Description of contents RMS Response to DoE review of Referral response R2 Road Ecology

DoE Requirement 2: Independent Review on mitigation measures for Road Ecology for Warrell Creek to Nambucca Heads Pacific Highway Upgrade

The documents in this package include

- Niche Harrington WC2NH Mitigation Measures Road Ecology
- Harrington Independent review statements and CV
- Response to DoE review comments on independent review road ecology
- RMS response to road ecology review
- WC2NH Information for independent Road Ecologist Review
  - Attachment A - Figures 1
  - Attachment B – 100511 OEH letter
  - Attachment C - Letter to DoPI WC2U_Fauna Connectivity
  - Attachment D - Letter Updated Fauna Crossing Structures June 2011
  - Attachment E - EPA Inspection 26Nov2013
  - Attachment F - Extract from SWTC App 5
  - Attachment G – MD 201 D02 A Standard Fauna Fence Design
  - Attachment H - Extract from SWTC Appendix 4 and 14 EMP
  - Attachment I – 140206 Figure 14.1
  - Attachment J - Use of Fauna Passage structures on RTA Roads 2009
- RMS Response to DoE review comments on independent review road ecology
- Email confirmation from Niche re RMS response to independent road ecology review
5th March 2014

Rachel Vazey
Environmental Planner / GIS Analyst
Sinclair Knight Merz
PO Box 2147
Dangar NSW 2309

via email: RVazey@globalskm.com

Dear Rachel,

RE: WARRELL CREEK TO NAMBUCCA HEADS PACIFIC HIGHWAY UPGRADE – INDEPENDENT REVIEW OF THE PROPOSED MEASURES TO MITIGATE IMPACTS ON EPBC ACT THREATENED SPECIES (OUR REF 1998)

The NSW Roads and Maritime Services (RMS) have recently submitted a referral to the Commonwealth Department of the Environment (DoE) for the upgrade of approximately 19.5 kilometres of the Pacific Highway, starting at the northern end of the Allgomera deviation south of Warrell Creek to Old Coast Road, west of Nambucca Heads (the proposed action). The proposed action is the second stage of the Warrell Creek to Urunga (WC2U) Pacific Highway upgrade (the project) which has undergone assessment under the Environmental Planning and Assessment Act 1979 (EP&A Act). The project was approved on 19 July 2011, subject to the Minister’s Conditions of Approval (CoA) being met.

Subsequent to the WC2U project approval a flying-fox camp became established in October 2011 in a part of a 23.5 hectare patch of swamp sclerophyll forest, 8.5 km north of the southern end of the proposed action boundary. This flying-fox habitat meets the criteria for Roosting Habitat Critical to Survival of Grey-headed Flying-foxes as defined in the Draft National Recovery Plan for Grey-headed Flying-fox (DECCW 2009). The population meets the criteria for ‘important population’ under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) criteria for vulnerable species. The population is considered to be an ‘important population’ as defined under the EPBC Act as it is likely to be a key source population for breeding and dispersal. Due to impacts to the Grey-headed Flying-fox and the Koala, which was listed as vulnerable under the EPBC Act in 2013, a referral to the federal government for the proposed action was made in December 2013 (EPBC 2013/7101) (http://www.environment.gov.au/cgi-bin/epbc/epbc_ap.pl?name=current_referral_detail&proposal_id=7101).

DoE has reviewed the referral and made a decision that the proposed action is a controlled action and requires approval under the EPBC Act. One of the DoE conditions of approval for assessing the project is as follows:

An independent review, by a duly qualified person(s), as to the suitability and likely effectiveness of proposed measures to mitigate the impacts of the proposed action on threatened species. The review should encompass the overall design, location and number of crossing structures/fauna fencing, methodology for collection of baseline data and monitoring of the wildlife crossing structures.

This review covers the relevant mitigation measures described in Chapter 4 of the referral, as well as other background information regarding the design, location and number of crossing structures/fauna fencing, methodology for collection of baseline data and plan for monitoring of the wildlife crossing structures.

I trust the information provided in this review is sufficient for your needs. However, should you require further information please do not hesitate to contact me on the details below.
Yours Sincerely,

[Signature]

Rhidian Harrington
Director/Ecologist
rharrington@niche-eh.com
0488 224 999
WARRELL CREEK TO NAMBUCCA HEADS PACIFIC HIGHWAY UPGRADE – INDEPENDENT REVIEW OF THE PROPOSED MEASURES TO MITIGATE IMPACTS ON EPBC ACT THREATENED SPECIES

1. Introduction

This review is being undertaken to meet the requirements made under the Department of the Environment (DoE) referral for the Warrell Creek to Nambucca Heads Upgrade of the Pacific Highway, specifically:

An independent review, by a duly qualified person(s), as to the suitability and likely effectiveness of proposed measures to mitigate the impacts of the proposed action on threatened species. The review should encompass the overall design, location and number of crossing structures/fauna fencing, methodology for collection of baseline data and monitoring of the wildlife crossing structures.

This review covers the relevant mitigation measures described in Chapter 4 of the referral, as well as other background information regarding the design, location and number of crossing structures/fauna fencing, methodology for collection of baseline data and plan for monitoring of the wildlife crossing structures, including:

1. Referral - Warrell Creek to Nambucca Heads, Pacific Hwy Upgrade (WC2NH Upgrade). Report prepared by Sinclair Knight Mertz, on behalf of the RMS, for the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPaC; now DoE), 18/12/2013.

2. Pacific Highway Upgrade - Warrell Creek to Urunga Upgrade Addendum to Submissions Report - Fauna Crossing Structures. Letter from RMS to the Department of planning, dated 25/05/2011.

3. Pacific Highway Upgrade - Warrell Creek to Urunga Upgrade Addendum to Submissions Report - Fauna Crossing Structures. Letter from RMS to the Department of planning, dated 01/06/2011.


This review will provide a specific assessment of the general mitigation methods used to minimise the impacts of the Upgrade on EPBC listed fauna as detailed in the Chapter 4 of the Referral, which will include consideration of the crossing structures as agreed to after negotiations with the EPA and RMS. It will also include an assessment of the proposed methods used to monitor the success of fencing and crossings to allow passage of fauna under the Upgrade and minimise mortality of fauna on the roads. Finally it includes general review of monitoring strategies and how this reflects on the monitoring requirements for this proposed Upgrade.
Species under consideration

Based on the referral (SKM 2013) eight fauna species listed on the EPBC Act were considered to have a moderate to high likelihood of occurrence in the study area for the proposed action (Table 1). Based on updated searches of the EPBC Protected Matters Search Tool and the OEH Wildlife Atlas on 7 March 2014 the only other EPBC Act species that might possibly occur within the study area is the Australasian Bittern *Botaurus poiciloptilus*. However, given the absence of its specific habitat requirements (permanent wetlands with tall dense vegetation) within the study area it is considered to have a low likelihood of occurrence and is not considered further in this review.

