



# Wildlife Connectivity and Road Risk Minimisation Strategy

FINAL REPORT

Prepared for Ferrovial York Joint Venture

23 April 2020

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## Glossary

<b>BOP</b>	Biodiversity Offset Plan
<b>EEC</b>	Endangered Ecological Community
<b>EIS</b>	Environmental Impact Statement
<b>EP&amp;A Act</b>	<i>Environmental Planning and Assessment Act 1979</i>
<b>EPBC Act</b>	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
<b>FBA</b>	<i>Framework for Biodiversity Assessment: NSW Biodiversity Offsets Policy for Major Projects</i>
<b>FFMP</b>	Flora and Fauna Management Plan
<b>FYJV</b>	Ferrovial York Joint Venture
<b>IS</b>	Infrastructure Sustainability
<b>ISCA</b>	Infrastructure Sustainability Council of Australia
<b>LGA</b>	Local Government Area
<b>LEP</b>	Local Environment Plan
<b>NBHCaNE</b>	Northern Beaches Hospital Connectivity and Network Enhancement
<b>NBMP</b>	Nest Box Management Plan
<b>NSW</b>	New South Wales
<b>NV Act</b>	<i>Native Vegetation Act 2003</i>
<b>NW Act</b>	<i>Noxious Weed Act 1993</i>
<b>OEH</b>	NSW Office of Environment and Heritage
<b>Project Area</b>	The area encompassed by the Stage 1 and Stage 2 EIS boundaries.
<b>SIS</b>	Species Impact Statement
<b>SWTC</b>	Scope of Works and Technical Criteria
<b>TSC Act</b>	<i>Threatened Species Conservation Act 1995</i>
<b>UBLR</b>	Urban Design and Landscape Report
<b>VMP</b>	Vegetation Management Plan
<b>WCCRMS</b>	Wildlife Connectivity and Road Risk Minimisation Strategy

# 1 Introduction

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## 1.1 Background

Biosis Pty Ltd was commissioned by Ferrovial York Joint Venture (FYJV) to prepare a Wildlife Connectivity and Road Risk Minimisation Strategy (WCRMS) for the Northern Beaches Hospital Connectivity and Network Enhancement (NBH CaNE) Project (the Project).

The Project will focus on upgrading the existing road network servicing the Northern Beaches Local Government Area (LGA) to ensure projected increases in traffic associated with the construction of the Northern Beaches Hospital are catered for (Figure 1). Construction works associated with the Project consist of the following:

- Widening of Warringah Road from west of Fitzpatrick Avenue to east of Allambie Road.
- Upgrades to intersections with Forest Way, Hilmer Street and Wakehurst Parkway.
- Widening, intersection upgrades, new signalised intersections and changes to access along sections of Forest Way, Naree Road, Frenchs Forest Road and Allambie Road.
- Construction of a 1.1 kilometre grade separated underpass.
- Widening Wakehurst Parkway from north of the intersection with Frenchs Forest Road to south of Aquatic Drive.
- Provision of new connection at Aquatic Drive and Wakehurst Parkway.
- Substantial utility relocations, including water, sewer, telecommunications, electricity and gas services.
- Ancillary works for construction including construction compounds and stockpile sites.

The Project is located entirely within the Northern Beaches LGA, the entire extent of which is shown in Figure 1.

The Project Conditions of Approval Stage 1 (SSI-6434) and Stage 2 (SSI-6622) stipulate that a connectivity strategy is to be created for the Project. The WCRMS is to be created in accordance with Condition B19 (SSI-6434) and Condition B13 (SSI-6622). Condition B13 (SSI-6622) stipulates that:

*"The proponent must develop and implement a Wildlife Connectivity and Road Risk Management Strategy in Consultation with OEH. The Strategy must describe the measures to be implemented during the design, construction and operation of the SSI to mitigate fauna connectivity impacts and wildlife road kill from the SSI where reasonable and feasible."*

Condition B19 (SSI-6434) stipulates that;

*"The Proponent shall implement all feasible and reasonable corridor and wildlife connectivity, measures, including those identified in Chapter 5 Biodiversity Assessment Report, Northern Beaches Hospital Connectivity and Network Enhancements, SMEC October 2014".*

To achieve these aims within a recognised frame work, FYJV have elected apply the Infrastructure Sustainability (IS) Rating Scheme to the project. The IS rating scheme has developed by the Infrastructure Sustainability Council of Australia (ISCA). The IS evaluates the sustainability of infrastructure and is nationally recognised.



