Spotted-tailed Quoll Management Plan

Warrell Creek to Nambucca Heads Upgrade of the Pacific Highway

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Prepared for: Acciona and Ferrovial Joint Venture and Roads and Maritime Services

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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 (NSW) governments to improve the standard and safety of the Pacific Highway between Hexham and the Queensland border.

The Warrell Creek to Urunga (WC2U) project forms part of the Pacific Highway Upgrade Program and comprises approximately 42 kilometres of dual carriageway road that would bypass the towns of Warrell Creek, Macksville, Nambucca Heads and Urunga on the Mid North Coast of NSW. The Project has been divided into two stages with Stage 1 consisting of the approximate 22.5 kilometres stretch from Nambucca Heads to Urunga (NH2U) and Stage 2 consisting of the remaining approximate 19.5 kilometres of dual carriageway between Warrell Creek and Nambucca Heads (WC2NH). This Spotted-tailed Quoll Management Plan relates to Stage 2 (WC2NH) which is referred to throughout this report as 'the Project' (refer to **Illustration 1.1**).

The NSW Minister for Planning approved the WC2U Pacific Highway Upgrade Project (the Project) under Part 3A (now repealed) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) on 19 July 2011, subject to the Minister's Conditions of Approval (CoA) being met. In accordance with transitional provisions included in Schedule 6A of the EP&A Act, the Project is characterised as a transitional Part 3A project. It is noted that despite its repeal, Part 3A of the EP&A Act continues to apply in respect of transitional Part 3A projects. Under section 75C of the EP&A Act, the Minister for Planning declared, by Order dated 5 December 2006 and published in the NSW Government Gazette No. 175, that development for the purposes of upgrading segments of the Pacific Highway is a project to which Part 3A of the EP&A Act applies (the declared Project). The Minister also declared by Order dated 8 December 2006 published in Gazette No. 175 that the same development is a critical infrastructure project under section 75C of the EP&A Act. This was subsequently modified through a further Ministerial Order gazetted on 3 December 2010 (Gazette No. 133).

Impacts to the Spotted-tailed Quoll (*Dasyurus maculatus*) were assessed in the WC2U Environmental Assessment (EA) (Sinclair Knight Merz – SKM 2010a, SKM 2010b), in regard to relevant State and Federal legislation. The Spotted-tailed Quoll is listed as a 'Vulnerable' species under the NSW Government *Threatened Species Conservation Act 1995* (TSC Act) and as Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). In relation to the Spotted-tailed Quoll, the Assessment of Significance completed for the WC2U EA concluded that "*the proposal WC2U Project will remove potential habitat for the species and its prey, leading to further fragmentation of habitat, a known threat to the species. Measures to conserve fauna corridors and movement avenues for terrestrial fauna have been incorporated into the design for the proposed action. Breeding, foraging and movement life-cycle opportunities would remain in the region and are likely to sustain a local population. It is concluded that the WC2U Project is unlikely to have a significant impact on the Spotted-tailed Quoll.*"

The Roads and Maritime Services has prepared a referral seeking approval from the Australian Government for the Project. The referral was lodged with the Department of the Environment (DoE) on 20 December 2013. For further information refer to http://www.environment.gov.au/cgi-bin/epbc/epbc_ap.pl?name=current_referral_detail&proposal_id=7101. The referral provides detail on the Project, including a detailed description, proposed construction staging, excluded activities, description of impacts and measures to avoid or manage impacts, for Commonwealth Matters of National Environmental Significance (MNES), including the Spotted-tailed Quoll. The DoE have reviewed the referral (number 2013/7101) on 23 January 2014 and made the decision under section 75 of the EPBC Act that that the Project is a controlled action and requires approval under the EPBC Act.

1.2 Purpose and Objectives

This management plan identifies the potential impacts of the WC2NH project on the local population of Spotted-tailed Quoll, hereafter referred to as the STQ. It outlines the proposed management measures to be implemented for the STQ on the project and a program for monitoring the effectiveness of these measures. The objective of the management plan is to provide measures that minimise impacts to the STQ on the Project.

The plan covers pre-construction, construction and operational phases of the project and applies to all areas within the WC2NH project boundary.

1.3 Order of Precedence

In the event of any inconsistency, ambiguity or discrepancy between this Management Plan and the Flora and Fauna Management Plan for the Warrell Creek to Nambucca Heads Pacific Highway upgrade project, the following order of precedence must apply:

a. This Spotted-tailed Quoll Management Plan.
b. The Flora and Fauna Management Plan for the Warrell Creek to Nambucca Heads Pacific Highway upgrade project.

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 actions 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.

The STQ management plan has been prepared in consultation with Roads and Maritime Services, the Environment Protection Authority (EPA) and the Commonwealth DoE. 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. Roads and Maritime and the D&C Contractor for this project (Acciona and Ferrovial Joint Venture [AFJV]) would be responsible for implementing the measures in this STQ Management Plan and this would include the engagement of suitably qualified specialists to undertake and oversee surveys and monitoring activities where necessary.

1.5 Plan Authors

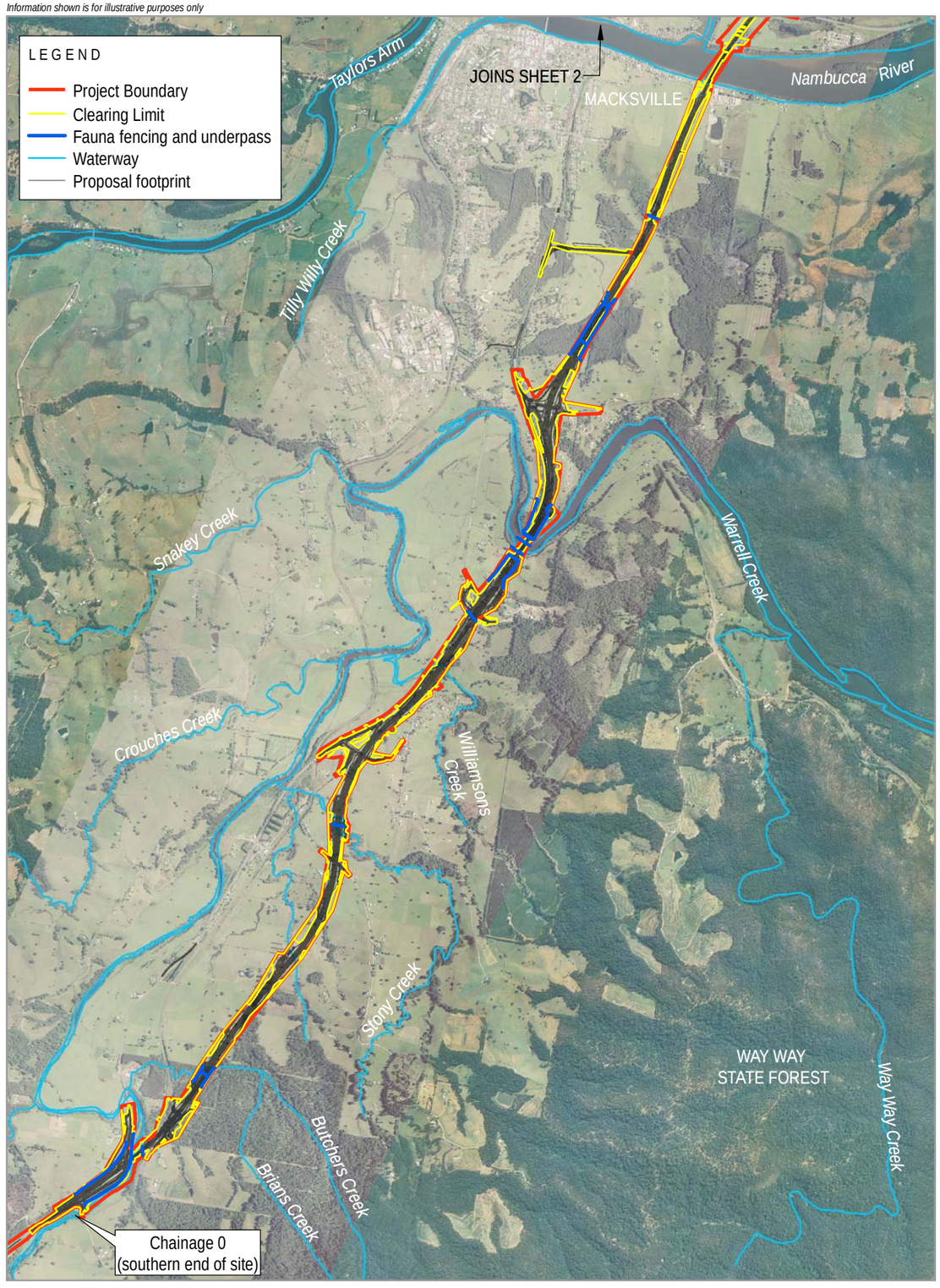
The STQ Management Plan has been prepared by the following personnel from the AFJV Project Ecologist GeoLINK:

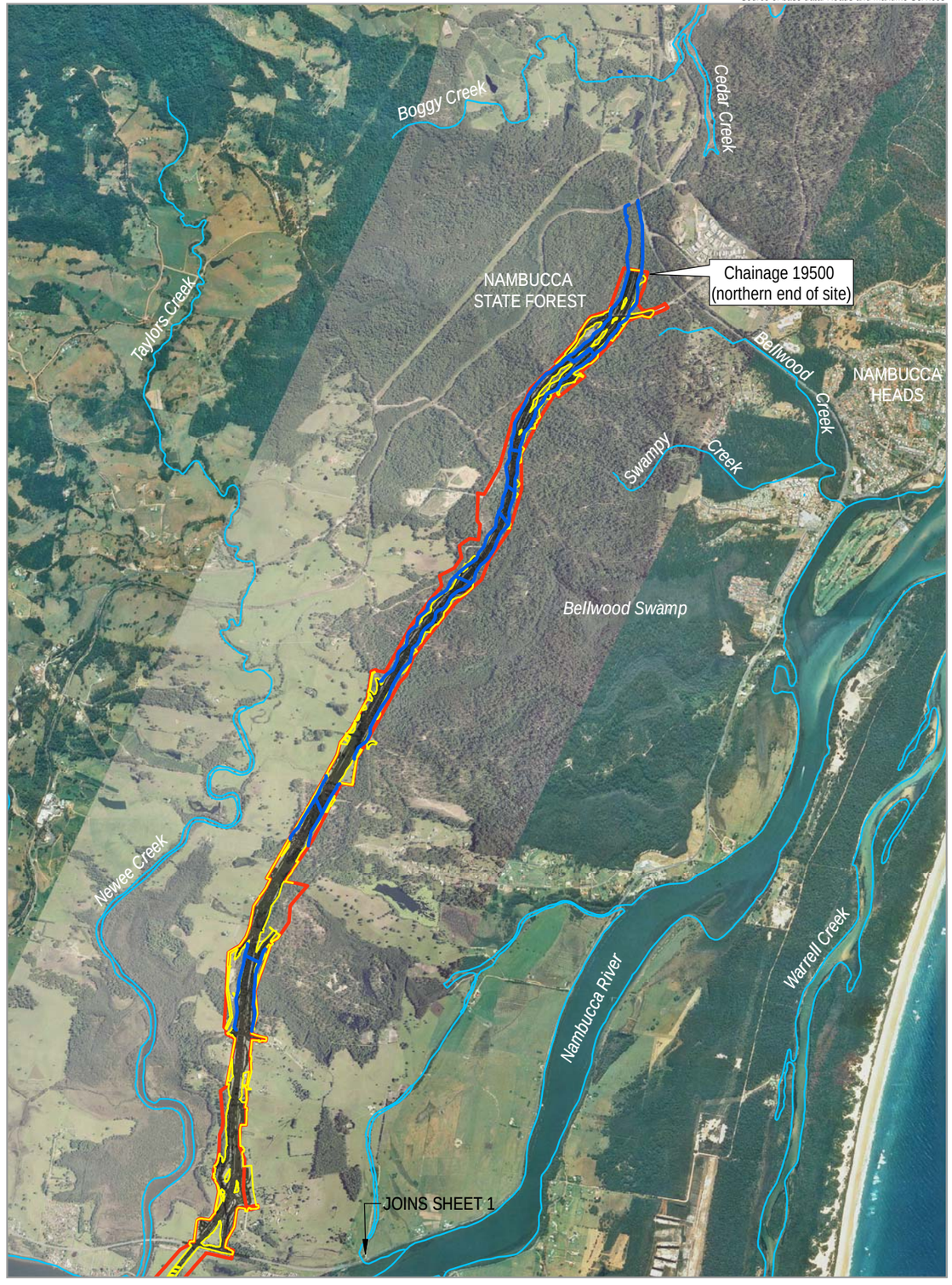
- David Havilah (Senior Ecologist).
- Veronica Silver (Senior Ecologist – Peer Review).

Qualifications and experience of the plan authors are included in **Appendix A**.

Information shown is for illustrative purposes only

Drawn by: RE Checked by: GJM Reviewed by: JOL Date: 05/09/2016
Source of base data: Roads and Maritime Services





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GeoLINK environmental management and design

WC2NH Spotted-tailed Quoll Management Plan
2378-1267

The Site

Illustration 1.1

2 Spotted-tailed Quoll Population

2.1 Species Description

Detailed reviews of STQ biology and ecology based on recent research are provided on the DoE *Species Profile and Threats Database* (DoE 2013b) and the *National Recovery Plan for the Spotted-tailed Quoll (Dasyurus maculatus)* (Department of Sustainability and Environment [DoSE], 2008). A summary of this information is provided below.

2.1.1 Biology/Ecology

The STQ is one of Australia's largest extant marsupial carnivores (Belcher, Burnett and Jones 2008) with fur which is sandy to rufous or dark brown with irregular white spots covering the animals back, sides and extending down the tail, and it's stomach is cream to white (Belcher, 2000 cited in DoSE, 2008). Males can grow to 1.3 metres in length (including the tail) and weigh up to 7.0 kilograms (average 2.6 – 4.6 kilograms) while females are smaller, to about 85 centimetres in length and 4.0 kilograms in weight (average 1.5 – 2.2 kilograms) (DoSE, 2008).

The STQ typically occurs at low densities, as adults are solitary and occupy large home ranges. Female home ranges are generally non-overlapping and 350 – 500 hectares in size. Male home ranges are much larger, approximately 2000 hectares in size and overlap and encompass multiple female home ranges (Belcher & Darrant, 2004). The species is capable of covering large distances in a short period of time, with animals recorded moving at least 8.0 kilometres in a day and 19 kilometres in a week (Andrew, 2005 cited in DoSE, 2008) and is known to traverse their home ranges along densely vegetated creek lines.

The species is known to use communal 'latrine sites' often on flat rocks among boulder fields, rocky cliff faces or along rocky stream beds or banks. Such sites may be visited by multiple individuals and be recognised by the accumulation of the sometimes 'twisty shaped' faeces deposited by animals (Office of Environment and Heritage (OEH), 2014).

2.1.2 Habitat

The STQ has a preference for mature wet forest habitat (Belcher, 2000 cited in DoSE, 2008) where it occupies home ranges of several hundred to several thousand hectares in size. The Spotted-tailed Quoll may be largely diurnal or a mix of nocturnal and diurnal depending on major prey (Belcher and Darrant, 2004). Habitat requirements include suitable den sites such as hollow logs, tree hollows, rock outcrops or caves (DoSE, 2008). STQs use multiple dens (possibly in excess of 20) and usually move between them every one to four days. Dietary studies have found that medium sized mammals are the majority prey (Belcher et al 2007) with birds and small mammals a minor component of the diet. This species is moderately arboreal and approximately 11 per cent of travelling is done in trees (Jones et al. 2001, cited in DoSE, 2008). At many sites arboreal mammals are the main prey and STQ take prey such as Greater Gliders in tree hollows and have been observed and radio tracked over 30 metres up trees hunting/feeding (Belcher pers. comm. 2014).

2.1.3 Diet

The species is a generalist predator with a preference for medium sized (500 grams – 5.0 kilograms) mammals. It consumes a variety of prey, including gliders, possums, small wallabies, rats, birds, bandicoots, rabbits, reptiles and insects. It will also eat carrion and domestic fowl (OEH, 2014).

2.2 Known Distribution

The STQ is widely but patchily distributed in eastern Australia, occurring from north-eastern Queensland to Tasmania although is apparently absent from central Queensland. The mainland population of the species occurs from near Gladstone in south-eastern Queensland, through NSW to western Victoria, but is now presumed to be extinct in South Australia (DoSE, 2008).

2.2.1 Database Records

The OEH Atlas of NSW Wildlife (OEH, 2013) database shows ten STQ records occurring within the Project Site locality. Typically these records occupy a network of habitat patches to the north of the Project Site associated with large tracts of native vegetation (i.e. Newry and Nambucca State Forest) and extending west to the Great Dividing Range. Records have been made both within Nambucca State Forest and along riparian habitat found alongside the Nambucca River and Warrell Creek. The nearest Atlas record to the Project Site (recorded in September 2004) is around 1.1 kilometres form the Project Site in the vicinity of the Nambucca River.

2.2.2 Field Surveys

Field surveys undertaken as part of the WC2U EA (SKM, 2010) did not record any STQs from targeted surveys undertaken for ground-dwelling and arboreal mammal species. The WC2NH EA (SKM, 2010) concluded "*that despite not being recorded on the site, the STQ was likely to occur*".

Baseline STQ monitoring surveys have recently been completed and did not identify any STQ individuals (refer to **Section 7** for further details). One road kill record was however recently detected near the southern end of the Project associated with the existing Pacific Highway near Butchers Creek. The nearby database record and recent road kill record suggest that the STQ occurs at a low density within the locality.

2.3 Habitat within the Project Footprint

Suitable habitat for the STQ is well represented in the larger forested areas associated with the Project Site, particularly the Nambucca State Forest and adjoining vegetation occurring on private properties. Gullies and riparian zones within this area provide suitable habitat and areas for movement of the species throughout the surrounding landscape.

The population of STQs occurring throughout the broader area surrounding the Project Site is difficult to ascertain due to the large home ranges held by this species and associated difficulties in surveying for this species. Given that recent records have been recorded within habitat associated with the Project Site, it is likely that the Project Site provides potential habitat for a population of STQs occurring within broader areas encompassing the study area.

3

Key Threats and Potential Impacts of the Project

3.1 Key Threats to the Species

The main recognised threats to the STQ (DoSE, 2008) include:

- Loss, fragmentation and degradation of habitat.
- Competition with introduced predators such as cats and dogs.
- Deliberate poisoning, shooting and trapping primarily in response to predation of chickens.
- Mortality from vehicle strike.
- Climate Change.
- Poisoning from Cane Toads.
- Weeds and feral animals.
- Fire.

SKM (2010a) provides a detailed assessment of the overall biodiversity impacts of the Project on biodiversity. The main threats identified which are relevant to the STQ for the WC2NH Project include:

- Habitat loss, fragmentation and degradation.
- Mortality from vehicle strike.

3.2 Potential Impacts from the Project

3.2.1 Habitat Loss, Fragmentation and Degradation

An assessment of the area of habitat affected by direct clearing and damage to vegetation during construction of the Warrell Creek to Nambucca Heads upgrade was undertaken based on vegetation surveys completed for the WC2U EA (SKM, 2010) and based on the following:

- Concept design with 15 metre buffer.
- Construction/operational water quality basins with 10 metre buffer.
- Adjustments to access roads within Nambucca State Forest with 10 metre buffer.
- Utility adjustments with clearing requirements of utility authorities.
- Three metre clearing width for boundary fencing – excluding within Nambucca State Forest and swamp forest where flying fox camp is located.

The area identified for clearing includes a 10 per cent contingency which allows provision for clearing construction phase water quality basins, accesses to ancillary facilities, stockpile sites and design refinements.

The Project would remove 114.1 hectares of potential habitat for the species and its prey, leading to further fragmentation of habitat, a known threat to the species. These impacts are likely to result in an estimated 0.6 per cent loss of Spotted-tailed Quoll habitat within the locality. The total area of habitat directly impacted is comprised of the following:

- Map Unit 1 – Blackbutt Open Forest – 75.2 hectares.
- Map Unit 2 – Mixed Floodplain Forest – 4.0 hectares.
- Map Unit 3 – White Mahogany/Grey Gum/Ironbark Moist Open Forest – 7.3 hectares.
- Map Unit 4 – Flooded Gum Moist Open Forest – 14.8 hectares.
- Map Unit 6 – Swamp Mahogany /Paperbark Swamp Forest – 5.3 hectares.
- Map Unit 7 – Swamp Forest - Swamp Oak – 0.4 hectares.
- Map Unit 8 – Freshwater Wetlands – 0.64 hectares.
- Map Unit 9 – Mangrove Forest – 0.1 hectares.
- Map Unit 12 – Hardwood plantation – 3.6 hectares.

This area contains vegetation providing foraging, denning and movement/partial movement habitat. In terms of habitat loss, it is considered that individual females are comparatively more sensitive to this habitat loss than males due to their smaller home range, higher energy requirements for breeding and habitat centred on areas containing high prey densities.

The Project would increase the fragmentation of habitat in the surrounding landscape by impacting on contiguous forested areas, particularly the larger fragments associated with Nambucca State Forest. The impacts of habitat fragmentation on wildlife are detailed in SKM (2010b). The main impacts relevant to the STQ include impacts on movement corridors, access to habitat to satisfy biological requirements, genetic exchange, increasing edge effects, and reduced ability for population recovery following stochastic events. While parts of the local landscape have already been fragmented from past clearing and development, the Project would contribute to this cumulative fragmentation through habitat clearing and construction of a major highway, approximately 16.5 kilometres of which deviates from the existing highway alignment.

To counter these impacts the Project design includes a number of dedicated and combined fauna underpasses with fauna fencing. Therefore while the Project will lead to habitat fragmentation and reduced connectivity, opportunities for the STQ to move between habitats on opposing sides of the highway post construction would be available. During the construction stage of the Project, there is some risk of STQ mortality/injury during clearing. However mitigation measures associated with the Project aim to reduce the risk of such impacts.

3.2.2 Road Kill

Like other large carnivorous marsupials, STQs are susceptible to road mortality because they scavenge the carcasses of other road kill fauna. Males, particularly dispersing juveniles, are probably at greatest risk because of their extensive ranging behaviour which means that they encounter roads more frequently (DoSE, 2008).

Approximately 16.5 kilometres of the 19.5 kilometres WC2NH Pacific Highway upgrade will deviate from the existing Pacific Highway alignment. The overall risk of STQ road kill locally is however unlikely to be significantly increased as:

- Extensive fauna fencing is proposed along the highway where it adjoins forest north of Nambucca River and at several locations south of the Nambucca River where the highway intersects vegetation (refer to **Appendix B**).. In total, approximately 12.1 kilometres of the new highway would support fauna exclusion fencing, approximately 6.7 kilometres of which is located north of the Nambucca River and 5.4 kilometres of which is located south of the Nambucca River. Details of fauna fencing to be provided on the project are included in **Appendix B.**
- Dedicated and combined fauna underpasses would be established to allow for safe passage across the highway.
- The study area north of the Nambucca River is subject to a low level of STQ activity.
- South of the Nambucca River:
  - The study area is highly fragmented.

- The potential frequency of east-west STQ movements is likely to be very low and better quality habitat connectivity occurs to the south of the study area.
- The new highway alignment runs roughly parallel to the existing highway therefore any STQs potentially moving through the area are vulnerable to an existing road collision threat.

The use of fauna fencing and associated underpasses has been proven as effective measures to reduce road kill on other highway upgrade projects.

4 Pre-construction Management Measures

4.1 Overview of Activities

Pre-construction activities would involve the following works:

- Survey works.
- Water quality monitoring.
- Translocation of threatened plants.
- Geotechnical investigations.
- Completion of utility relocations.
- Construction of site accesses.

4.2 Timing

Pre-construction works are to be undertaken up until the commencement of construction stage works which are anticipated to commence in December 2014.

4.3 Summary of Potential Impacts

Pre-construction activities may have the following potential impacts to STQs:

- Habitat loss from minor clearing associated with early works.
- Potential mortality to STQs from pre-construction activities/local traffic.

4.4 Main Goals for Management

The main goals for management are as follows:

- No habitat loss for the STQ from pre-construction activities.
- No injury/mortality to STQ from pre-construction activities/local traffic.

4.5 Mitigation Measures

4.5.1 **Detailed Design Considerations**

As detailed design progresses, a number of factors will be addressed to minimise the impacts of the Project on the STQ. These include:

- Avoiding and minimising vegetation/habitat removal where feasible and reasonable.
- Placement of ancillary facilities outside of vegetated areas (STQ habitat).
- Maximising the suitability of fauna crossing structures and fauna exclusion fencing to reduce road kills and enhance habitat connectivity (refer to **Section 6** for further information).

4.5.2 Identifying Habitat Restoration/Connectivity Areas

It is proposed to enhance connectivity in the landscape wherever possible through the provision of strategic tree planting in road reserves and residual land acquired for the Project. A number of areas have been identified by the Project team (Roads and Maritime, Jacobs, AFJV and GeoLINK) and described within preliminary documentation submitted to DoE on 9 September 2014 (refer to **Appendix C**). Of the areas identified, most of these have potential to be used by the STQ. These areas would be rehabilitated during the construction stage of the Project (refer to **Section 5.4.7**).

4.5.3 Controls on Habitat Clearing (Pre-construction)

During the pre-construction stage of the Project (prior to approval of the CEMP) only clearing defined as 'minor' (refer to Approval Instrument – Definitions for Construction) can be undertaken, unless approval is sought from the Director-General. Prior to any clearing taking place, the Project Ecologist will undertake an inspection of vegetation to be cleared to determine that only 'minor clearing' is to be undertaken. Minor clearing will be defined as the following:

- Vegetation that does not include mature trees >150mm DBH.
- Vegetation that does not comprise known threatened fauna habitat. In the case of the STQ, this is defined as potential denning habitat.
- Areas of vegetation that have ecological constraints (e.g. threatened flora habitat/areas of EEC).

All areas to be cleared are to be delineated with flagging tape to clearly mark the clearing extents.

4.5.4 Pre-clearing Surveys

For any area of vegetation to be cleared during the pre-construction stage of the Project, a suitably qualified ecologist will undertake a search for native fauna (including STQs) in the vicinity of clearing immediately prior to clearing commencing. In the event that a STQ is identified, no works would be undertaken within a 200 metre radius of this sighting and works within this area would be rescheduled to be initiated until the construction stage of the Project.

4.5.5 Environmental Work Method Statements

Environmental Work Method Statements (EWMS) will be prepared for all pre-construction tasks potentially impacting environmentally sensitive areas. The EWMS will provide an opportunity to assess any risks to fauna (including STQs) for the pre-construction activities and to incorporate mitigation measures into work methodologies where necessary to minimise the potential for impacts. Where an EWMS identifies risks to fauna, the Project Ecologist will be consulted to provide input where necessary.

4.5.6 Inductions

An environmental induction will be prepared and delivered to personnel involved with the pre-construction activities. Relevant points to be delivered in this induction in relation to STQ management are as follows:

- Potential presence on site (identification and potential habitat).
- Requirements for all personnel to report sightings (including road kill) immediately to the Environmental team.
- Requirement for works to cease within a 200 metre radius of any live STQ detected on/near the site until authorisation has been given for works to commence from the Environmental Manager/Project Ecologist.
- Other aspects of the Fauna Management Protocol for STQs (refer to **Table 4.1**).

4.5.7 STQ Management Protocol

For all STQs detected on/near the site the following protocol as shown in **Table 4.1** is to be implemented with compliance documented.

Table 4.1 STQ Management Protocol

Action		*Personnel Responsible*	*Reporting*
1	Report sightings of any STQs (including road kill) immediately to the Environmental team.	All personnel working on site	Environmental Manager to be notified immediately.
2	In the case that STQ road kill is detected, an assessment of future road kill risk will be undertaken by a suitably qualified Project Ecologist who will aim to provide actions to mitigate the risk of future road kill in this area. Additional measures to be considered will include (but not be limited to): ▪ Provision of signage. ▪ Temporary fauna fence.	AFJV/Roads and Maritime/ suitably qualified Project Ecologist	Adaptive management recommendations will be provided by a suitably qualified Project Ecologist to the AFJV/Roads and Maritime for consideration. The Environmental Manager shall notify the RMS Authorised Representative who will inform the EPA project officer.
3	Where a live STQ is detected on/near the site, no works are to be undertaken within 200 metres of the individual until the animal has relocated from the area and authorisation has been given by the Project Ecologist.	AFJV/suitably qualified Project Ecologist	Actions of foreman to be reported to Environmental Manager.
4	A suitably qualified Project Ecologist will inspect the STQ and assess the health of the individual. If the animal is injured/diseased it will be taken to a local vet or WIRES Wildlife Carer for treatment.	AFJV/suitably qualified Project Ecologist	A suitably qualified Project Ecologist to contact WIRES if animal shows signs of injury/disease.
5	A suitably qualified Project Ecologist is to assess if self-relocation or capture/relocation is required based on a risk assessment of the animals' welfare. The animal will either be allowed to self-relocate from the site or an ecologist with experience and approval to handle fauna will be engaged to capture/relocate the animal.	AFJV/suitably qualified Project Ecologist	EPA/Roads and Maritime to be consulted if capture/relocation required.
6	No works will proceed within 200 metres of the individual until authorisation has been provided by the AFJV (Environmental Manager) and the Project Ecologist. For pre-construction works where a STQ has been detected, works within this area would be rescheduled to be initiated until the construction stage of the Project.	AFJV/suitably qualified Project Ecologist	The suitably qualified Project Ecologist will provide written confirmation that the area is free from STQs and works can proceed.

4.5.8 Pre-construction Monitoring

Pre-construction STQ monitoring has been undertaken to obtain baseline data relating to current usage of habitats by the STQ within proximity to the WC2NH Project. The details of this monitoring are summarised in **Section 7** with the baseline monitoring report included in **Appendix D**.

4.6 Performance Measures and Corrective Actions

Table 4.2 presents the main goals of STQ management for pre-construction activities and includes relevant mitigation measures for the STQ that are to be employed prior to the commencement of construction. The table also describes how the identified mitigation measures are to 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.