Table 1. Threatened fauna with a moderate to high likelihood of occurrence in the study area

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>TSC Act</th>
<th>EPBC Act</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixophyes iterates</td>
<td>Giant Barred Frog</td>
<td>E</td>
<td>E</td>
<td>This species is found along larger streams of the coast and adjacent ranges of NSW and SE QLD. It inhabits rainforest and wet sclerophyll forest, but is also found within cleared farmland where fringing vegetation is retained, including lantana beds. Many sites where the Giant Barred Frog are known to occur are the lower reaches of streams which have been affected by major disturbances such as clearing, timber harvesting and urban development in their headwaters.</td>
</tr>
<tr>
<td>Anthochaera Phrygia</td>
<td>Regent Honeyeater</td>
<td>CE</td>
<td>E,M</td>
<td>The Regent Honeyeater mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years. has contracted dramatically in the last 30 years to between north-eastern Victoria and south-eastern Queensland. There are only three known key breeding regions remaining: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region. In NSW the distribution is very patchy and mainly confined to the two main breeding areas and surrounding fragmented woodlands. In some years flocks converge on flowering coastal woodlands and forests.</td>
</tr>
<tr>
<td>Lathamus discolor</td>
<td>Swift Parrot</td>
<td>E</td>
<td>E</td>
<td>The Swift Parrot occurs in woodlands and forests of NSW from May to August, where it feeds on eucalypt nectar, pollen and associated insects. The Swift Parrot is dependent on flowering resources across a wide range of habitats in its wintering grounds in NSW. This species is migratory, breeding in Tasmania and also nomadic, moving about in response to changing food availability.</td>
</tr>
<tr>
<td>Rostratula australis</td>
<td>Australian Painted Snipe</td>
<td>E</td>
<td>E, M</td>
<td>In NSW, this species has been recorded at the Paroo wetlands, Lake Cowell, Macquarie Marshes and Hexham Swamp. Most common in the Murray-Darling Basin. Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds.</td>
</tr>
<tr>
<td>Dasyurus maculatus</td>
<td>Spotted-tailed Quoll</td>
<td>V</td>
<td>E</td>
<td>Spotted-tailed Quoll are found on the east coast of NSW, Tasmania, eastern Victoria and north-eastern Queensland. Only in Tasmania is it still considered common. Recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline.</td>
</tr>
<tr>
<td>Phascolarctos cinereus</td>
<td>Koala</td>
<td>V</td>
<td>V</td>
<td>Inhabits eucalypt forests and woodlands. The suitability of these forests for habitation depends on the size and species of trees present, soil nutrients, climate and rainfall.</td>
</tr>
<tr>
<td>Pteropus poliocephalus</td>
<td>Grey-headed Flying-fox</td>
<td>V</td>
<td>V</td>
<td>This species is a canopy-feeding frugivore and nectarivore of rainforests, open forests, woodlands, melaleuca swamps and banksia woodlands. Bats commute daily to foraging areas, usually within 15 km of the day roost although some individuals may travel up to 70 km.</td>
</tr>
</tbody>
</table>
2. Review of Referral

The following comments are provided for each section of the mitigation measures detailed in Part 4 of the Referral documents.

Section 4.1
Relates specifically to measures undertaken to avoid impacts on local fauna and flora and these clearly provide some relief from the impacts of the Upgrade.

Section 4.2
The Giant Barred Frog Management Strategy and proposed mitigation measures have been reviewed in a separate document by Niche (Niche 2014a). In summary, the review concluded that current “best” mitigation practice is being followed, but the effectiveness of such methods remain untested and the monitoring program proposed to test mitigation is inadequate to determine their effectiveness.

Mitigation measures proposed for the Koala have also been reviewed separately (Niche 2014b) and came to similar conclusions.

The review of the Management Plan for the Grey-headed Flying Fox has not been provided for comment as yet.

Section 4.2.2
The proposed levels of pre-clearing survey are in line with current best-practice, but limitations have been noted in the separate Giant Barred Frog review.

One area that needs to be clarified in this section and in various others is what actually constitutes an expert in a given species.

It is recommended that the level of experience considered suitable is fully detailed in the CEMP as this avoids an inconsistent application in the process. This must include actual demonstrated experience with the koala or other species where expert advice is required.

The process to remove hollow bearing trees follows current best practice. As above, what makes someone a suitably qualified ecologist and carer is not stated and this needs to be clarified.

It is recommended that the level of experience considered suitable is fully detailed in the CEMP. This must include actual demonstrated experience with handling fauna and in fauna care where these activities are required.

The proposed fauna rescue procedures set in place follow current guidelines.

The proposed dewatering procedures follow current industry standards.

Section 4.2.4
The presence of 16 underpasses along a length of 19km would appear adequate providing the underpasses are used effectively. However, there is a lack of definition as to what would be considered acceptable maintenance of connectivity and fauna movement. It is possible that just one successful passage per year is acceptable as demonstrating use of mitigating structures, even though such levels of migration may be too low to maintain populations. This stems from the lack of actual definition of what is supposed to be achieved by mitigation and so what would constitute successful mitigation. If it is to allow animals safe migration under the Upgrade consistent with current levels, then success is unlikely given the much greater barriers to be developed. If it is simply to ensure sufficient long-term genetic interchange, preventing long term genetic isolation and so differentiation between the two sides of the highway, that may be achieved by a minimal number of animals crossing under the Upgrade. However, the terms of success do not appear to be defined anywhere.
It is recommended that the CEMP specifically defines what the objective of the mitigation is and how successful mitigation would be demonstrated by the monitoring program.

The positioning of underpasses appear to be well considered and placed, taking into consideration the location of areas of retained vegetation that remain as the best terrestrial corridors available and the use of streams to provide riparian corridors. The Spotted-tailed Quoll, Koala and Giant Barred Frog are dependent on continuous areas of vegetation and the location of crossings at sites that connect areas of vegetation is essential for their ongoing successful migration. The Regent Honeyeater also has a strong preference for continuous native vegetation and the location of underpasses that will “funnel” this species to points of connecting native vegetation will provide the best potential to retain regular connectivity of populations.

The inclusion of streams and riparian areas as corridors wherever possible is important as they provide much broader underpass areas that represent natural habitats that fauna may be much more comfortable in utilising in comparison with highly enclosed man-made culverts. They are particularly important for frogs and especially the Giant Barred Frog and are important passageways for some species of bats such as the Large-footed Myotis and Golden-tipped Bat. Riparian corridors will also maintain habitat suitable for the use of the Australian Painted Snipe and should provide valuable connections to areas of adjacent habitat that are dissected by the Upgrade.

The positioning of crossing structures at currently proposed sites should ensure effective linkages for fauna as far as is possible.

One issue that is of concern in regards to some of the underpass structures is their length and the proposed construction of them such that they run at various angles instead of at right angles to the road alignment (from Figure 14.1). An underpass that is longer than is necessary is likely to compromise its effectiveness for at least some fauna, particularly where the smaller (2.4m x 1.2m) box culverts are used. A review of the use of underpasses by the RMS (RTA 2009) indicated that the actual use of underpasses is highly variable depending on species and groups of species. However, there has been enough research to indicate that use of underpasses decreases with increasing length. Based on this, the angling of underpasses that leads to increased length is to be avoided if possible. It is not clear in the information provided why some of the box culverts underpasses are not to be completed through the shortest route possible. It could be that they are attempting to connect riparian areas, but some or most are clearly not.

