of a string of lights inside the cells).

The Project Ecologist would inspect the exclusion devices and drainage structure on the morning after exclusion to ensure microbats are not roosting in vulnerable locations. The bat boxes would also be inspected at this time to check if microbats relocated to these structures.

Plate 3.1 Plastic sheeting at Binna Burra (Source: V Silver)

Plate 3.2 Plywood blocking a lift hole at Halfway Creek culvert (Source: V Silver)

Plate 3.3 Plywood, liquid nails and expandable foam beneath Mororo Bridge (Source: D Andrighetto)

Plate 3.4 One way flap secured with timber at Halfway Creek culvert Source: V Silver)

3.3.3 Exclusion Methodology for Bridges

Timing of exclusion must be in accordance with that outlined in **Section 3.3.1**.

The methodology would initially involve blocking crevices, scuppers and gaps using the methodologies listed in **Section 3.3.2** (ie. plywood, gap filler and one-way valves) and progress to plastic sheeting, if required (refer to **Plates 3.6** and **3.7**). An example of a suitable plastic sheeting previously been used for this purpose is 'Enviroguard' sourced from Burwell Technologies: http://www.burwell.com.au/catalogue/containmentscreen/Enviroguard. The Project Ecologist would guide this procedure. The approach that has had the least bats recorded would be excluded first so as to start gradually. Exclusion devices would be installed during the daytime where low numbers (<20)/ no microbats are present.

Table 3.3 Exclusion Process for Bridges if Large Numbers of Microbats are Present

Exclusion steps: task	***Exclusion steps: responsibility***	***Exclusion steps: Procedure***
Monitor bat boxes in adjacent habitat	Project Ecologist	Check bat boxes in adjacent habitat to determine if occupied or not. This information is important to determine if excluded microbats then relocate to these structures.
Observe fly-out	Project Ecologist	Watch from bank (using binoculars).
Install exclusion devices	Project Ecologist with assistance from Contractor	Gradually exclude bats from the bridge starting with the least used areas to encourage microbats into the boxes. Dependent upon the number of microbats present, this may be undertaken over two-three nights however staged exclusion is not required if no or only small numbers (<20) of bats are present.
Monitor exclusion devices	Project Ecologist	Watch from bank to see if microbats return (using binoculars, spotlight and/ or thermal imager). Note if bats were able to re-gain access. Identify where breaches occur. Check for microbats roosting in unsafe areas as a result of exclusion. On final night of exclusion, remove microbats roosting in unsafe (exposed) areas and place in bat boxes.
Modify exclusion devices (if required)	Contractor under guidance of Project Ecologist	Wrap sections in plastic.
Confirm exclusion successful	Project Ecologist	Check bat boxes in adjacent habitat to determine if excluded microbats relocated to these structures. Physical inspection for microbats on the day before and the morning of demolition work.
Where relevant, relocate bat boxes to newly constructed bridge following its completion	Project Ecologist with assistance from Contractor	Depending on timing of exclusion (undertaken between late August and early October or between mid-April and end of May) there may be a delay between exclusion and relocation of the bat box. Pre-drill holes in the newly constructed bridge with

Exclusion steps: task	Exclusion steps: responsibility	Exclusion steps: Procedure
		chem-set bolts in place ready to receive the bat box structure. Cover the openings of the existing bat box to be removed with a breathable material (eg. geofabric/ hessian). Gently transport the bat box to its new location (positioned as close to water as possible, in a corner of the bridge with low light safe from predators).

Plate 3.5 Exclusion Option – Plastic wrap bridge (Source: A Lloyd)

Plate 3.6 Exclusion – Plastic over scuppers (Source: D Andrighetto)

3.4 Create Permanent Cave-dwelling Roost Habitat

A series of 'in culvert' design modifications are proposed for the replacement drainage structures to promote and replace insitu habitat. For each subject drainage structure, the alterative roosting habitat provided would have a minimum carrying capacity of the existing structure. These features are essential at the subject high and medium conservation/ habitat value drainage structures however are also recommended elsewhere where new drainage structures provide good microbat roost opportunities. Despite bat boxes being included as 'permanent cave-dwelling roost habitat', it is acknowledged that these may become weathered and damaged. It is therefore important that the full suite of 'in culvert' design features are implemented to ensure permanency of provision of microbat habitat.

3.4.1 Maximum Jointing Gaps

Microbats were frequently observed roosting in jointing gaps of RCBCs and CPCs during surveys undertaken for the Project. These ranged in habitat value from minor hold points providing exposed roosting opportunities, to deep protected cavities. Cell joins were present in most drainage structures. It is therefore recommended to replicate this situation and ensure that all CPCs and RCBC in the vicinity of medium and high conservation habitat structures are laid with maximum jointing gap allowance (as specified by manufacturer).

3.4.2 Bat Boxes within Drainage Structures

Following completion of works on the new drainage structures, bat boxes would be installed. The bat boxes that were erected in adjacent vegetation prior to exclusion would be moved into the drainage structures only if microbats have not taken to these boxes. If microbats have occupied the boxes in adjacent habitat, then these would remain insitu and new boxes would be installed within the drainage structures. It is essential that the identification number of the bat boxes that are retained insitu and those that are relocated are accurately recorded.