Table 4.2 Pre-construction Management Goals, Mitigation Measures, Performance Thresholds and Corrective Actions

Management Goal	*Mitigation/Control Measure*	*Monitoring /Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
No habitat loss for the STQ from pre-construction activities.	▪ Minimise areas of vegetation (STQ habitat) to be cleared where feasible and reasonable during the detailed design phase.	▪ Design team to reference vegetation mapping for the project to minimise impacts.	AFJV (Design and construction team)/suitably qualified Project Ecologist	▪ No STQ habitat to be cleared during the pre-construction stage.	▪ Consideration of additional offsets for habitat loss.
	▪ All ancillary sites to be located outside of STQ habitat.	▪ Ecological assessments to be prepared for ancillary sites to verify minimal impacts to STQ habitat.	AFJV (Environmental team)/suitably qualified Project Ecologist	▪ No areas of STQ habitat to be impacted by the ancillary facilities.	▪ Consideration of additional offsets for habitat loss.
	▪ Prior to any clearing taking place, the Project Ecologist will undertake an inspection of vegetation to be cleared to determine if work activities do not constitute "Construction" as defined in the planning approval under the NSW EP&A Act and are excluded from the Referral under the Federal EPBC Act.	▪ Pre-clearing permits to be completed by the Project Ecologist prior to the clearing of areas of vegetation.	AFJV/suitably qualified Project Ecologist	▪ No STQ habitat to be cleared during the pre-construction stage.	
	▪ The limits of clearing are to be clearly marked on all relevant work plans and protective fencing erected to mark these limits (i.e. no-go areas).	▪ Limits of clearing will be marked out prior to clearing commencing in each works area. ▪ No-go fencing will be installed prior to vegetation clearing activities commencing in each works area. ▪ Fencing and no-go signage will be inspected weekly, until construction is completed.	AFJV (Environmental team, Survey team)	▪ Final Sensitive Area Plans identify sensitive areas and 100% of clearing drawings identify clearing extents. ▪ Completion of pre-clearing survey prior to construction including mark out of clearing extents.	▪ Notification to DoE, EPA if over clearing occurs.

Management Goal	*Mitigation/Control Measure*	*Monitoring /Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
	▪ Areas for STQ habitat restoration/connectivity are to be identified and included in the detailed design.	▪ Identified areas for habitat restoration/connectively have been determined (refer to **Appendix C**).	Roads and Maritime/AFJV (Design team)	▪ All areas outlined as habitat restoration opportunities are to be shown on the detailed design and planted appropriately.	▪ Areas for habitat restoration/connectivity are to be identified and included in the detailed design.
No injury/mortality to the STQ from pre-construction activities.	▪ Preparation of an EWMS would be undertaken for all work activities and would include where necessary measures to minimise risk to the STQ. ▪ Induction of all personnel involved with pre-construction activities would be undertaken to advise of STQ management requirements. ▪ For any area of vegetation to be cleared during the pre-construction stage of the project, a suitably qualified ecologist will undertake a search for native fauna (including STQ) in the vicinity of clearing immediately prior to clearing commencing. ▪ For any STQ detected on/near the site the protocol shown in **Table 4.1** is to be implemented. As mentioned, for the pre-construction works, in the event that a STQ is identified no works would be undertaken within a 200 metre radius of this sighting until the construction stage of the Project.	▪ Pre-clearing permits to be completed by the suitably qualified Project Ecologist prior to the clearing of any vegetation. ▪ Post-clearing inspections to be undertaken of areas cleared to identify any animal (including STQ) injured or killed during clearing.	AFJV (Environmental and Construction team)/suitably qualified Project Ecologist	▪ No STQ injuries/mortalities as a consequence of pre-construction activities.	▪ Notification to DoE, EPA if a STQ mortality is recorded on the Project. ▪ Adaptive management response plan to be provided by Project Ecologist if mortality recorded.

Management Goal	*Mitigation/Control Measure*	*Monitoring /Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
Minimise vehicle strike of STQs during pre-construction activities.	▪ STQ Management Protocol (**Table 4-1**) to be implemented requiring all personnel to report STQs (including road kill). ▪ Assessment of future road kill risk including adaptive management actions to be provided by Project Ecologist where STQ road kill is detected.	▪ Road kill monitoring to be undertaken (refer to **Section 7**).	AFJV/Roads and Maritime	▪ No road kill of STQs resulting from the Project.	▪ Where STQ road kill is detected in proximity to the Project the Project Ecologist will provide an assessment of future road kill risk for STQs and adaptive management requirements where appropriate.

5

Construction Management Measures

5.1 Timing

Construction works are anticipated to commence in December 2014 and are expected to be completed in early 2018.

5.2 Summary of Potential Impacts

The construction stage works are anticipated to have the following potential impacts on STQs:

- Habitat loss for the STQ from clearing works.
- Fragmentation of habitat and impacts to quoll movements.
- Injury/mortality to individuals from clearing/construction works.
- Increased levels of vehicle strike on the existing highway from changed movement patterns in the locality of the site.

5.3 Main Goals for Management

The main goals for management are as follows:

- Minimise habitat loss for the STQ from clearing.
- Undertake habitat rehabilitation works within identified areas associated with the Project Site for to create additional STQ habitat.
- No injury/mortality to STQ from construction activities.
- Minimise vehicle strike of STQ during construction activities.

5.4 Mitigation Measures

5.4.1 Environmental Work Method Statements

Environmental Work Method Statements (EWMS) will be prepared for all construction activities potentially impacting fauna (including STQ). The EWMS will provide an opportunity to assess any risks to fauna (including STQs) 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 will be consulted to provide input where necessary.

5.4.2 Inductions

An environmental induction will be prepared and delivered to all personnel involved with the construction stage as detailed in **Section 4.5.3**.

5.4.3 Controls on Habitat Clearing

The following controls will be implemented to ensure that no over clearing occurs on the project:

- Clearing limits are to be marked out accurately with no-go delineation.
- Clearing limits to be checked prior to the commencement of clearing by survey and environmental team and routinely during the construction stage of the project.

5.4.4 Habitat Rehabilitation Areas

Areas identified for additional habitat/connectivity (refer to **Appendix C**) would be rehabilitated during the construction stage works. Key rehabilitation measures will include:

- Progressive revegetation/rehabilitation during the construction phase using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation.
- Planting of locally occurring species, including plants representative of groundcover, understorey and canopy strata.
- Plantings are to be undertaken around fauna crossing structures to optimise utilisation of these structures.
- Appropriate hollow logs and other large woody material (e.g. root balls and logs) identified during pre-clearing surveys would be placed within rehabilitation areas in order to provide habitat.
- Monitoring and maintenance of plantings.
- Managing and controlling weeds.

A planting list for habitat rehabilitation is to be determined in consultation with the project ecologist.

Ongoing weed management along the edge of cleared areas and post construction habitat restoration and landscape rehabilitation within the project boundary would be undertaken as part of the Project.

5.4.5 Pre-clearing Surveys

A suitably qualified ecologist will undertake pre-clearing surveys for threatened fauna species (including STQs) prior to (within 5 days) any clearing commencing. For the STQ, these would focus on dens, large hollow-bearing trees, scats and any other potential habitat features such as rock formations.

During pre-clearing surveys, the ecologist will identify and mark (spray paint with a white H) all habitat features, which consist of large fallen logs (greater than 300mm diameter and not in an advanced stage of decay). AFJV will relocate these habitat features to areas adjacent to the clearing footprint and within the Project boundary. Key areas where these habitat features will be relocated include:

- Around the inlet/outlet of fauna crossing structures.
- Native vegetation rehabilitation areas.
- Areas of retained vegetation within the project boundary (particularly within the Nambucca State Forest).

Immediately prior (within 2 hours) of clearing commencing within a given clearing area, an additional ecologist inspection is to be undertaken to confirm that clearing areas remain free of fauna (including STQs). In the event that a STQ is identified, no works would be undertaken within 200 metres of the animal and the measures within the Fauna Management Protocol for STQs (refer to **Table 4.1**) would be implemented. This process will affect a two staged approach to clearing of habitat.

5.4.6 STQ Management Protocol

The STQ Management Protocol outlined in **Table 4.1** will be undertaken in the event that a STQ (including road kill) is detected on or near to the site.

5.4.7 Type F Barrier Arrangement

The arrangement of Type F concrete barriers in a continuous line along one side (or centre) of the existing highway has the potential to create additional barriers to STQs attempting to cross the highway and increase the risk of car strike. Prior to the construction of fauna passage locations and installation of fauna fence, where continuous lines of Type F concrete barriers are to be installed, gaps are to be provided to allow escape of any animals off the highway. The provision of these gaps is to be designed in consultation with the Project Ecologist. It is acknowledged that traffic safety requirements will need to be taken into account. Where continuous lines of Type F concrete barriers are required in STQ habitat, material is to be attached at strategic locations (as advised by the Project Ecologist) to allow STQ's to climb over barriers.

5.4.8 Construction Stage Monitoring

Construction stage monitoring will be undertaken. The details of this monitoring are summarised in **Section 7**.

5.5 Performance Measures and Corrective Actions

Table 5.1 presents the main goals of STQ management for construction activities and includes a summary of the relevant mitigation measures for STQs that are to be completed during the construction phase of the Project. The table also describes how the identified mitigation measures are to 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.

Table 5.1 Construction Management Goals, Mitigation Measures, Performance Thresholds and Corrective Actions

Management Goal	*Mitigation/Control Measure*	*Monitoring/Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
Minimise habitat loss for the STQ from clearing.	▪ Minimise clearing of vegetation (STQ habitat) where feasible and reasonable. ▪ Design changes (e.g. additional ancillary facilities, batch plants etc to) avoid clearing of vegetation (STQ habitat).	▪ Ecological assessments to be prepared for additional areas to be cleared to verify minimal impacts to STQ habitat.	AFJV (Environmental team, Design team)	▪ STQ habitat to be cleared to not exceed areas detailed in **Section 3.2**.	▪ Notification to DoE, EPA if the performance thresholds cannot be met. ▪ Additional habitat rehabilitation works to be undertaken on the Project to offset losses.
	▪ The limits of clearing are to be clearly marked on all relevant work plans and protective fencing erected to mark these limits (i.e. no-go areas).	▪ Limits of clearing will be marked out prior to clearing commencing in each works area. ▪ No-go fencing will be installed prior to vegetation clearing activities commencing in each works area. ▪ Fencing and no-go signage will be inspected weekly, until construction is completed.	AFJV (Environmental team, Survey team)	▪ Final Sensitive Area Plans identify sensitive areas and 100% of clearing drawings identify clearing extents. ▪ Completion of pre-clearing survey prior to construction including mark out of clearing extents.	▪ Rehabilitation of inadvertently cleared area. ▪ Notification to DoE, EPA if over clearing occurs. ▪ Consideration of additional offsets for habitat loss.
	▪ Fauna habitat resources for the STQ to be marked by the ecologist and retained within areas adjacent to the clearing footprint and within the Project boundary where appropriate.	▪ Fauna habitat resources re-used on the project to be recorded and documented in the Clearing/Pre-clearing report to be prepared at the completion of clearing activities.	AFJV (Environmental team) Project Ecologist	▪ Suitable habitat features relocated into appropriate areas.	▪ Consideration of additional offsets for habitat loss. ▪ Additional habitat rehabilitation works to be undertaken on the Project to offset losses.

Management Goal	*Mitigation/Control Measure*	*Monitoring/Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
Undertake habitat rehabilitation works within identified areas associated with the Project Site to create additional STQ habitat.	▪ Progressive rehabilitation of identified areas (refer to **Appendix C**) during the construction stage using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation. Key rehabilitation measures would include: – Progressive revegetation/rehabilitation during the construction phase using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation. – Planting of locally occurring species, including plants representative of groundcover, understorey and canopy strata. – Plantings are to be undertaken around fauna crossing structures to optimise utilisation of these structures. – Monitoring and maintenance of plantings. – Managing and controlling weeds.	▪ Monitoring and maintenance of rehabilitation areas to be undertaken regularly as part of the project landscaping contract. ▪ Weed monitoring would be undertaken on the site.	AFJV (Landscape Design/ Construction team)	▪ Successful establishment of STQ habitat in nominated areas.	▪ Consideration of additional landscaping/habitat rehabilitation works.

Management Goal	*Mitigation/Control Measure*	*Monitoring/Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
No injury/mortality to STQs from construction activities.	▪ Preparation of an EWMS would be undertaken for all pre-construction activities and where necessary, would include measures to minimise risk to STQs. ▪ Induction of all personnel involved with construction activities would be undertaken to communicate STQ management requirements. ▪ A suitably qualified ecologist will undertake pre-clearing surveys for threatened fauna species (including STQs) prior to (within 48 hours) any clearing commencing. For the STQ, these would focus on dens, large hollow-bearing trees, scats and any other potential habitat features such as rock formations. ▪ Immediately prior to (within 2 hours) of clearing commencing within a given clearing area an additional ecologist inspection is to be undertaken to confirm that clearing areas remain free of fauna (including STQs). In the event that a STQ is identified, no works would be undertaken within 200 metres of the animal and the measures within the Fauna Management Protocol for STQs (refer to **Table 4.1**) would be implemented.	▪ Pre-clearing permits to be completed by the Project Ecologist prior to the clearing of any vegetation. ▪ Within 24 hours after the completion of clearing within a given area, post-clearing inspections to be undertaken of areas cleared to identify any animal (STQs) injured or killed during clearing.	AFJV (Environmental/ Construction team)/Project Ecologist	▪ No STQ injuries/mortalities as a consequence of construction activities.	▪ Notification and consultation to DoE, EPA if a STQ mortality is recorded on the project. ▪ Adaptive management response plan to be provided by Project Ecologist if mortality recorded.

Management Goal	*Mitigation/Control Measure*	*Monitoring/Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
Minimise vehicle strike of STQ during construction activities.	▪ STQ Management Protocol to be implemented requiring all personnel to report STQs (including road kill) (refer **Table 4-1**). ▪ An assessment of future road kill risks including adaptive management actions is to be provided by the Project Ecologist where: – A STQ is detected within/near the site, or – STQ road kill is detected.	▪ Road kill monitoring to be undertaken (refer to **Section 7**).	AFJV (Environmental team/Project Ecologist	▪ No road kill of STQs resulting from the project.	▪ An assessment of future road kill risk will be undertaken by the Project Ecologist for areas where STQ road kill have been detected. This assessment will aim to provide actions to mitigate the risk of future STQ road kill in such areas.
Ensure fauna crossing structures are constructed to maximise usage by fauna.	▪ EPA will be consulted during the detailed design phase on fauna crossing structure specific requirements for fauna furniture and treatments in and around fauna crossing structures. This will include, but not necessarily be limited to requirements for refuge poles and/or horizontal rails, pathways and appropriate plantings and/or sizing/ placement of scour rock & treatment of the substrate e.g. soil and/or mulch over the concrete floor and apron. ▪ Advice will be provided by the project ecologist on fauna furniture to be installed within fauna crossing structures.	▪ To be undertaken during the detailed design phase.	AFJV/Project Ecologist	▪ Concurrence from EPA on fauna furniture/treatments in and around fauna crossing structures.	▪ Ensure fauna crossing structures are constructed to maximise usage by fauna.

6 Operational Management Measures

6.1 Summary of Potential Impacts

The operational stage of the project is anticipated to have the following potential impacts on STQs:

- Fragmentation of habitat and impacts to quoll movements.
- Increased risk of vehicle strike associated with the upgrade

6.2 Main Goals for Management

The main goals for management are as follows:

- Maintain connectivity for STQs potentially utilising habitats on either side of the upgrade.
- Minimise vehicle strike of STQs during operational activities.
- Maintain habitat rehabilitation areas.

6.3 Mitigation Measures

6.3.1 Habitat Offset Strategy

This Strategy (the WC2NH Biodiversity Offset Strategy) is currently being prepared and would be implemented to offset the biodiversity impacts of the project to address the Minister's Conditions of Approval (MCoA B8) for the WC2U Upgrade Project to meet EPBC offset requirements.

6.3.2 Maintenance of Habitat Rehabilitation Areas

Areas identified for additional habitat/connectivity (refer to **Appendix C**) would be maintained by the AFJV during the landscape maintenance period, which extends into the operational stage of the project. Maintenance would include weed control works and replacement plantings if necessary. Maintenance would also be undertaken near fauna crossing structures and fencing and in all cases would be undertaken until rehabilitation areas have become self-sustaining.

6.3.3 Fauna Connectivity/Passage

The Proposal design includes fauna underpass and fauna exclusion fencing to allow for safe passage of fauna (including the STQ) crossing the Pacific Highway and reduce the risk of injury/road kill.

The location and sizes of fauna underpass structures had been identified in the Conditions of the Approval of the project under the NSW Environmental Planning and Assessment Act 1979 (EP&A Act) issued by the Minister for Planning and Infrastructure on 19 July 2011.

In response to a request from DoE following submission of the Referral under the EPBC Act, these fauna crossing locations were subject to an independent review by the STQ expert Chris Belcher and were modified in response to the recommendations of the review. There are a number of differences between the underpass structures identified in the Conditions of Approval under the EP&A Act, those recommended in the independent review and those that would be required to comply with the comments received from DoE following review of the Referral.

A workshop with NSW Environment Protection Authority (EPA), Chris Belcher, ecologists involved with the project and other stakeholders was held to review the fauna underpass options developed, including additional options developed by the project team, and to reach agreement on the most appropriate underpass option for each location. Details of the agreed fauna underpasses being constructed as part of the project are provided in **Appendix E**.

Approximately 12.1 kilometres of the new highway (where it intersects/adjoins the main areas of forest) would support fauna exclusion fencing. Most of this comprises 'floppy-top' fauna exclusion fencing design which was developed by Koala expert Casper Pieters and has been refined for fauna (including STQs) to minimise road strike. Details of fauna fencing to be provided as part of the project are provided in Attachment B of **Appendix B.** Attachment A of **Appendix B** is provided to give indicative locations of the fauna crossings and fauna fences. The Chainages in Attachment A reflect the WC2U EA chainages. To convert these to the referral chainages add 41765.

The majority of the remaining sections of highway where no fencing is proposed intersects or adjoins mostly cleared pastoral land. Ongoing maintenance and repair of the permanent fauna exclusion fencing would be undertaken to restrict STQ from crossing the Pacific Highway upgrade and facilitate the use of fauna crossings would be undertaken post construction under the operational environmental management system.

Following further consultation with EPA additional fauna fence requirements have been agreed to at the following locations:

- Ch 1600 (16365) to Ch 2500 (17265) (eastern side of carriageway) – additional length of 900 metres.
- Floodplain and Bridges at Ch 8500 (23265) to 10300 (25065) (1800m both sides of the carriageway in both directions) – additional 3600 metres.
- Ch 13500 (28265) to 14400 (29165) (western side of carriageway) – additional length of 900 metres.

6.3.4 Ecological Monitoring

Operational stage monitoring for STQs will be undertaken. The full methodology and timing for this monitoring is provided in **Section 7**.

6.4 Performance Measures and Corrective Actions

Table 6.1 presents the main goals of STQ management during operation of the WC2NH Upgrade and includes a summary of the relevant mitigation measures for STQs that are to be completed during the construction phase of the project. The table also describes how the identified mitigation measures are to be monitored, the timing and frequency of monitoring, nominates 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.

Table 6.1 Operational Management Goals, Mitigation Measures, Performance Thresholds and Corrective Actions

Main Goal	*Mitigation/Control Measure*	*Monitoring/Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
Maintain connectivity for STQs potentially occurring either side of the upgrade.	▪ Fauna Crossing Structures.	▪ Monitoring of the use of fauna crossing structures (refer to **Section 7**).	Roads and Maritime Services	▪ No change to densities, distribution, habitat use and movement patterns compared to baseline STQ population data.	▪ Consideration of the following options: – Maintenance of the existing connectivity measures. – Additional planting around the entrances of fauna crossing structures. – Consider additional offset measures to improve connectivity elsewhere.
Minimise road kill of STQ during operation of the WC2NH project.	▪ Fauna Fencing.	▪ The Roads and Maritime Services Roads Asset Division will undertake monitoring of fauna fencing on a regular basis after contractual obligations (refer to **Appendix F**). ▪ Road kill/injury monitoring will be undertaken during the operational stage (refer to **Section 7.4**.	Roads and Maritime Services	▪ No STQs recorded in road kill monitoring during operation.	▪ Where results identify a significant difference between the road kill numbers of the different treatments (transect types), DoE and EPA shall be notified, and a meeting will be set to discuss such differences with the relevant agencies, Roads and Maritime Services and the reporting Ecologist.
Maintain habitat rehabilitation areas.	▪ Maintenance of plantings until self-sufficient.	▪ Regular maintenance of habitat rehabilitation areas (refer to **Appendix C**) would be undertaken as part of the landscape maintenance works.	Roads and Maritime Services /AFJV (for maintenance period only)	▪ Self-sufficient areas of rehabilitated habitat for STQ within all nominated areas.	▪ Further maintenance/additional planting after the end of the landscape maintenance period.

7

Monitoring Program

A pre-construction (baseline) monitoring program has been prepared by Roads and Maritime Services, and peer reviewed/endorsed by STQ expert, Dr Chris Belcher. This program is summarised in **Section 7.1** and aims to compliment the monitoring of fauna crossing structures for the STQ to be undertaken as part of the WC2NH Monitoring Program (Benchmark, 2013) which is summarised within **Section 7.2**. Additional road kill monitoring is proposed as part of this management plan.

7.1 STQ Population Monitoring

7.1.1 Objective of Monitoring Program

The objective of the STQ Population Monitoring Program (Winter, 2014) was to establish baseline data relating to densities, distribution and current usage of habitats by the STQ within proximity to the WC2NH Project. Specifically, the baseline monitoring aimed to attain robust data to assist in the identification of changes in STQ densities, distribution and usage of habitats in response to the completion of WC2NH Project, and also to assist with determination of the effectiveness of STQ habitat connectivity mitigation structures.

7.1.2 Methodology

Pre-construction (baseline) monitoring was completed between mid-July and mid-August 2014, three months prior to construction commencing. Dr Chris Belcher provided concurrence with the methodology implemented which is summarised below.

7.1.2.1 Fauna Underpass Locations

Eleven locations where fauna underpasses are to be provided were surveyed with the use of baited camera traps and hair tubes in order to detect STQs.

Camera traps were deployed for three weeks at each site in winter (July/August) to coincide with the peak period for detection of STQs. Each camera trap consisted of one Scoutguard SG560K camera aimed at a caged bait station. The camera was set 3.0 – 4.0 metres from a small bait cage attached to a steel pole, approximately 1.5 metres above the ground and baited with a mixture of chicken and tuna oil. Additionally, tuna oil was drizzled on nearby features (e.g. rocks, logs) as a further attractant. Cameras were set to record during the day and night as quolls are known to range throughout both periods.

In addition, hair tubes were deployed at each of these locations for three weeks along transects centred on the location of each fauna crossing structure. Transects comprised ten tubes/transect placed 20 metres apart and were baited with a mixture of flour, sardines and tuna oil.

Opportunistic scat surveys were also undertaken at the time of collecting the cameras after the completion of the 21 day survey period.

7.1.2.2 Habitat Associated with the Project Site

Further to above, broader areas associated with the WC2NH Project Site were surveyed to determine the usage of habitats by the STQ. Two baited camera traps were placed every 100 hectare/1.0 kilometre square grid with one camera and bait at each site as per the methodology detailed in **Section 7.1.2.1** to detect STQs. The rationale for camera placement for the monitoring program is provided below:

- Two baited camera traps would be placed every 100 hectare/1.0 kilometre square grid, with one camera and bait at each site.

- Camera traps are to be located within 2.0 kilometres of the proposal, predominantly in larger blocks of vegetation (e.g. Nambucca State Forest, Ingalba State Forest), but also in some narrow patches of remnant vegetation situated within the partially cleared farmland mosaic that is contiguous with these larger blocks of forested vegetation.
- Moist forest along riparian zones adjacent to creek lines would primarily be targeted.
- Small areas of fragmented vegetation in otherwise cleared farmland would not be targeted (e.g. most of the area between Macksville and Warrell Creek).
- No camera traps are proposed within the Saltmarsh/Swamp Oak forest in low-lying areas to the north of the Nambucca River due to a lack of suitable habitat features for STQ.

A total of 50 survey sites were identified and utilised for the broader habitat assessment. Opportunistic scat surveys were also undertaken at the time of collecting the cameras after the completion of the 21 day survey period.

Photograph analysis of the images recorded by the cameras and hair analysis from hair tubes traps were undertaken at the completion of the surveys.

7.1.3 Results of Pre-construction (Baseline) STQ Population Monitoring

The baseline STQ Monitoring Report is included as **Appendix D**. Analysis of the images captured on the 61 deployed remote cameras showed that no STQ visited the bait stations over the three week period that cameras were deployed. The cameras captured images of a range of other native and exotic fauna species. The three most commonly encountered species were Red-necked Wallaby (captured at 49.2 per cent of camera traps), Bush Rat (captured at 36.1 per cent of camera traps), and Common Brushtail Possum (Recorded at 32.8 per cent of camera traps).

Identification of hair left behind in deployed hair tubes at the fauna underpass sites indicated no presence of STQ. Hair from a range of other mammals was present consisting mainly of Bush Rat and Brown Antechinus. Despite not recording STQ by either the remote cameras or hair tube methods used in the monitoring, a previous local OEH BioNet record and a recent 2014 road kill record in the vicinity of the southern end of the Project suggest that the STQ occurs at a low density within the locality.

7.2 Monitoring of Fauna Underpasses/Fauna Fences

7.2.1 Objective of Monitoring Program

The objective of the monitoring program is to determine whether mitigation measures (fauna underpasses and fauna fence) are effective in maintaining connectivity for fauna (including STQs in the vicinity of the project.

7.2.2 Methodology

7.2.2.1 Fauna Underpasses

Monitoring of fauna underpasses would be undertaken in winter (July/August) to coincide with the peak period of detection for STQs and involve the use of remote camera surveys at fauna underpasses as agreed between Roads and Maritime and EPA (refer to **Table 7.1**). Monitoring of underpasses will be undertaken using the following techniques:

- A motion-detecting camera would be installed at both ends of each crossing structure to be monitored. Cameras are to operate continuously for a period of 60 days during winter.
- Sand-plots would be established at each end of each crossing structure to be monitored for a period of eight nights per monitoring event. Sand plots, at least 1.0 metre wide, will be established across the entire width of the underpass and will be inspected each following morning period for tracks each morning and then raked clean.
- Scat searches within crossing structures (approximately 1.0 to 2.0 metres from the end to minimise wind and rain disturbance) and in adjoining habitat would be undertaken. Searches to be undertaken when installing and checking sand plots (i.e. twice per monitoring period).

Table 7.1 Fauna Crossing Structures to be Monitored

Chainage	*Fauna Crossing Structure Type*	*Structure Form*	*Dimensions*
42500	Combined	Bridge over Warrell Ck	
55120	Dedicated	Box Culvert	3000x3000
56410	Combined	Box Culvert	2400x2400
57770	Dedicated	Box Culvert	3000x3000
58510	Combined	Box Culvert	3000x3000
58560	Dedicated	Box Culvert	3000x3000
59090	Dedicated	Box Culvert	3000x3000
59550	Dedicated	Box Culvert	3000x3000
59750 North Bound lanes	Dedicated	Box Culvert	24000x2400
59760 South Bound Lanes	Dedicated	Box Culvert	2400x2400
60600 North Bound Lanes	Dedicated	Box Culvert	2400x2400
60610 South Bound Lanes	Dedicated	Box Culvert	2400x2400

7.2.2.2 Adjacent Forested Areas

Forested habitats adjacent to fauna underpass entrances will be surveyed to assess the range of fauna species occurring in proximity to each underpass structure. These results will then be compared with underpass monitoring results to identify which species present in the immediate area are not utilising the underpass structure. A one hectare area adjacent to fauna underpass entrances (in forested areas) will be surveyed at the time of fauna underpass surveys and will include spotlighting, arboreal and ground-based trapping, hairtube sampling, timed diurnal and nocturnal searches and scat and track searches.

7.2.2.3 Fauna Fences

Fauna fence monitoring would be undertaken frequently post construction as part of standard ongoing road maintenance to ensure that fences are not damaged. The contractor has a contractual period of 36 months to maintain fences. At the completion of this time period, Roads and Maritime Services Asset Division will continue to monitor and maintain fauna fencing in perpetuity.

7.2.3 Timing/Frequency

Fauna underpass monitoring (including surveys of adjacent forested areas) will commence upon completion of construction of the Project (year 4) and will be undertaken in winter each year for a minimum of 60 days. Monitoring will continue in years 5 to 8 of the operational phase and additional monitoring may be required if fauna underpasses are determined to be ineffective.

7.2.4 Performance Indicators

Indicators of success for fauna underpasses/fauna fences are as follows:

- Demonstrated use of fauna crossing structures by STQs with consideration of population estimates as derived from the STQ population monitoring surveys.

7.3 Road Kill Monitoring

7.3.1 Objective of Monitoring Program

The aim of the monitoring program is to :

- Report on any animal road kill on the project following the opening to traffic; and
- Assess the effectiveness of the presence of fauna fencing to prevent fauna being killed by vehicles while attempting to cross the WC2NH Upgrade.

A detailed methodology for road kill monitoring to achieve this objective is included in **Appendix F**. The methodology and timing of this monitoring are summarised below.

7.3.2 Methodology

7.3.2.1 Monitoring Procedure

A two person team vehicle being driven along the entire length of the existing highway in the Project area and identifying dead wildlife (road kill) seen on the roads and within three metres of the road edge. Both driver and passenger will search the left-hand side of the road and its verge for road kill with the driver searching the road and shoulder and the passenger searching the verge. When a road kill is observed from the vehicle, a close visual inspection of the carcass will be undertaken where access is possible and where safely limitations permit. If safe access is not possible, due to local traffic conditions, binoculars will be used to try to identify and provide as detailed information as is possible on the carcass. Where there is any doubt to the identification of the carcass, photographs will be taken and forwarded to a qualified ecologist for identification/confirmation of species.

7.3.2.2 Detailed Methodology

Specific details of the monitoring methodology are:

- The highway will be monitored using a two-person team traversing the Upgrade in a vehicle to locate and identify road kills.
- The speed of travel will be the same in all cases to avoid confounding the data collection, and should be as slow as is safely possible.
- The highway will be surveyed weekly for 12 weeks commencing the week of opening each stage to traffic and for four weeks in spring, summer, autumn and winter (refer to **Section 7.3.3**).
- When possible, each survey shall be completed within two hours of sunrise in order to maximise the potential to record road kills before either carrion eating animals or traffic render and road kill unidentifiable.
- If possible, each survey will be carried out on the same day to remove the influence of varying environmental conditions and to ensure consistent temporal spacing.
- For each road kill observed, the following attributes will be recorded:
    a. Geographic Coordinates of any road kill.
    b. Whether fauna fencing was installed at the location.
    c. Species of road kill, however, where there is any doubt to the identification of the carcass, photographs shall be forwarded to a qualified ecologist for identification/confirmation of the species.
- If the animal is identified as an EPBC Act threatened species, the carcass will be photographed and the following information will also be recorded where possible and where safety considerations permit:
    a. Sex and age class (juvenile or adult).
    b. Presence of pouch young (for marsupials).
    c. Presence of flightless young (for flying-foxes or other bats).
    d. Distance to a fauna connectivity structure.
    e. Distance to drop down structure
    f. If fauna fencing was installed, is there any damage to the fence in the vicinity.
    g. Weather conditions at the time of the monitoring (from the Bureau of Meteorology) – including temperature, rainfall in the last 24 hours, moon phase.
    h. If the animal is identified as a flying-fox:
        i. Distance to nearest camp,
        ii. Distance to nearest canopy vegetation,
        iii. Presence of flowering food trees in neighbouring median or roadside vegetation; plants identified to species and referenced with diet list.