It is suggested that the construction lines be reviewed for culverts that do not run perpendicular to the Upgrade to determine if they can be made to do so, thereby minimising crossing distances for fauna.

The following design elements are noted for the crossings.

- The design must ensure that fauna can view the entrance to the underpass by careful placement of vegetation and other features.
- Underpasses must be located and installed so that entrance slopes are not steeper than 3:1 H:V nor rocky and must provide suitable fauna passage.
- Clearance of natural vegetation adjacent to underpasses must be minimised during construction.
- Use of poles within structures to assist arboreal species and other animals that may use them.
- The density of vegetation planting or seeding must match the surrounding natural habitat and be endemic and representative of the surrounding natural habitat.

All of these elements appear to be effective options to maximise the potential for the target EPBC species to use these crossings. The use of internal pole structures may be particularly important for Koalas, although they are known to use crossings by walking along the ground.

It is suggested that, if not already incorporated into a crossing design, that a ledge be included on the crossing wall as this may encourage their use for crossings by small mammals.
The proposed fencing meets currently considered best practice in regards to the styles and construction of fencing. Floppy top fencing is used in appropriate places as are the frog fences, which are the main fauna fencing considerations. The use of mesh pinned to the ground to prevent burrowing fauna passing under the fence appears to be appropriate as are the lengths of return fencing being considered to be extended into cleared areas.

The provision of fauna escape points where there are long sections of fauna fence is an appropriate practice, but little detail is provided as to their actual construction. This makes it difficult to judge their exact value.

The Referral notes that “Long-term monitoring of fauna underpass structures has shown success for a range of small to medium sized fauna in eastern Australia”. It is noted that, whilst successful use of these structures has been demonstrated for a number of species, success in maintaining genetically viable and stable populations through their long-term use has not been adequately tested (see later for more generalised discussion on this point).

Issues regarding the use of culverts and bridge structure are dealt with specifically in both the review of Koala mitigation report and the Giant Barred Frog Management Strategy review.

The assumptions made in Table 4.1 in regards to value of the different Underpass structures to fauna appear to be logical, although there is no body of scientific evidence to conclude whether the structures will or will not be used and their use is likely to be unpredictable based on variability in results from other monitoring programs (RTA 2009).

The reviews provided for the Koala, Spotted-tailed Quoll and Giant Barred Frog cover the range of the available literature and studies. Notably, it also includes details on known use of crossings by each of these species. These reviews however, do not provide any assessment of what the information is able to demonstrate about the effectiveness of fauna crossings in maintaining populations and connectivity. This is a failing in this review as it would appear that the result is a strong suggestion that crossings are occurring regularly enough to maintain required levels of migration and genetic interchange. This may be true, but it is not known and is not possible to determine from such scattered datasets. Being truthful would put appropriate and realistic pressure on developing adequate monitoring and/or research programs to inform of the true effectiveness of such structures.

*It is suggested that it be noted in the CEMP that the actual effectiveness of crossing structures in maintaining viable levels of population and genetic interchange remains unknown and so the long term effectiveness of this mitigation process is not known.*

The use of crossing structures by the Giant Barred Frog is discussed in the separate review. There is essentially no useful information on the effectiveness or otherwise of crossing structures in mitigating impacts of roads on Australian frogs.

The provision of widened median strips appears to provide a logical additional mitigation measure. However, no information is provided to indicate what benefit it actually will have. This is probably because there is no information available on which to make an assessment. The retention of mature trees within the median should provide a stepping stone for glider populations and is a useful provision.

4.2.5 Compensatory Habitat

The use of nest-boxes is standard best practice in mitigating road impacts. The numbers and types of nest boxes proposed should provide mitigation for the loss of hollows. It is not possible to determine how effective they will be in doing so. This has never been adequately researched and tested.

The redistribution of ground cover outside of cleared areas is an appropriate step to take to ensure that the relative amounts of sheltering habitats are retained in the local area. *However, it is recommended that any such material must be spread evenly across the adjacent habitat and that*
this should be recorded in the CEMP. Otherwise it might be piled up in the nearest available location.

**Section 4.2.6 Landscape Rehabilitation**
This appears to be adequate. The use of local species of plants is essential to maintain the character of the local habitats.

The planting of winter flowering trees to provide an additional food source is a good idea in theory, but needs to be considered carefully in regards to location. Trees should be planted such that they are not likely to lead to Regent Honeyeaters and Swift Parrots attempting to make low level crossings of the Upgrade and so risk vehicle collisions.

*A recommendation is that planting of winter flowering trees be confined to only one side of the Upgrade at any one point to discourage low-level crossings of the Upgrade route by flying fauna.*

**Section 4.3.3 Koala**
The mitigation requirements for the Koala have already been dealt with in a separate report conducted by a recognised koala expert.

**Section 4.3.4 Spotted-tailed Quoll**
There are no suggested changes or additions to the proposed measures for mitigating the impacts of the Upgrade on the Spotted-tailed Quoll as they appear to be suitable.

**Section 4.3.5 Giant Barred Frog**
The Giant Barred Frog Management strategy and mitigation measures suggested for the Giant Barred Frog have already been dealt with in a separate report conducted by a recognised expert.

**Section 4.3.6 Grey-headed Flying Fox**
The range of mitigating measures proposed within the Referral all appear to be based on sound logic and are applied sensibly.

**Section 4.3.7 Regent Honeyeater and Swift Parrot**
The measures proposed appear useful, but the lack of any detail on their application means it is not possible to tell what value they may have. As above, it is recommended that plantings of feed trees are sited so as to minimise the chances of low-level flights across the Upgrade. One obvious step is to plant only one side of the Upgrade or to plant both sides only where there is a deep cutting so that birds are likely to fly high over the road.

**Section 4.3.8 Australian Painted Snipe**
There are no suggested changes or additions to the proposed measures for mitigating the impacts of the Upgrade on the Australian Painted Snipe as they appear to be suitably targeted to protecting the habitat of this species.

**Section 4.4 Monitoring of Mitigation Measures**
The issues regarding the implementation of a monitoring program are discussed later in this document.

**Section 4.5 Offsets**
This is not covered in this review.
3. Generalised Discussion on Crossings Use

Whilst there is an increasing use of crossing structures to mitigate road impacts and an apparent strong belief that such structures have strong mitigating effects, the actual evidence demonstrating such positive effects is very limited. At a global scale, Van der Ree et al. (2007) evaluated the use and effectiveness of 1864 wildlife crossing structures (underpasses 83%, and overpasses 17%) recorded in 123 studies from the scientific literature. Importantly, whilst they were able to conclude that such structures allowed for increased opportunities for fauna to cross roads safely they could not determine if this reduced the negative effects of the road to a point where the risk of extinction was at a satisfactory level. There were insufficient studies of any rigour to state that such an outcome could be achieved or could not be achieved. This was because the level of scientific rigour, including the availability of adequate controls, the amount of replication and sample sizes, as well as descriptions of adjacent habitat and understanding of local animal populations, varied considerably among previous studies, limiting the level of inference that could be made. Most studies (88%) commenced after the structures had been built and were therefore unable to include a rigorous assessment of the pre-mitigation scenario. Very few studies had true controls (note this important point in relation to the proposed Upgrade).