A bat box (approximately 30 cm x 40 cm) within a RCBC (ranging between 2.4 m x 3 m to 3 m x 3 m) would occupy approximately 1 % of the cross sectional area of the RCBC. As such, it is assumed that the bat boxes would have a negligible impact on the hydraulic function of the drainage structure.

A variety of designs are once again proposed to increase the chances of uptake. These include:

- Hanging four-chambered bat boxes with bash plate to deflect any debris and reduce damage during a flood event (refer to **Plates 3.8**);
- Light weight concrete blocks (Hebel) with holes drilled to create cavities (refer to **Plates 3.10** and **3.11**); and
- Lattice style bat boxes (refer to **Plates 3.12** and **3.13**).

Plate 3.7 Bat boxes with bash plate beneath Myott Bridge (Source: A Lloyd)

Plate 3.8 Installation of bat boxes beneath Mororo Bridge (Source: D Andrighetto)

Plate 3.9 Lightweight concrete blocks with drill holes, microbat visible in chamber (Source: N Williams)

Plate 3.10 Lightweight concrete beneath bridge (Source: N Williams)

Plate 3.11 Lattice style bat box beneath Halfway Creek Bridge occupied by Large-footed Myotis (Source: V Silver)

Plate 3.12 Lattice style bat box under Halfway Creek Bridge (Source: V Silver)

3.4.3 Roughed Concrete Obvert

Microbats were frequently observed roosting on areas of rough concrete on the obvert of RCBCs and CPCs during surveys within W2B Sections 3 to 11 undertaken over winter 2014 and spring/ summer 2015 for the Project. It is acknowledged that these areas provide exposed roosting opportunities however were common throughout. In order to minimise impacts to flow regimes, roughened concrete would be implemented in the middle third of the drainage structure >900 mm diameter for a width of approximately 30 cm. Several options are available to roughen obverts of replacement CPCs and RCBCs:

- Sponge the obvert during manufacturing;
- Spray the obvert with a sand/ cement mixture;
- Paint on a sand/ cement/ epoxy mixture;
- Sandblast the obvert of the drainage structure;
- Apply shotcrete.

3.4.4 Lift Holes

Culvert cell lift holes vary from provision of minor hold points providing exposed roosting opportunities, to deep protected earth cavities. Lift holes ranged from rectangular to circular in shape and the relative depths ranged from 20 mm to 200 mm. It is recommended that lift holes are not capped or filled.

3.4.5 Recessed Chambers

A recessed chamber in the form of a manufactured man hole would provide bats with a well-insulated replacement cavity that would provide a safe roosting location. Recessed chambers are only recommended within CPCs, due to structural reinforcing being compromised within the obvert of a RCBC. The recessed chamber would be located approximately one third of the way through the culvert at the outlet end (as pools of water are often present at the outlet rather than inlet). The CPC would have a pre-fabricated hole the size of the man hole (chamber) and would be fitted with four-chambered hanging bat boxes (refer to **Plate 3.14**).

Plate 3.13 Recessed chamber with bat boxes (Source: V Silver)

3.4.6 Fauna Underpasses

The Project design includes fauna underpasses to allow for safe passage of fauna crossing the Pacific Highway. Although these fauna underpasses have not specifically targeted microbats, it is recommended that bat boxes be installed and design modifications such as laying pipes or box cells with maximum jointing gap (as specified by manufacturer) be included at these locations. This design feature is important to cater for flyways of low-wing loading bat species (in particular Little Bentwing Bat and Large-eared Pied Bat) which are unlikely to traverse the open space created by the upgraded highway footprint (Shultz, 2013). Fauna underpasses also need to allow for open airspace above furniture to be free of obstacles.

3.4.7 Bridge Roost Features

Bridge roost features would replicate those currently being utilised by microbats where possible. This would include maximising cavities between concrete planks/ segments and around piers/ headstocks and replicating areas of rough concrete, concrete ledges and concrete angles.

3.4.8 Maintenance

Shultz (2013) recommends that RMS employees and contractors be educated and advised not to remove disused Fairy Martin nests or mud dauber wasp nests on the ceiling and sides of culverts or bridges post construction as these provide roosting habitat for at least three of the cave-dwelling bat species. Contractors need to ensure that flyways under bridges and water bodies are not obstructed and bat boxes are not disturbed. Required repairs would be identified at the time of monitoring (biannual within summer and winter for six years - refer to **Section 4.3**). Damaged habitat features (bat boxes) would then be repaired or replaced as required.

3.4.9 Summary of Management Measures

As previously noted, provision of a variety of types of replacement habitat would increase the chances of uptake by microbats. Furthermore, the alterative roosting habitat provided would have a minimum carrying capacity of the existing structure. **Table 3.4** summarises the management measures required at each of the subject drainage structures.