7.3.2.3 Data Analysis

The data to be collected will be analysed using a suitable non-parametric test such as a Kruskal-Wallis test. The aim will be to test both whether the fenced and unfenced locations have different mean numbers of road kills and if the amount of road kill varies through time in either or both of the two types of areas. Such information will indicate if the mitigation measures in the area are working as expected to keep road kills to acceptable levels and that none of the target species are killed.

7.3.3 Timing/Frequency

The timing and frequency of road kill monitoring is summarised in **Table 7.2**

Table 7.2 Road Kill Monitoring Timing

Project Phase	*Timing of Surveys*	*Location*	*Responsibility*
During clearing operations.	Daily	Portion of existing Pacific Hwy adjacent to clearing operations.	AFJV
One month following clearing operations	Daily	Portion of existing Pacific Hwy adjacent to clearing operations.	AFJV
Duration of construction.	Weekly	Entire length of existing Hwy in Project area.	AFJV/Roads and Maritime Services
Upon opening of each stage of the Project to traffic (operational phase)	Weekly for 12 weeks commencing the week of opening each stage to traffic..	Entire length of opened stage.	Roads and Maritime Services
Upon completion of the Project (operational phase)	Excluding the season/s covered by the initial 12 week monitoring period (refer above), weekly during October (spring), January (summer), April (autumn) and July (Winter) for up to 5 consecutive years post construction, or until mitigation measures have been demonstrated to be effective.	Entire length of completed Project	Roads and Maritime Services

7.3.4 Performance Indicators

Indicators of success for fauna underpasses/fauna fences are as follows:

- Lower rates of road kill in proximity to fauna fencing (i.e. areas of the main carriageways within areas adjacent to installed fauna fencing) than in sections of the upgrade not near fauna fencing during monitoring events up to five years post construction phase, or until such time as mitigation measures have been demonstrated to be effective.

7.4 Summary of Monitoring Program

A summary of the monitoring program relevant to the STQ is provided in **Table 7.3**.

Table 7.3 Summary of Monitoring Program

Monitoring Component	*Main Goal*	*Timing/Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from Performance Criteria*
STQ population monitoring.	To provide baseline data relating to densities, distribution and current usage of habitats by the STQ.	▪ Pre-construction baseline surveys completed (winter 2014).	Roads and Maritime Services	▪ Accurate/robust survey design and information interpretation.	▪ NA as the survey design has been confirmed as appropriate by STQ expert Dr Chris Belcher.
Monitoring of fauna underpasses, fauna fences and adjacent forested habitat.	To determine if possible whether mitigation measures (fauna underpasses and fauna fence) are effective in maintaining connectivity for fauna (including STQs) in the vicinity of the project.	▪ Operational stage (winter - year 4, to 8).	Roads and Maritime Services	▪ Demonstrated use of fauna crossing structures by STQs with consideration of population estimates as derived from the STQ baseline monitoring surveys. ▪ No breaches in fauna exclusion fencing.	▪ Consideration of the following options: – Maintenance of the existing connectivity measures. – Investigate habitat adjoining the structure, consider improving habitat and connectivity – Modify design of existing measures where feasible and reasonable. – Consider additional offset measures to improve connectivity elsewhere.
Road kill monitoring	To effectively demonstrate that road kill rates are mitigated by the presence of fauna fencing by preventing fauna of concern from attempting to cross the WC2NH Upgrade.	▪ During clearing operations (up until one month after clearing is completed) – daily. ▪ Duration of construction (weekly). ▪ Upon opening of each stage of the Project to traffic (operational phase), weekly for 12 weeks commencing the week of opening each stage to	Roads and Maritime Services/AFJV	▪ Lower rates of road kill in proximity to fauna fencing (i.e. areas of the main carriageways within areas adjacent to installed fauna fencing) than in sections of the upgrade not near fauna fencing during monitoring events up to 5 years post construction phase, or until such time as mitigation measures have been	▪ Where results identify a significant difference between the road kill numbers of the different treatments (transect types), DoE and EPA shall be notified, and a meeting will be set to discuss such differences with the relevant agencies, Roads and Maritime Services and the reporting Ecologist.

Monitoring Component	Main Goal	Timing/Frequency	Responsibility	Performance Threshold	Corrective Actions if Deviation from Performance Criteria
		traffic. ▪ Operational stage - Excluding the season/s covered by the initial 12 week monitoring period (refer above), wweekly during October (spring), January (summer), April (autumn) and July (winter) for up to 5 consecutive years post construction, or until mitigation measures have been demonstrated to be effective.		demonstrated to be effective. ▪ All fauna fencing is installed at the minimum of locations as identified in the EPBC approval prior to the operational phase of the WC2NH Upgrade.	

References

Andrew, D. L. (2005). Ecology of the tiger quoll *Dasyurus maculatus maculatus* in coastal New South Wales. M.Sc thesis, University of Wollongong, Wollongong. Cited from DoSE, 2008.

Belcher, C. A. (2000) The ecology of the Tiger Quoll, *Dasyurus maculatus*, in south-eastern Australia. Ph.D thesis, Deakin University, Geelong. Cited from DoSE, 2008.

Belcher, C. A. and Darrant, J. P. (2004) Home range and spatial organization of the marsupial carnivore. Cited from DoSE, 2008.

Benchmark Environmental Management, 2014. Warrell Creek to Urunga Pacific Highway upgrade Ecological Monitoring Program, Stage 2: Warrell Creek to Nambucca Heads. Draft Report 4 prepared for Roads and Maritime Services May, 2014.

DoSE (2008). *National Recovery Plan for the Spotted-tailed Quoll (Dasyurus Maculata)*. VIC Department of Sustainability and Environment.

DoE (2013a). *EPBC Act Policy Statement 1.1 Significant Impact Guidelines*. Department of Environment and Heritage, Canberra.

DoE (2013b). *Species Profile and Threats Database – Dasyurus maculata*.

DoPI (2013). *Project Approval (Modification 4 approved on 22 March 2013).* NSW Department of Planning and Infrastructure, Sydney.

Edgar, R. and Belcher, C. (1995) Spotted-tailed Quoll. Pp. 67-69 In The Mammals of Australia. Ed. R Strahan. Australia Museum and Reed Books, Sydney.

GHD (2013). *Roads and Maritime Services Nambucca Heads to Urunga Road, Pacific Highway Upgrade EPBC Act MNES Report*. Unpublished report to NSW Roads and Maritime Services.

Glen, A. S. and Dickman, C. R. (2006a) Home range, denning behaviour and microhabitat use of the carnivorous marsupial *Dasyurus maculatus* in eastern Australia. Journal of Zoology, London 268, 347-354. Cited from DoSE, 2008.

OEH (2013). Atlas of NSW Wildlife. NSW Office of Environment and Heritage website: www.environment.nsw.gov.au. Accessed 01 August 2014.

OEH (2014). Atlas of NSW Wildlife. Species Profile for the Spotted-tailed Quoll. Accessed 01 August 2014.

Scotts, D (2003). *Key Habitats and Corridors for Forest Fauna*. Occasional Paper 32. NSW National Parks Wildlife Services.

SKM (2010a). Upgrading the Pacific Highway, Warrell Creek to Urunga Environmental Assessment – Volume 1. Report to NSW Roads and Maritime Services. Sinclair Knight Merz, St Leonards NSW.

SKM (2010b). Upgrading the Pacific Highway, Warrell Creek to Urunga Environmental Assessment – Volume 2 – Working paper 1 – Flora and fauna. Report to NSW Roads and Maritime Services. Sinclair Knight Merz, St Leonards NSW.

SKM (2010c). *Warrell Creek to Urunga Submissions and preferred project report*. Report to NSW Roads and Maritime Services. Sinclair Knight Merz, St Leonards NSW.

Taylor, B.D. and Goldingay, R.L. (2003). Cutting the carnage: wildlife usage of road culverts in north-eastern New South Wales, In *Wildlife Research*, Vol. 30. Page 529-537.

Definitions and Acrynoms

ACT	Australian Capital Territory
CEMP	Construction Environmental Management Plan
DoE	Australian Government Department of Environment
DoPI	NSW Department of Planning and Infrastructure
DSEWPaC	Australian Government Department of Sustainability, Environment, Water, Population and Communities
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPA	NSW Environment Protection Authority
FFMP	Flora and Fauna Management Plan
NH2U	Nambucca Heads to Urunga Pacific Highway Upgrade Project
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
QLD	Queensland
RCBC	Reinforced Concrete Box Culvert
SKM	Sinclair Knight Merz
STQ	Spotted-tailed Quoll
TSC Act	NSW *Threatened Species Conservation Act 1995*
WC2NH	Warrell Creek to Nambucca Heads Pacific Highway Upgrade Project
WC2U	Warrell Creek to Urunga Pacific Highway Upgrade Project (referred to throughout the document as 'the Project')

Copyright and Usage

Appendix A

Plan Authors CVs

David HAVILAH

BSc (Biol)

Ecologist

Qualifications

Bachelor of Science (Biology), Sydney University, 2003

Professional Affiliations

Member, Ecological Consultants Association of NSW
Member, NSW Wildlife Information, Rescue and Education Services Inc (WIRES-Northern Rivers)

Experience

David is an experienced ecological consultant who has developed a broad range of skills from working on a variety of small and large-scale projects. He specialises in undertaking terrestrial flora and fauna surveys and providing high quality ecological reports within Queensland and New South Wales. This work has included designing and implementing threatened species management plans and ecological monitoring programs. David has a detailed working knowledge of environmental legislation relevant to ecological impact assessment and an ability to balance practical applications of environmental requirements with good environmental outcomes.

Key Experience and Skills

A large focus of David's work has been providing ecological services on large infrastructure projects. He has been engaged as the Project Ecologist for construction contractors on a number of sections of the NSW Pacific Highway upgrade project. This work has included providing technical advice, ecological surveys and assessments and managing threatened species on these projects.

David's skills and key areas of expertise include:

- Design, implementation and management of ecological monitoring programs.
- Determining and documenting best practice and innovative management plans for threatened species occurring on infrastructure projects.
- Undertaking detailed systematic terrestrial flora / fauna surveys and vegetation / weed mapping.
- Preparing high quality ecological / environmental assessments for a broad range of projects in accordance with NSW, QLD and Federal environmental legislation.
- Preparing vegetation management plans and environmental management plans.
- Providing peer reviews of ecological assessments.
- Providing technical advice, ecological surveys and reporting in the role of project ecologist for large-scale infrastructure projects.
- Supervising and delivering pre-clearing surveys and spotter / catcher (fauna capture / relocation services) as part of large infrastructure projects.
- Delivering environmental awareness presentations.

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Veronica SILVER

BEnvSc Grad Dip (UrbRegPlan)

Senior Associate / Ecologist / Planner

Qualifications

Bachelor of Environmental Science (Environmental Management),
The University of Newcastle, [2000]
Graduate Diploma of Urban and Regional Planning, The University of New England, [2007]

Professional Affiliations

Member, Planning Institute Australia
Member, Environment Institute of Australia and New Zealand
Member, Ecological Consultants Association of NSW Inc.
Member, Australian Network for Plant Conservation Inc.

Professional Short Courses

- Planning for Bushfire Prone Areas
- Certificate IV Bushland Regeneration
- Certificate IV Workplace Training and Assessment
- Certificate II Australian Land Conservation and Restoration
- Project Management, Chifley Business School
- Effective Communication, Negotiation and Mediation, Chifley Business School
- Urban Design, Chifley Business School
- Acid Sulfate Soils: Identification, Assessment and Management
- Woodland Birds Identification and Ecology
- Signed English, TAFE Newcastle

Licences

- Scientific Licence (SL100152) issued by the Office of Environment and Heritage.
- Animal Research Authority issued by the Animal Care and Ethics Committee of the Director-General of NSW Department of Primary Industries to undertake fauna surveys throughout NSW and SE Queensland.

Experience

Veronica has been a key member of GeoLINK's ecology team since 2004. She specialises in flora / fauna field surveys; ecological monitoring; bushfire assessment; environmental impact assessment and bushland regeneration.

Veronica has further diversified her skills and knowledge in the built environment, having completed a Graduate Diploma of Urban and Regional Planning through The University of New England in 2007.

Veronica possesses high level project management skills, developed through working with a broad range of public and private sector clients on challenging environmental projects. Having project managed a variety of ecological and planning projects; she has significant skills in liaison and the management of multidisciplinary teams.

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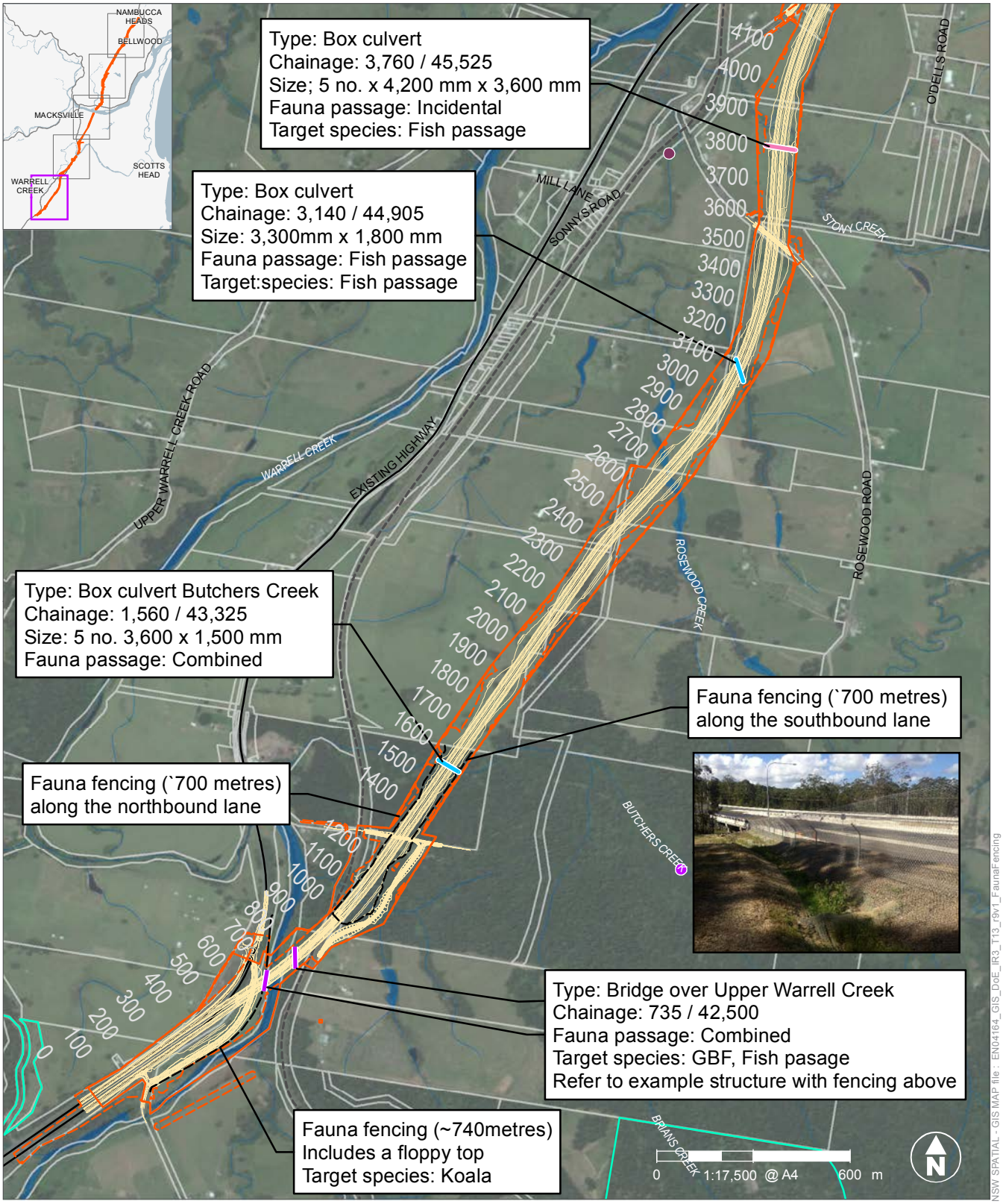
Appendix B

Fauna Exclusion Fencing



Legend

- Road design
- Service Road - Old Coast Road
- Road boundary
- Clearing boundary
- Lot (survey)
- State Forest boundary
- Combined culvert with fauna underpass
- Dedicated fauna underpass
- Fauna fence
- Bridge with fauna passage
- Incidental fauna passage

Threatened fauna

- Black Bittern
- Black Grass-dart Butterfly
- Black-necked Stork
- Brolga
- Brush-tailed Phascogale
- Cattle Egret
- Common Greenshank
- Eastern Bentwing-bat
- Eastern Freetail-bat
- Eastern Osprey
- Glossy Black-Cockatoo
- Glossy Ibis
- Greater Broad-nosed Bat
- Green and Golden Bell Frog
- Grey-headed Flying-fox
- Koala
- Latham's Snipe
- Little Bentwing-bat
- Masked Owl
- Oriental Pratincole
- Osprey (nest site)
- Pacific Golden Plover
- Powerful Owl
- Rainbow Bee-eater
- Regent Honeyeater
- Sooty Owl
- Southern Myotis
- Spotted-tailed Quoll
- Square-tailed Kite
- Squirrel Glider
- White-bellied Sea-Eagle
- Yellow-bellied Glider

NOTES

- The chainages in this figure reflect the WC2U EA chainages. To convert these to the referral chainages add 41765.
- The locations of the fauna crossings and fauna fences are indicative only.

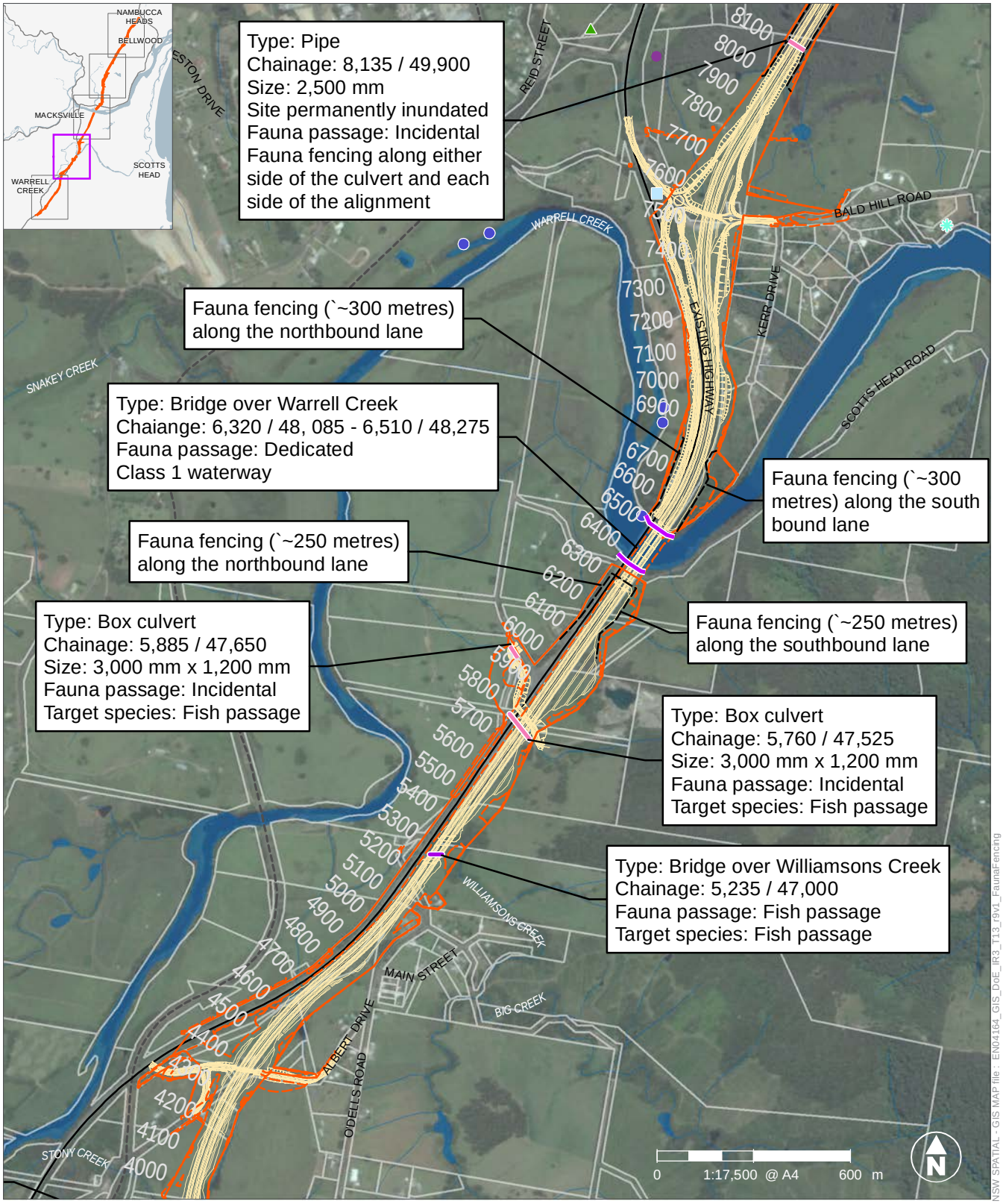
DATA SOURCES

ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013

This mapping is current as at December 2013 and could be refined with updated survey information

NSW SPATIAL - GIS MAP file : EN04164_GIS_DoE_IR3_T13_r9v1_FaunaFencing

Transport Roads & Maritime Services | JACOBS



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Road design
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Lot (survey)
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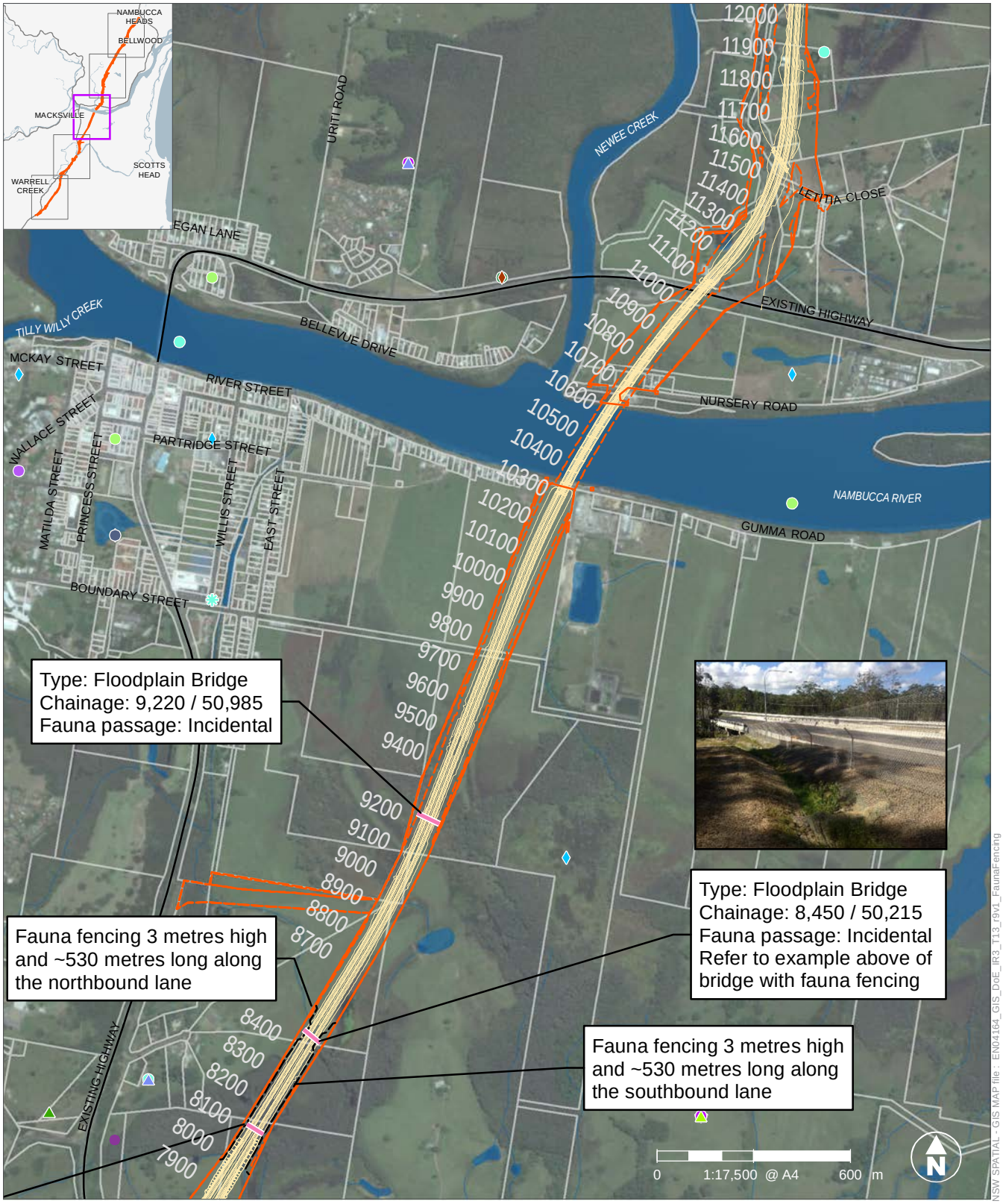

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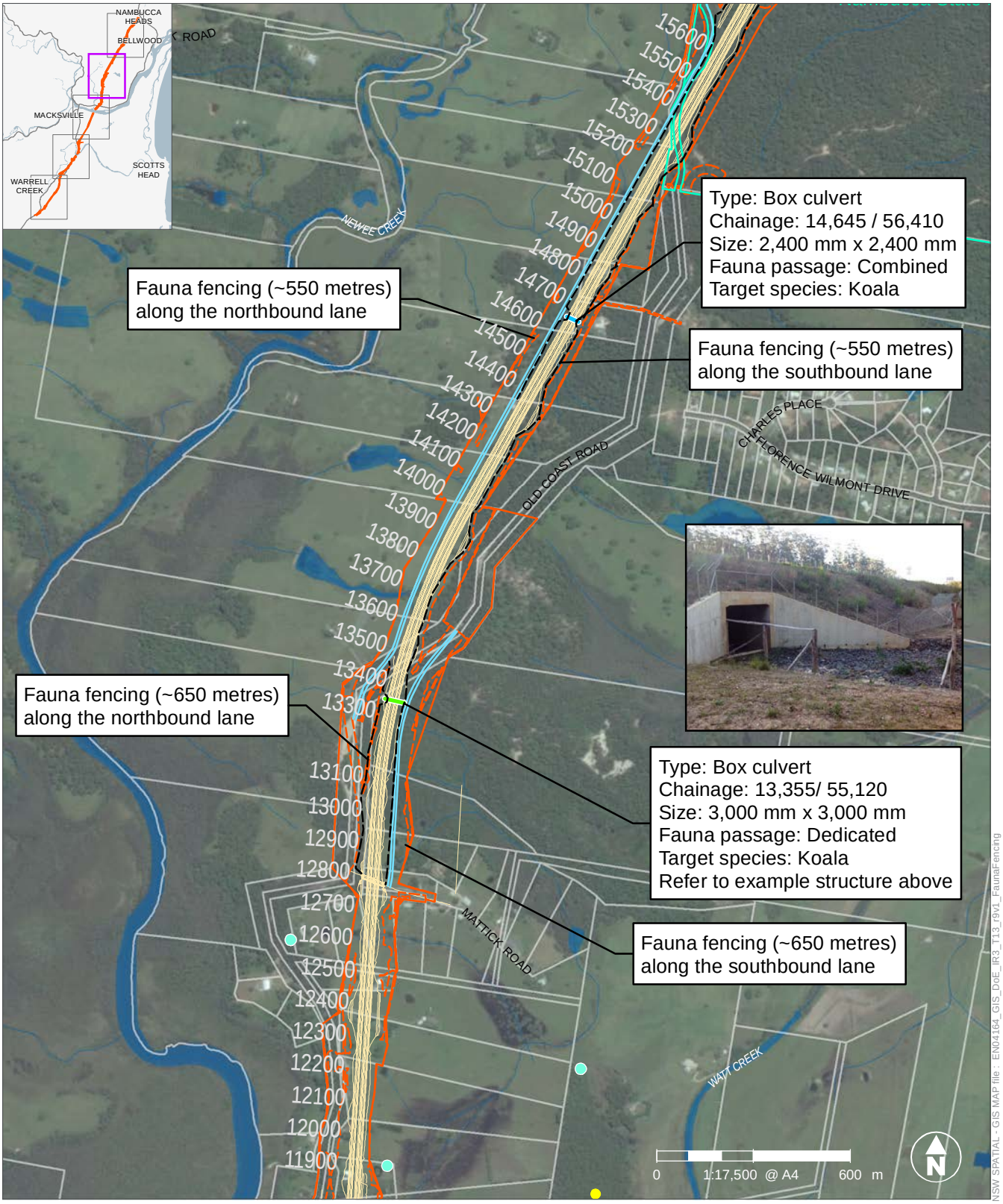

NSW SPATIAL - GIS MAP file: EN04164_GIS_DoE_IR3_T13_r9v1_FaunaFencing

Legend

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Road boundary
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Lot (survey)
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Dedicated fauna underpass
Fauna fence
Bridge with fauna passage
Incidental fauna passage