Taylor and Goldingay (2010) reviewed 244 studies (17% from Australia) published over the past decade. They reported a prevalence of studies on wildlife road mortality (34%), but noted that there was very little understanding of population impacts. A wide range of vertebrate species have been reported as using road-crossing structures, particularly underpasses, but this knowledge has largely outpaced an understanding of any population benefits. Of particular relevance is that there were no published studies in Australia that have examined the effects of roads on gene flow of wildlife populations. It is noted that structural, landscape and road-related attributes influence the pattern of usage of road structures by wildlife and these responses are species-specific such that generalisations about expectations of crossing use are not possible. Crossing structures combined with exclusion fencing to prevent animals from entering a road, and which funnel them towards the crossing structure, appear more likely to be used, although rigorous experiments on the efficacy of ‘funnel-fencing’ are lacking.

Goosem (2012) reviewed fauna underpasses and canopy bridges across rainforest roads in North Queensland rainforests also concluded that, whilst there is good evidence for road-crossing structures being used by many species, information is lacking about their effectiveness in terms of population and genetic implications. A holistic approach is needed to assess the effectiveness of these connectivity structures and this includes systematic monitoring before and after construction.

Bond and Jones (2008) reported the results of upgrading a major arterial road in Brisbane and the use of two underpasses and one overpass by wildlife (the Koala was not present in this study). The two identical fauna underpasses were each 2.4 m high, 2.5 m wide and 48 m long and included “furniture” (a raised log railing and a wooden shelf attached to the wall) which ran along their full length. Evidence was found for increasing use of these structures by a wide range of species in the years following construction, however no pre-construction assessments were available for comparison. The exclusion fencing was effective in preventing most road-kills, at least of medium-large sized mammals, except following human-related breaches of the fence.

Finally the RMS itself provided a review of the use of fauna crossings on highways in NSW (RTA 2009). Just as before, there were numbers of records for species using these crossings from a wide range of vertebrate groups. However, the extent of use varied greatly between species and between studies. Larger vertebrates tended to use crossings more often that smaller vertebrates, although this could simply be an artefact of poorly chosen monitoring methods.

These studies all emphasise the lack of current credible knowledge available on the effectiveness of crossing structures in mitigating impacts. There is no doubt that individual animals use such crossings, but whether that constitutes mitigation in any useful form is not known. This failure in understanding relates to a continuous lack of rigorous research and monitoring of crossing structures that can supply the needed information.
4. Review of the Proposed Monitoring Program.

The extent and intent of monitoring is provided in several documents. Relevant excerpts from these reviews and comments are provided as follows:

10.5.10 Monitoring
An adaptive monitoring program would be developed to assess the effectiveness of mitigation and offset measures and allow for refinement and modification of these measures if monitoring results suggest that this is required. The program would be implemented prior to construction to establish baseline numbers of threatened flora and fauna and would continue for a minimum of two years after construction is complete. Further details are provided in Section 6.2.3 of Working paper 1 - Flora and fauna.

Subject to the availability of suitable control sites, monitoring of the fauna underpasses and exclusion fencing will employ a Before-After Control versus Impact (BACI) design. The BACI design allows for monitoring to occur on treated and untreated sites both before and after the subject mitigation measures have been installed or implemented.

Selection criteria used to determine which fauna underpasses should be monitored should include specification of: continuous underpass length of greater than 90 metres (excludes bridges and arches) and/or location of the structure within an area of suitable habitat for one or more of the target threatened species (ie. koala, brush-tailed phascogale, spotted-tailed quoll or giant barred frog).

And

B10. Prior to the commencement of any construction work that would result in the disturbance of any native vegetation, the Proponent shall develop an Ecological Monitoring Program to monitor the effectiveness of the mitigation measures implemented as part of the project. The program shall be developed in consultation with EPA and prepared by a suitably qualified ecologist and shall include but not necessarily be limited to:

(a) an adaptive monitoring program to assess the effectiveness of the mitigation measures identified in condition B1 to B6, B7(b), B7(d), B21(c) and B31(b) and allow amendment to the measures if necessary. The monitoring program shall nominate appropriate and justified monitoring periods and performance targets against which effectiveness will be measured. The monitoring shall include operational road kill surveys to assess the effectiveness of fauna crossing and exclusion fencing implemented as part of the project;

(b) mechanism for developing additional monitoring protocols to assess the effectiveness of any additional mitigation measures implemented to address additional impacts in the case of design amendments or unexpected threatened species finds during construction (where these additional impacts are generally consistent with the biodiversity impacts identified for the project in the documents listed under condition;

(c) monitoring shall be undertaken during construction (for construction-related impacts) and from opening of the project to traffic (for operation/ongoing impacts) until such time as the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of five successive monitoring periods (i.e. 5 years) after opening of the project to traffic, unless otherwise agreed to by the Director General. The monitoring period may be reduced with the agreement of the Director General in consultation with EPA, depending on the outcomes of the monitoring;

(d) provision for the assessment of the data to identify changes to habitat usage and if this can be attributed to the project;

(e) details of contingency measures that would be implemented in the event of changes to habitat usage patterns directly attributable to the construction or operation of the project;

And

(f) provision for annual reporting of monitoring results to the Director General and EPA, or as otherwise agreed by those agencies.

The following comments on the proposed monitoring programs are based on the requirements stated above:
The monitoring period of five years after completion of construction is likely to be sufficient to provide some indication in changes in population size for the Spotted-tailed Quoll and Giant Barred Frog as both species have life-spans that average less than five years. However, this time-frame does not cover the predicted lifespan of a Koala in the wild which is at least 10 years. Hence it may not allow enough time to see declines in crossing usage where there is a longer term population decline as reproduction fails.

The monitoring has been determined to commence after the vegetation clearing phase of the project has been completed, but before the underpass structures become operational. The stated reason for this is that “the impacts resulting from vegetation clearing are not relevant to assessing the effectiveness of fauna underpass or exclusion fence mitigation measures” and doing so will “eliminate or control this variable so that its effects cannot be confused or confounded with those of the independent variable (ie. impacts of underpasses and exclusion fencing)“. Whilst this sounds a reasonable argument, the reality is that clearing itself may have such a significant impact on the local fauna and flora that it may confound the efforts to monitor the effectiveness of the mitigation measures. That is, the clearing of vegetation may lead to a serious decline in fauna through time that extends significantly beyond the period of clearing and into the period when mitigation is being carried out. The result is that it would appear that declines are occurring due to limitations to migration even though mitigation for this aspect has been put in place. If monitoring commences prior to vegetation clearing, the extent to which clearing has caused change in the fauna and flora can be documented and the trajectory of the local populations documented prior to the emplacement of mitigation. The impact that the mitigation has had on the populations can then be determined by comparing sites with mitigation and those without to determine the differences between the two, even if both sites decline because of the impacts of the initial vegetation clearance. To wait until after the vegetation clearance takes place risks confounding the ability to effectively test the positive impacts of underpasses and exclusion fencing.