Table 3.4 Summary of Permanent Cave-dwelling Roost Habitat

Section	*Chainage*	*Ref. No./ ID*	*Management Measures*
4	82020	506007	Install four bat boxes in adjacent vegetation. Exclusion as per **Section 3.3**. Roughened concrete obvert. Maximum jointing gaps (as per manufacturer's specifications). Note: The alterative roosting habitat provided would require a minimum carrying capacity of the existing structure. Existing culvert has 17 cell joints. Unused bat boxes from surrounding vegetation would be relocated within the drainage structure once construction is complete. At least four bat boxes (combination of lattice, concrete blocks and hanging bat-boxes) positioned within the new drainage structure. Monitoring.
5	82300	506008	Install two bat boxes in adjacent vegetation. Exclusion as per **Section 3.3**. Roughened concrete obvert. Maximum jointing gaps (as per manufacturer's specifications). Unused bat boxes from surrounding vegetation would be relocated within the drainage structure once construction is complete. At least two bat boxes (combination of lattice, concrete blocks or hanging bat-boxes) positioned within the new drainage structure. Monitoring
5	89370	A3 (Old Serpentine Creek Bridge)	Two bat boxes currently installed at this bridge. Monitoring
5	89400	A2 (New Serpentine Creek Bridge)	Four bat boxes currently installed at this bridge. Monitoring.
5	94090	2154 (North bound Mororo Bridge)	Monitoring.
5	94090	8297 (South bound Mororo Bridge)	Monitoring.

Section	Chainage	Ref. No./ ID	Management Measures
6	101610	7555	If not retained, install eight bat boxes in adjacent vegetation and follow exclusion as per **Section 3.3** and create permanent cave dwelling habitat as per **Section 3.4**. Monitoring.
6	102900	7532	If not retained, install four bat boxes (combination of concrete and timber) in adjacent vegetation and follow exclusion as per **Section 3.3** and create permanent cave dwelling habitat as per **Section 3.4**. Monitoring.
Devil's Pulpit	106190	9507	If not retained, install one bat box in adjacent vegetation and follow exclusion as per **Section 3.3** and create permanent cave dwelling habitat as per **Section 3.4**. Monitoring.
7	122280	2161	Install one bat box in adjacent vegetation. Exclusion as per **Section 3.3**. Create permanent cave dwelling habitat as per **Section 3.4**. Unused bat box from surrounding vegetation would be relocated within the drainage structure once construction is complete. At least one lattice style bat boxes positioned within the new drainage structure. Monitoring.
10	157400	2167	If not retained, install one bat box in adjacent vegetation and follow exclusion as per **Section 3.3** and create permanent cave dwelling habitat as per **Section 3.4**. Monitoring.

3.5 Mitigation Measures

3.5.1 Environmental Work Method Statements

Environmental Work Method Statements (EWMS) would be prepared for all construction activities potentially impacting fauna (including microbats). The EWMS would provide an opportunity to assess any risks to fauna (including microbats) from the works and to incorporate mitigation measures into work methodologies to minimise the potential for impacts. Where an EWMS identifies risks to fauna, the Project Ecologist would be consulted to provide input where necessary.

3.5.2 Inductions

An environmental induction would be prepared and delivered to all personnel involved with the construction stage works. Relevant points to be delivered in this induction in relation to microbat management are as follows:

- Presence on site (identification and potential habitat);
- Education on the potential of microbats to carry disease and that any microbat found during the works would be reported immediately to the Project Ecologist and would not be handled by an untrained or unvaccinated person;
- Clearing/ pre-clearing requirements;
- Maintenance of fly-ways;
- Location of and instructions not to disturb bat boxes or artificial roost habitat;
- Requirements for works to cease within 100 m of any unexpected microbats detected within drainage structures until authorisation has been given for works to commence from the Environmental Manager/ Project Ecologist; and
- Requirements for works to cease if microbats take flight from drainage structures during daylight hours until authorisation has been given for works to commence from the Environmental Manager/ Project Ecologist.

3.5.3 Pre-work Microbat Inspections

A suitably qualified Ecologist would undertake checks for microbats prior to works on each subject drainage structure as outlined in **Table 3.5**.

Table 3.5 Pre-work Microbat Inspection Methodology – procedure

Action	Timing	Responsibility	Procedure
Pre-work microbat inspection	One day prior to starting work on the subject drainage structure and on the day of work.	Project Ecologist/ Contractor	Check the drainage structure for the presence of microbats.

Table 3.6 Pre-work Microbat Inspection Methodology – mitigation steps

Outcome of inspections	Response	Timing	Responsibility	Steps/ Notes
Bats not present	Proceed with work.	-	Contractor	-
Bats present	Contact Environmental Manager/ Project Ecologist and decide: avoid microbat/s by working elsewhere; exclude after dusk fly-out; or remove microbat/s.	Prior to any work	RMS site supervisor/ Project Ecologist to remove microbat/s	Handling of microbats only in accordance with s132c licence and **Section 3.6.1**.

3.5.4 Management Measures for Drainage Structures being Extended if >20 Microbats are Present

The following management measures would be implemented at drainage structures that are extended:

- Restrict pedestrian access to the drainage structure (limited to essential entry only);
- No vehicular access within the existing drainage structure;
- Sandbag water within the existing drainage structure to trap water (which is an essential requirement for microbats) for the duration of construction;
- Install a temporary barrier in the form of a series of geofabric/ plastic sheets on the end of the drainage structure between the works area and the microbats which is to be extended to be lowered during daily works and raised prior to dusk daily;
- Ensure the fly-way through the drainage structure is not obstructed at night;
- Ensure water flow is re-instated following completion of works; and
- Works directly adjoining the drainage structure would be avoided during the Large-footed Myotis breeding season (ie. no works between early October and mid-April), if Large-footed Myotis are present. Further consultation would take place with EPA if works are proposed during this period.