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DATA SOURCES

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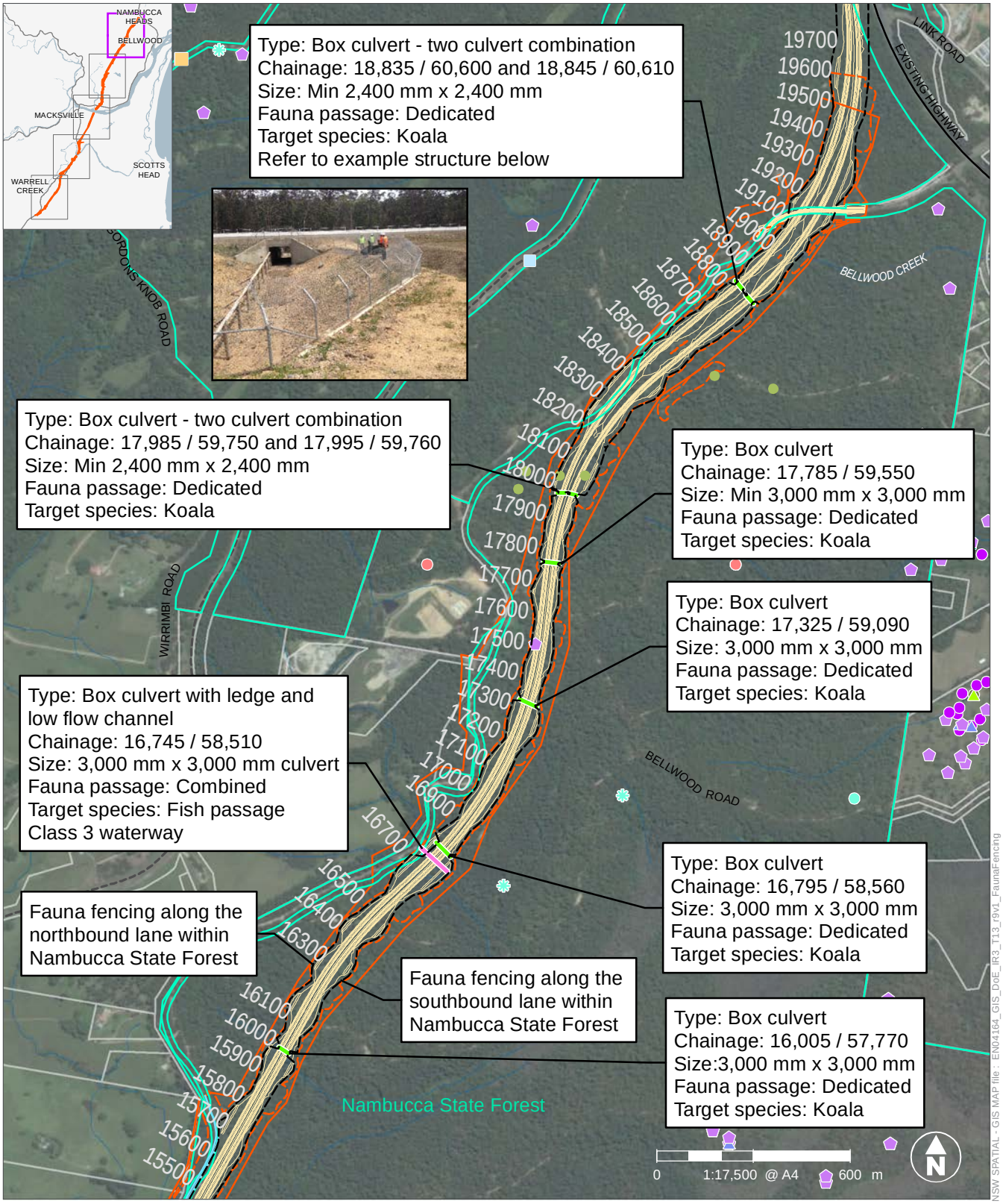

Legend

Road design
Service Road - Old Coast Road
Road boundary
Clearing boundary
Lot (survey)
State Forest boundary
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Dedicated fauna underpass
Fauna fence
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Incidental fauna passage

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DATA SOURCES
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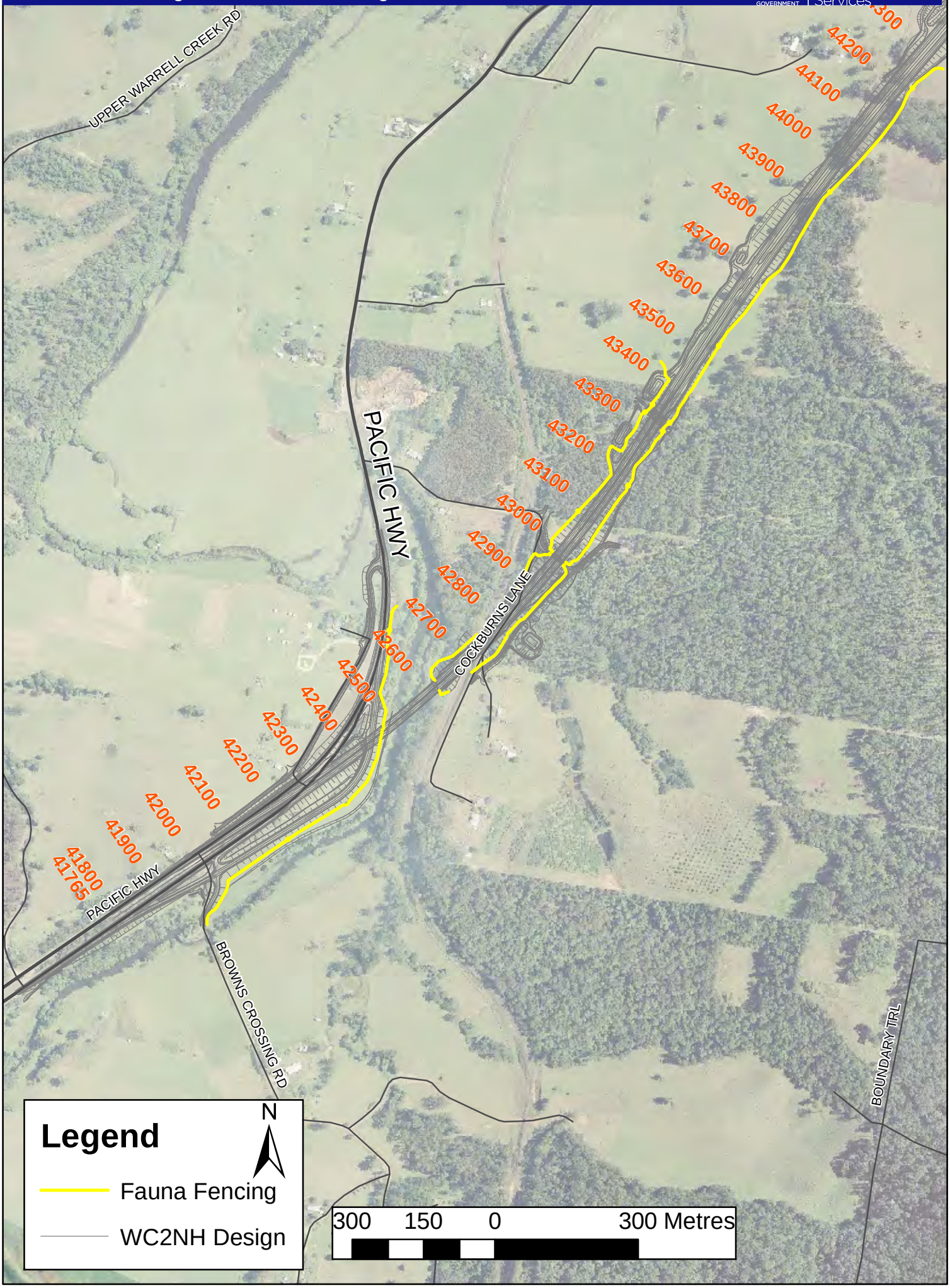
This mapping is current as at December 2013 and could be refined with updated survey information

PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

Attachment B Figure 1 Fauna Fencing locations

Transport Roads & Maritime Services



PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

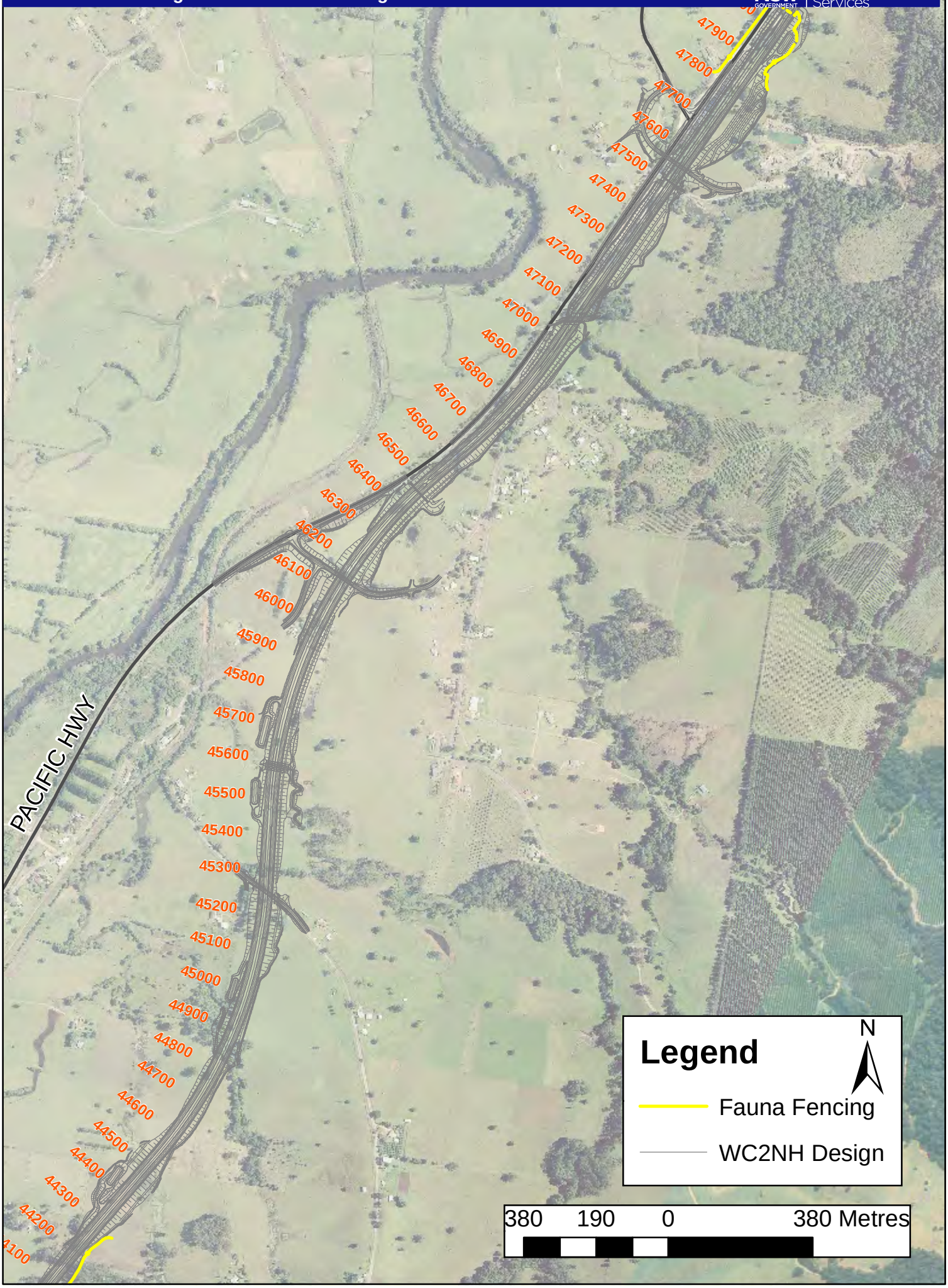
Attachment B Figure 2 Fauna Fencing locations

Transport Roads & Maritime Services

PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

Attachment B Figure 3 Fauna Fencing locations

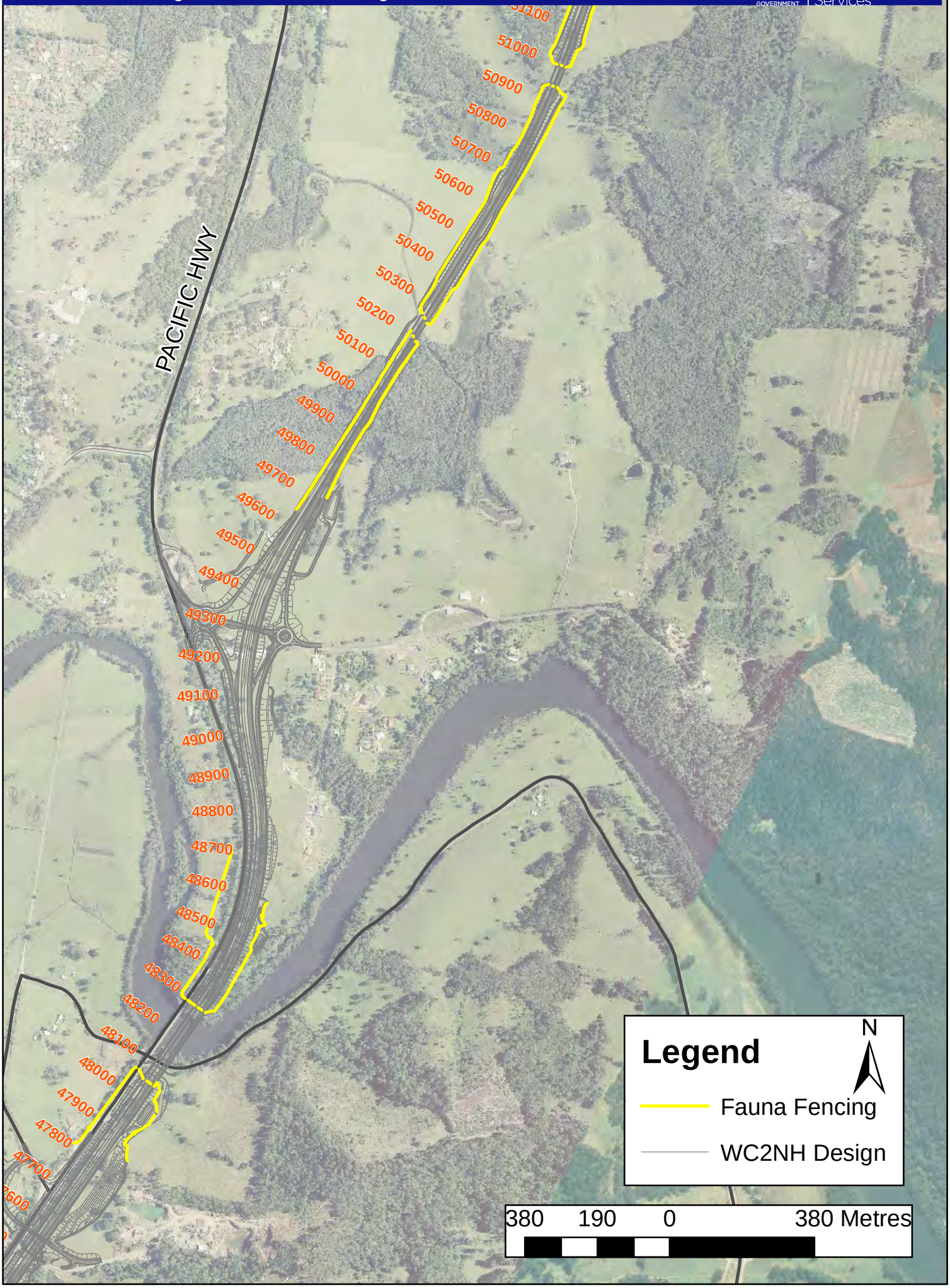
Transport Roads & Maritime Services



PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

Attachment B Figure 4 Fauna Fencing locations

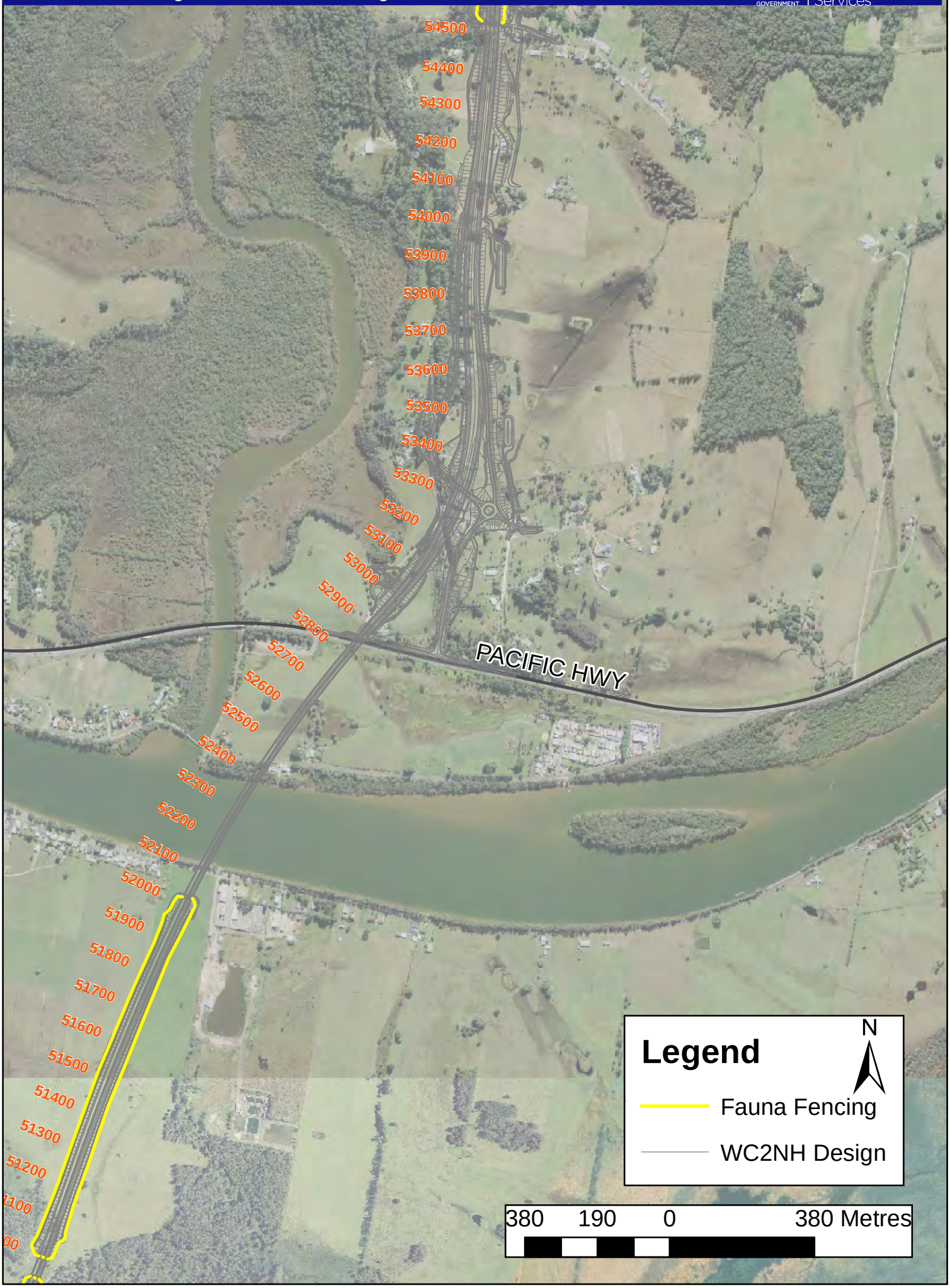
Transport Roads & Maritime Services



PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

Attachment B Figure 5 Fauna Fencing locations

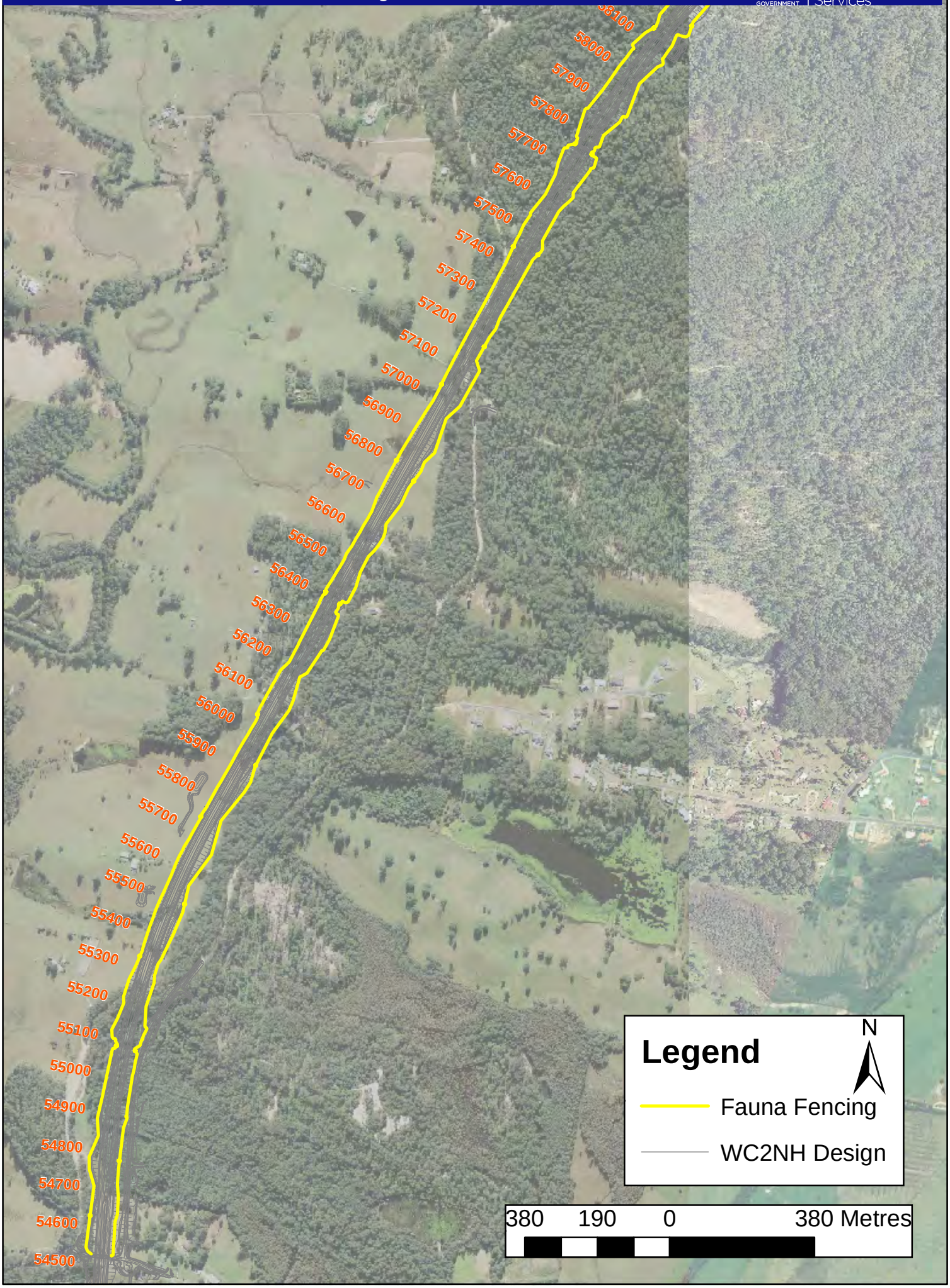
Transport Roads & Maritime Services



PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

Attachment B Figure 6 Fauna Fencing locations

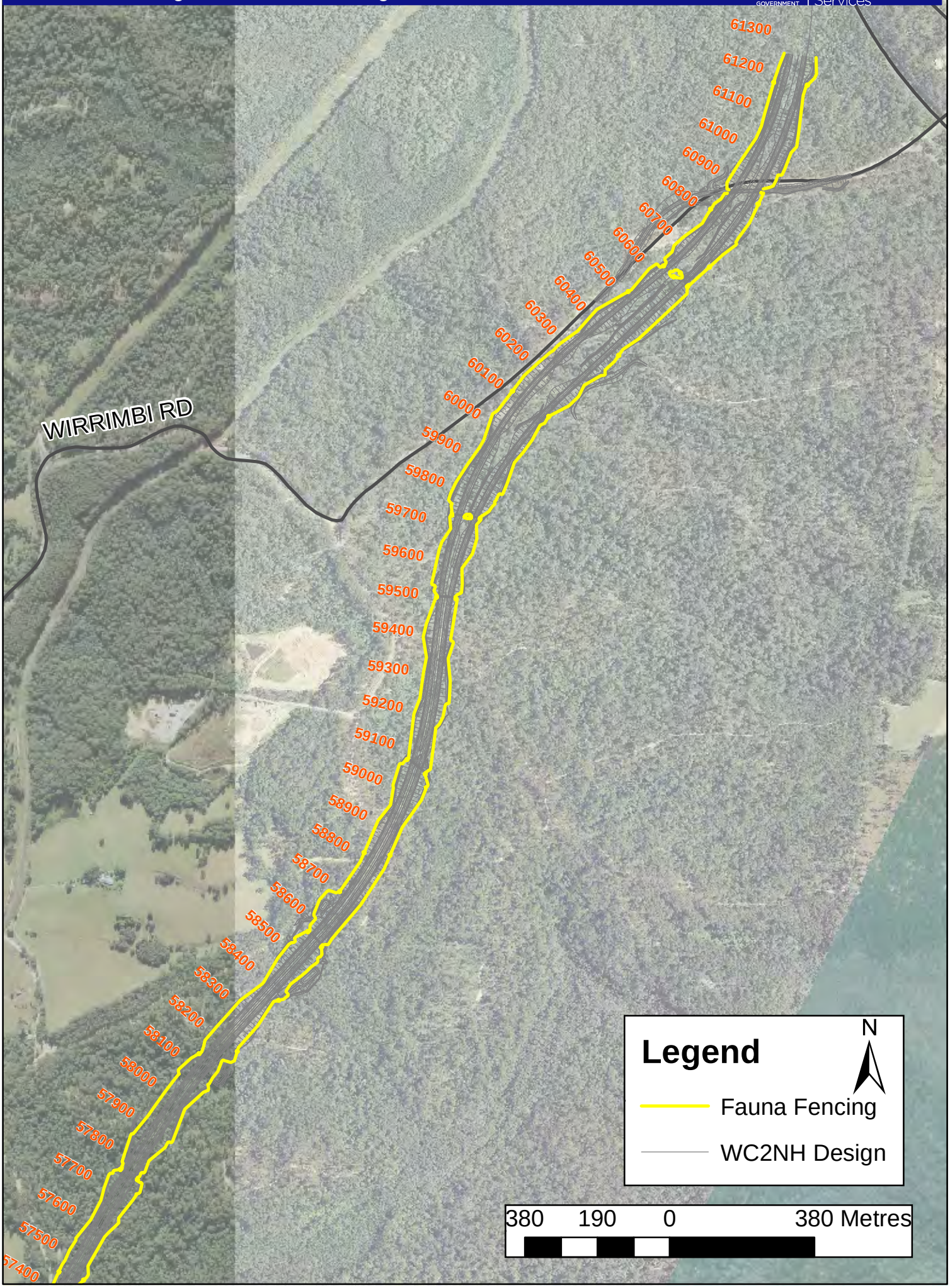
Transport Roads & Maritime Services



PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

Attachment B Figure 7 Fauna Fencing locations

Transport Roads & Maritime Services



Appendix C

Connectivity Habitat Restoration Areas

DoE Information Request 3, Task 5 and 6 – Connectivity and fragmentation of habitat

Document: Item 2-1 Independent review Koala, Table 4-1.

DoE comment 5:

Given the likely residual impact from connectivity loss and increased fragmentation of the koala habitat/population, please demonstrate how connectivity will be increased in the landscape (e.g. through tree plantings) to compensate for this loss. Please include this information in the proposed Urban Design and Landscape Plan (UDLP) (see comment 6a below).

DoE comment 6:

Table 1.2:

(a) Habitat restoration and management –

(i) It is unclear what areas of the proposed action will require a targeted UDLP. Please show on a map the locations along the length of the highway where habitat restoration and management will occur and how this will result in connectivity for relevant threatened species (e.g. see comment 5 regarding the koala above). Additionally, to provide context, please overlay all fauna mitigation measures proposed on the same map.

(ii) Please advise the likely timing for completion of the UDLP, noting that RMS must provide the plans to the Department for approval prior to commencement (Note: The submission of the plans can be staged to align with construction staging).

Response Task 5:

Identification of potential opportunities to enhance connectivity

Roads and Maritime Services propose to enhance connectivity in the landscape wherever reasonable and feasible through the provision of strategic tree planting in road reserves and residual land acquired for the project. In a brief memorandum provided by GeoLINK environmental consultants (dated 24th July 2014), the ecologists involved in the baseline Koala surveys identified opportunities to enhance habitat / vegetation connectivity post-construction for fauna in general including the Koala, refer to Table 1 of **Attachment A**.

Further to this Roads and Maritime Services identified several small parcels of residual property acquired for the project and outside the road corridor that are also well suited to enhancing connectivity in the landscape. This includes

- Additional planting within the Roads and Maritime residual property on the eastern side of the project between chainages 1,600 / 43,365 and 1,900 / 43,665 with vegetation indicative of the Moist Open Forest Flooded Gum community to expand areas of habitat in this area.

- Additional planting within the Roads and Maritime residual property on the eastern side of the project between chainages 14,900 / 56,665 and 15,100 / 56,865 with vegetation indicative of the Blackbutt community to expand areas of habitat in this area.

Review of potential opportunities to enhance connectivity

Subsequent to the identification of connectivity sites along the project by GeoLINK reviews of the proposed areas of revegetation and planting from a flooding and visual impact perspective were undertaken. This included an assessment by Spackman Mossop Michaels of visual amenity impacts and an assessment by Arup to assess any potential flood afflux impacts and changes in roughness values as a result of increasing the planting density along creeks and rivers.

The results of the visual impact assessment of the proposed connectivity sites are summarised below:

- 735 / 42,500 - Upper Warrell Creek eastern bank: This area would benefit visually from as much re-vegetation and planting as can be provided to assist with visual mitigation of the interchange from multiple viewpoints (including road users).
- 3,140 / 44,905 – Rosewood Creek: This location south of the over bridge appears to be in fill, so road user views would be largely unaffected. Houses are approximately 500 metres away so visual mitigation can be addressed fairly easily. Re-vegetation and planting would form part of the visual mitigation approach in this area anyway.
- 9,220 / 50,985 - Floodplain Bridge No.2: This location is in a combination of open/ wooded landscape and is located in fill, so road user views would be largely unaffected. Houses are well away and few in number so visual mitigation can be addressed fairly easily.
- 10,600 / 52,365 - Nambucca River Bridge north bank: The north bank is currently reasonably well vegetated, additional planting here would have a positive visual impact.

In addition, Roads and Maritime Services made the following comments:

- 3,140 / 44,905 – Rosewood Creek – Roads and Maritime Services have no concerns with this location subject to any connectivity planting in this area being limited to replacement of vegetation removed for the project to minimise potential impacts on flooding.
- 5,235 / 47,000 Williamsons Creek - Roads and Maritime Services don't see the need / benefit of connectivity planting in this area noting that it is identified for fish passage only and that there is no native vegetation downstream of the old highway crossing.
- Ch.14800 - 15500 west of the alignment - Roads and Maritime Services don't see the need / benefit of connectivity planting in this area noting that there are no fauna underpasses between Ch.14645 (56,410) and Ch.16005 (57,770).
- Ch.13300 fauna underpass - Roads and Maritime Services don't have any concerns with the proposed connectivity planting in this area due to the extent of existing vegetation and noting that the natural surface slopes from west to east at this location.

The results of the flood afflux assessment of the proposed connectivity sites as completed by Arup is provided below. It should be noted that the assessment is very high level and has tried to identify if an increase in roughness would result in an increase in flood levels and afflux. In addition, no modelling has however been completed to date. Arup notes that assuming that the afflux of the project is calculated as the difference between the existing levels (with existing vegetation) and the design levels (with the improved vegetation) then it is possible that changing the roughness values (as a result of increasing the planting density) will impact on flood afflux.

The results of the high level assessment indicates that it is most likely that the areas around the culverts are not of major concern, however the areas around the major water way crossings may be more problematic. **Table 1** provides a summary of the structures / locations which may be sensitive.