The WCRRMS shall also be developed with the aim of achieving an excellent "Design" and "As built" rating under the Infrastructure Sustainability (IS) Rating Scheme developed by the Infrastructure Sustainability Council of Australia (ISCA), at the request of FYJV. To this end the Project is seeking credits for a range of categories under the IS Rating Scheme. In conjunction with a range of other reports and studies, the WCRRMS will provide supporting documentation for the Project to meet the requirements to obtain credits using the IS Rating Tool for the category: Eco-4 Habitat connectivity.

This WCRRMS has been prepared by suitably qualified professionals, Nicola Trulock (Botanist), Callan Wharfe (Botanist) and Brendon True (Field Botanist) of Biosis under the guidance of Jane Raithby-Veall (Principal Ecologist) and Anthony Cable (Senior Ecologist).

This WCRRMS has been prepared based on the most current information available as at 22 October 2016. Some of the documents referenced are currently in draft format and may undergo future revisions. This WCRRMS may require revision during the "As built" submission stage once all supporting documents have been approved.

## **1.2 Aims and objectives of the Connectivity Strategy**

The primary aim of the WCRRMS is to demonstrate how the Project will maintain or enhance benchmark habitat connectivity values throughout the landscape during the construction and post construction phases of the Project. The secondary aim of the WCRRMS is to provide supporting documentation for obtaining Eco-4 Habitat connectivity credits under the IS Rating Scheme.

The objectives of the WCRRMS are to:

- Describe the current habitat connectivity values present within the land comprising the Project area and surrounds, and how these link to relevant local and regional connectivity plans.
- Provide an action plan for maintaining or enhancing habitat connectivity within the Project area and surrounds at a local, regional and bioregional scale during and post construction.
- Demonstrate that benchmark levels of habitat connectivity can be maintained or improved on completion of the Project.

### 1.3 Literature used in the preparation of the Connectivity Strategy

Preparation of the WRRMS was guided by local and regional habitat connectivity plans and prepared using definitions provided in the IS Rating Tool technical manual (AGIC 2012).

Prior to undertaking preparation of the WRRMS, Biosis completed a review of the following resources:

- Relevant local, state and national habitat connectivity and bio-regional reports and studies to ensure the WRRMS links with other initiatives, such as:
  - Warringah Biodiversity Conservation Study – Northern Beaches LGA (Eco Logical Australia 2011).
  - National Wildlife Corridors Plan – Commonwealth of Australia (2012).
  - Great Eastern Ranges Initiative (formerly the "Alps to Atherton" Initiative) – Lead Partners (Greening Australia, National Parks Association of NSW, Nature Conservation Trust of NSW, Office of Environment and Heritage and OzGREEN).
- Results of ecological assessments conducted for the Project Environmental Impact Statement (EIS) (SMEC 2014, 2015).
- The *Project Flora and Fauna Management Sub Plan* (Biosis 2016a) and all relevant sub-reports (including reports prepared for the Project by Biosis; *Nest Box Management Plan* (Biosis 2016b), *Vegetation Management Plan Stage 1 and 2* (Biosis 2016c) *Ecological Monitoring Program* (Biosis 2016d) and the *Red-crowned Toadlet Management Plan* (Biosis 2016e).
- *Ecologist review of fauna fencing and fauna crossing designs and locations* (Biosis 2015).
- The *Project Urban Design and Landscape Report* (AECOM, 2015).
- Roadkill register (FYJV 2017).
- Appendix D1: *Project Scope of Work and Technical Criteria* (SWTC) (Roads and Maritime Services 2015)
- IS Technical Manual Version 1.0 (AGIC 2012).