3.6 Contingency Measures

3.6.1 Capturing and Releasing Healthy Microbats

The following methodology would be implemented if microbats are unexpectedly found in a drainage structure during works where microbats have not been excluded.

All handling of microbats would be undertaken by a qualified and vaccinated Ecologist experienced in handling bats. The Ecologist must hold an Animal Care and Ethics Committee approval and a NPWS Scientific Licence for handling native flora and fauna.

The Project Ecologist would have spare bat boxes on hand to accommodate for unexpected finds of more than ten microbats. The Project Ecologist would nominate a suitable location for the bat box to be positioned.

If less than ten microbats are encountered, the microbats would be housed in small cloth bags. Bags containing bats would be hung in a cool, dry place off the ground and out of the direct sun. Bats of the same species would be housed together with no more than three in any one bag. Large bats (head and body 80-95 mm) would not be grouped with smaller bats (head and body <75 mm) as some larger species predate on smaller species. The Ecologist is responsible for releasing the bats in the evening at the site of capture.

3.6.2 Injured or Dead Microbats

If bats are unexpectedly injured during works the Project Ecologist would carefully remove the bat with a cloth bag. With a gloved hand encased within the cloth bag, gently pick up the bat and then turn the bag inside out to free the gloved hand and capture the bat. The bag would be tied off at the entrance and hung in a cool, shaded sheltered location.

The local wildlife carer group would be contacted immediately for collection of any injured bat/s captured. Options for treatment and future release would be decided at the discretion of the wildlife carer. Any costs for treatment would be the responsibility of the contractor.

If a dead or injured microbat is found during the works, the Works Supervisor and Project Ecologist must be notified immediately.

All dead microbats would be collected and retained for the Project Ecologist. The Ecologist would lodge bodies with the Australian Museum as specimens for future research and study.

3.6.3 Adaptive Procedures

It is not desirable to design a rigid plan when dealing with fauna related issues. Animals can display unpredicted or unexpected behaviour and therefore management plans such as this need to be adaptable to deal with a range of potential outcomes. The procedures of this plan may be adapted in response to factors such as pace of the works or results of inspections. Modifications to the exclusion procedure may be undertaken, for example, minor modification may be required to the exclusion devices to improve their success. The aim is to facilitate the identification of the best course of action for the particular situation, including time and logistical constraints, as well as the biological constraints posed by the microbats.

4. Monitoring Program

4.1 Monitoring Objectives

Monitoring of bat boxes, artificial habitat and design modification components would be undertaken to determine the effectiveness of the artificial habitat in terms of providing alternative microbat roosting habitat and compensating for the roosting habitat losses from the Project at high and medium conservation/ habitat value drainage structures. It would also provide useful information on breeding, age class and therefore population dynamics and population survival post-construction. The information would be useful for future RMS projects involving exclusion of microbats and provision of alternative habitat.

4.2 Pre-construction Monitoring

In accordance with the TMMP (RMS 2013) and peer review (Shultz 2013), pre-construction microbat monitoring surveys have been undertaken in winter (July-August 2014), spring (October – November 2014) and summer (February 2015) to provide baseline data relating to current usage of drainage structures by microbats within Sections 3 to 11 of the Project. This information has been utilised during the preparation of this Microbat Management Plan.

4.3 Timing

Monitoring of each of the subject drainage structures and bat boxes established in adjacent vegetation is recommended following exclusion of microbats from the subject drainage structures and to continue quarterly until the end of construction. At the completion of construction, monitoring would continue in line with the nest box management plans that have been prepared for respective sections as listed below in **Table 4.1** with summer and winter surveys on a bi-annual basis for six years. Corrective actions would be required should the performance criteria not be achieved following two years of monitoring. Following the initial two years of monitoring, if results indicate early uptake consistently, monitoring can cease and is not required for the full six years.

Table 4.1 Nest Box Management Plans

W2B Upgrade Section	*Nest Box Management Plan Author*
Section 1	Biosis
Section 2	Ecosure
Section 3, 4 and 5	GeoLINK
Section 6	AECOM
Section 7	Biosis
Section 8 & 9	Melaleuca Group Pty Ltd
Section 10 & 11	Australian Museum Consulting

4.4 Control Sites

Monitoring of microbat persistence and behaviour would also be undertaken at the frequency and duration nominated above, at the drainage structures classified as high or medium that would not be subject to direct impacts once adjacent construction begins. These drainage structures would provide control sites for monitoring to provide a measure of natural variability and indirect impacts.

If, following completion of the detailed design, it is found that despite the actual drainage structure not being removed, works occur within 20 m of the drainage structure, these structures are not regarded as control sites and the following management measures would be implemented:

- Restrict pedestrian access to the drainage structure;
- Project Ecologist to have input into the EWMS for this specific site;
- If bats are taking flight during daylight hours, cease works within 50 m of the subject drainage structure and contact the Project Ecologist. The Project Ecologist would advise if bat boxes, exclusion devices or alternative measures are required.