Table 1 Summary of the connectivity areas identified by GeoLINK that may potentially be flood sensitive

Location	Existing roughness	Revised vegetation roughness	Possible impact
735 / 42,500 - Upper Warrell Creek	0.04	0.08	Probable impact as afflux here is sensitive to channel works and vegetation.
5,235 / 47,000 Williamsons Creek	0.04	0.08	Probable impact as afflux here is sensitive to channel works and vegetation.
6,510 / 48,275 Warrell Creek	0.08	0.08	Limited as out of bank and already high roughness
8,450 / 50,215 Floodplain Bridge 1	0.08	0.08	Limited as already high roughness
9,220 / 50,985 Floodplain Bridge 2	0.06	0.08	Possible impact as within the Nambucca floodplain and only 15mm allowable afflux
10,600 / 52,365 Nambucca Bridge north bank	0.04	0.08	Possible impact as within the Nambucca floodplain and only 15mm allowable afflux

Roads and Maritime Services concurred with Arup regarding the potential flooding impacts identified in **Table 1** with the possible exception of:

- 735 / 42,500 - Upper Warrell Creek eastern bank: subject to any connectivity planting in this area being limited to replacement of vegetation removed for the project and planting of vegetation suitable for Giant Barred Frog.
- 735 / 42,500 - Upper Warrell Creek western bank: subject to any connectivity planting in this area being limited to planting of vegetation suitable for Giant Barred Frog.
- 9,220 / 50,985 - Floodplain Bridge No.2: due to the very low velocities in this area (noting the 15mm afflux limit) and 10,600 / 52,365 - Nambucca River Bridge north bank: subject to any connectivity planting in this area would be limited to replacement of vegetation removed for the project.

Based on the analysis completed above, the connectivity sites identified by GeoLINK in Table 1 of **Appendix A** would be modified as follows:

- Connectivity plantings would not be included at:
  - 5,235 / 47,000 Williamsons Creek due to visual impacts and lack of vegetation connectivity.
  - Ch.14800 - 15500 west of the alignment due to visual impacts and lack of vegetation connectivity.

- Connectivity planting would be limited to replacement of vegetation removed for the project in the following areas:
  - 735 / 42,500 - Upper Warrell Creek eastern bank due to flooding impacts.
  - 3,140 / 44,905 - Rosewood Creek (visual impacts)
  - 9,220 / 50,985 -Floodplain Bridge No.2 due to flooding and visual impacts.
  - 10,600 / 52,365 -Nambucca River Bridge north bank due to flooding and visual impacts.

Selected locations for planting to enhance connectivity

The updated locations for connectivity planting are provided in the map series included as **Attachment B**. In summary, 14 separate locations across the 19 kilometre upgrade have been identified where there is opportunity to conduct strategic planting to enhance connectivity. The areas identified are generally associated with riparian zones as they are viewed to present the best opportunity to enhance connectivity. The locations selected within these zones include future road reserve.

Of the areas identified, twelve of these sites are identified as areas with potential to be used by Koalas. In these locations it is recommended that the use of primary Koala feed trees be targeted in the planting mixes. The specific Koala food trees associated with each of the vegetation map unit impacted are summarised in **Table 2**.

Table 2. Summary of primary and secondary Koala feed trees and corresponding vegetation type

Vegetation Community	Habitat Type	Primary Koala Food (DECC 2008)	Secondary Food Tree Species (DECC 2008)
Map Unit 1: Open Forest – Blackbutt	Dry Sclerophyll Forest	Tallowwood (*Eucalyptus microcorys*)	• Small-fruited Grey Gum (*E. propinqua*). • Red Mahogany (*E. resinifera*). Note Blackbutt (*E. pilularis*) may also be considered and is identified as a supplementary feed tree (Professor Rob Close, University of Western Sydney. pers. comm. 2013).
Map Unit 2: Mixed Floodplain Forest	Wet Sclerophyll Forest	Tallowwood (*E. microcorys*)	• Small-fruited Grey Gum (*E. propinqua*). • Red Mahogany (*E. resinifera*).
Map Unit 3: Moist Forest – White Mahogany/ Grey Gum/ Ironbark	Wet Sclerophyll Forest	Tallowwood (*E. microcorys*)	• Small-fruited Grey Gum (*E. propinqua*). • Red Mahogany (*E. resinifera*).

Vegetation Community	Habitat Type	Primary Koala Food (DECC 2008)	Secondary Food Tree Species (DECC 2008)
Map Unit 4: Moist Forest – Flooded Gum	Wet Sclerophyll Forest	Tallowwood (*E. microcorys*)	• Small-fruited Grey Gum (*E. propinqua*). • Red Mahogany (*E. resinifera*).
Map Unit 6: Swamp Forest – Swamp Mahogany/ Paperbark	Swamp Sclerophyll Forest	Swamp Mahogany (*E. robusta*)	• Small-fruited Grey Gum • (*E. propinqua*). • Red Mahogany (*E. resinífera).*

It is noted that five of the connectivity sites are located within Nambucca State Forest which is associated with the known Koala population in this location. A review of Koala records for the study area from the Atlas of NSW Wildlife identifies a low number of records between Warrell Creek and Macksville, both to the east and west of the project. Given the high degree of fragmentation between chainage 0 / 41,765 to 7,500 / 49,265 the corridor south of Macksville represents the best opportunities for enhancement of connectivity.

Of the combined number of proposed habitat planting locations, three of these sites are located between chainage 5,200 / 46,965 and 6,600 / 48,365 and are associated with where the road alignment occurs immediately adjacent to the existing Pacific Highway. This includes the riparian corridors along Warrell Creek. There are very limited opportunities for Koalas to cross the existing highway in this location due to the lack of connectivity structures on the existing highway and extensive habitat fragmentation. The proposed strategic plantings in this location are therefore considered to present a substantial improvement or enhancement over the current situation.

Response Task 6:

In regards to the Department of the Environment (DoE) comment to include this information in the proposed Urban Design and Landscape Plan (UDLP) the following is noted. During a discussion between Colette Boraso from the DoE and Chris Clark from Roads and Maritime Services on the 10 July 2014, it was agreed that the UDLP was not the appropriate document to identify measures to improve connectivity in the landscape, including the locations of habitat restoration and management measures. It was agreed that these measures were best identified in the five individual species management plans that are being prepared to address the requirements of Attachment A2 of the DoE letter provided to Roads and Maritime Services on the 27 June 2014. As such this information will be included in these management plans which will be available for review by DoE in the near future.

The map series included as **Attachment B** shows all proposed fauna mitigation measures on the same map.

ATTACHMENT A GeoLINK Memorandum Koala Connectivity (24th July 2014)

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24 July 2014
Ref No: 2378-1004

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Level 10, 207 Kent St
Sydney, NSW 2000

Attention: Alex Dwyer

WC2NH: Assessment of Opportunities to Enhance Vegetation/ Habitat Connectivity as part of the Project

GeoLINK has been requested to undertake an assessment to identify opportunities to enhance habitat/ vegetation connectivity as part of the landscaping and urban design plan to be adopted for the WC2NH project. This assessment involved a desktop review of the following information:

- Aerial imagery of vegetation surrounding the project site;
- Vegetation mapping for the project site and surrounds;
- Current locations and designs of fauna crossing structures; and
- WC2U Urban Landscape Design Plan.

Areas identified as opportunities to enhance habitat/ vegetation connectivity are shown on a series of mark ups contained within Appendix A. These areas are summarised in Table 1.1.

Identified areas are generally associated with bridges/ culverts, as riparian zones throughout the broader landscape provide the best opportunity to provide fauna habitat connectivity. Additionally, a small number of areas were identified where planting of endemic vegetation communities have the potential to create additional linkages between fragmented patches of vegetation occurring within the local landscape.

A number of recommendations were made for identified areas which are included in Table 1.1.

Feel free to contact me if you require any additional information.

Yours sincerely
GeoLINK

David Havilah
Ecologist/ Associate

Table 1.1 Proposed Habitat Connectivity Focus Areas

Area	*Chainages*	*Connectivity Opportunity*	*Recommendation*
Upper Warrell Creek (bridge site and fauna crossing location)	200 - 900	▪ A section of primarily cleared grazing land adjacent to Warrell Creek (between CH 200-700). Revegetation of this area would improve habitat/ vegetation connectivity along a relatively large portion of Warrell Creek. Additional benefits to improving aquatic fauna habitat. ▪ Areas associated with the fauna passage (CH 800) inlet/ outlet could be enhanced with additional planting of native vegetation in these areas to encourage fauna usage	▪ Riparian restoration planting along the western side of Warrell Creek (CH 200-700) with endemic species recommended. ▪ Habitat enhancement planting using appropriate endemic species proposed in areas either side of the fauna crossing culvert (CH 800) to maximise the potential use of this structure. ▪ As this area has potential to be used by Koalas the use of primary Koala feed trees in planting mixes (e.g. Tallowwood, Forest Red Gum, Grey Gum) is recommended.
Butchers Creek (combined culvert with fauna underpass)	1,450 – 1,600	▪ Areas associated with the fauna passage (CH 1,550) inlet/ outlet could be enhanced with additional planting of native vegetation in these areas to encourage fauna usage	▪ Habitat enhancement planting using appropriate endemic species proposed in areas either side of the fauna crossing culvert (CH 800) to maximise the potential use of this structure. ▪ As this area has potential to be used by Koalas the use of primary Koala feed trees in planting mixes (e.g. Tallowwood, Forest Red Gum, Grey Gum) is recommended.
Rosewood Creek (combined culvert with fauna underpass)	3,100	▪ A combined culvert with fauna underpass is to be provided at this location. The creek line is currently vegetated with Camphor Laurel forest. Connectivity could be enhanced by bush restoration works being undertaken along sections of Rosewood Creek occurring within the project site with the aim of maximising use of the culvert by fauna.	▪ Riparian plantings using endemic flora species recommended along Rosewood Creek (within the project site) as well as control of Camphor Laurel.
Unnamed tributary (incidental fauna passage)	3,800	▪ Tributary largely cleared with little vegetation/ habitat connectivity currently.	▪ No major gains to be made by restoration plantings in this area as little connectivity is currently present.

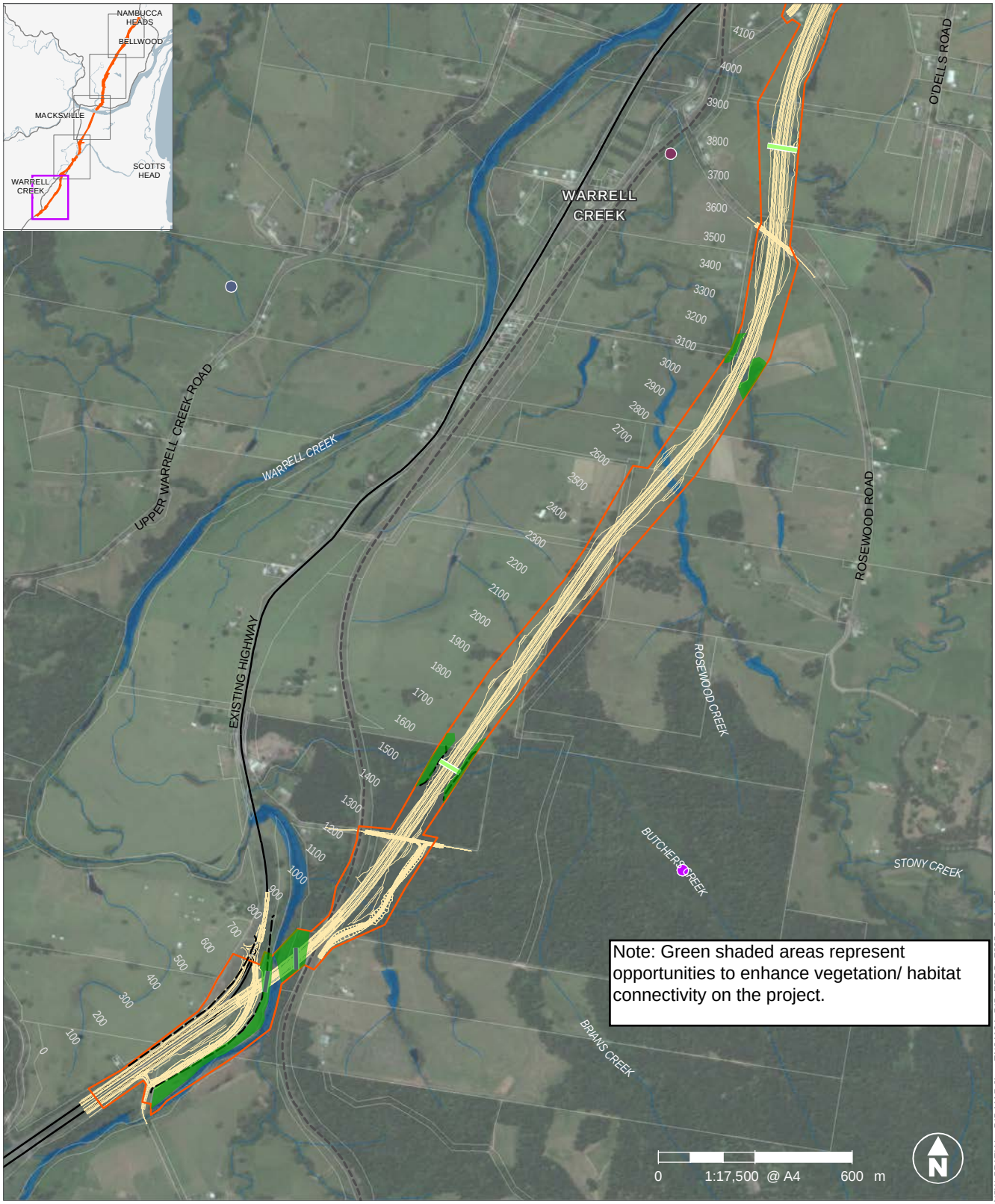
Williamsons Creek (bridge site and eastern side of the alignment)	5,200 - 5,700	▪ Habitat/ vegetation connectivity could be enhanced along Williamsons Creek by providing additional planting of appropriate riparian vegetation which would improve the likelihood of fauna movements along Williamsons Creek. ▪ Planting of a corridor of native vegetation on the eastern side of the alignment between Williamsons Creek and the unnamed tributary to the north (Ch 5,750) would improve connectivity between fragmented patches of forest in the locality.	▪ Habitat enhancement and additional riparian plantings are recommended along Williamsons Creek to improve connectivity. ▪ Planting of a corridor of native plantings including primary Koala feed trees (Tallowwood, Forest Red Gum, Grey Gum) are recommended along the eastern edge of the site between CH 5,200 and 5,700 to link fragmented patches of vegetation.
Lower Warrell Creek (areas associated with southern and northern abutment of new bridge.	6,400 - 6,800	▪ Only minor opportunities exist on the southern bank of Warrell Creek either side of the bridge footprint to enhance connectivity by a small amount of native plantings along the riparian zone. ▪ Restoration plantings within an area to the east of the new bridge site (northern bank) where vegetation is sparse and fragmented would improve connectivity by enhancing habitat values within the riparian zone	▪ Minor additional riparian plantings recommended along the southern bank either side of the bridge site where possible. ▪ Restoration/ regeneration of vegetation recommended in an area on the northern side of Warrell Creek (to the east of the new bridge site). This area is currently highly disturbed with scattered mature trees and dense weeds in the understorey.
Floodplain Plank Bridges and incidental fauna passage locations	8,000 - 9,400	▪ Minor opportunities to enhance and extend areas of EEC/ fauna habitat either side of the alignment primarily associated with fauna crossing structures and plank bridges.	▪ Recommend planting of Broad-leaved Paperbark/ Swamp Oak to enhance/ extend areas of habitat where possible and improve the likelihood of fauna movement at fauna crossing locations.
Nambucca River Bridge (northern bank)	10,600	▪ Additional planting/ restoration along the riparian corridor would enhance connectivity under the bridge which forms a linkage with large areas of vegetation associated with Newee Creek.	▪ Recommend planting of Swamp Oak, Forest Red Gums and other appropriate riparian plantings either side of the new bridge (within the riparian zone).

Area on the western side of the alignment, north of Mattick road (combined fauna passage)	13,100 – 13,450	▪ Areas associated with the fauna passage (CH 13,350) inlet/ outlet could be enhanced with additional planting of native vegetation in these areas to encourage fauna usage. ▪ Additional planting associated with Old Coast Road as it occurs within the project site would extend and enhance habitat values and linkages to large areas of vegetation to the west (Newee Creek).	▪ Habitat enhancement planting using appropriate endemic species proposed in areas either side of the fauna crossing culvert (CH 800) to maximise the potential use of this structure. ▪ Additional planting of endemic vegetation to the west of the alignment to improve connectivity. ▪ As this area has potential to be used by Koalas the use of primary Koala feed trees in planting mixes (e.g. Tallowwood, Forest Red Gum, Grey Gum) is recommended.
Nambucca State Forest (south) – fauna passage combined.	14,600 - 14,700	▪ Areas associated with the fauna passage inlet/ outlet could be enhanced with additional planting of native vegetation in these areas to encourage fauna usage.	▪ Habitat enhancement planting using appropriate endemic species proposed in areas either side of the fauna crossing culvert to maximise the potential use of this structure. ▪ As this area has potential to be used by Koalas the use of primary Koala feed trees in planting mixes (e.g. Tallowwood, Forest Red Gum, Grey Gum) is recommended.
Nambucca State Forest – six fauna crossing locations between CH 16,600 and 18,800.	16,600 – 18,800	▪ Minimal opportunities exist within this part of the project site to enhance vegetation/ habitat connectivity given the already heavily forested nature of this part of the site. ▪ Areas associated with the fauna passage inlets/ outlets could be enhanced with additional planting of native vegetation in these areas to encourage fauna usage, including the use of Koala feed trees where possible.	▪ Habitat enhancement planting using appropriate endemic species proposed in areas either side of the fauna crossing culvert to maximise the potential use of this structure. ▪ As this area has potential to be used by Koalas the use of primary Koala feed trees in planting mixes (e.g. Tallowwood, Forest Red Gum, Grey Gum) is recommended.

Appendix A

Proposed Habitat Connectivity Focus Areas

Attachment A Figure 5-1 Threatened fauna, exclusion fencing and underpasses



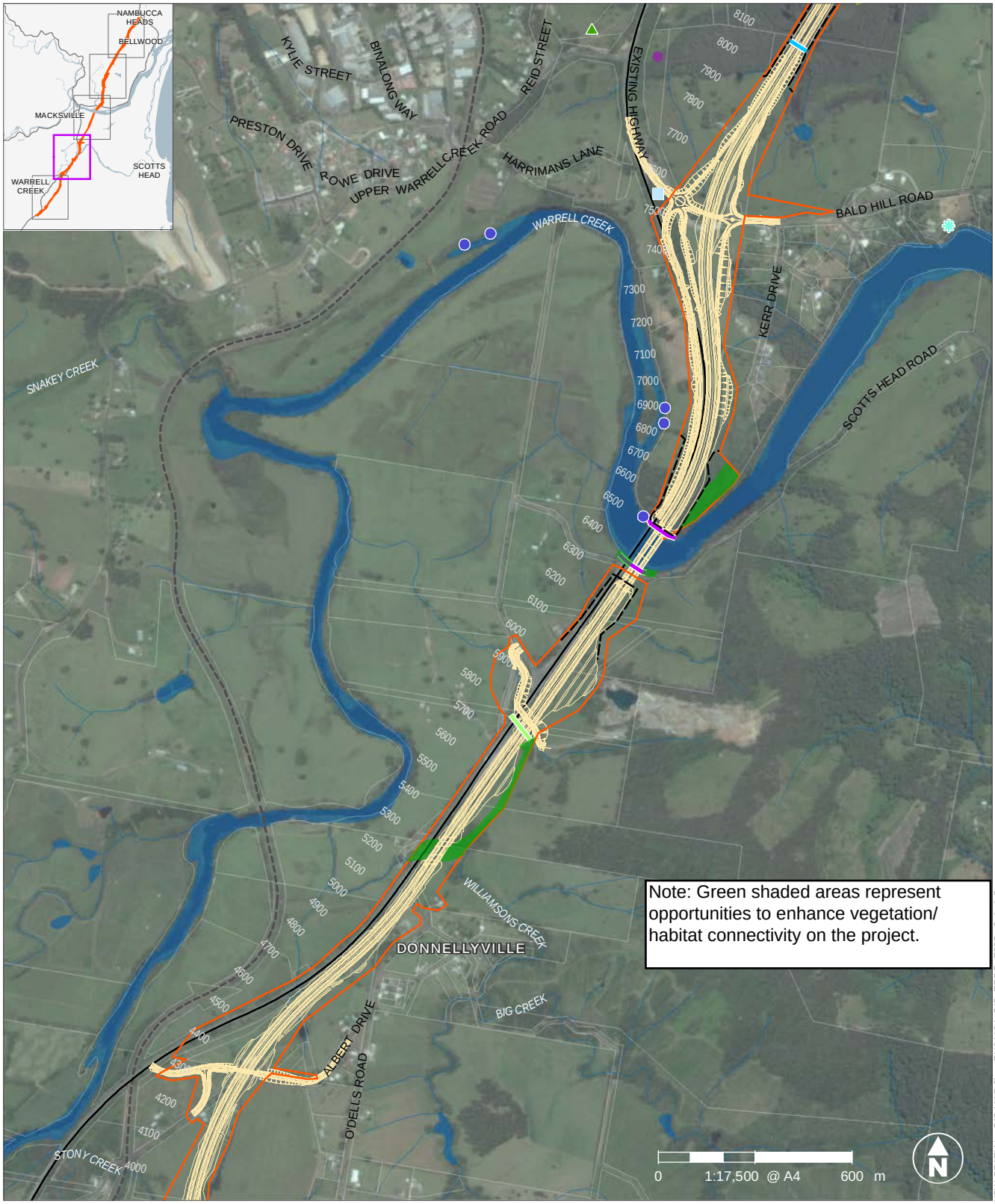
Road boundary
Road design
Temporary construction road boundary
Temporary construction road
November 2013 Flying-fox camp footprint
Combined culvert with fauna underpass
Dedicated fauna underpass
Fauna passage
Fauna fence

Threatened fauna

- Black Bittern
- Black Grass-dart Butterfly
- Black-necked Stork
- Brolga
- Brush-tailed Phascogale
- Cattle Egret
- Common Greenshank
- Eastern Bentwing-bat
- Eastern Freetail-bat
- Eastern Osprey
- Glossy Black-Cockatoo
- Glossy Ibis
- Greater Broad-nosed Bat
- Green and Golden Bell Frog
- Grey-headed Flying-fox
- Koala
- Latham's Snipe
- Little Bentwing-bat
- Masked Owl
- Oriental Pratincole
- Osprey (nest site)
- Pacific Golden Plover
- Powerful Owl
- Rainbow Bee-eater
- Regent Honeyeater
- Sooty Owl
- Southern Myotis
- Spotted-tailed Quoll
- Square-tailed Kite
- Squirrel Glider
- White-bellied Sea-Eagle
- Yellow-bellied Glider

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

Attachment A Figure 5-2 Threatened fauna, exclusion fencing and underpasses



Road boundary
Road design
Temporary construction road boundary
Temporary construction road
November 2013 Flying-fox camp footprint
Combined culvert with fauna underpass
Dedicated fauna underpass
Fauna passage
Fauna fence

Threatened fauna

- Black Bittern
- Black Grass-dart Butterfly
- Black-necked Stork
- Brolga
- Brush-tailed Phascogale
- Cattle Egret
- Common Greenshank
- Eastern Bentwing-bat
- Eastern Freetail-bat
- Eastern Osprey
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- Glossy Ibis
- Greater Broad-nosed Bat
- Green and Golden Bell Frog
- Grey-headed Flying-fox
- Koala
- Latham's Snipe
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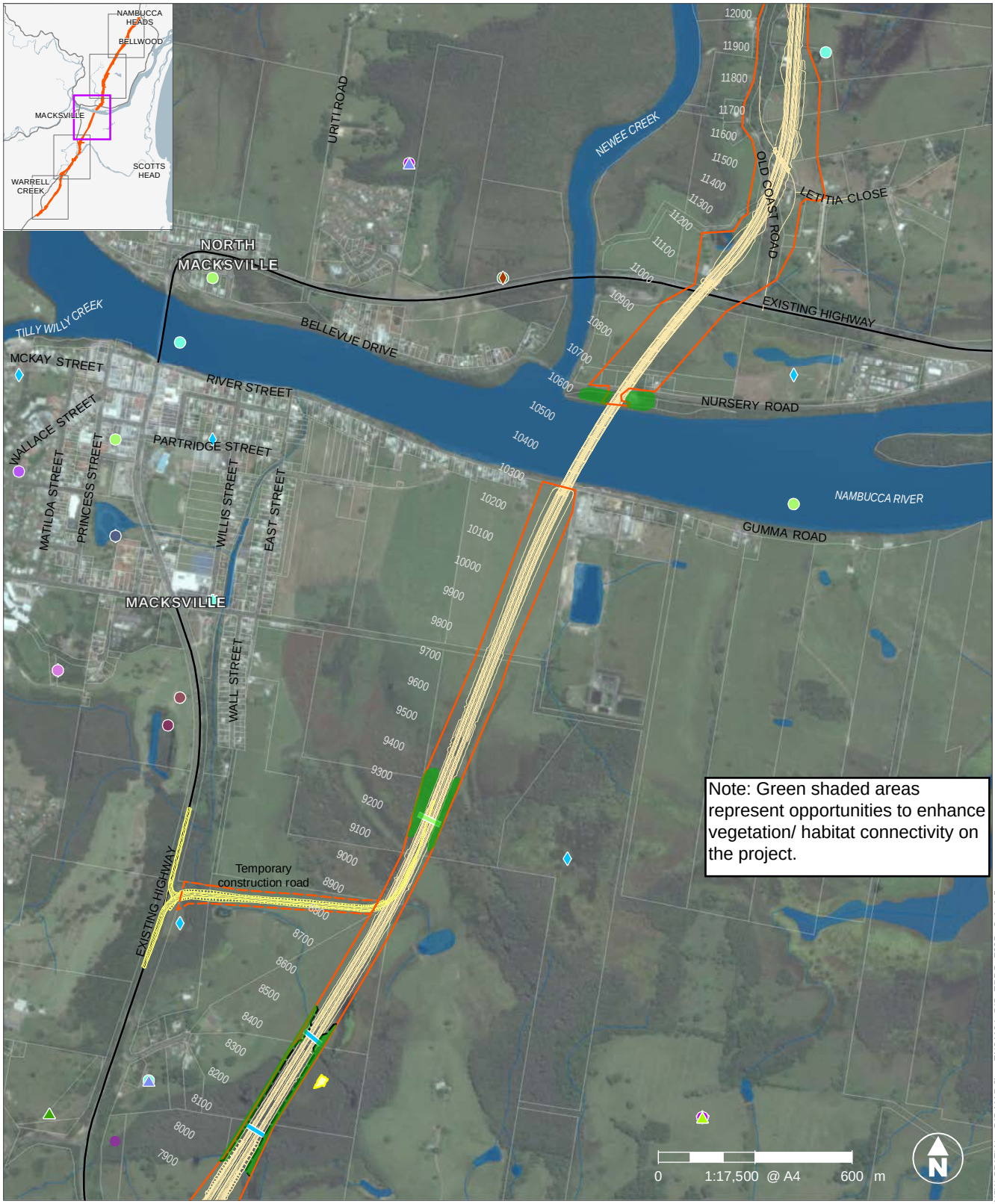
- Masked Owl
- Oriental Pratincole
- Osprey (nest site)
- Pacific Golden Plover
- Powerful Owl
- Rainbow Bee-eater
- Regent Honeyeater
- Sooty Owl
- Southern Myotis
- Spotted-tailed Quoll
- Square-tailed Kite
- Squirrel Glider
- White-bellied Sea-Eagle
- Yellow-bellied Glider

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

Attachment A Figure 5-3 Threatened fauna, exclusion fencing and underpasses



Road boundary
Road design
Temporary construction road boundary
Temporary construction road
November 2013 Flying-fox camp footprint
Combined culvert with fauna underpass
Dedicated fauna underpass
Fauna passage
Fauna fence

Threatened fauna

- Black Bittern
- Black Grass-dart Butterfly
- Black-necked Stork
- Brolga
- Brush-tailed Phascogale
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- Eastern Bentwing-bat
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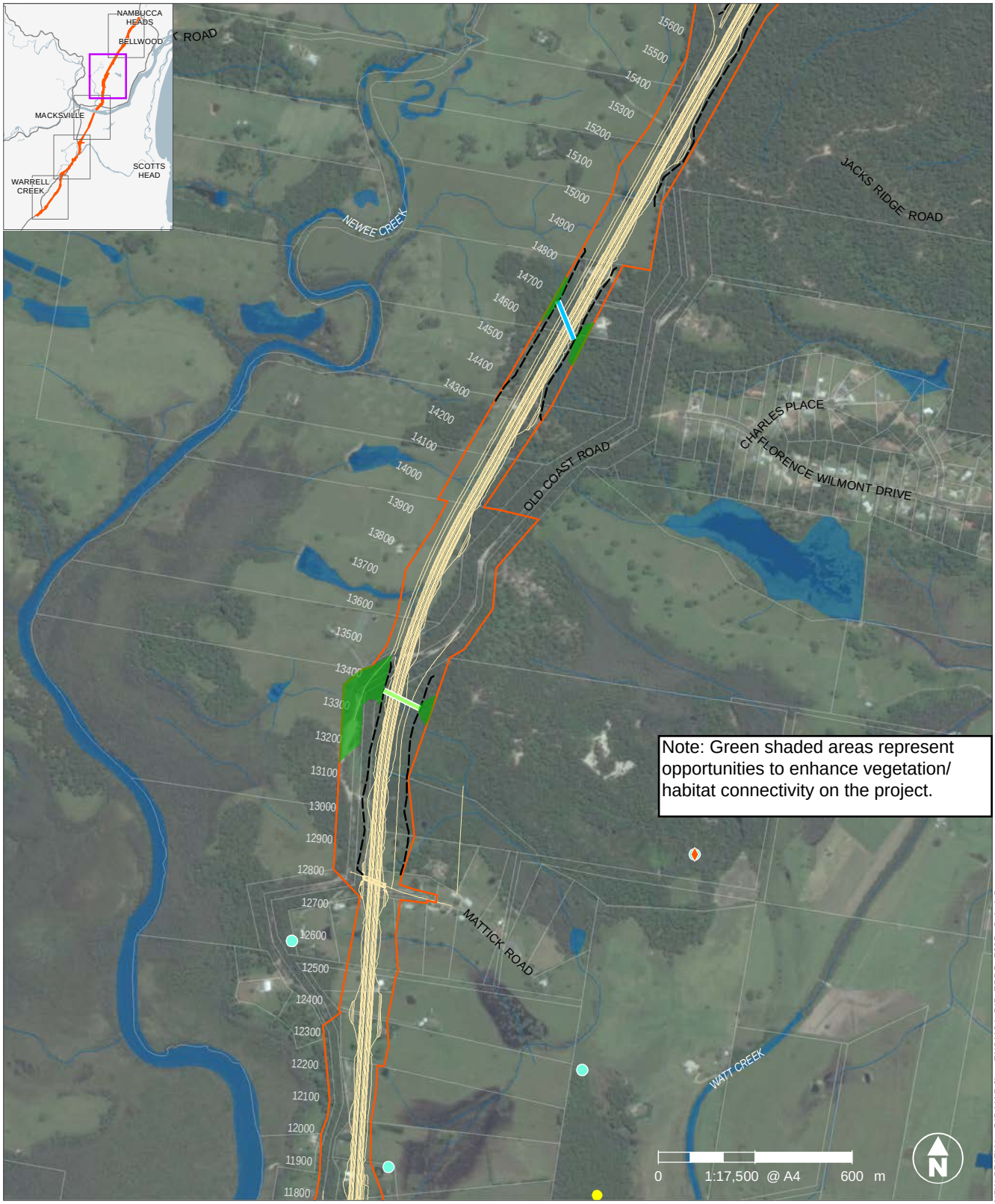
- Square-tailed Kite
- Squirrel Glider
- White-bellied Sea-Eagle
- Yellow-bellied Glider