Monitoring of the selected fauna underpasses will involve sampling within each underpass structure and its entrances, in retained habitats adjacent to the fauna underpass and in the areas isolated by exclusion fencing leading into the underpass structures. This design itself is suitable for assessing if underpasses are used by Quolls, Koalas and Giant Barred Frogs. The testing of the surrounding areas will determine which species are present in the adjacent habitats and so which species are available to use the underpasses.

The following methods are suggested as means to monitor the use of underpasses:
• sand pad sampling (eight sampling nights per sand pad per monitoring event);
• hairtube sampling (minimum 20 sampling nights per hairtube per monitoring event);
• detection with automated cameras (minimum 40 sampling nights per camera per monitoring event);
• scat and track searches; and
• use of artificial groundcover (e.g. corrugated iron or plywood sheeting).

Before assessing the value of these methods, it should be clearly understood that the data that is to be collected needs to be of sufficient quality and quantity to allow an adaptive monitoring program to be developed and test the success of mitigation measures as is indicated to be the intent of the Condition of Approval B10. To conduct a valid statistical analysis that can detect changes in population sizes or even differences in the number of animals seen in an area requires relatively large and constant counts of species.

The above methods from previous reporting offer a variety of opportunities to detect fauna using the underpasses, but there appears to be little thought into their actual overall combined value. Sand pads provide only a very coarse measure of the fauna using an underpass and are not known to detect frogs in any useful way. Sand pads do not indicate if 20 tracks are cause by 20 different animals or by one animal crossing 20 times unless the animals are clearly very different sizes. Hair tubes represent a similar problem as collected hairs can belong to one or multiple animals (unless genetic sampling is included). They will not sample the Giant Barred Frog. Scat searches are very unreliable and provide no useful quantitative data given the relative scarcity of scats in general. Track searches would provide the same outcomes as sand pad searches and almost certainly much less data. None of these methods are useful for quantitative monitoring as it is not possible to
determine the number of individuals of a species that have used the underpass or adjacent areas. None are useful for frogs. Camera traps offer the same results through one single medium and it would appear that the use of this system alone would make the others redundant, although they offer the same problems. Camera traps can also possibly be able to detect Giant Barred Frogs, although reptiles or amphibians are generally poorly detected by them. Camera traps retain the same problem in that it is not possible usually to uniquely identify each individual captured on a camera and so the numbers of different individuals of a species using an underpass cannot be determined. It is possible that Spotted-tailed Quolls may be individually identifiable if the camera recordings are sufficient.

The alternative methods to provide useful monitoring data are:
Continuous shot security type cameras - these record constantly at a frame every second or two and do not require to be triggered by the movements of an animal. They also provide a constant image set to determine the behaviour of individual animals - whether they complete a crossing or turn back. They retain the disadvantage in that they can still often not distinguish between individuals making crossing attempts.

Microchip tag system - there is a potential to microchip target fauna, marking as many individuals as is possible in the local population, and using an automatic chip sensor placed at each end of the crossing structure to determine movements through the structure. These can be waterproof and thus provide accurate readings of numbers of different individuals using an underpass, and how often, and if the crossing is completed or not. This system is costly to set up, but has the potential to work with almost any species of interest and may reduce costs of continuous repeat visits to a site which might be required using methods such as sand pads.

In regards to the design of the monitoring program, it is not clear if the design is adequate to determine the overall effectiveness of crossing structures as it is not clear how many will actually be monitored. A minimum of at least five replicate sites in each treatment or control category are required to provide a robust BACI monitoring design. It also requires that suitable control sites are monitored for comparisons. This will need to include sampling in areas where there is no new road construction as a proper control to determine if changes observed can be attributed specifically to the mitigation measures or are just part of a broad regional pattern in population trends. The numbers of animals counted needs to be large enough per sample and variance in counts low enough to allow statistical detection of changes in populations in the areas being sampled.

*It is recommended that a statistically robust and properly designed monitoring program be developed for monitoring crossing structure use in this Upgrade. This should occur after the first round of planned sampling, which would allow an estimation of the data likely to be obtained in any one sampling period, which can then be used to test the power of any sampling design. This would require the services of a qualified Biometrician.*
CONCLUSION

a. Is the design of crossing structures and fauna fencing suitable for the listed threatened fauna?
   Yes, based on current best practice. It is recognised that larger underpasses are likely to be more effective and longer crossings less effective. This has been considered through the negotiations between the RMS and EPA where an increase in size has been sought for some culverts and additional large underpasses included.

b. Are the locations of the crossing structures/fencing suitable for the listed threatened fauna?
   As far as possible - yes. They are concentrated into areas where there is retained native vegetation that is the required habitat of some of the target species and along riparian zones that are the preferred habitat of other target species.

c. Are the number of crossing structures and/or extent of fauna fencing adequate to mitigate the impacts on threatened fauna?
   They may be, but that cannot be determined until it is determined what level of mitigation is acceptable.

d. Is the methodology proposed for the collection of baseline data to assess the effectiveness of the mitigation measures adequate?
   Not at this time, based on the very limited available information. Understanding the success of the measures will require an understanding of the numbers of animals undertaking crossings, not the number of crossings being recorded. The methods proposed are unlikely to be able to tell individual animals apart and probably cannot detect, to an adequate degree, the use of the crossing structure by smaller individuals and smaller species such as frogs. Therefore the methods will not allow for an accurate assessment in the number of animals using the crossing structures in any period and so if there is a change associated with mitigation. The methodology also does not collect data prior to vegetation clearing, which may confound the effects of mitigation measures where clearing has a stronger effect on population size and crossing movement than introduction of the road barrier. There is also the potential for a lack of control sites being used in monitoring, thus rendering any statistical comparisons or assessments invalid.

e. Are the proposed corrective measures, should impacts be detected, adequate to mitigate any detected impacts?
   Such measures are not detailed and so it is not possible to determine whether any corrective measures would be adequate.
REFERENCES


25 February 2014

Ms Rachel Vazey  
Environmental Planner/GIS Analyst  
Sinclair Knight Merz  
Phone: 0403 390 649

Via email: RVazey@globalskm.com

Dear Rachel,

RE: Warrell Creek to Nambucca Heads Pacific Highway Upgrade - Conflict of Interest

As an authorised representative of Niche Environment and Heritage Pty Ltd I confirm that neither myself, Frank Lemckert or Rod Kavanagh have previously worked on the Warrell Creek to Nambucca Heads Pacific Highway Upgrade project, nor do any of us have a conflict of interest with the commission for work on this project.