4.5 Monitoring Methodology

The following monitoring methodology would be undertaken for both the bat boxes in adjacent vegetation as well as 'in culvert' design features and bat boxes within drainage structures.

An Ecologist would physically inspect the subject drainage structures and alternative habitat features and record the following:

- Identification code of nest box or habitat feature;
- Evidence of microbats (guano and/or staining);
- Number of microbats present;
- Identification of species;
- Indications of breeding activity;
- Occurrence of any pest species such as feral bees;
- Condition of the bat roost box (eg. Any deterioration, structurally unstable) if applicable;
- Date and time of inspection;
- Drainage structure/ roost identification number;
- Roost features present; and
- Record of rainfall during monitoring period.

It should be noted that evidence of microbats in the form of guano can be influenced by wet weather. Less guano would be expected following significant periods of rainfall.

4.6 Reporting

Annual results of the information stated within **Section 4.5** would be provided to RMS, Department of Planning and the Environment (DP&E) and EPA (consistent with the requirement under condition D8(l) of the approval) during construction with a final post construction monitoring report incorporating an analysis of the results provided to EPA and DP&E.

Post-construction monitoring would be consistent with condition D8(k) of the approval.

4.7 Performance Measures and Corrective Actions

Table 4.1 presents the main goals of microbat management and includes relevant management measures for microbats that would be employed prior to the commencement of construction, during construction and post construction. The table also describes how the identified mitigation measures would be monitored, the timing and frequency of monitoring, the parties responsible for implementing the measures, the performance thresholds that each goal is measured against and the corrective actions if deviation from the performance criteria occurs.

4.8 Summary of Monitoring Program

A summary of the monitoring program is provided in **Table 4.1**.

Table 4.2 Summary of Monitoring Program

Monitoring Component	*Goal*	*Timing/ Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from Performance Criteria*
Exclusion devices	Ensure exclusion devices remain effective.	Day after installation. Following significant rainfall events (>50 mm in 24 hours). Quarterly if no significant rainfall events.	Project Ecologist/ Contractor	Any breach of exclusion devices.	Re-instate damaged exclusion devices (eg. Apply additional gap filler or replace plywood with liquid nails).
Bat boxes	Successfully provide alternate roost habitat in suitable locations in proximity to the subject drainage structures. Observe uptake, breeding and persistent use of replacement roosting habitat.	Day after exclusion from subject drainage structures. Quarterly during construction. Bi-annual summer and winter for six years following completion of construction.	Project Ecologist	No evidence of usage within two years of installation.	Re-locate within adjacent vegetation (changing aspect, move closer to water etc). If not inhabited by microbats following completion of construction on the subject drainage structures, bat boxes would be re-located within the new RCBCs.
Pre-work checks	Low number of injuries/ mortality to microbats from construction activities.	One day prior to starting work on the subject drainage structure and on the day of work.	Construction team/ Project Ecologist	Low number of injuries/ mortality to microbats from construction activities.	Notification to DoE, EPA if a microbat mortality is recorded on the Project. Adaptive management response plan to be provided by Project Ecologist if mortality recorded. Stop construction and review the Microbat Management Plan procedures for exclusion and removal of microbats. Preparation of an EWMS for all construction activities and where

Monitoring Component	Goal	Timing/ Frequency	Responsibility	Performance Threshold	Corrective Actions if Deviation from Performance Criteria
					necessary, include measures to minimise risk to microbats. Induction of all personnel involved with construction activities would be undertaken to communicate microbat management requirements.
Habitat design features within drainage structures	Observe uptake, breeding and persistent use of replacement roosting habitat.	Commence six months following installation. Quarterly during construction. Bi-annual summer and winter for six years following completion of construction.	Project Ecologist	Evidence of usage is confirmed consistently (numbers not decreasing over two years).	Modify the design of existing roost features. Consider provision of additional roost features.
Control sites	Identify natural variability of microbats within the Project footprint.	Quarterly from pre-exclusion. Quarterly during construction. Bi-annual summer and winter for six years following completion of construction.	Project Ecologist	N/A	N/A

References

Churchill, S. (2008). *Australian Bats*, Second Edition. New Holland Publishers.

Biosis (2014). *Nestbox Management Plan. Woolgoolga to Ballina Pacific Highway Upgrade, Section 1 – Woolgoolga to Halfway Creek*. Report for RMS. Biosis Pty Ltd.

Department of Environment [DoE], (2014). *Species Profiles and Threats Database – Chalinolobus dwyeri – Large-eared Pied Bat, Large Pied Bat*. Australian Government Department of Environment.

Ecosure (2014). *Woolgoolga to Ballina Pacific Highway Upgrade Habitat Tree Assessment and Nest Box Management Plan for Section 2 – Halfway Creek to Glenugie*. Report for RMS.

GeoLINK (2014). *Woolgoolga to Glenugie Pacific Highway Upgrade Microbat Management Plan – Sections 1 and 2 (Ref. 2149-1059).* Unpublished report to Roads and Maritime Services.