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

Attachment A Figure 5-4 Threatened fauna, exclusion fencing and underpasses



Road boundary
Road design
Temporary construction road boundary
Temporary construction road
November 2013 Flying-fox camp footprint
Combined culvert with fauna underpass
Dedicated fauna underpass
Fauna passage
Fauna fence

Threatened fauna

- Black Bittern
- Black Grass-dart Butterfly
- Black-necked Stork
- Brolga
- Brush-tailed Phascogale
- Cattle Egret
- Common Greenshank
- Eastern Bentwing-bat
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- Greater Broad-nosed Bat
- Green and Golden Bell Frog
- Grey-headed Flying-fox
- Koala
- Latham's Snipe
- Little Bentwing-bat
- Masked Owl
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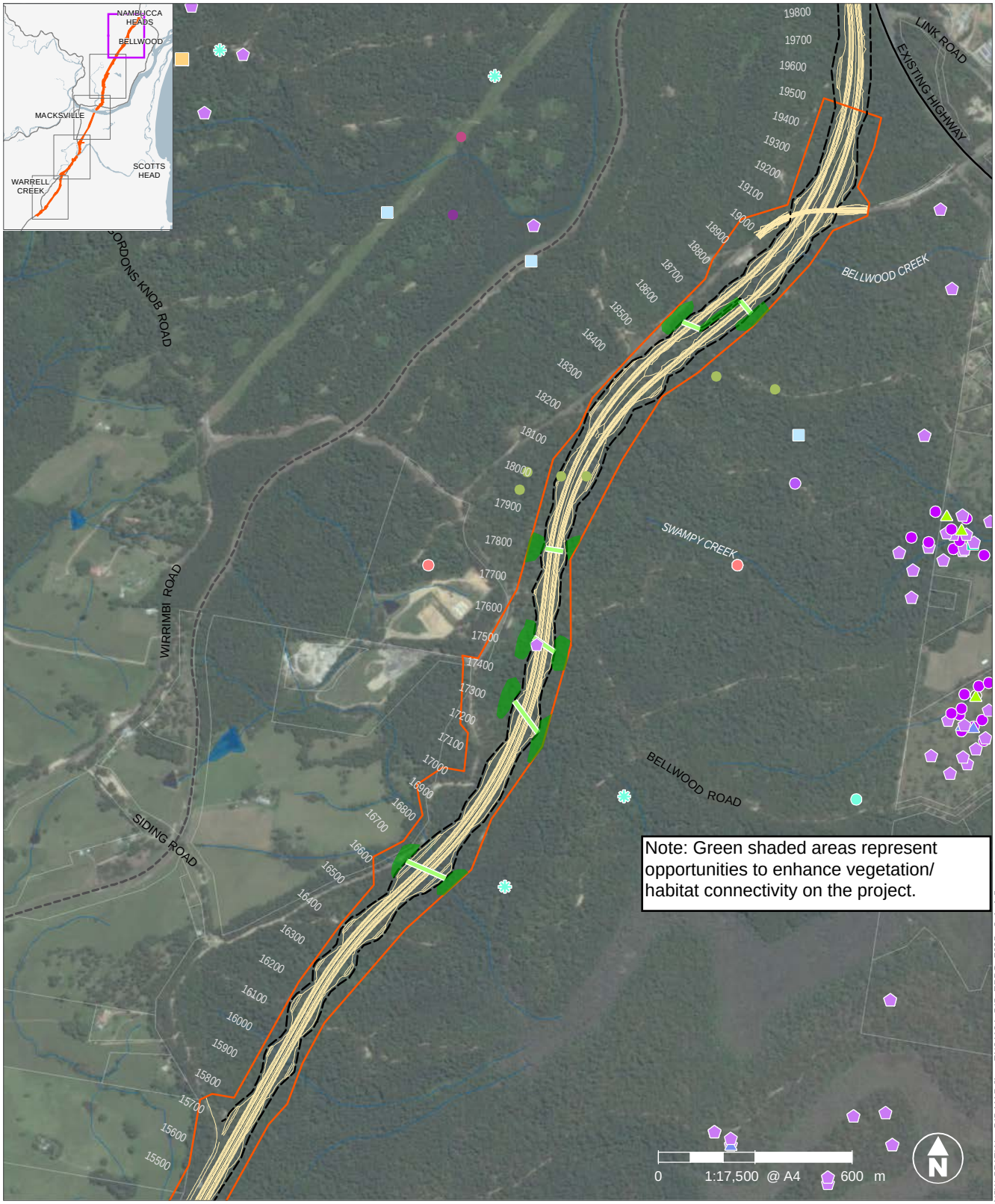
- Pacific Golden Plover
- Powerful Owl
- Rainbow Bee-eater
- Regent Honeyeater
- Sooty Owl
- Southern Myotis
- Spotted-tailed Quoll
- Square-tailed Kite
- Squirrel Glider
- White-bellied Sea-Eagle
- Yellow-bellied Glider

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

Attachment A Figure 5-5 Threatened fauna, exclusion fencing and underpasses



Road boundary
Road design
Temporary construction road boundary
Temporary construction road
November 2013 Flying-fox camp footprint
Combined culvert with fauna underpass
Dedicated fauna underpass
Fauna passage
Fauna fence

Threatened fauna

- Black Bittern
- Black Grass-dart Butterfly
- Black-necked Stork
- Brolga
- Brush-tailed Phascogale
- Cattle Egret
- Common Greenshank
- Eastern Bentwing-bat
- Eastern Freetail-bat
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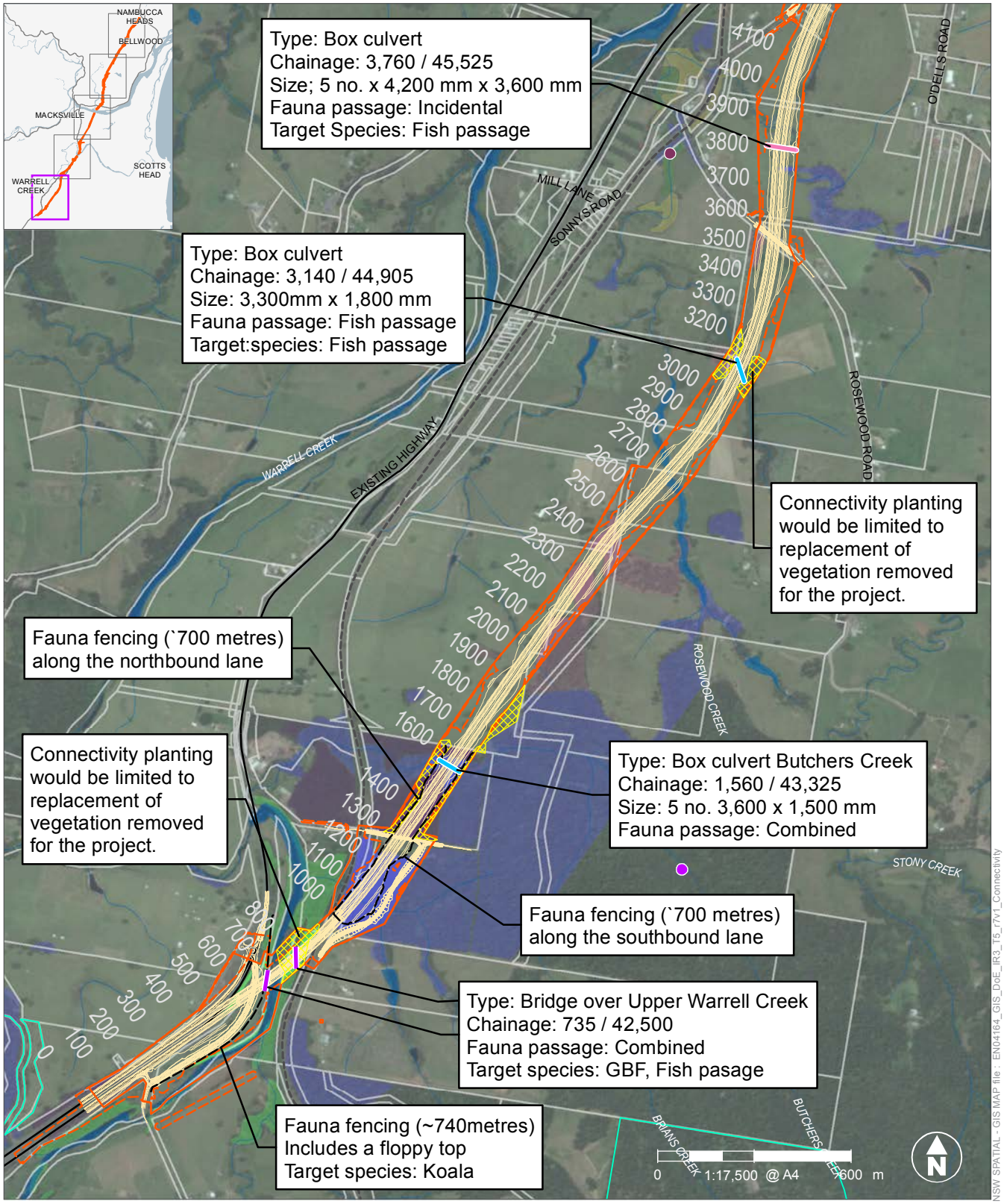
- White-bellied Sea-Eagle
- Yellow-bellied Glider

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

ATTACHMENT B Map Series of Connectivity / Habitat Restoration Areas



Legend

- Proposed areas of connectivity and habitat restoration
- Road boundary
- Road design
- Service Road - Old Coast Road
- Clearing boundary
- State Forest boundary
- Lot (survey)
- Combined culvert with fauna underpass
- Dedicated fauna underpass
- Fauna fence
- Bridge with fauna passage
- Incidental fauna passage

Vegetation map units (WC2U EA, RTA 2010)

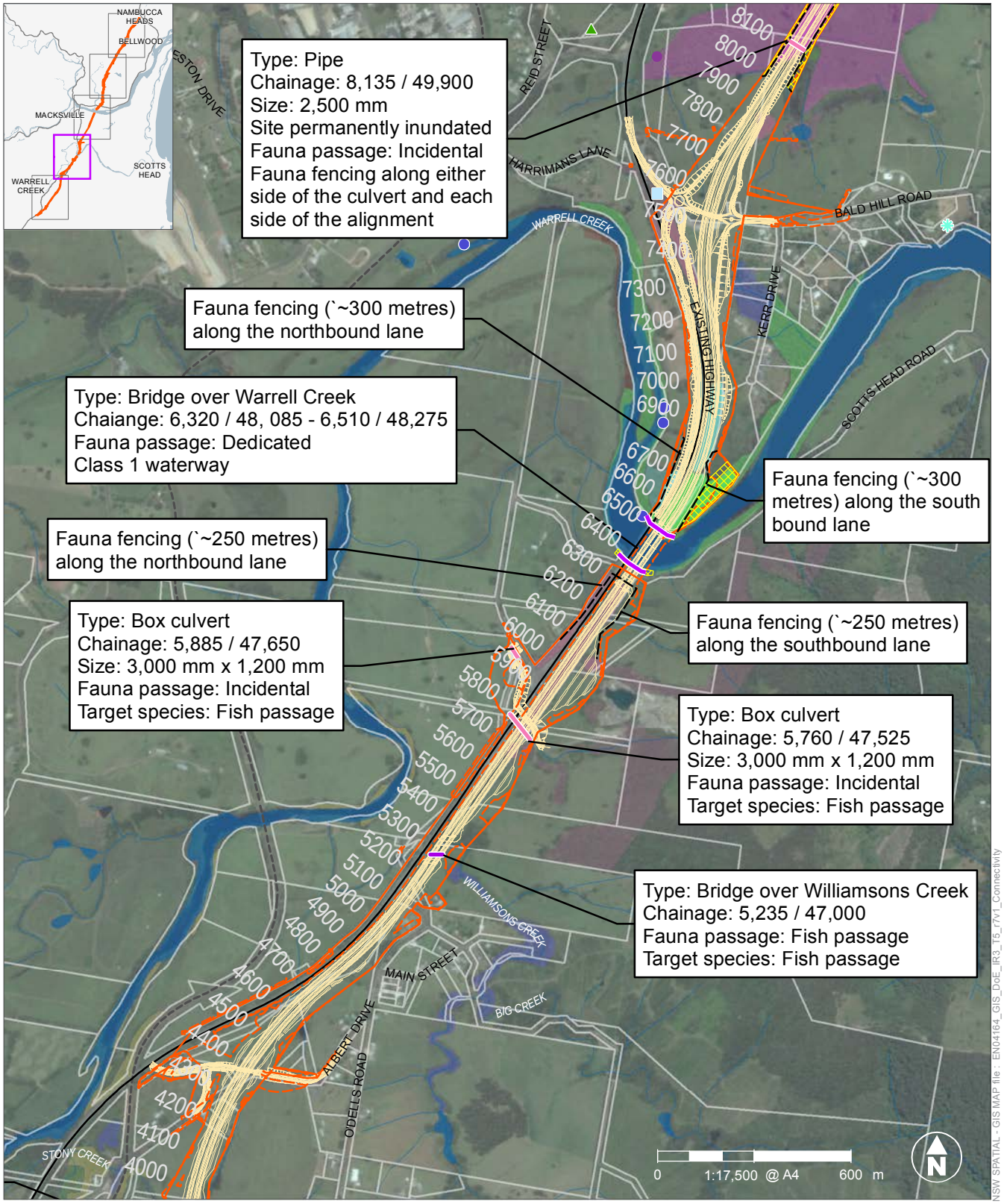
- Map Unit 1: Open Forest - Blackbutt
- Map Unit 2: Mixed Floodplain Forest (Subtropical Coastal Floodplain Forest (EEC – TSC Act)
- Map Unit 3: Moist Open Forest - White Mahogany/Grey Gum/Ironbark
- Map Unit 4: Moist Open Forest - Flooded Gum
- Map Unit 5: Lowland Rainforest (EEC – EPBC Act and the TSC Act)
- Map Unit 6: Swamp Forest - Swamp Mahogany/Paperbark (Swamp Sclerophyll Forest (EEC – TSC Act)
- Map Unit 7: Swamp Forest - Swamp Oak (Swamp Oak Floodplain Forest (EEC – TSC Act)
- Map Unit 8: Freshwater Wetlands (TEC – TSC Act)
- Map Unit 9: Mangrove Forest
- Map Unit 10: Coastal Saltmarsh (VEC – EPBC Act and TSC Act)
- Map Unit 11: Open Forest - Scribbly Gum
- Map Unit 12: Hardwood plantation
- Map Unit 13: Softwood plantation

NOTES

- The chainages in this figure reflect the WC2U EA chainages. To convert these to the referral chainages add 41765.
- The locations of the fauna crossings and fauna fences are indicative only.

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

NSW GOVERNMENT Transport Roads & Maritime Services JACOBS



NSW SPATIAL - GIS MAP file : EN04164_GIS_DoE_IR3_T5_r7v1_Connectivity

Legend

- Proposed areas of connectivity and habitat restoration
- Road boundary
- Road design
- Service Road - Old Coast Road
- Clearing boundary
- State Forest boundary
- Lot (survey)
- Combined culvert with fauna underpass
- Dedicated fauna underpass
- Fauna fence
- Bridge with fauna passage
- Incidental fauna passage

Vegetation map units (WC2U EA, RTA 2010)

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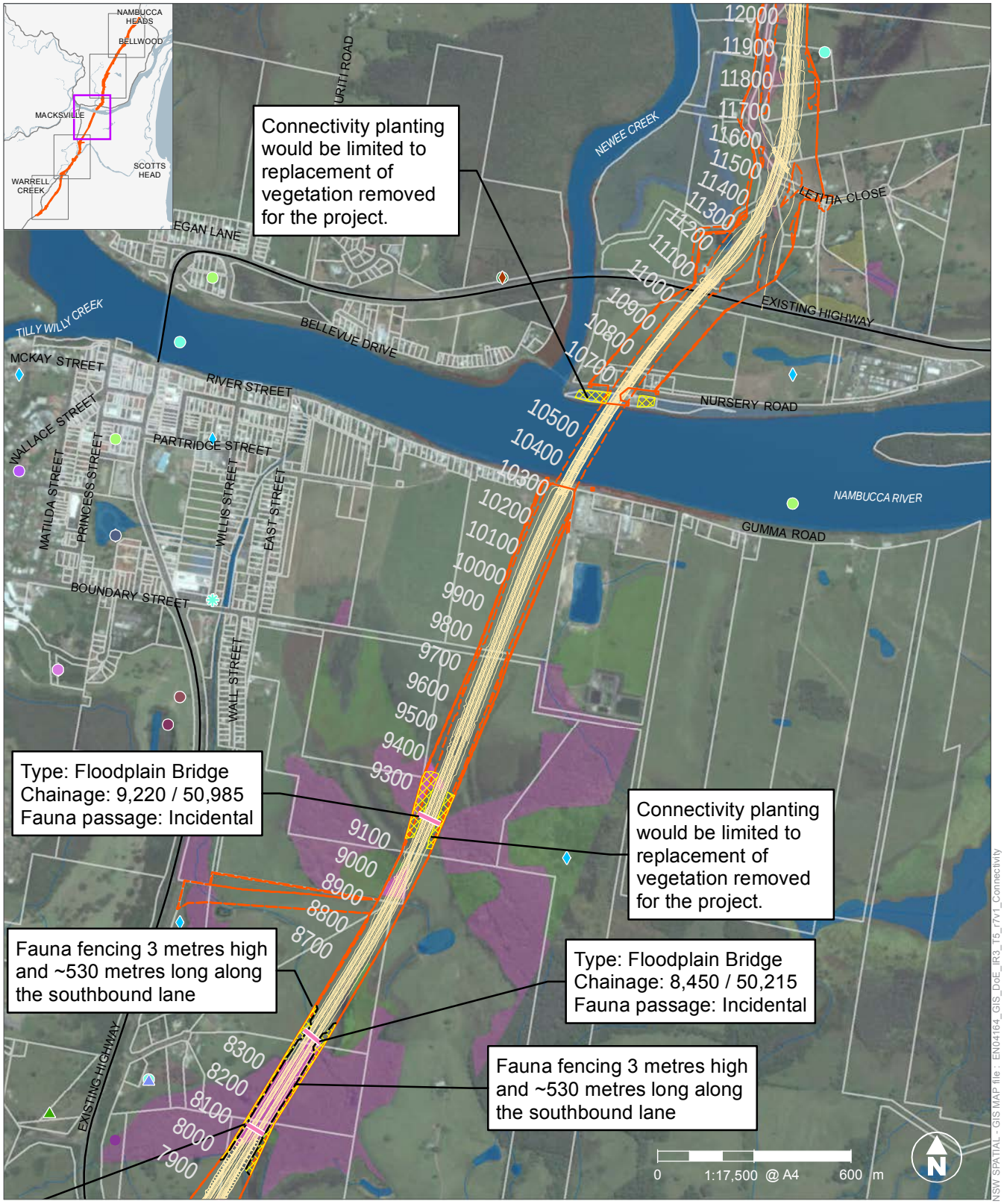
- Map Unit 7: Swamp Forest - Swamp Oak (Swamp Oak Floodplain Forest (EEC – TSC Act)
- Map Unit 8: Freshwater Wetlands (TEC – TSC Act)
- Map Unit 9: Mangrove Forest
- Map Unit 10: Coastal Saltmarsh (VEC – EPBC Act and TSC Act)
- Map Unit 11: Open Forest - Scribbly Gum
- Map Unit 12: Hardwood plantation
- Map Unit 13: Softwood plantation

NOTES

- The chainages in this figure reflect the WC2U EA chainages. To convert these to the referral chainages add 41765.
- The locations of the fauna crossings and fauna fences are indicative only.

DATA SOURCES

ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information



Legend

- Proposed areas of connectivity and habitat restoration
- Road boundary
- Road design
- Service Road - Old Coast Road
- Clearing boundary
- State Forest boundary
- Lot (survey)
- Combined culvert with fauna underpass
- Dedicated fauna underpass
- Fauna fence
- Bridge with fauna passage
- Incidental fauna passage

Vegetation map units (WC2U EA, RTA 2010)

- Map Unit 1: Open Forest - Blackbutt
- Map Unit 2: Mixed Floodplain Forest (Subtropical Coastal Floodplain Forest (EEC – TSC Act)
- Map Unit 3: Moist Open Forest - White Mahogany/Grey Gum/Ironbark
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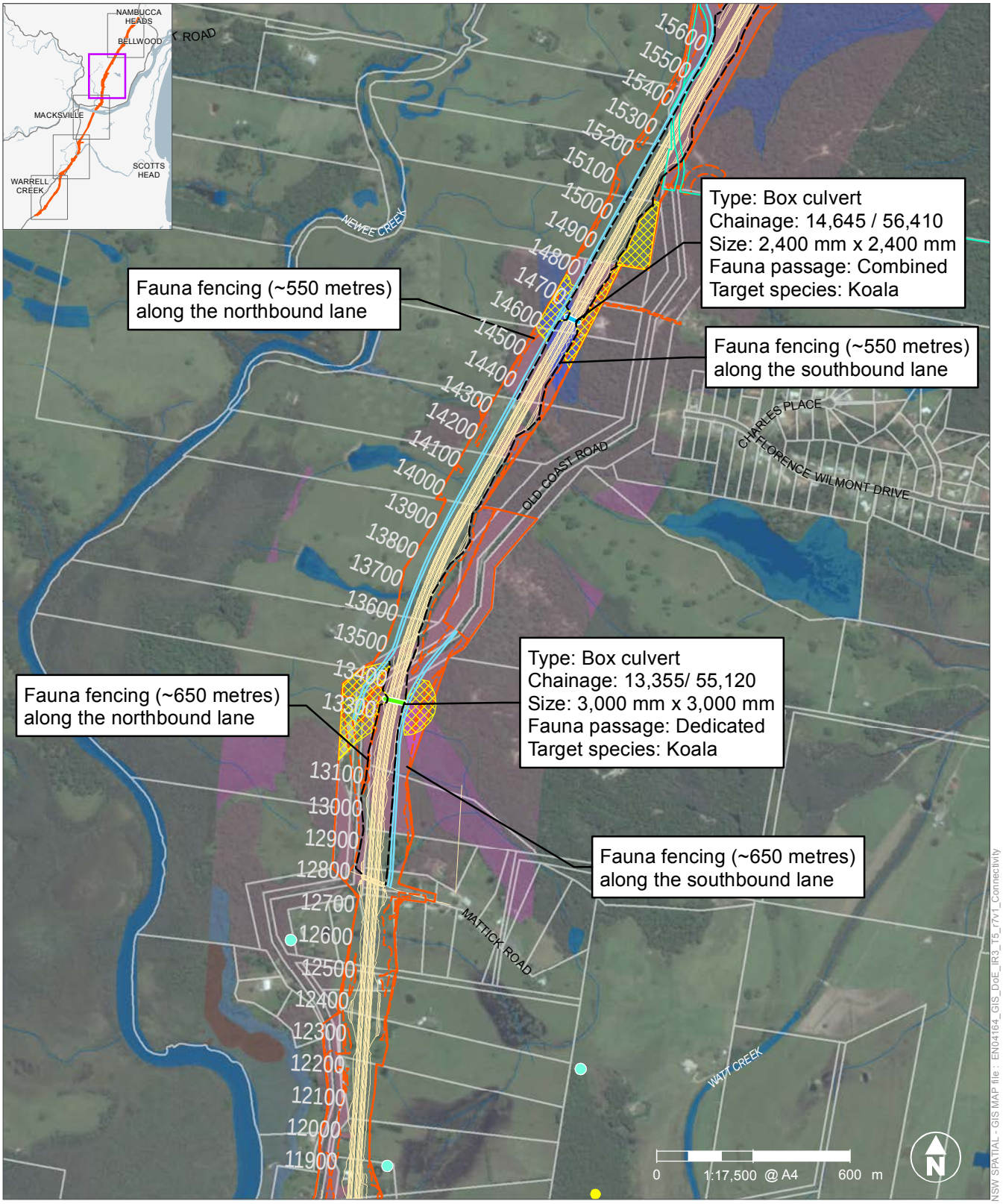
- Map Unit 8: Freshwater Wetlands (TEC – TSC Act)
- Map Unit 9: Mangrove Forest
- Map Unit 10: Coastal Saltmarsh (VEC – EPBC Act and TSC Act)
- Map Unit 11: Open Forest - Scribbly Gum
- Map Unit 12: Hardwood plantation
- Map Unit 13: Softwood plantation

NOTES

- The chainages in this figure reflect the WC2U EA chainages. To convert these to the referral chainages add 41765.
- The locations of the fauna crossings and fauna fences are indicative only.

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

NSW GOVERNMENT Transport Roads & Maritime Services JACOBS



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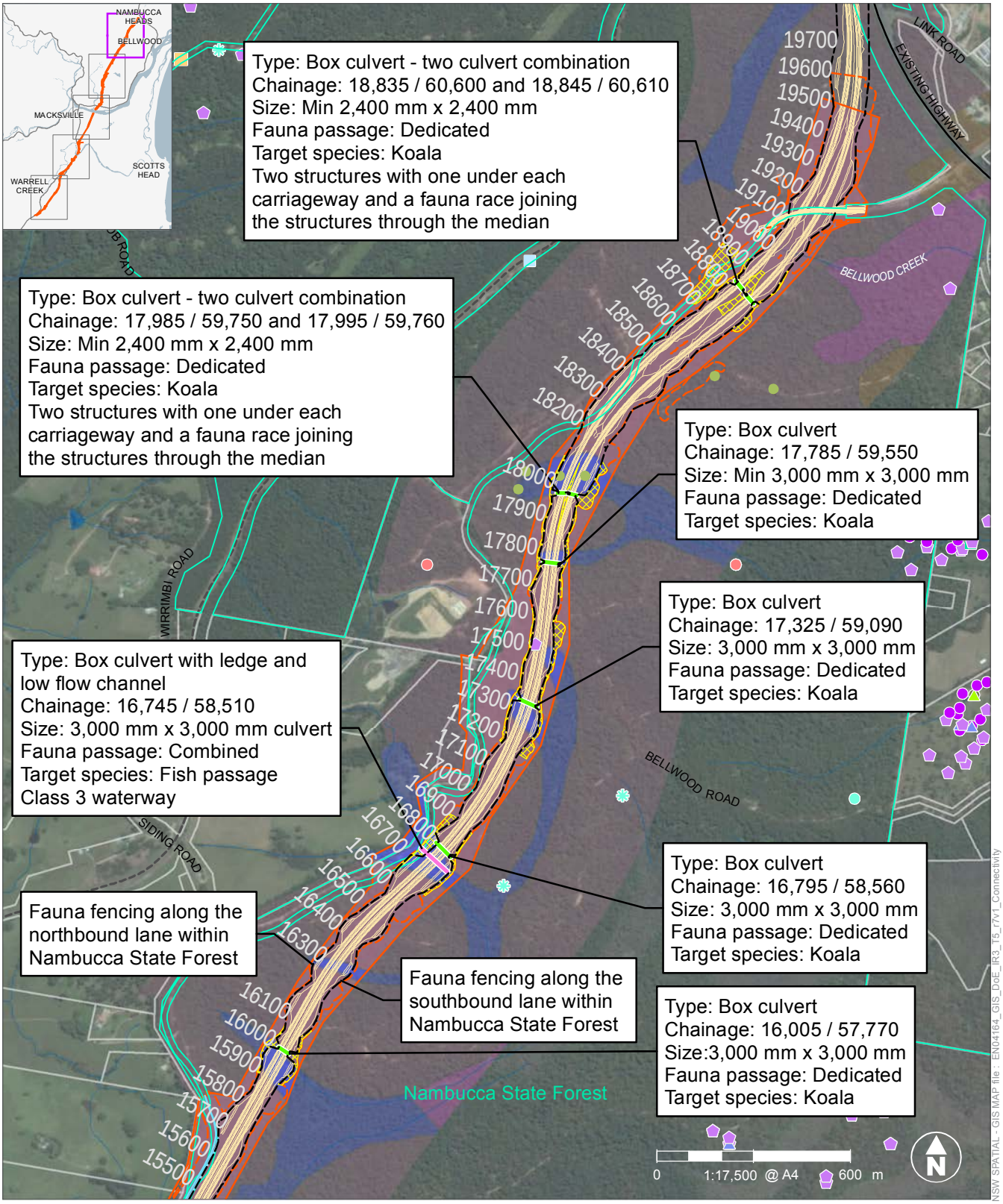
NSW Government Transport Roads & Maritime Services JACOBS



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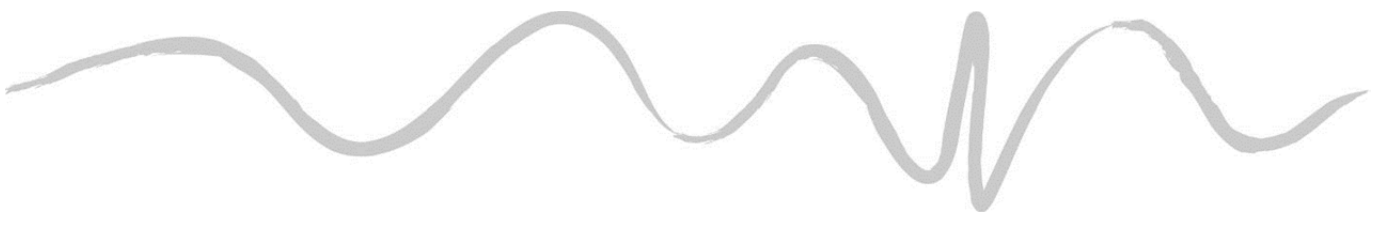
Appendix D

WC2NH STQ Baseline Monitoring

Spotted-tailed Quoll Monitoring

Warrell Creek to Nambucca Heads
Pacific Highway Upgrade



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Spotted-tailed Quoll Monitoring

Warrell Creek to Nambucca Heads
Pacific Highway Upgrade

Prepared for: Roads and Maritime Services

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info@geolink.net.au

UPR	*Description*	*Date Issued*	*Issued By*
2394-1005	First issue	25/09/2014	Tom Pollard
2394-1013	Second issue	24/10/2014	Tom Pollard

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1

Introduction

1.1 Introduction

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.