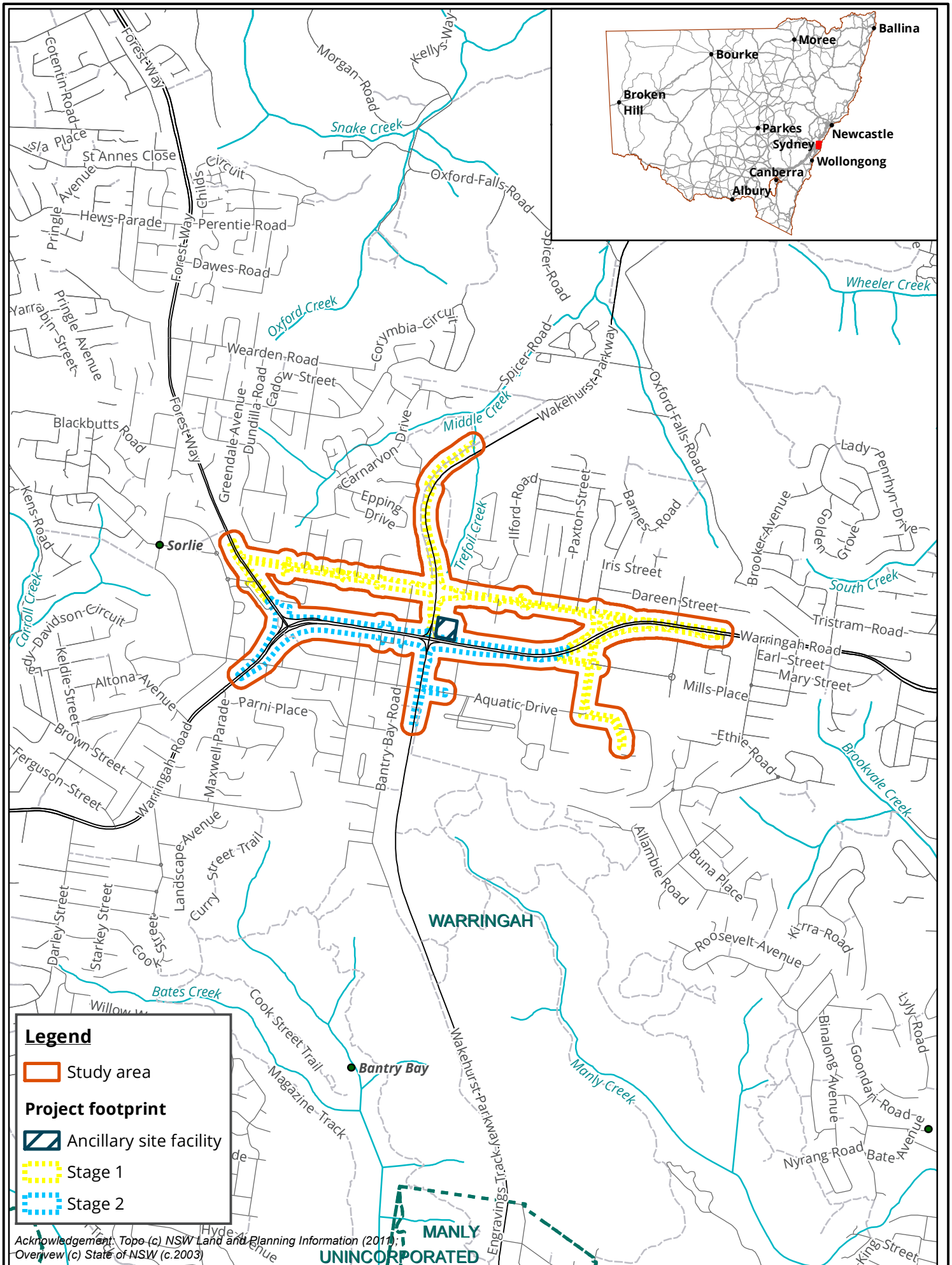
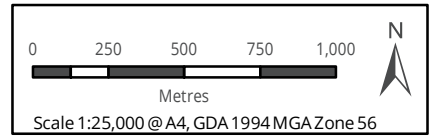


Figure 1: Location of the Study Area



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Matter: 20367  
Date: 16 November 2015,  
Checked by: APS, Drawn by: LH, Last edited by: Iharley  
Location: P:\20300s\20367\Mapping\



## 2 Habitat Connectivity

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### 2.1 Definition of connectivity

Habitat connectivity reflects the degree to which biota (including flora and fauna) can disperse throughout the landscape based on the presence of suitable habitat (AGIC 2012). Habitat connectivity is important for maintaining the long-term viability of ecological communities by facilitating genetic exchange and providing movement corridors for fauna to re-colonise areas following stochastic events (e.g. bushfires) and undertake migratory movements associated with species life histories. Habitat connectivity is defined by both structural and functional components.