GeoLINK (2015). *Woolgoolga to Ballina Pacific Highway Upgrade Targeted Bat Surveys – Sections 3-11 (Ref. 2373-1013).* Unpublished report to Roads and Maritime Services.

Lloyd, S., Hall, L. S. and Bradley, A. J. (1999). Reproductive strategies of a warm temperate vespertilionid, the large-footed myotis, Myotis moluccarum (Microchiroptera:Vespertilionidae). In *Australian Journal of Zoology*, Vol. 47 (3), page 261-274.

Office of Environment and Heritage [OEH], (2012). *Threatened Species Profile. NSW Office of Environment and Heritage website:* http://www.environment.nsw.gov.au/threatenedspeciesapp/. Accessed 1/08/2014

Roads and Maritime Services [RMS], (2012). *Pacific Highway Upgrade: Woolgoolga to Ballina Environmental Impact Statement. December 2012.* Report prepared by NSW Roads and Maritime Services, Aurecon and Sinclair Knight Merz.

Roads and Maritime Services [RMS], (2013). *Woolgoolga to Ballina Pacific Highway Upgrade – Threatened Mammal Management Plan.* Report prepared by NSW Roads and Maritime Services, Aurecon and Sinclair Knight Merz.

Schulz, M. (2013). *Expert Review of Threatened Mammal Management Plan*. Australian Museum Consulting.

Temby. I., (2012). *Bats in your Belfry.* http://www.ausbats.org.au/download/i/mark_dl/u/4008973680/4567401504/abs. Accessed 27/8/14

Van Dyck, S. and Strahan, R. (2008). *The Mammal of Australia* (Third Edition). Reed New Holland.

Definitions and Acronyms

CEMP	Construction Environmental Management Plan
CPC	Concrete Pipe Culvert
DoE	Australian Government Department of Environment
DP&E	NSW Department of Planning and the Environment
EIS	Environmental Impact Statement
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EPA	NSW Environmental Protection Authority
EWMS	Environmental Work Method Statement
FFMP	Flora and Fauna Management Plan
NSW	New South Wales
OEH	Office of Environment and Heritage
Project Ecologist	A suitably qualified Ecologist engaged to advise on/ undertake ecological management throughout the project.
Project footprint	All areas to be cleared as part of the Project inclusive of permanent and temporary works.
RCBC	Reinforced Concrete Box Culvert
TSC Act	NSW *Threatened Species Conservation Act 1995*
S2W	Sapphire to Woolgoolga Pacific Highway Upgrade Project
W2B	Woolgoolga to Ballina Pacific Highway Upgrade Project (referred to throughout the document as 'the Project'.

Copyright and Usage

Appendix A

Subject Drainage Features

Table A1 Field Survey Results - Bridges

Section	Chainage	Bridge No.	Bridge Type	Bridge Name/ Location Description	Easting	Northing	Date/s Inspected	Broad Habitat Type	Presence of Water/ Moisture July 2014	Presence of Water/ Moisture Nov 2014	Presence of Water/ Moisture February 2015	Potential Microbat Roost Features within Culvert/ Bridge	Evidence of Microbat Usage (July 2014)	Evidence of Microbat Usage (October-November 2014)	Evidence of Microbat Usage (February 2015)	Habitat Potential/ Significance	Proposed Action	Proposed Management
5	89370	A3	Bridge	Old Serpentine Creek Bridge	523594	6747116	11/02/14, 8/07/14, 11/02/15	Mangroves, Swamp sclerophyll forest	Dry	-	Serpentine Channel full	Scuppers, expansion joints 8 - 10 cm wide, rough concrete.	40 x *Miniopterus schreibersii* in 8-10 cm wide expansion join on northern bank. Very large accumulations of guano on ground and footings on northern side. Large amounts of staining. Low amounts of guano on southern bank.	-	Large amounts of guano on northern side. Staining and bat bugs present.	Medium	Likely retain	Two bat boxes currently installed at this bridge. Monitoring.
5	89400	A2	Bridge	New Serpentine Creek Bridge	523573	6747151	11/02/14, 8/07/14, 11/02/15	Mangroves, Swamp sclerophyll forest	Standing water.	-	Serpentine Channel full	17 horizontal gaps 1-5 cm wide with foam at the top.	131 x *Miniopterus schreibersii*. Large amounts of guano throughout, less on southern side.	-	10 x *Myotis macropus* in four different groups.	High	Retain	Four bat boxes currently installed at this bridge. Monitoring.
5	94090	2154	STRUS	Mororo Bridge north bound on North Arm of Clarence River	524378	6751394	5/11/14, 05/02/15	Swamp Sclerophyll	-	Clarence River	Clarence River	Raker piles, scuppers.	-	Staining between raker piles, guano on pier 4 beneath raker pile. 1 x *Myotis macropus* in join of pier 4 raker pile.	Piles numbered P1-P12. P2, western side 2x *Myotis macropus* roosting, staining and bat bugs present. Eastern side staining and bat bugs present. P3 Eastern and Western sides, staining plus bat bugs present. P4 to P6, staining and bat bugs present Eastern and Western sides. P11 staining and bat bugs present both eastern and western sides.	High	Retain	Monitoring.
5	94090	8297	PTROG	Mororo Bridge south bound on North Arm of Clarence River	524393	6751401	05/11/14, 05/02/15	Swamp Sclerophyll	-	Clarence River	Clarence River	Four bat boxes installed during Pacific Highway maintenance works	-	Approximately 127-153 *Myotis macropus* in the four bat boxes including nine unfurred pups indicating evidence of breeding.	Boxes from north to south: 1) All chambers full, box panels run north-south, est 150+ *Myotis macropus*. 2) 1 chamber of box occupied est 5x *Myotis macropus*. 3) All chambers occupied, panels run east-west, est 60x *Myotis macropus*. 4) All chambers occupied, panels run north-south, estimate 40x *Myotis macropus*.	High	Retain	Monitoring.