The NSW Minister for Planning approved the Warrell Creek to Urunga (WC2U) Pacific Highway Upgrade Project (the Project) under Part 3A (now repealed) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) on 19 July 2011, subject to the Minister's Conditions of Approval (CoA) being met.

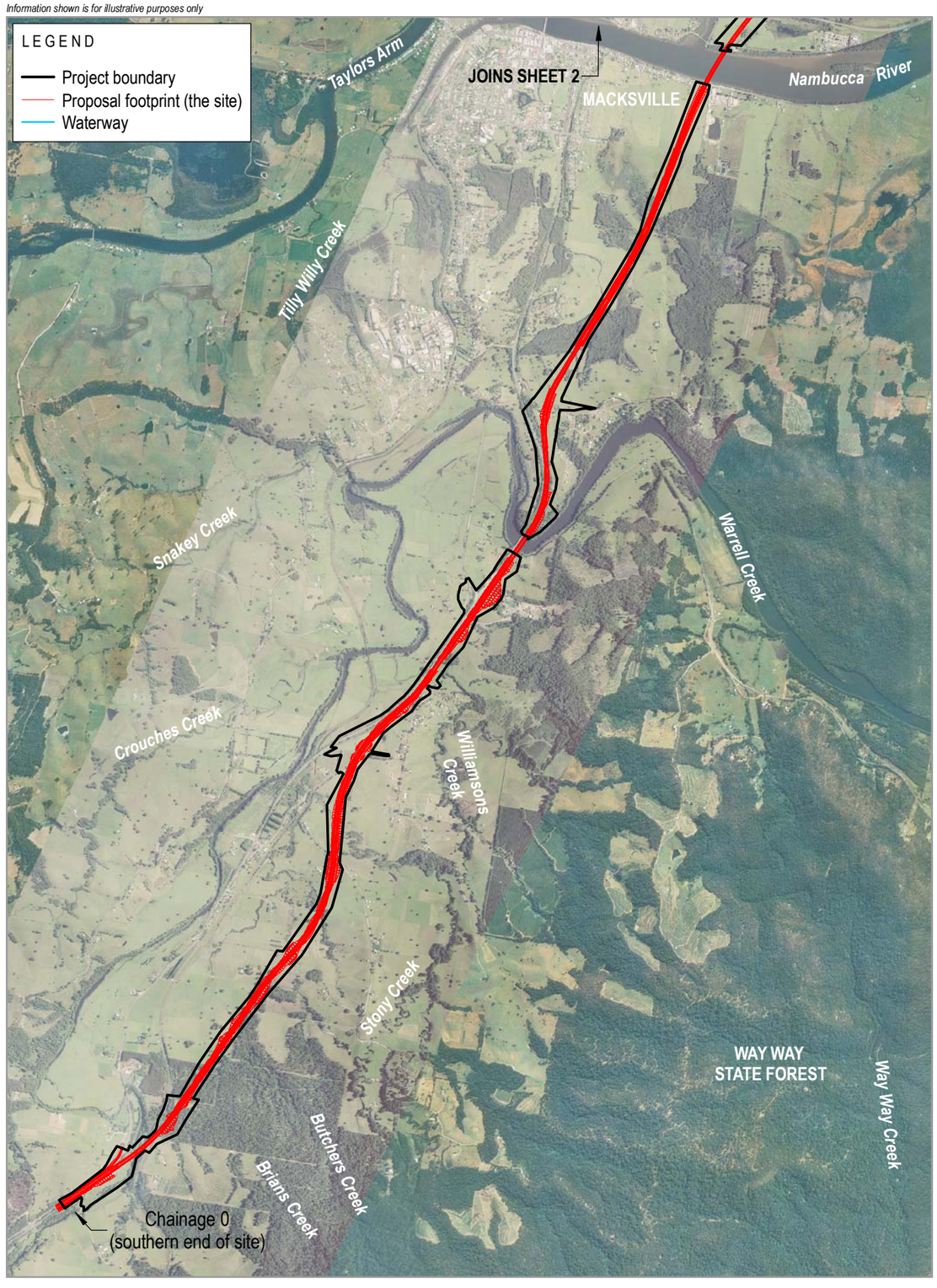
The Project comprises approximately 42 kilometres of dual carriageway road that would bypass the towns of Warrell Creek, Macksville, Nambucca Heads and Urunga on the Mid North Coast of NSW. The Project has been divided into two stages with Stage 1 consisting of approximately 22.5 kilometres from Nambucca Heads to Urunga (NH2U) and Stage 2 consisting of the remaining 19.5 kilometres of dual carriageway between Warrell Creek and Nambucca Heads (WC2NH) (refer to Illustration 1.1).

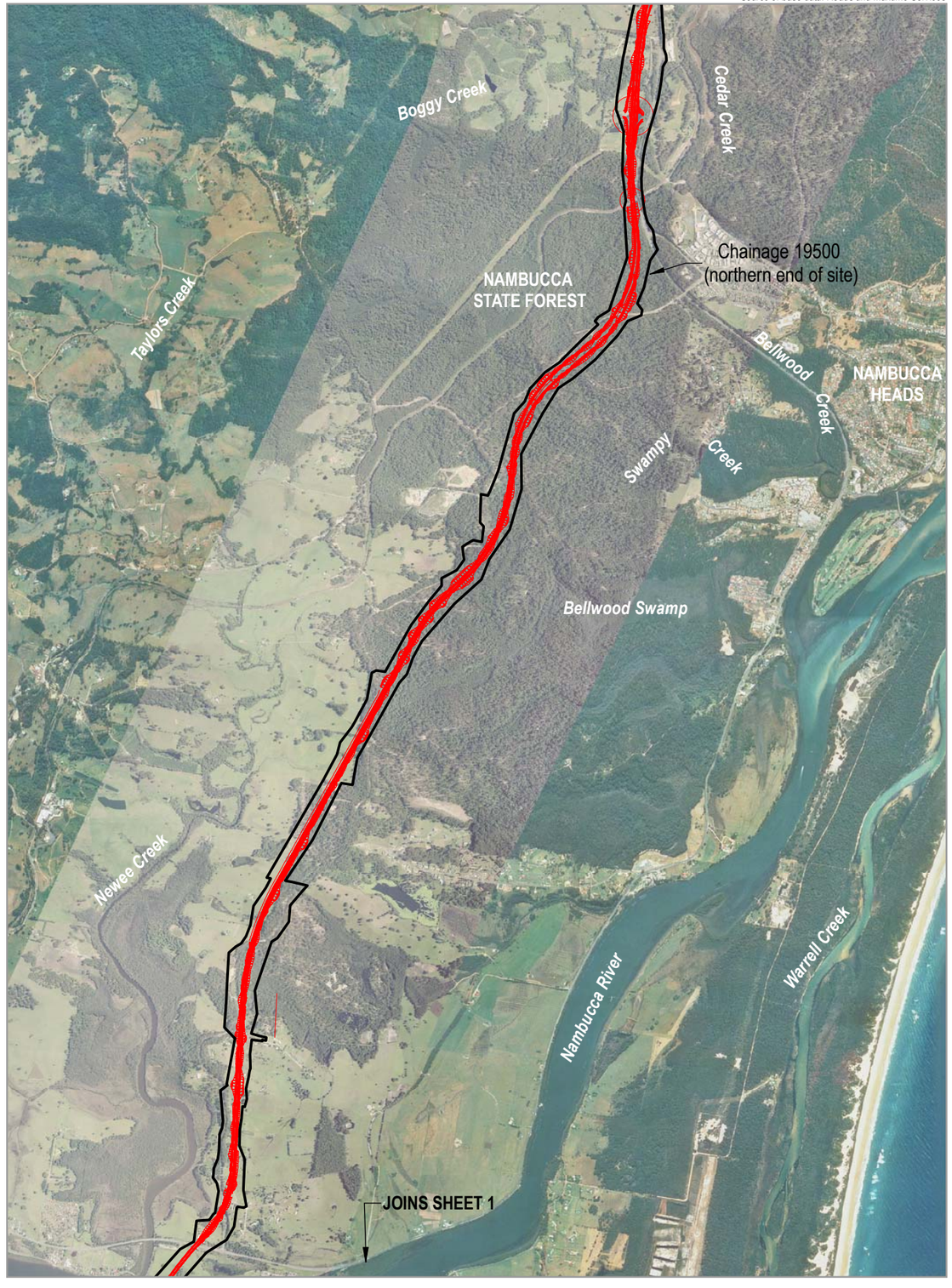
GeoLINK has been engaged to undertake baseline Spotted-tailed Quoll (STQ) monitoring for the WC2NH Project during winter 2014, prior to commencement of clearing of vegetation. As indicated in Belcher (2014) monitoring for a minimum of three weeks during winter is recommended as *"males move between female territories during the breeding season, monitoring female reproductive status. Monitoring suggests that it usually takes males approximately three weeks to visit the available females. Three weeks is also the length of the female oestrous cycle".*

This monitoring is for the purpose of providing data on the pre-construction usage by STQ of habitats within vicinity to the WC2NH Project, with particular focus of determining potential usage at proposed fauna underpass locations.

Information shown is for illustrative purposes only

Drawn by: TJP Checked by: GJM Reviewed by: DGH Date: October 2014
Source of base data: Roads and Maritime Services





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North

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WC2NH Spotted-tailed Quoll Monitoring
2394-1011

The Site

Illustration 1.1

2 Methodology

The methodology utilised for this STQ monitoring was reviewed by Spotted-tailed Quoll expert Chris Belcher and is described in detail in the following section.

2.1 Field Surveys

2.1.1 Remote Cameras

2.1.1.1 Determination of camera trap locations

Remote camera traps were established at 61 locations consisting of:

- Eleven fauna underpass sites.
- Fourteen survey sites previously surveyed by Benchmark for the NH2U Project within Nambucca State Forest.
- Thirty-six additional sites not previously surveyed.

The location of fauna underpass sites and previously established Benchmark sites were pre-determined and essentially fixed. The most appropriate location for the additional sites needed to be established (via aerial imagery), and was based on the following criteria:

- Sites were located within two kilometres of the proposal, predominantly in larger blocks of vegetation (e.g. Nambucca State Forest, Ingalba SF), but also in some narrow patches of remnant vegetation situated within the partially cleared farmland mosaic that is contiguous with these larger blocks of forested vegetation.
- Moist forest along riparian zones adjacent to creek lines was targeted.
- Small areas of fragmented vegetation in otherwise cleared farmland were not targeted (e.g. most of the area between Macksville and Warrell Creek).
- No sites were located within the Saltmarsh/ Swamp Oak forest in low-lying areas to the north of the Nambucca River due to a lack of suitable habitat features.
- Sites were located so that where suitable forested habitat occurred (as determined by the four dot points above) two camera traps were deployed for every 100 hectare/one kilometre square grid (including the fauna underpass sites and previously established Benchmark sites).

In the field, some site locations were found to be impractical and therefore minor adjustment was made to these locations (e.g. to avoid particularly dense Lantana patches etc.).

The final locations of deployed remote cameras are displayed in Illustration 2.1 to Illustration 2.5 and corresponding GPS coordinates are provided in Appendix A.

2.1.1.2 Camera trap setup

Remote cameras used for the monitoring consisted of Bushnell 8MP Natureview Cam HD for the 11 fauna underpass sites and Scoutguard SG560K for the remaining sites.

Camera setup was as follows:

- Mode – camera.
- Image size – 8M pixel.
- Image format – Wide screen.
- Capture number – 3 photos.
- LED control – high.
- Length – 10S.
- Interval – 10S.

- Sensor level – auto.
- NV shutter – medium.
- Camera mode – 24 hours.
- Time stamp – on.

At each location a remote camera trap (refer to Plate 2.1) was established using the following procedure:
- A remote camera was attached to a tree and pointed at an open area located three to four metres away.
- In this area a steel pole was driven in and a small bait cage attached approximately 1.5 metres above the ground.
- This bait cage was baited with chicken necks soaked in tuna oil.
- Tuna oil was also drizzled on exposed areas such as rocks or logs nearby as an extra attractant.
- Cameras were set to record during the day and night as quolls are known to range throughout both periods.

Cameras were deployed for a minimum period of three weeks from mid-July to mid-August 2014. This winter period (between late May and August) coincides with the peak period for detection of the STQ.

Plate 2.1 Typical Camera Trap Set-up

2.1.1.3 Hair funnels

Faunatech hair funnels (refer to Plate 2.2) were deployed at fauna underpass sites for a minimum period of three weeks from mid-July to mid-August 2014. Hair funnels were located along transects centred on the location of each fauna crossing structure with each transect consisting of 10 tubes/transect placed 20 metres apart. The bait used consisted of a mixture of flour, sardines and tuna oil.

The location of fauna underpass sites at which hair funnels were deployed are displayed in Illustration 2.1 to Illustration 2.5 and corresponding GPS coordinates are provided in Appendix A.

As for the camera traps, hair funnels were deployed for a minimum period of three weeks from mid-July to mid-August 2014, coinciding with the peak detection period for STQ in winter (between late May and August).

Fauna hairs collected in the hair funnels were identified by Scats About (Georgeanna Story).

Plate 2.2 Hair Funnel

2.2 Survey Limitations

Remote cameras were not able to be deployed at nine potential locations due to property access restrictions and/ or the inability to contact the relevant landholder. These locations are identified in Illustration 2.1 to Illustration 2.5. Despite this, the survey effort was considered appropriate to adequately undertake the monitoring.

At two of the fauna underpass sites hair funnels were not deployed (FU9 and FU10). These locations are identified in Illustration 2.1 to Illustration 2.5. These sites consisted of open cattle paddocks, with a high probability that the hair funnels would be damaged/ destroyed by the hooves of browsing cattle.

Information shown is for illustrative purposes only

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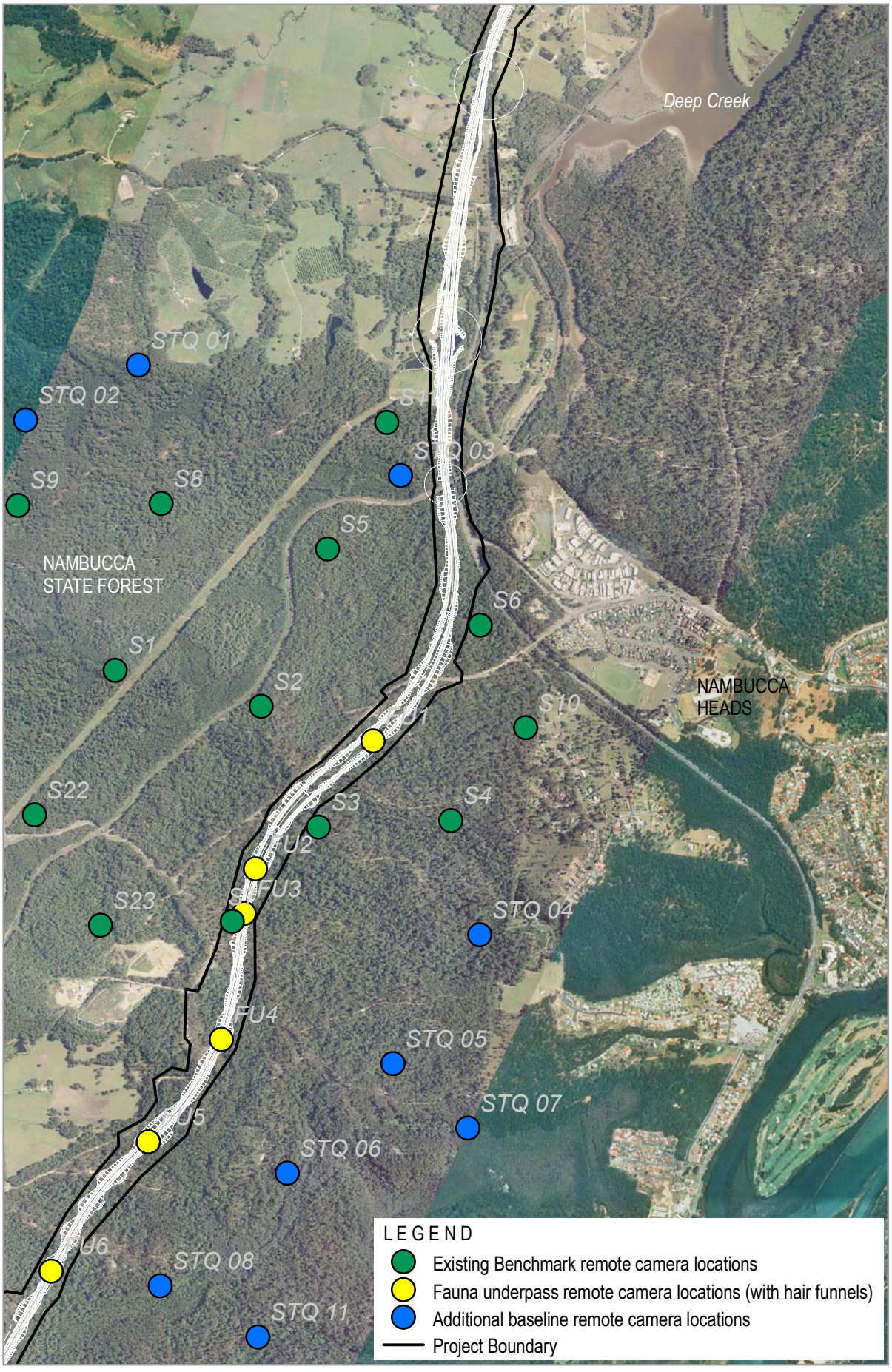
Source of base data: Roads and Maritime Services



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North

Location of Remote Cameras and Hair Funnels (Sheet 1 of 5)

GeoLINK environmental management and design

WC2NH Spotted-tailed Quoll Monitoring
2394-1006

Illustration 2.1

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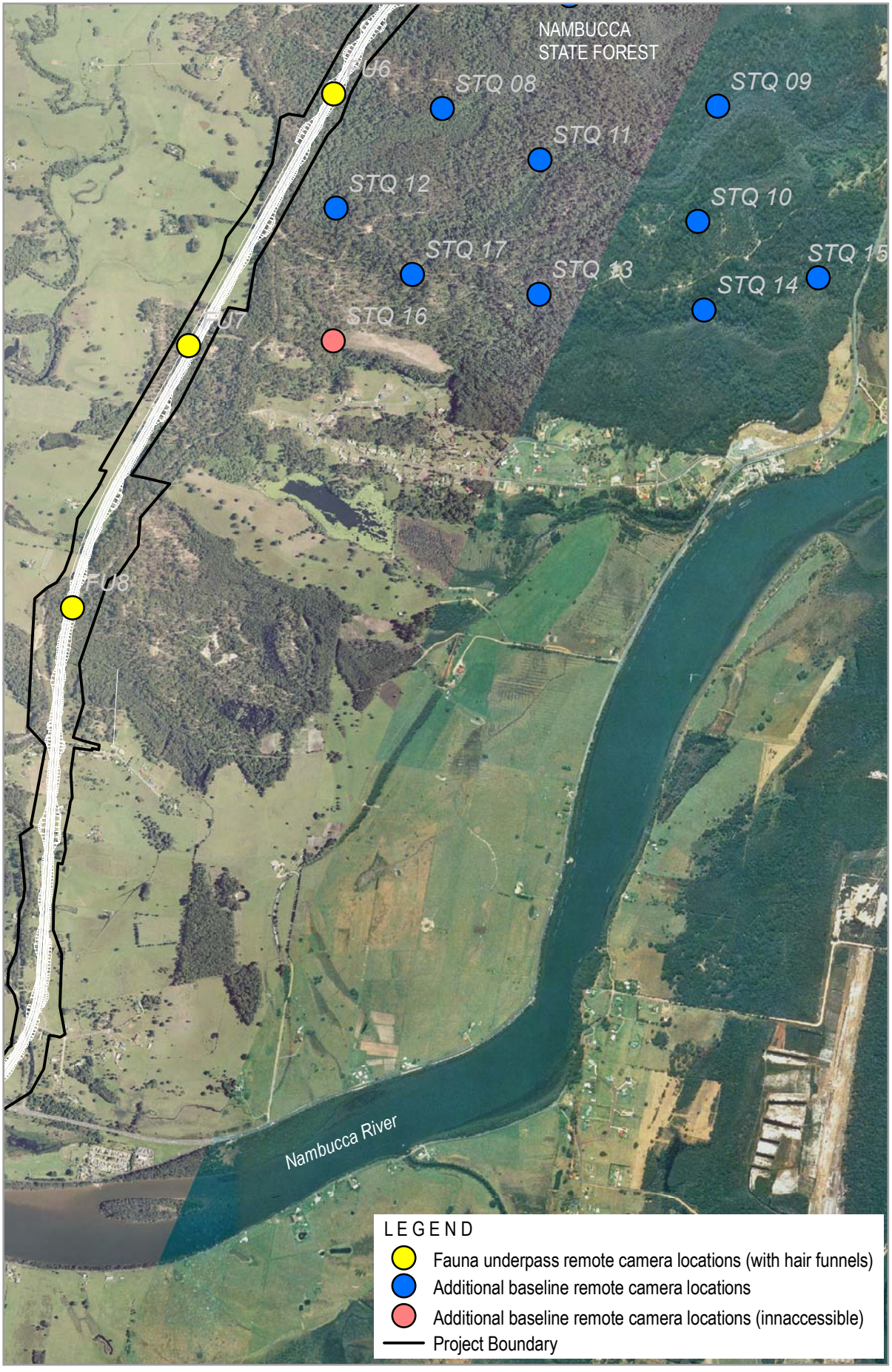
Source of base data: Roads and Maritime Services



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North

Location of Remote Cameras and Hair Funnels (Sheet 2 of 5)

GeoLINK environmental management and design

WC2NH Spotted-tailed Quoll Monitoring
2394-1007

Illustration 2.2

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Drawn by: TJP Checked by: GJM Reviewed by: DGH Date: September 2014
Source of base data: Roads and Maritime Services

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North

Location of Remote Cameras (Sheet 3 of 5)

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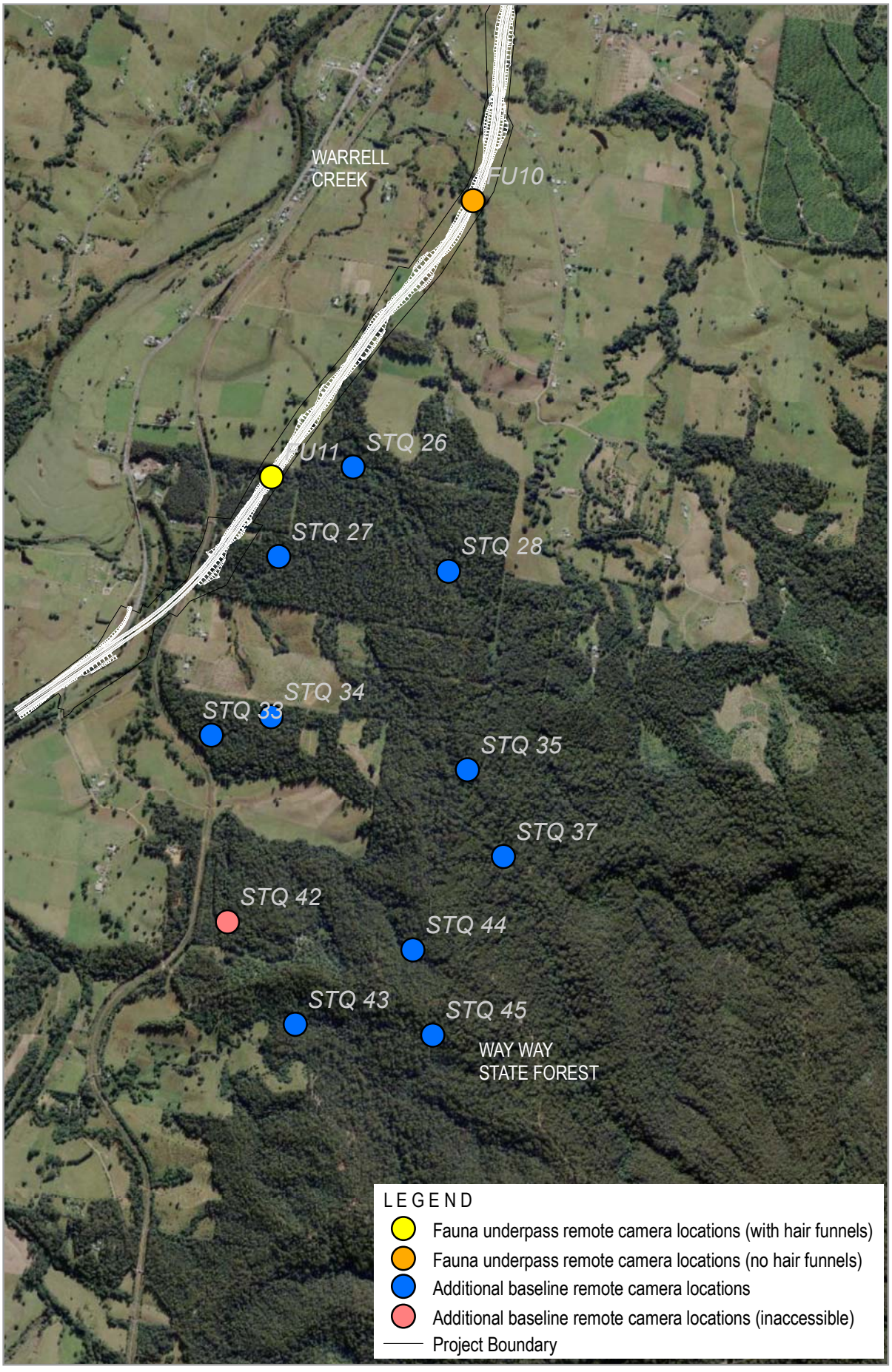
Source of base data: Roads and Maritime Services and Sixmaps Imagery



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North

Location of Remote Cameras and Hair Funnels (Sheet 4 of 5)

Information shown is for illustrative purposes only

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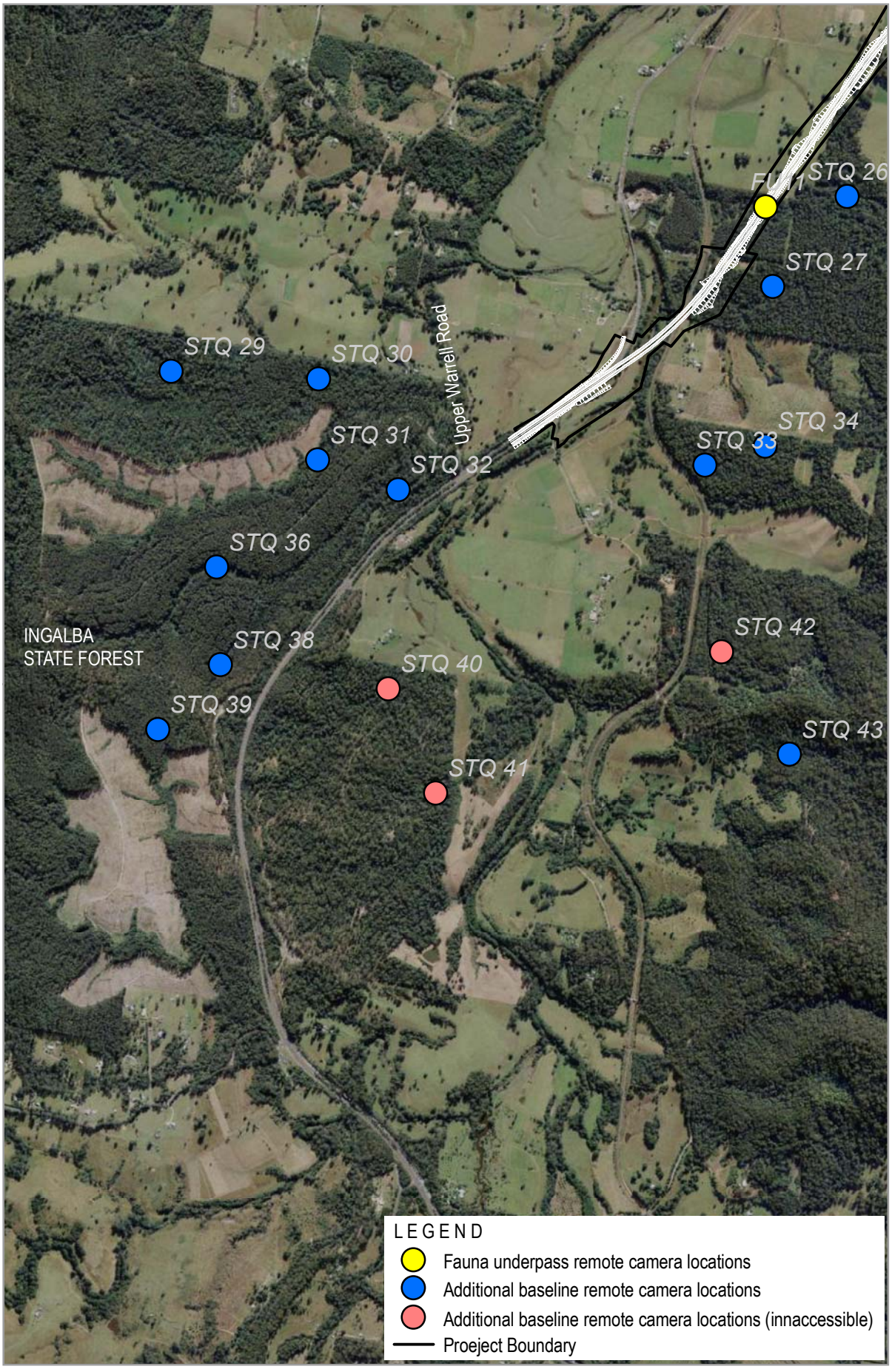

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Location of Remote Cameras and Hair Funnels (Sheet 5 of 5)

GeoLINK environmental management and design

WC2NH Spotted-tailed Quoll Monitoring
2394-1009

Illustration 2.5

3

Results and Discussion

3.1 Desktop Review

3.1.1 Previous Monitoring at Broader Locality

Baseline monitoring for Spotted-tailed Quoll using equivalent remote camera methodology was undertaken for the adjacent NH2U Project (Benchmark 2014).