#### 2.1.1 Structural connectivity

Structural connectivity refers to the influence that structural components of the landscape exert on the ability for fauna to move through the landscape (Worboys & Pulsford 2011). Structural components include topography, vegetative cover, hydrology, and land use patterns (Rudnick et al., 2012).

The spatial configuration of these components form larger connectivity features in the landscape such as:

- Habitat corridors – Parts of the landscape that facilitates the flow or movement of individuals, genes and ecological processes between larger non-contiguous habitat patches.
- 'Stepping stones' – Small patches of habitat that that are utilised by individuals during movement for shelter, feeding and resting.
- Landscape matrix – The intervening and surrounding lands between larger areas, typically altered by human land use. Examples include urban development and agricultural land.

#### 2.1.2 Functional connectivity

Functional connectivity refers to how the ecological attributes of organisms, such as habitat preference or dispersal mechanisms govern the responses of individuals, species or ecosystems to the structural attributes of the landscape (Worboys & Pulsford 2011; Rudnick et al., 2012). Functional connectivity can be measured by how easily individuals or populations as well as genes and propagules move through the landscape (Rudnick et al., 2012). Functional connectivity is both species and site specific.

#### 2.1.3 Connectivity and the Project

Figure 2 shows the pattern of habitat connectivity in the locality of the Project. Definitions for habitat connectivity values from the IS Rating Tool (AGIC 2012) are provided in Table 1. The habitat connectivity categories assigned in Figure 2 are broadly consistent with these categories, and were estimated based on a detailed visual inspection of aerial imagery (Near Maps 2016) and vegetation mapping (OEH 2013a) of the locality.

## 2.2 IS Eco-4 Habitat connectivity

### 2.2.1 IS Rating Tool

The ISCA is a non-profit industry council established with the aim of advancing the principles of ecologically sustainable development in the design, construction and operation of Australian infrastructure developments. The ISCA developed and administer the IS Rating Tool, which is a comprehensive rating system for evaluating sustainability of infrastructure projects and assets under the IS Rating Scheme. The

Project is seeking credits for the IS Rating Tool category: Eco-4 Habitat connectivity. The aim of Eco-4 Habitat connectivity is to reward maintenance or enhancement of habitat connectivity for infrastructure projects.

Definitions used in the IS Rating Tool for degrees of connectivity are provided in Table 1.

**Table 1 Eco-4 Degree of connectivity definitions**

Degree of connectivity	Definition
<b>High</b>	Native vegetation in good condition > 100m wide that forms a sole link between other native vegetation in good condition.
<b>Moderate</b>	Low condition native vegetation > 100m wide or native vegetation in good condition 50-100m wide that forms part of a sole link between other vegetation in good condition.
<b>Low</b>	Low condition native vegetation > 100m wide or native vegetation in good condition > 50m wide that is part of one of several links to other native vegetation in good condition.
<b>Nil</b>	None of the above.

Table 2 outlines the criteria specified in the IS Rating Tool for determining the level of credits that can be achieved for the Eco-4 category.

**Table 2 IS Rating Tool criteria for credit levels**

Benchmark connectivity	Level 1	Level 2	Level 3
<b>High</b>	N/A	Existing habitat connectivity is maintained (offsetting allowed).	Existing habitat connectivity maintained (with no offsetting).
<b>Moderate or Low</b>	Existing habitat connectivity is maintained (offsetting allowed).	Existing habitat connectivity is enhanced (offsetting allowed).	Existing habitat connectivity enhanced (with no offsetting).
<b>Nil</b>	N/A	N/A	N/A

### 2.2.2 Evidence for Eco-4 credit eligibility

In accordance with the requirements of the IS Rating Tool, a Biodiversity Management Plan (or equivalent) is required as supporting documentation when applying for Eco-4 credits for the Project. A range of reports and studies have been prepared for the Project, including:

- The Project EIS (SMEC 2014, 2015).
- Flora and Fauna Management Sub Plan (FFMP), and the associated sub-reports.
  - Vegetation Management Plan (VMP) – Stage 1 and 2.
  - Weed and Pathogen Management Strategy.