Yours sincerely,

Dr Rhidian Harrington  
Director/Ecologist  
rharrington@niche-eh.com  
0488 224 999
**Professional Memberships**
- Environmental Institute of Australia and New Zealand (EIANZ)
- Ecological Consultants Association of NSW - President
- Birds Australia
- Ecological Society of Australia

**Qualifications**
- Bachelor of Science (Honours) - James Cook University
- Masters of Science (Zoology) - University of the Witwatersrand
- Doctor of Philosophy (Zoology) - University of Melbourne
- BioBanking Assessors Course - Ryde TAFE

**Employment History**

<table>
<thead>
<tr>
<th>Year</th>
<th>Position/Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009-present</td>
<td>Director/Senior Ecologist, Niche Environment and Heritage Pty Ltd</td>
</tr>
<tr>
<td>2003-09</td>
<td>Manager/Senior Ecologist, Biosis Research Pty. Ltd.</td>
</tr>
<tr>
<td>2002-03</td>
<td>Project Officer, Black-eared Miner Recovery Team, La Trobe University</td>
</tr>
<tr>
<td>2002</td>
<td>Scientific Writer, Institute for Land and Food Resources, University of Melbourne</td>
</tr>
<tr>
<td>2000-01</td>
<td>Zoologist/Project Manager, Melbourne Enterprises International Ltd</td>
</tr>
<tr>
<td>1998-2002</td>
<td>Research Assistant/Demonstrator, University of Melbourne</td>
</tr>
<tr>
<td>1995-96</td>
<td>Research Assistant, Botswana National Parks</td>
</tr>
<tr>
<td>1993-95</td>
<td>Lecturer/Demonstrator, University of the Witwatersrand, South Africa</td>
</tr>
<tr>
<td>1992</td>
<td>Research Assistant, Australian Centre for Tropical and Freshwater Research</td>
</tr>
</tbody>
</table>

**Career Overview**
Rhidian has over 18 years experience in teaching and practicing terrestrial wildlife ecology. He has experience in flora and fauna survey, Biobanking and offset design and project management for environmental approvals projects. Rhidian has conducted ecological work throughout Australia (NSW, Victoria, Queensland, South Australia and the Northern Territory) as well as overseas in southern Africa and Pakistan. He has been the senior scientist and project manager on a number of major investigations, including environmental assessments, management plans and mitigation design, particularly for major linear developments. He is experienced in the application of state and federal legislation which relates to the conservation of threatened species and communities, and related planning instruments.

As the project manager for both large and small projects, Rhidian has been required to develop methodology, co-ordinate multi disciplined field teams, prepare reports incorporating results from several disciplines and maintain effective communication with the client and various regulatory and/or public authorities. Rhidian has acted as an expert witness in the NSW Land and Environment Court. Rhidian is an accredited Biobanking assessor.

**Professional Vision**
To significantly contribute to the sustainable management of Australia’s natural resources and promote a greater awareness and understanding of the unique natural history of this country. To balance community growth and development with ecological conservation by ensuring all development projects adhere to the principals of Ecologically Sustainable Development. By helping clients identify issues of high ecological value I hope to not only facilitate the conservation and management of these values, but also facilitate efficient project delivery.

**Skills**
- Ecological surveys, assessment and monitoring
- BioBanking assessments and offsetting strategies
- Project management
- Environmental approvals
- Expert witness and peer review
- Government agency consultation and advocacy
- Impact minimisation (mitigation)
**Hunter Expressway, 2009-present**
For over four years Rhidian has been the Ecologist on the Hunter Expressway Environmental Advisor team. Work has included vegetation mapping surveys, fauna surveys, pre-clearing surveys, fauna rescue, nest box installation, a BioBanking Assessment, offset strategies and technical advice to the Project’s environmental manager.

**F3 to Branxton Link, 2003-09**
For over six years Rhidian managed the ecological components of this 40 km dual carriageway freeway project, including targeted flora and fauna surveys, impact assessment, mitigation design, offsets, environmental management plans and a Referral. There were numerous and significant ecological issues on this project and Rhidian worked closely with the RTA engineers during the design phase to minimise any impacts. Rhidian was also required to complete an Environmental Assessment and Species Impact Statement (SIS) for the associated electricity adjustments for this project.

**Pacific Highway Upgrade: Tintenbar to Ewingsdale, 2004-09**
Rhidian managed the ecological components of this 16 km dual carriageway freeway project, including constraints assessment, vegetation mapping, targeted flora and fauna surveys, route option assessment, mitigation design and impact assessment. Liaison with commonwealth and state agencies was a key element of Rhidian’s work on this project.

**Pacific Highway Upgrade: Woodburn to Ballina, 2006-08**
Rhidian managed the ecological components of this 32 km dual carriageway freeway project, including targeted flora and fauna surveys, route option assessment, mitigation design and impact assessment. Liaison with commonwealth and state agencies was a key element of Rhidian’s work on this project.

**Other major road projects that Rhidian has project managed**
- Oxley Highway Upgrade: Species Impact Statement, 2004-06
- Pacific Highway Upgrade: Moorland to Herons Creek; Environmental Assessment, 2004-06
- Pacific Highway Upgrade: F3 to Raymond Terrace; Environmental Assessment, 2004-06
- Pacific Highway Upgrade: Ballina Bypass modifications; Environmental Assessment, 2007-08
- Central Coast Highway Upgrade: Carlton to Matcham Road; EA, 2008-09
- Central Coast Highway Upgrade: Matcham Road to Ocean View Drive; EA, 2008-09
- Central Coast Highway Upgrade: Woy Woy Road Intersection at Kariong; EA, 2009
- Princes Highway Upgrade: Tomerong Bypass; Environmental Assessment, 2011
- Terrigal Drive Upgrade: Jessie Hurley Drive intersection; Environmental Assessment, 2011
- Terrigal Drive Upgrade: Charles Kay Drive intersection; Environmental Assessment, 2011
- Picton Road Upgrade: Reverse Curves Stage 2; Environmental Assessment, 2012
- Princess Highway Upgrade: Nowra Bypass; threatened species assessments, 2012
- Pacific Highway Upgrade: Wyong Town Centre Study; Environmental Assessment, 2012
- Shortland to Sandgate; Threatened species surveys and assessments, 2013
- Muswellbrook Bypass; Environmental Assessment, 2013
- East West Link; Technical Due Diligence Advisor, 2013-2014

**Linear Infrastructure Mitigation panel, 2007**
Rhidian provided expert advice at a workshop for developing mitigation measures for linear infrastructure for the Department of the Environment, Water, Heritage and the Arts.
<table>
<thead>
<tr>
<th>Section</th>
<th>Recommendation</th>
<th>Roads and Maritime response</th>
</tr>
</thead>
</table>
| Section 2 Review of Mitigation measures | Section 4.2.2 It is recommended that the level of experience considered suitable is fully detailed in the CEMP as this avoids an inconsistent application in the process. This must include actual demonstrated experience with the koala or other species where expert advice is required. | • Agree  
• Roads and Maritime to ensure CEMP describes the necessity of an ecologist with demonstrated experience |
| Section 2 Review of Mitigation measures | Section 4.2.2 The process to remove hollow bearing trees follows current best practice. As above, what makes someone a suitably qualified ecologist and carer is not stated and this needs to be clarified.  