The main findings of this monitoring were:

- No spotted-tailed quolls were photographed or evidence (scats or tracks) of quolls recorded.
- Three records of koala; one on private property east of the highway and two in Newry State Forest west of the upgrade.
- Records of four recognised prey species: common brushtail possum, short-eared brushtail possum, northern brown bandicoot and long-nosed bandicoot.
- Similar occurrence of brushtail possums between north and central sites but lower occurrence in south and trend of decreasing abundance of bandicoots from north to south.
- Presence of three introduced predators, dog, fox and cat, with variable occurrence between sample locations.
- Inverse pattern of occurrence between dog and red fox. Dog recorded at 30% of north sites, 19.6% of central and 4.2% of southern sites and red fox recorded at no north sites, 3.9% central and 25% of south sites.
- Moderate occurrence (20-35%) of small ground mammals (*Rattus* spp., *Antechinus* spp., *Melomys* spp.).
- Lace monitor was the most commonly recorded species in all three zones, with occurrence ranging from 79.2% to 85%.
- Macropods, particularly swamp wallaby, were commonly recorded, with a general trend of increasing occurrence from north to south.
- Most birds were recorded infrequently, with the exception of scrub turkey (16.7-41.2% of sites), wonga pigeon (4.2-20%) and superb lyrebird (7.8-10%).

3.1.2 OEH BioNet Atlas of NSW Wildlife Records

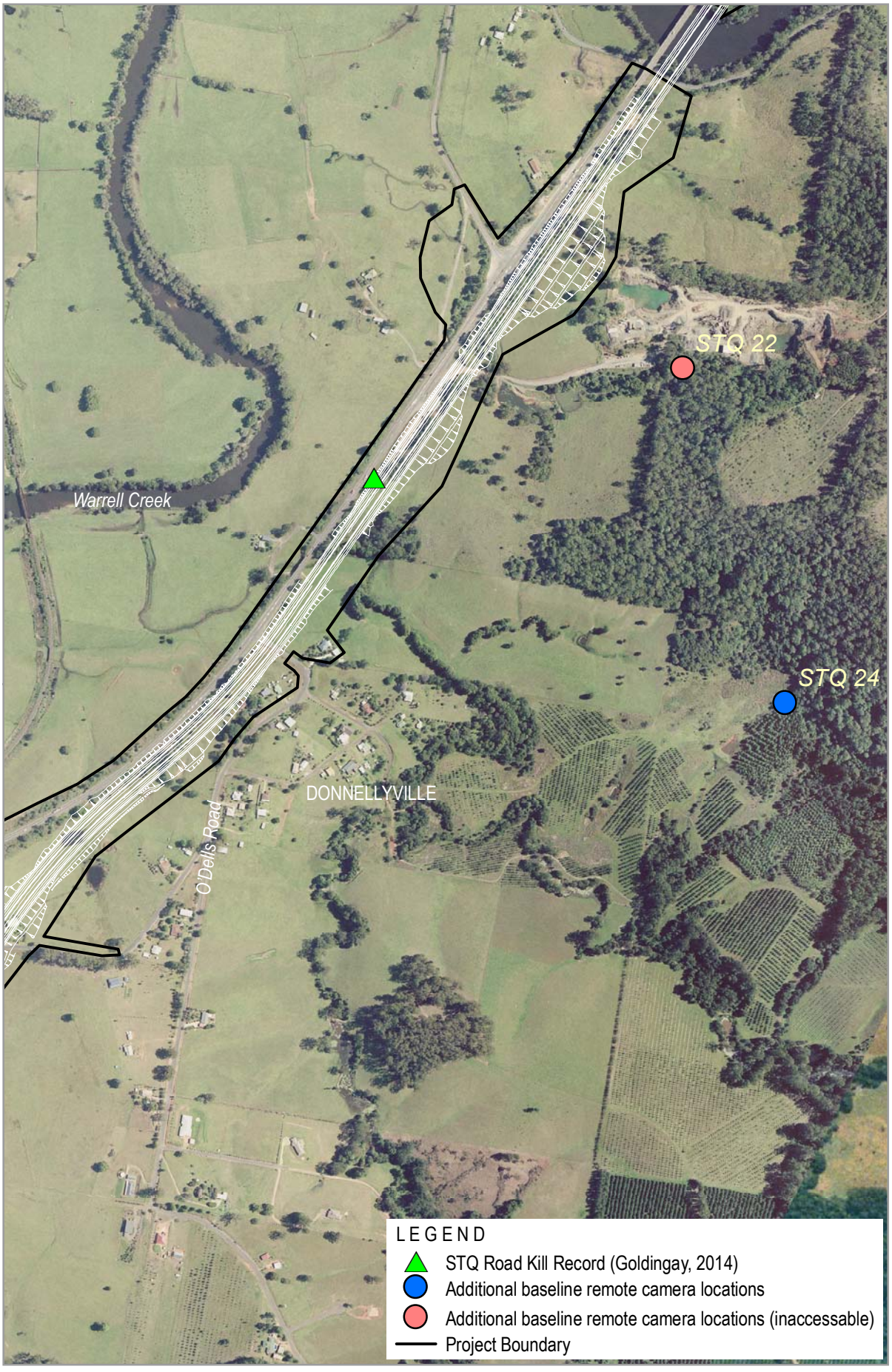
An online search of OEH BioNet records (undertaken 19 September 2014) showed eight records of STQ within approximately five kilometres of the WC2NH Project. Of these records, seven are from the Dan Lunney Community Wildlife Survey dataset and are potentially of limited reliability. The remaining record is more reliable, being from a Scientific Licences dataset and was made in 2004 near Bald Hill Road, Macksville.

3.1.3 Other Incidental Records

During August 2014, a road-kill STQ was recorded near the Pacific Highway-Scotts Head Road intersection at Warrell Creek and verified by ecologist Ross Goldingay from Southern Cross University (refer to Illustration 3.1).

Information shown is for illustrative purposes only

Drawn by: TJP Checked by: GJM Reviewed by: DGH Date: October 2014
Source of base data: Roads and Maritime Services, Ross Goldingay



North

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Location of STQ Road Kill

GeoLINK environmental management and design

WC2NH Spotted-tailed Quoll Monitoring
2394-1012

Illustration 3.1

3.2 Remote Camera Images

Analysis of the images captured on the 61 deployed remote cameras showed that no STQ visited the bait stations over the three week period that cameras were deployed.

The cameras captured images of a range of other native and exotic fauna species as detailed in Table 3.1. The three most commonly encountered species were Red-necked Wallaby (captured at 49.2% of camera traps), Bush Rat (captured at 36.1% of camera traps), and Common Brushtail Possum (Recorded at 32.8% of camera traps).

Main prey items for STQ generally consist of medium-sized mammals (Belcher *et al.* 2008). Such species that were recorded at camera traps included Common Brushtail Possum, Northern Brown Bandicoot and Long-nosed Bandicoot.

Four exotic fauna species were recorded, consisting of three carnivores; the Feral Dog, Feral Cat and European Red Fox, along with Domestic Cattle at farmland locations.

A single threatened species, the Koala, was recorded at two camera traps (camera locations FU6 and STQ-11; refer to Plate 3.1). The Koala is listed as vulnerable under both the *Threatened Species Conservation Act 1995* (TSC Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). These two camera locations are separated by a relatively small distance of approximately one kilometre. Koala dispersal distances between natal and breeding home ranges are typically at least several kilometres (Dique *et al.* 2003). Therefore, although the images may be of two Koala individuals, it is also possible that the images are of a single dispersing individual.

Table 3.1 Remote Camera Captures

Common Name	*Scientific Name*	*% Camera Stations Recorded*
Birds		
Eastern Yellow Robin	*Eopsaltria australis*	1.6
Eastern Whipbird	*Psophodes olivaceus*	1.6
Torresian Crow	*Corvus orru*	1.6
Australian Magpie	*Cracticus tibicen*	1.6
Wonga Pigeon	*Leucosarcia melanoleuca*	6.6
Satin Bowerbird	*Ptilonorhynchus violaceus*	1.6
Grey Shrike-thrush	*Colluricincla harmonica*	3.3
Green Catbird	*Ailuroedus crassirostris*	18.0
Australian Brush Turkey	*Alectura lathami*	13.1
Grey Goshawk	*Accipiter novaehollandiae*	1.6
Superb Lyrebird	*Menura novaehollandiae*	1.6
Unidentified bird spp.	n/a	4.9
Mammals		
Common Brushtail Possum	*Trichosurus vulpecula*	32.8
Common Ringtail Possum	*Pseudocheirus peregrinus*	3.3
Bush Rat	*Rattus fuscipes*	36.1
Unidentified rodent/ Antechinus spp.	n/a	31.1
Long-nosed Bandicoot	*Perameles nasuta*	21.3
Northern Brown Bandicoot	*Isoodon macrourus*	9.8
Unidentified small mammal spp.	n/a	21.3

Common Name	*Scientific Name*	*% Camera Stations Recorded*
#Koala	*Phascolarctos cinereus*	3.3
Red-necked Wallaby		49.2
Unidentified macropod spp.	n/a	18.0
*Feral Cat	*Felis Catus*	11.5
*Feral Dog	*Canis familiaris*	4.9
*European Red Fox	*Vulpes vulpes*	13.1
*Domestic Cattle	*Bos taurus*	3.3
Monotremes		
Short-beaked Echidna	*Tachyglossus aculeatus*	24.6
Reptiles		
Lace Monitor	*Varanus varius*	4.9

* Denotes exotic/ pest fauna species

# Denotes threatened species listed under the TSC Act or EPBC Act

3.3 Hair Funnels

Identification of hair left behind in deployed hair funnels at the fauna underpass sites indicated no presence of STQ. Hair from a range of other mammals was present consisting mainly of Bush Rat and Brown Antechinus (refer to Table 3.2). No hair was collected in any of the hair funnels at site FU7.

Table 3.2 Results of Hair Analysis

Site	*Common Name*	*Scientific Name*
FU1	Bush Rat	*Rattus fuscipes*
	Brown Antechinus	*Antechinus stuartii*
FU2	Brown Antechinus	*Antechinus stuartii*
	an Antechinus	*Antechinus* sp.
	Bush Rat	*Rattus fuscipes*
	Northern Brown Bandicoot/ Long-nosed Bandicoot	*Isoodon macrourus/ Peremales nasuta*
FU3	Bush Rat	*Rattus fuscipes*
	Brown Antechinus	*Antechinus stuartii*
	an Antechinus	*Antechinus sp.*
FU4	Bush Rat	*Rattus fuscipes*
	a Rat	*Rattus* sp.
	Brown Antechinus	*Antechinus stuartii*
FU5	Bush Rat	*Rattus fuscipes*
	Brown Antechinus	*Antechinus stuartii*
	an Antechinus	*Antechinus sp.*
FU6	*House Mouse	*Mus musculus*
	Bush Rat	*Rattus fuscipes*
	a Rat	*Rattus* sp.
FU8	Brown Antechinus	*Antechinus stuartii*
	Bush Rat	*Rattus fuscipes*
	a Rat	*Rattus* sp.
	Northern Brown Bandicoot/ Long-nosed Bandicoot	*Isoodon macrourus/ Peremales nasuta*

Site	*Common Name*	*Scientific Name*
FU11	Bush Rat	*Rattus fuscipes*
	*Black Rat	*Rattus rattus*
	Brown Antechinus	*Antechinus stuartii*

* Denotes exotic/ pest fauna species

Plate 3.1 Koala Captured on Camera at FU6

3.4 Discussion

Despite not recording STQ by either the remote cameras or hair funnel methods used in the monitoring, a previous local OEH BioNet record and the recent 2014 road-kill record suggest that STQ occurs at a low density within the locality. Considering this, the fauna underpass structures that are to be constructed for the WC2NH Project will be an important management measure to minimise potential impacts on STQ by allowing connectivity between areas of STQ habitat that will be dissected by the upgraded highway.

4

Summary

- The results of the monitoring did not provide evidence of occurrence of STQ in habitats within vicinity of the WC2NH Project.
- A small number of previous OEH BioNet records are within five kilometres of the WC2NH project, and along with a verified 2014 road-kill record on the current Pacific Highway within the study area, this suggests a low density STQ population occurs at the locality.
- A variety of native fauna species were recorded at the camera traps, including a main prey item for STQ; the Brushtail Possum, which was recorded at 32.8% of camera locations.
- Exotic carnivores including the Feral Dog, Feral Cat and Eurpoean Red Fox were also recorded on up to 13.1% of camera traps.
- A single threatened species, the Koala, was recorded at two camera traps during the monitoring.
- No STQ hair was found in the deployed hair funnels, with *Rattus* spp. and *Antechinus* spp. dominating.
- Provision of fauna underpass structures on the WC2NH Project to enable for STQ movement to be retained between habitat areas will be an important mitigating measure aimed at minimising adverse impacts of the WC2NH Project on STQ.

References

Belcher, C. (2014). WC2NH Upgrade of the Pacific Highway Review of Mitigation Measures. *Prepared for NSW Roads and Maritime Services.*

Belcher, C., Burnett, S. & Jones, M. (2008). Spotted-tailed Quoll, *Dasyurus maculatus* (Kerr, 1792). In: Strahan, R., ed. *The Mammals of Australia*. Page(s) 61-62. Carlton, Victoria: Reed New Holland.

Benchmark (2014). Nambucca Heads to Urunga Pacific Highway Upgrade – Koala and Spotted-tailed Quoll Baseline Population Monitoring. *Prepared for NSW Roads and Maritime Services*.

Dique D.S., Thompson J., Preece H.J., de Villiers D.L. and Carrick F.N. (2003). Dispersal patterns in a regional koala population in south-east Queensland. *Wildlife Research* 30:281-290.

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Appendix A

Locations of Remote Cameras and Hair Funnel Transects

Table 1 GPS Coordinates of Remote Cameras and Hair Funnel Transects (UTM Zone 56)

Remote Camera site ID	*Site Type*	*Easting*	*Northing*
*FU1	Fauna Underpass	497135	6610002
*FU2	Fauna Underpass	496611	6609431
*FU3	Fauna Underpass	496560	6609232
*FU4	Fauna Underpass	496458	6608668
*FU5	Fauna Underpass	496132	6608212
*FU6	Fauna Underpass	495700	6607634
*FU7	Fauna Underpass	495054	6606511
*FU8	Fauna Underpass	494535	6605340
FU9	Fauna Underpass	493273	6601511
FU10	Fauna Underpass	490717	6596130
*FU11	Fauna Underpass	489817	6594896
S1	Benchmark	495985	6610316
S2	Benchmark	496636	6610157
S3	Benchmark	496892	6609616
S4	Benchmark	497482	6609647
S5	Benchmark	496932	6610859
S6	Benchmark	497613	6610517
S7	Benchmark	496507	6609196
S8	Benchmark	496190	6611062
S9	Benchmark	495550	6611054
S10	Benchmark	497816	6610061
S11	Benchmark	497196	6611424
S21	Benchmark	495066	6610604
S22	Benchmark	495624	6609672
S23	Benchmark	495919	6609179
STQ 01	Additional Baseline	496088	6611680
STQ 02	Additional Baseline	495585	6611434
STQ 03	Additional Baseline	497259	6611187
STQ 04	Additional Baseline	497611	6609137
STQ 05	Additional Baseline	497225	6608560
STQ 06	Additional Baseline	496753	6608071
STQ 07	Additional Baseline	497559	6608274
STQ 08	Additional Baseline	496186	6607568
STQ 09	Additional Baseline	497415	6607579
STQ 10	Additional Baseline	497326	6607064
STQ 11	Additional Baseline	496621	6607340
STQ 12	Additional Baseline	495712	6607124
STQ 13	Additional Baseline	496617	6606739
STQ 14	Additional Baseline	497354	6606668
STQ 15	Additional Baseline	497864	6606813
#STQ 16	Additional Baseline	495699	6606532
STQ 17	Additional Baseline	496051	6606828
#STQ 18	Additional Baseline	493761	6599699

Remote Camera site ID	*Site Type*	*Easting*	*Northing*
#STQ 19	Additional Baseline	493957	6599323
#STQ 20	Additional Baseline	494298	6599067
#STQ 21	Additional Baseline	494799	6599417
#STQ 22	Additional Baseline	492254	6598392
STQ 23	Additional Baseline	492821	6598395
STQ 24	Additional Baseline	492437	6597795
STQ 25	Additional Baseline	492649	6597479
STQ 26	Additional Baseline	490181	6594941
STQ 27	Additional Baseline	489848	6594540
STQ 28	Additional Baseline	490606	6594475
STQ 29	Additional Baseline	487163	6594161
STQ 30	Additional Baseline	487821	6594128
STQ 31	Additional Baseline	487818	6593766
STQ 32	Additional Baseline	488178	6593632
STQ 33	Additional Baseline	489547	6593742
STQ 34	Additional Baseline	489815	6593826
STQ 35	Additional Baseline	490691	6593588
STQ 36	Additional Baseline	487367	6593288
STQ 37	Additional Baseline	490850	6593201
STQ 38	Additional Baseline	487384	6592851
STQ 39	Additional Baseline	487105	6592562
#STQ 40	Additional Baseline	488132	6592744
#STQ 41	Additional Baseline	488344	6592279
#STQ 42	Additional Baseline	489620	6592909
STQ 43	Additional Baseline	489922	6592452
STQ 44	Additional Baseline	490446	6592784
STQ 45	Additional Baseline	490536	6592404
*FU1	Fauna Underpass	497135	6610002
*FU2	Fauna Underpass	496611	6609431
*FU3	Fauna Underpass	496560	6609232
*FU4	Fauna Underpass	496458	6608668
*FU5	Fauna Underpass	496132	6608212
*FU6	Fauna Underpass	495700	6607634
*FU7	Fauna Underpass	495054	6606511
*FU8	Fauna Underpass	494535	6605340
FU9	Fauna Underpass	493273	6601511
FU10	Fauna Underpass	490717	6596130
*FU11	Fauna Underpass	489817	6594896
S1	Benchmark	495985	6610316
S2	Benchmark	496636	6610157
S3	Benchmark	496892	6609616
S4	Benchmark	497482	6609647
S5	Benchmark	496932	6610859
S6	Benchmark	497613	6610517

Remote Camera site ID	*Site Type*	*Easting*	*Northing*
S7	Benchmark	496507	6609196
S8	Benchmark	496190	6611062
S9	Benchmark	495550	6611054
S10	Benchmark	497816	6610061
S11	Benchmark	497196	6611424
S21	Benchmark	495066	6610604
S22	Benchmark	495624	6609672
S23	Benchmark	495919	6609179

Appendix E

Fauna Crossing Structures

Appendix A Summary of the fauna crossing locations for the upgrade of the Pacific Highway, WC2NH.

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
42km500	735	Combined	Bridge over Upper Warrell Creek	(-)	Class 1 waterway[3]	Minimum 3 metre wide fauna passage required at each abutment. Giant Barred Frog and fish included as target species.
43km325	1,560	Combined	Box culvert Butchers Creek	Minimum 5 no. x 3600mm x 1500mm high	Class 2 waterway[3] Set one culvert cell 200mm (minimum) below existing bed level. Continue low flow channel through scour protection	Two outside cells must provide dry passage during a 1 in 1 year ARI, 3 day (72 hour) storm event and must not have wet sections that retain water for longer than three days.. No refuge poles required. Approximate culvert length is 47 m.
44km905	3,140	Fish passage	Box culvert	Minimum 3300 mm wide x 1800 mm high	Class 3 waterway [3]. Include low flow channel 200 mm (minimum) below existing bed level and 450 mm wide. Continue low flow channel	Waterway realignment must ensure bed stability; and maintain existing flow velocity. Fish passage.
45km525	3,760	Incidental	Box culvert	Minimum 5 no. x 4200 mm wide x 3600 mm high	Class 3 waterway [3]. Set one culvert cell 200 mm (minimum) below existing bed level. Continue low flow channel through scour protection	Waterway realignment must ensure bed stability; minimise increasing or decreasing existing waterway length; and maintain existing flow velocity. Fish passage.

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
47km000	5,235	Fish passage	Bridge over Williamsons Creek	(-)	Class 3 waterway[3]	
47km525	5,760	Incidental	Box culvert	Minimum 3000 mm wide x 1200 mm high	Class 3 waterway [3]. Include low flow channel 200 mm (minimum) below existing bed level and 450 mm wide. Continue low flow channel through scour protection	Must extend under existing Pacific Highway. Fish passage.
47km650	5,885	Incidental	Box culvert	Minimum 3000 mm wide x 1200 mm high	Fish passage.	
48km085	6,320	Dedicated	Bridge	(-)		Fauna corridor listed is under southern end span of bridge. Minimum 3 metre wide fauna passage required.
48km215	6,450	Dedicated	Bridge	(-)	Class 1 waterway[3]	
48km275	6,510	Dedicated	Bridge	(-)		Fauna corridor listed is under northern end span. Minimum 3 metre wide fauna passage required
49km900	8,135	Incidental	Pipe	2,500 mm diameter	No	Must provide water connectivity across Main carriageways. Site permanently inundated.

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
50km215	8,450	Incidental	Bridge	Minimum width between the intersection of the scour protection and the finished ground level under the bridge to be 50.4m (see Note 1). Minimum vertical clearance to be 2.0 m (subject to detailed design).	No	
50km985	9,220	Incidental	Bridge	Minimum width between the intersection of the scour protection and the finished ground level under the bridge to be 50.4m (see Note 1). Minimum vertical clearance to be 2.0 m (subject to detailed design).	No	

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
55km120	13,355	Dedicated	Box culvert	3000 mm x 3000 mm	No	Approximate length of culvert under main carriageway is 50 m. No culvert is to be provided under the service road but detailed design to investigate lowering the service road to provide better visibility across the service road from the culvert. Fauna fencing to be provided along the bottom of the batter slope between the highway and the service road to prevent fauna accessing the main highway. Koala included as target species
56km410	14,645	Combined	Box culvert	Minimum 2400 mm x 2400 mm	No	Approximate culvert length under main carriageway is 45 m. No fauna underpass is required under the service road. Koala included as target species. Provide ledge for dry passage during a 1 in 1 year ARI, 3 day (72 hour) storm event and must not have wet sections that retain water for longer than three days.
57km770	16,005	Dedicated	Box culvert	3000 mm x 3000 mm	No	Maximum culvert length is 50 m. Koala included as target species

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
58km510	16,745	Combined	Box culvert	3000 mm x 3000 mm	Class 3 waterway3 Include low flow channel 1200mm wide x 200mm deep below existing bed level. Continue low flow channel through scour protection. Fish passage.	Approximate culvert length is 84m. Provide ledge for dry passage during a 1 in 1 year ARI, 3 day (72 hour) storm event and must not have wet sections that retain water for longer than three days. Adjacent box or pipe culvert to also be provided for drainage.
58km560	16,795	Dedicated	Box culvert	3000 mm x 3000 mm	No	Maximum culvert length is 50 m. Koala included as target species
59km090	17,325	Dedicated	Box culvert	3000 mm x 3000mm	No	Culvert length is 58 m. Length slightly in excess of 50 metres however was agreed to be acceptable if needed to achieve desired location. Koala included as target species
59km550	17,785	Dedicated	Box culvert	Minimum 3000 mm x 3000 mm	No	Approximate culvert length is 50 m. Koala included as target species
59km750 (northbound carriageway)	17,985	Dedicated	Box culvert	2400 mm x 2400 mm	No	Approximate culvert length is 38 m. Culvert to be moved up the bank to achieve the 1 in 100 year ARI flood immunity. Koala included as target species

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
59km760 (southbound carriageway)	17,995	Dedicated	Box culvert	Minimum 2400 mm x 2400 mm	No	Approximate culvert length is 25 m. Combined length of the northbound and southbound underpasses is around 63 m. Carriageway separation is approximately 10 m with a fauna fenced race in between underpasses. Koala included as target species
60km615 (northbound carriageway)	18,850	Dedicated	Box culvert	2400 mm x 2400 mm	No	Approximate culvert length is 29 m. Structure to be shifted to the north around 15 metres to align with southbound carriageway. Koala included as target species.
60km600 (southbound carriageway)	18,835	Dedicated	Box culvert	Minimum 2400 mm x 2400 mm	No	Approximate culvert length is 30 m. Combined length of the northbound and southbound underpasses is around 59 m. Carriageway separation is approximately 19 m with a fauna fenced race in between underpasses. Koala included as target species.

1 A bridge may be provided in lieu of a box culvert provided that the total width between the intersection of the scour protection and the finished ground level under the bridge is at least equivalent to the total clear width of the cells of the replaced box culvert.

2 Separate fauna crossing structures must be provided for the Main Carriageways and Service Road to provide daylight between the Main Carriageways and Service Road structures.

3 Classification identified in consultation with DPI (Fisheries Conservation and Aquaculture)

Appendix F

Road Kill Monitoring Methodology

WC2NH Road Kill Monitoring Program

1.1 Timing of Monitoring

Timing of road kill surveys for the WC2NH Project is described in Table 1.

Table 1 – Timings and locations of road kill surveys

Project Phase	Timing of Survey	Location
During clearing operations	Daily	Portion of existing Pacific Highwayadjacent to clearing operations
One month following clearing operations	Daily	Portion of existing Pacific HwHighwayy adjacent to clearing operations
Duration of construction	Weekly	Entire length of existing Highwayin Project area
Upon opening of each stage of the Project to traffic (operational phase)	Weekly for 12 weeks commencing the week of opening each stage to traffic.	Entire length of opened stage.
Upon completion of the Project (operation phase)	Excluding the season/s covered by the initial 12 week monitoring period (refer above), weekly during October (spring), January (summer), April (autumn) and July (Winter) for up to five consecutive years post construction, or until mitigation measures have been demonstrated to be effective.	Entire length of completed Project

1.2 Monitoring Program Objectives

The aim of the monitoring program is to;

- report on any animal road kill on the project following the opening to traffic; and
- assess the effectiveness of the presence of fauna fencing to prevent fauna being killed by vehicles while attempting to cross the WC2NH Upgrade.

1.3 Monitoring Procedure

A two-person team vehicle being driven along the entire length of the highway in the Project area and identifying dead wildlife (road kill) seen on the road and within three metres of the road edge. The passenger will search the road and its verge for road kill. When a road kill is observed from the vehicle, a closer visual inspection of the carcass will be undertaken where safe access is available. If safe access is not possible, due to local traffic conditions, binoculars will be used to try to identify and provide as detailed information as is possible on the carcass.

Road kill fauna will be identified to species level where possible, with reference to field guides. Where there is any doubt to the identification of the carcass, photographs will be taken and forwarded to a qualified ecologist

for identification /confirmation of species. Those too seriously damaged to be accurately identified will be recorded as “unknown”.

To assist with the correct identification of road kills, the following will be undertaken –

a. The provision of a qualified ecologist (shall be a recognised expert in mammal identification in coastal northern NSW) to undertake the initial phase of operational monitoring (first season) with relevant Roads and Maritime team members providing appropriate detailed training and a baseline of expert monitoring of road kills;

b. The provision of specialist training (to be provided by an expert as above in point a) in fauna identification for Contractors and Roads and Maritime staff involved in the construction phase monitoring of road kill; and

c. Where there is any doubt to the identification of the carcass, the provision of photographs of road kill to be sent to a qualified ecologist (an expert as above in point a) to confirm the identity of road kill and to maintain a permanent record of road kill for further comparisons, if needed.

1.4 Monitoring Methodology

- The highway will be monitored using the method previously indicated (section 1.3) consisting of a two-person team traversing the upgrade in a vehicle to locate and identify road kills;

- The speed of travel will be the same in all cases to avoid confounding the data collection, and should be as slow as is safely possible;

- The highway will be surveyed weekly for four weeks in spring, summer, autumn and winter (see Table 1);

- Where possible, each survey shall be completed within two hours of sunrise in order to maximise the potential to record road kills before either carrion eating animals or traffic render any road kill unidentifiable;

- if possible, each survey will be carried out on the same day of the week to remove the influence of varying environmental conditions and to ensure consistent temporal spacing;

- For each road kill observed, the following attributes will be recorded

    a. Geographic Coordinates of any road kill.

    b. Whether fauna fencing was installed at/near the location.

    c. Species of road kill where possible, however, where there is any doubt as to the identification of the carcass, photographs shall be forwarded to a qualified ecologist for identification /confirmation of the species.

If the animal is identified as an EPBC Act threatened species, the carcass will be photographed and the following information will also be recorded where possible and safety considerations permit

a. Sex and age class (juvenile or adult).

b. Presence of pouch young (for marsupials).

c. Presence of flightless young (for flying-foxes or other bats).

d. Distance to a fauna connectivity structure.

e. Distance to drop down structure.

f. If fauna fencing was installed, is there any damage to the fence in the vicinity.

g. Weather conditions at the time of the monitoring (from the Bureau of Meteorology) – including temperature, rainfall in the last 24 hours, moon phase.

h. If the animal is identified as a flying-fox:
   - Distance to nearest camp,
   - Distance to nearest canopy vegetation,
   - Presence of flowering food trees in neighbouring median or roadside vegetation; plants identified to species and referenced with diet list.

1.5 Analysis of data

The data to be collected will be analysed using a suitable nonparametric test such as a Kruskal-Wallis test. The aim will be to test both whether the fenced and unfenced locations have different mean numbers of road kills and if the amount of road kill varies through time in either or both of the two types of areas. Associations with other measured variables will be described as data allow, including sex, age class, presence of dependent young and, in the case of flying-foxes, proximity to roost sites or flowering food trees. Such information will indicate if the mitigation measures in the area are working as expected to keep road kills to acceptable levels and that none of the target species are killed.

1.6 Reporting

1.6.1 Quarterly reports

A report will be prepared by the ecologist following the initial 12 week monitoring period (after opening for each stage) to identify any roadkill hotspots and review the mitigation measures. The initial report and ongoing seasonal reports of the data collected will be provided to Roads and Maritime. This will include graphs of the data and any previously collected data to provide simple visual comparisons of road kill. This will also include overall road kill counts as well as separate graphs for each of the target species (if deaths have occurred).

Anecdotal road kill information collected on days that are not monitored as part of this program may be added as a note for discussion.

1.6.2 Annual Reports

The annual report will be prepared in consultation with a qualified ecologist and provided to DoEE and EPA within one month of completion of the fourth monitoring season. From then on it will be provided within one month of the same monitoring season in subsequent years until monitoring is completed (Table 1).

Analysis of the data itself shall be included in an annual monitoring report. This report will include a statistical analysis of all of the data collected to that time including graphical representations of the road kill that is recorded.

Annual reports will record any potential or obvious failures in road kill mitigation identified in the monitoring program and provide a date by which meetings will take place to discuss any such adverse findings. This will include at least:

- where statistically larger number numbers of road killed animals are detected on fenced sections compared to unfenced sections;
- where any of the target threatened fauna are recorded as killed;
- where there is a clear pattern of unexpected road kill at any point on the Upgrade.

1.7 Performance Measures

Lower rates of road kill in proximity to fauna fencing (i.e. areas of the main carriageways within areas adjacent to installed fauna fencing) than in sections of the upgrade not near fauna fencing during monitoring events up to five years post construction phase, or until such time as mitigation measures have been demonstrated to be effective.

1.8 Adaptive Management

Where any annual report identifies a significant difference between the road kill numbers of the fenced and unfenced areas, DoEE and EPA shall be notified, and a meeting will be set to discuss such differences with the relevant agencies and Roads and Maritime.

Such a meeting would occur within one month of completion of the annual report, which should ensure sufficient time to consider/review the response to any recorded significant differences.