- 
- Protocol for Managing Pest Animal Species.
  - Anticipated Threatened Species EEC Management Procedure.
  - Nest Box Management Plan (NBMP).
  - Red-crowned Toadlet Management Plan.
- Urban Design and Landscape Report (UBLR) (AECOM, 2015).
  - Wildlife Connectivity and Road Risk Minimisation Strategy (WCRRMS).

The above reports and studies will be provided as supporting documentation equivalent to a Biodiversity Management Plan for the Project as evidence of eligibility for ISCA Eco-4 credits. Table 3 below demonstrates how each of the requirements specified in the IS Rating Tool for obtaining Eco-4 credits has been addressed in the Project documentation.

The Project is seeking credits for Eco-4 Habitat connectivity under the IS Rating Scheme. Adhering to the actions outlined in this document and further detailed in Table 6 will facilitate maintaining or enhancing “Moderate or Low” benchmark habitat connectivity in the locality for the Project to be eligible for Level 2 Eco-4 credits.

**Table 3 IS Rating Tool requirements**

IS requirement	Project documentation
<p>A set of measurable biodiversity objectives, incorporating a list of the values that can be offset and a brief summary of the logic and feasibility behind the design.</p>	<p>Project EIS – provides an inventory of existing biodiversity values.</p> <p>WCRRMS – Section 4.1.establishes benchmark values to be used to measure success of Project objectives to maintain or enhance habitat connectivity.</p> <p>WCRRMS – Section 4 provides specific objectives to achieve Eco-4 credits.</p> <p>FFMP and sub-reports – refined inventory of biodiversity values that will be impacted by the Project.</p> <p>UDLR –outlines the logic and feasibility of rehabilitation works within the Approved Construction Footprint).</p> <p>BOP – currently being prepared by SMEC in accordance with the <i>Framework for Biodiversity Assessment: NSW Biodiversity Offsets Policy for Major Projects</i> (FBA) (OEH 2014b). This policy will outline the logic and feasibility of using the <i>BioBanking Assessment Methodology 2014</i> (OEH 2014a) to purchase credits that will be used to offset the impacts of the Project.</p>
<p>A brief explanation of how one can be at least 50% confident that 20% habitat connectivity gains are likely to be achievable.</p>	<p>WCRRMS – Section 4.1.</p> <p>UDLR – describes how rehabilitation works will contribute to habitat connectivity and measures to achieve &gt; 50% success.</p> <p>BOP – once complete, the BoP will outline the number and type of BioBanking credits that have been secured that will contribute to regional habitat connectivity and protection in perpetuity.</p>
<p>An explanation of how the plan meets each of the principles of biodiversity offsets.</p>	<p>BOP –once complete the BOP will outline how each of the NSW Offset Principles for Major Projects are met.</p>
<p>A monitoring program, including a set of performance indicators that will be measured at least every three years.</p>	<p>WCRRMS - Section 4.3; Table 6.</p>
<p>A suggested adaptive management and continual improvement process, including options for maintaining or revising the trajectory of habitat connectivity improvements, to maintain the value of outcomes (if necessary).</p>	<p>WCRRMS – Section 5.3.</p>
<p>Roles and responsibilities</p>	<p>WCRRMS - Section 4.3; Table 6.</p>

## 2.3 Wildlife connectivity in the Project area

Benchmark habitat connectivity values within the Approved Construction Footprint for the Project and surrounding lands has been established from results obtained during a range of studies. The results of these studies are discussed below.

### 2.3.1 Project EIS (SMEC 2014, 2015)

The study area has been identified as including an important regional wildlife corridor connecting large patches of remnant native vegetation including expanses of Garigal National Park to the north and south. The Project EIS identified and mapped local scale habitat connectivity within the Project area as being restricted to linear patches of vegetation bounding Wakehurst Parkway. These patches are likely to facilitate east-west movement through the Project area; however Warringah Road presents a formidable physical barrier to north-south traversal.

Though some connectivity is present, the Project EIS concluded that overall connectivity value within the study area is limited by Warringah Road, industrial estates, residences and the surrounding road network.