Section	Chainage	Bridge No.	Bridge Type	Bridge Name/ Location Description	Easting	Northing	Date/s Inspected	Broad Habitat Type	Presence of Water/ Moisture July 2014	Presence of Water/ Moisture Nov 2014	Presence of Water/ Moisture February 2015	Potential Microbat Roost Features within Culvert/ Bridge	Evidence of Microbat Usage (July 2014)	Evidence of Microbat Usage (October-November 2014)	Evidence of Microbat Usage (February 2015)	Habitat Potential/ Significance	Proposed Action	Proposed Management
6	101610	7555	PPLNK	Tabbimoble Creek, 62.51 km north of Grafton	521143	6758106	16/07/14, 29/10/14 05/02/15	Dry Sclerophyll	Tabbimoble Creek, water flowing only beneath middle of bridge (Section F).	Tabbimoble Creek, pool under Section F, dries in middle of bridge but creek extends to east and west.	Tabbimoble Creek flowing beneath 2 of the centre piers. Creek flowing down western side of cells G-H.	Gaps 1-5 cm wide and 10-15 cm deep, some bats observed to grip feet onto foam gap filler.	24 groups of bats comprising: 553 x *M.australis,* 10 x *Nyctophilus* sp.	Staining, bat bugs, 1 x *Vespadelus* sp. under A15, 2 x *Myotis macropus* under G1.	Guano present in gaps indicating use. Bat bugs present in plank gaps. Cell G1 x 2 *Myotis macropus* roosting in plank gap.	High	Likely retain	If not retained, install eight bat boxes in adjacent vegetation and follow exclusion as per **Section 3.3** and create permanent cave dwelling habitat as per **Section 3.4**. Monitoring.
6	102900	7532	PPLNK	Tabbimoble Overflow, 63.83 km north of Grafton	520620	6759257	16/07/14, 29/10/14 05/02/15	Swamp Sclerophyll	Tabbimoble Creek, water only present beneath middle of bridge (Section C).	Tabbimobile Creek, water under span 3.	Creek present under centre span, 2-5cm of standing water under southern span.	Gaps between concrete plants, foam in gaps.	11 groups of bats comprising: 166 x *M.australis,* 1 x *M.oceanensis,* 1 x *Nyctophilus* sp.	2 x *Myotis macropus* (male) in D2, guano	Guano present in gaps indicating use.	High	Likely retain	If not retained, install four bat boxes in adjacent vegetation and follow exclusion as per **Section 3.3** and create permanent cave dwelling habitat as per **Section 3.4**. Monitoring.
Devils Pulpit	106190	9507	CPIPE	62.14 km south of Ballina, south of Pine Road	521687	6762321	16/07/14, 29/10/14, 03/02/15	Swamp/ wet Sclerophyll	<5 cm deep in cells 1, 2, 3	Cells 1, 2, 3 - 5 cm deep water, cells 4, 5, 6 - dry but moist sediment present. Inlet and outlet dry.	Cells 1 & 2 - 20cm deep pool. Cell 3 - 10cm deep. Cell 4 - mud and water up to 5cm deep.	Jointing gaps, lift points, rough concrete.	Staining around lift points and rough gaps in joins, small- large amounts of guano	Guano amounts vary from nil in cells 1, 3, 6 to moderate and large amounts of guano in cell 4, staining, bat bugs	Cell 2 guano present on side walls of culvert. Larger deposits in cell 4. Cell 5 small to moderate deposits of guano beneath rough concrete associated with joint gaps. Staining visible in cells 2 & 3. Bat bugs also present in cell 2 at joint and lift points.	Medium	Retain	If not retained, install one bat box in adjacent vegetation and follow exclusion as per **Section 3.3** and create permanent cave dwelling habitat as per **Section 3.4**. Monitoring.
7	122280	2161	CCULV	46.01 km south of Ballina, Oakey Flat #3, Oakey Creek	529998	6775697	23/07/14, 28/10/14, 03/02/15	Swamp Sclerophyll	Water 50 cm deep in culvert.	Oakey Creek approximately 10 m wide. Water 30 cm deep in culvert.	Oakey Creek pool/ channel at inlet and outlet. Water 50 cm deep in culvert.	Joins tight and only exist in the middle and the additional units on the southern end of 1,200 mm spacings, rough concrete. One cavity (3 x 4 cm opening) where new joins old on northern side of northern cell.	Some stains associated with previous use.	1 x *Myotis macropus*, staining, unable to observe guano due to water.	5 x *Myotis macropus* in two groups - mother with baby under wing and 3 x *Myotis macropus* grouped together in opposite corner in northern cell on eastern side where culvert extension provides step	Medium	Likely remove (could extend	Install one bat box in adjacent vegetation. Exclusion as par **Section 3.3**. Create permanent cave roosting habitat as per **Section 3.4**. Unused bat box from surrounding vegetation would be relocated within the drainage structure once construction is complete. Monitoring.
10	157400	2167	CCULV	12.87 km south of Ballina, Saltwater Creek, south of Coolgardie Road	546383	6800255	15/07/14, 28/10/14, 03/02/15	Swamp Sclerophyll	Saltwater Creek 1 - 2 cm of standing water in pools.	Saltwater Creek is dry, occasional pools, some dampness at joints.	2 cm standing water in base, Saltwater Creek running through culvert.	3 cm gap in middle of bridge through all cells. Rough grooves along concrete plank roof.	Small amounts of guano and staining on roof. 1 x *M.oceansis* flying in middle culvert and northern culvert attempting to enter rock crevice in middle of bridge.	Two medium-large amounts of guano in northern cell beneath rough concrete, bat bugs, staining.	Small patches of staining around rough concrete, bat bugs present.	Medium	Retain	If not retained, install one bat box in adjacent vegetation and follow exclusion as per **Section 3.3** and create permanent cave dwelling habitat as per **Section 3.4**. Monitoring.