It is recommended that the level of experience considered suitable is fully detailed in the CEMP. This must include actual demonstrated experience with handling fauna and in fauna care where these activities are required. Note that this should be repeated for all cases where specialists are stated to be required to carry out any activities on the Upgrade. | • Agree |
| Section 2 Review of Mitigation measures | The proposed dewatering procedures follow current industry standards. One area that could be more detailed, based on the information available for review, is the location of release sites for any individuals captured during dewatering. Dependent on the species, individuals will have territories that encompass different distances from the point of capture. Releasing fauna too far from their capture point necessarily means that they will be placed in unfamiliar areas and so be at a | • Agreed  
• In discussions with Frank Lemckert the following measures where agreed  
  o For any individuals that have their home range within the construction site they will need to be temporarily relocated during construction.  
  Relocation points will be minimised as much as... |
<table>
<thead>
<tr>
<th>Section 2 Review of Mitigation measures</th>
<th><strong>Section 4.2.4</strong> It is recommended that the CEMP specifically defines what the objective of the mitigation is and how successful mitigation would be demonstrated by the monitoring program.</th>
<th>• RMS has no issues with implementation of this comment.</th>
</tr>
</thead>
</table>
| Section 2 Review of Mitigation measures | **Section 4.2.4** It is suggested that the construction lines be reviewed for culverts that do not run perpendicular to the Upgrade to determine if they can be made to do so, thereby minimising crossing distances for fauna. | • RMS has no issues with implementation of this comment.  
• In discussions with Rod Kavanagh, RMS has introduced an additional 4 dedicated culverts along the alignment and has revised culverts that do not run perpendicular minimising crossing distances for fauna.  
• Please see Appendix A of this response for a revised table of the Fauna Crossing Structure and Fish passage Requirements. |
| Section 2 Review of Mitigation measures | However, it is recommended that any such material must be spread evenly across the adjacent habitat and that this should be recorded in the CEMP. Otherwise it might be piled up in the nearest available location. | • RMS has no issues with implementation of this comment. |
### Section 2 Review of Mitigation measures

**Section 4.2.6 Landscape Rehabilitation**  
A recommendation is that planting of winter flowering trees be confined to only one side of the Upgrade at any one point to discourage low-level crossings of the Upgrade route by flying fauna.  

- RMS has no issues with implementation of this comment.

**Section 4.3.7 Regent Honeyeater and Swift Parrot**  
It is recommended that plantings of feed trees are sited so as to minimise the chances of low-level flights across the Upgrade. One obvious step is to plant only one side of the Upgrade or to plant both sides only where there is a deep cutting so that birds are likely to fly high over the road.  

- RMS has no issues with implementation of this comment.

### Conclusion

**Item a**  
Is the design of crossing structures and fauna fencing suitable for the listed threatened fauna?  

- Yes, based on current best practice. It is recognised that larger underpasses are likely to be more effective and longer crossings less effective. This has been considered through the negotiations between the RMS and EPA where an increase in size has been sought for some culverts and additional large underpasses included.  

- Noted

**Item B**  
Are the locations of the crossing structures/fencing suitable for the listed threatened fauna?  

- As far as possible - yes. They are concentrated into areas where there is retained native vegetation that is the required habitat of some of the target species and along riparian zones that are the preferred habitat of other target species.  