Table A2 Field Survey Results - Culverts

Section	Culvert No.	Chainage	Inlet Lat	Inlet Long	Location	Culvert Type	No. Pipe/ Cells	Pipe Inside Dia. (mm)	Date/s Inspected	Broad Habitat Type	Presence of Water/ Moisture July 2014	Presence of Water/ Moisture Nov 2014	Presence of Water/ Moisture February 2015	Potential Microbat Roost Features within Culvert/ Bridge	Evidence of Microbat Usage (July 2014)	Evidence of Microbat Usage (November 2014)	Evidence of Microbat Usage (February 2015)	Habitat Potential/ Significance	Proposed Action	Proposed Management
4	506007	82020	-29.4602	153.21466	North of Jubilee Street over-bridge, east of Maclean.	CPC	1	1230	11/02/14, 8/07/14, 11/02/15	Wet sclerophyll forest	Small trickle, moist sediment in base of culvert.	-	Small trickle, 0-5 cm to pooling at outlet 1-3 cm deep.	Jointing gaps 1-4 cm wide, rough edges, 5 cm lift holes in roof.	Moderate amount of guano throughout. Group 1 - 9 x *Miniopterus australis* in 2-3 cm wide cell joint 2nd from inlet. Group 2 - 2 x *M.australis* in lift hole. Group 3 - 5 x *M.australis*. Group 4 - 6 x *M.australis* in jointing gap. Group 5 - 1 x *M.australis* in 4 cm jointing gap. Group 6 - 6 x *M.australis*. Group 7 - 67 x *M.australis* in 3 cm jointing gap. Group 8 - 6 x *M.australis* in 2 cm jointing gap. Group 9 - 62 x *M.australis*. Group 10 - 1 x *M.australis*. Group 11 - 26 x *M.australis*. Group 12 - 50 x *M.australis* in 3 cm joint gap. Group 13 - 1 x *M.australis*. Group 14 - 3 x *M.australis* in lift hole. Group 15 - 9 x *M.australis* in lift hole. Group 16 - 1 x *M.australis* in 4 cm wide jointing gap. Group 17 - 6 x *M.australis* in lift hole. Total = 262 bats.	-	Staining, bat bugs and guano scattered on walls and accumulations under jointing gaps and lifting points.	High	Extend or remove	Install four bat boxes in adjacent vegetation. Exclusion as par **Section 3.3**. Maximum jointing gaps (note: existing culvert has 17 cell joints). Unused bat boxes from surrounding vegetation would be relocated within the drainage structure once construction is complete. Monitoring.
5	506008	82300	-29.4584	153.21676	North of Jubilee Street over-bridge, east of Maclean.	CPC	1	1500	11/02/14, 8/07/14, 11/02/15	Wet sclerophyll forest	Small trickle at inlet does not flow at outlet.	-	Trickle approx. 0-5 cm	Jointing gaps 3-5 cm wide x 20 cm deep. Lifting points round, 5-10 cm deep.	Staining along jointing gaps and around lift holes. Moderate amounts of guano throughout base of culvert. 12 x *M.australis* in lift hole 3rd from outlet, 17 x *M.australis* in lift point, 11 x *M.australis* in 5 cm wide jointing gap, 30 x mixed group in 3 cm wide joint gap. 2 x *M.australis*. Total: 72 microbats.	-	Heavy staining throughout, bat bugs present. Guano under 70% of all gaps and lifting points.	High	Extend or remove	Install four bat boxes in adjacent vegetation. Exclusion as par **Section 3.3**. Maximum jointing gaps (note: existing culvert has 17 cell joints). Unused bat boxes from surrounding vegetation would be relocated within the drainage structure once construction is complete. Monitoring.