- Noted
| Conclusion Item C | Are the number of crossing structures and/or extent of fauna fencing adequate to mitigate the impacts on threatened fauna?  
They may be, but that cannot be determined until it is determined what level of mitigation is acceptable. | • As stated above, additional dedicated culverts have been added in response to Koala Mitigation review by Rod Kavanagh. See Appendix A for details. Rod Kavanagh agreed to these changes and was satisfied that these additional culverts were adequate for mitigation measures. |
| Conclusion Item D | Is the methodology proposed for the collection of baseline data to assess the effectiveness of the mitigation measures adequate?  
Not at this time, based on the very limited available information. Understanding the success of the measures will require an understanding of the numbers of animals undertaking crossings, not the number of crossings being recorded. The methods proposed are unlikely to be able to tell individual animals apart and probably cannot detect, to an adequate degree, the use of the crossing structure by smaller individuals and smaller species such as frogs. Therefore the methods will allow for a determination that animals have used a crossing structure, but will not allow for an accurate assessment in the number of animals using the crossing structures in any period and so if there is a change associated with mitigation. The methodology also does not collect data prior to vegetation clearing, which may confound the effects of mitigation measures where clearing has a stronger effect on population size and crossing movement than introduction of the road barrier. There is also the potential for a lack of control sites being | • In response to Koala baseline data, RMS has been in discussions with Rod Kavanagh in the preparation of a monitoring program. This monitoring program outlines additional surveys that will need to be conducted as an effective measure to understand movements of the targeted species.  
• In response to Giant barred frog baseline data collection  
- Agree that having only one impact site and lack of control site restricts the ability to thoroughly explain disappearance from the impact site in Construction and Operation. However as agreed in phone meeting with Frank Lemckert on 19.3.14 Roads and Maritime will continue with monitoring as defined in the GBFMS with acknowledgement that presence/absence and breeding signs will provide useful data in results of mitigation. Roads and Maritime has also committed to collating results of monitoring programs from O2K, S2W W2B and T2E to provide a more comprehensive summary of mitigation success. |
| used in monitoring, thus rendering any statistical comparisons or assessments invalid. |
Appendix A – Table 4-1 Fauna Crossing Structure and Fish Passage Requirements
<table>
<thead>
<tr>
<th>Location</th>
<th>Fauna Crossing Structure Type</th>
<th>Structure Form¹</th>
<th>Number and Dimensions</th>
<th>Fish Passage Requirements</th>
<th>Additional Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chainage 42km500</td>
<td>Combined</td>
<td>Bridge</td>
<td>(-)</td>
<td>Class 1 waterway²</td>
<td>Minimum 3 metre wide fauna passage required at each abutment. Koala included as target species.</td>
</tr>
<tr>
<td>Chainage 43km325</td>
<td>Combined</td>
<td>Box culvert</td>
<td>Minimum 5 no. x 3600mm x 1500mm high</td>
<td>Class 2 waterway²</td>
<td>Fauna passage only required for Giant Barred Frog Two outside cells must provide dry passage in accordance with Appendix 5 of the SWTC No refuge poles required Approximate culvert length is 47m.</td>
</tr>
<tr>
<td>Chainage 44km905</td>
<td>Fish passage</td>
<td>Box culvert</td>
<td>Minimum 3300 mm wide x 1800 mm high</td>
<td>Class 3 waterway²</td>
<td>Waterway realignment must ensure bed stability; and maintain existing flow velocity</td>
</tr>
<tr>
<td>Chainage 45km525</td>
<td>Incidental</td>
<td>Box culvert</td>
<td>Minimum 7 no. x 4200 mm wide x 3600 mm high</td>
<td>Class 3 waterway²</td>
<td>Waterway realignment must ensure bed stability; minimise increasing or decreasing existing waterway length;</td>
</tr>
<tr>
<td>Location</td>
<td>Fauna Crossing</td>
<td>Structure Type</td>
<td>Number and Dimensions</td>
<td>Fish Passage Requirements</td>
<td>Additional Requirements</td>
</tr>
<tr>
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<td>-----------------------</td>
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<td>-------------------------</td>
</tr>
<tr>
<td>Chainage 47km000</td>
<td>Fish passage</td>
<td>Bridge</td>
<td>(-)</td>
<td>Class 3 waterway²</td>
<td>Must extend under Existing Highway</td>
</tr>
<tr>
<td>Chainage 47km525</td>
<td>Incidental</td>
<td>Box culvert</td>
<td>Minimum 3000 mm wide x 1200 mm high</td>
<td>Class 3 waterway³ Include low flow channel 200mm (minimum) below existing bed level and 450mm wide Continue low flow channel through scour protection</td>
<td></td>
</tr>
<tr>
<td>Chainage 48km085</td>
<td>Dedicated</td>
<td>Bridge</td>
<td>(-)</td>
<td>Fauna corridor listed is under southern end span of bridge. Minimum 3 metre wide fauna passage required</td>
<td></td>
</tr>
<tr>
<td>Chainage 48km215</td>
<td>Dedicated</td>
<td>Bridge</td>
<td>(-)</td>
<td>Class 1 waterway³</td>
<td></td>
</tr>
<tr>
<td>Chainage 48km275</td>
<td>Dedicated</td>
<td>Bridge</td>
<td>(-)</td>
<td>Fauna corridor listed is under northern end span. Minimum 3 metre wide fauna passage required</td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>Fauna Crossing Structure Type</td>
<td>Structure Type</td>
<td>Number and Dimensions</td>
<td>Fish Passage Requirements</td>
<td>Additional Requirements</td>
</tr>
<tr>
<td>-----------</td>
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</tr>
<tr>
<td>Chainage 49km880</td>
<td>Incidental</td>
<td>Box culvert</td>
<td>Minimum 2400 mm x 1200 mm</td>
<td>No</td>
<td>Must provide water connectivity across Main Carriageways</td>
</tr>
<tr>
<td>Chainage 50km215</td>
<td>Incidental</td>
<td>Bridge</td>
<td>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).</td>
<td>No</td>
<td>Koala included as target species.</td>
</tr>
<tr>
<td>Chainage 50km985</td>
<td>Incidental</td>
<td>Bridge</td>
<td>Minimum width between the intersection of the scour protection and the finished ground level under the bridge to be 50.4m (see</td>
<td>No</td>
<td>Koala included as target species.</td>
</tr>
<tr>
<td>Location</td>
<td>Fauna Crossing Structure Type</td>
<td>Structure Form</td>
<td>Number and Dimensions</td>
<td>Fish Passage Requirements</td>
<td>Additional Requirements</td>
</tr>
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</tr>
<tr>
<td>Chainage 55km115</td>
<td>Combined</td>
<td>Box culvert</td>
<td>Minimum 2400 mm x 2400 mm</td>
<td>No</td>
<td>Note 1. Minimum vertical clearance to be 2.0 m (subject to detailed design). Approximate length of culvert under Main Carriageway is 54m and under Old Coast Road is 29m². Koala included as target species.</td>
</tr>
<tr>
<td>Chainage 56km415</td>
<td>Combined</td>
<td>Box culvert</td>
<td>Minimum 2400 mm x 1200 mm</td>
<td>No</td>
<td>Approximate culvert length under Main Carriageway is 45m and under Old Coast Road is 28m². Koala included as target species.</td>
</tr>
<tr>
<td>Chainage 57km700</td>
<td>Dedicated</td>
<td>Box culvert</td>
<td>Minimum 2400 mm x 2400 mm</td>
<td>No</td>
<td>Maximum culvert length is 50m. Koala included as target species.</td>
</tr>
<tr>
<td>Chainage 58km420</td>
<td>Dedicated</td>
<td>Box culvert</td>
<td>Minimum 2400 mm x 2400 mm</td>
<td>No</td>
<td>Maximum culvert length is 50m. Koala included as target species.</td>
</tr>
<tr>
<td>Chainage 58km465</td>
<td>Incidental</td>
<td>Box or pipe culvert</td>
<td>To be based on drainage</td>
<td>No</td>
<td>Class 3 waterway² Include low flow channel 200mm (minimum) below existing bed level in Approximate culvert length is 106m. Koala included as target species.</td>
</tr>
</tbody>
</table>

**Deleted:** 14 no. x 3600 x 2100 mm

**Deleted:** Combined

**Deleted:** Minimum 2 no. x 3600 x 2400 mm

**Deleted:** Koala included as target species.
<table>
<thead>
<tr>
<th>Location</th>
<th>Fauna Crossing Structure Type</th>
<th>Structure Form</th>
<th>Number and Dimensions</th>
<th>Fish Passage Requirements</th>
<th>Additional Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>requirements</td>
<td>one cell</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low flow channel width to be consistent with existing low flow channel width</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Continue low flow channel through scour protection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chainage 59km000</td>
<td>Dedicated</td>
<td>Box culvert</td>
<td>Minimum 2400 mm x 2400 mm</td>
<td>No</td>
<td>Maximum culvert length is 50m. Koala included as target species</td>
</tr>
<tr>
<td>Chainage 59km040</td>
<td>Incidental</td>
<td>Box or pipe culvert</td>
<td>To be based on drainage requirements</td>
<td>No</td>
<td>Approximate culvert length is 93m.</td>
</tr>
<tr>
<td>Chainage 59km565</td>
<td>Dedicated</td>
<td>Box culvert</td>
<td>Minimum 3000 mm x 3000 mm</td>
<td>No</td>
<td>Approximate culvert length is 44m. Koala included as target species</td>
</tr>
<tr>
<td>Chainage 59km760</td>
<td>Dedicated</td>
<td>Box culvert</td>
<td>Minimum 2400 mm x 2400 mm</td>
<td>No</td>
<td>Maximum culvert length is 60m. Koala included as target species</td>
</tr>
<tr>
<td>Chainage 60km565</td>
<td>Combined</td>
<td>Box culvert</td>
<td>Minimum 2400 mm x 2400 mm</td>
<td>No</td>
<td>Maximum culvert length is 60m for each Carriageway. Carriageway separation is approximately 10m. Koala included as target species</td>
</tr>
</tbody>
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**Deleted:** Combined

**Deleted:** Koala included as target species

**Deleted:** Minimum 2400 x 1500 mm

**Deleted:** Approximate

**Deleted:** 40m

**Deleted:** Northbound Main Carriageway and 30m for Southbound Main

**Deleted:** Northbound Main Carriageway and 30m for Southbound Main

**Deleted:** 60km390

**Deleted:** Southbound Main Carriageway

**Deleted:** 55m
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<th>Location</th>
<th>Fauna Crossing Structure Type</th>
<th>Structure Form¹</th>
<th>Number and Dimensions</th>
<th>Fish Passage Requirements</th>
<th>Additional Requirements</th>
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</thead>
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<tr>
<td>Chainage 59km195</td>
<td>Incidental</td>
<td>Pipe culvert</td>
<td>Minimum 825 mm</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

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)
Dedicated fauna crossing
2.5m x 2.5m RCBE 4.6m long approx.
with furniture
Minimum clearance
> 2.4m.