### 2.3.2 Habitat connectivity

Habitat connectivity values are defined in Table 1 and mapped in Figure 2. The following benchmark habitat connectivity values occur within the Project area:

- **High** – No high habitat connectivity within the Approved Construction Footprint, however Manly Creek, Carroll Creek, Moores Creek, Bates Creek, Oxford Creek, Snake Creek, Frenchs Creek, Wheeler Creek and Middle Harbour (Bantry Bay) within the locality contributes high habitat connectivity to the Northern Beaches LGA.
- **Moderate** – Vegetation fringing the roadside interface of Wakehurst Parkway north of Frenchs Forest Road and south of the intersection with Warringah Road contribute to moderate habitat connectivity within the Approved Construction Footprint. Surrounding habitat of note within the locality includes; the lower end of Carroll Creek to the west, Vegetation forming stepping stones between Frenchs and Oxford Creeks to the north, the lower end of South Creek to the east and the roadside interface of Wakehurst Parkway to the south, all of which contribute to moderate connectivity within the Northern Beaches LGA.
- **Low** – Vegetation within and adjacent to the Approved Construction Footprint, along both sides of Warringah Road as well as the west side of Wakehurst Parkway north of the intersection with Frenchs Forest Road contribute to low habitat connectivity within the Approved Construction Footprint. Fragmented vegetation within and adjacent to the Approved Construction Footprint spanning from the North side of Warringah Road to Middle Creek currently provides low habitat connectivity within the Northern Beaches LGA.
- **Nil** – All other areas within or adjacent to the Approved Construction Footprint supporting existing development, where native vegetation has been removed. Some opportunities to enhance these areas to provide "Low" habitat connectivity have been identified and are designated for revegetation within the ULDR (AECOM 2015).

### 2.3.3 Flora and Fauna Management Plan

The FFMP and associated sub-plans identified the following:

- Disturbed areas (through construction) within the Approved Construction Footprint will be re-vegetated following construction for the Project. Revegetation measures will include:



- The use of appropriate planting stock including, comprising of species commensurate with prior existing vegetation communities. All seed collection and plant materials are to be sourced locally.
  - Ensuring that habitat connectivity along Wakehurst Parkway within and adjacent to the Project Approved Construction Footprint will continue to function as a pathway for genetic exchange through restoration of appropriate vegetation type, structure and diversity.
  - The Wakehurst Parkway/Warringah Road compound to be revegetated using species that occur in Duffys Forest EEC.
- Revegetation to be in Accordance with Roads and Maritime Biodiversity Guidelines (RTA 2011).

### **2.3.4 Northern Beaches LGA**

Northern Beaches Council has prepared a Bushland Policy for the Northern Beaches LGA (Warringah Council 2008). Aims of this policy relevant to wildlife connectivity include:

- Protecting, conserving and restoring fauna habitat and wildlife corridors.
- Alleviating barriers to fauna movement in vegetation corridors.

Although this policy does not provide connectivity mapping, studies have been undertaken to investigate the location and management requirements of wildlife corridors within the Northern Beaches Council - Northern Beaches LGA. Review of Smith and Smith (2005) reveals that the majority of vegetation within the Project area contributes to a Priority 1 Vegetation Corridor connecting Oxford Falls to Manly. As an important linkage, this study recommends that it should be protected and enhanced through bushland rehabilitation or revegetation.

### **2.3.5 National Wildlife Corridors Plan**

The Australian government has prepared a National Wildlife Corridors Plan (Commonwealth of Australia 2011). This plan is a long-term strategy for retention and restoration of national ecological connectivity. The plan sets out broad objectives to address connectivity at a national scale to provide a "framework to retain, restore and manage ecological connections in the Australian landscape" (Commonwealth of Australia 2012).

The plan does not provide mapping of national corridors. However, the local connectivity present within and surrounding the Project would form a small component of the mosaic of national connectivity addressed in the National Wildlife Corridors Plan. The National Wildlife Corridors Plan refers to other relevant initiatives, including the Great Eastern Ranges Initiative (discussed below).

### **2.3.6 Great Eastern Ranges Initiative**

The aim of the Great Eastern Ranges Initiative is to provide habitat connectivity along the 3,600 kilometres of the Great Dividing Range and Eastern Escarpment from central Victoria to far north Queensland (Commonwealth of Australia 2012). Mapping provided in the Great Eastern Ranges Initiative (The Great Eastern Ranges 2016) indicates that the closest corridors to the Project are the "Great Escarpment". This corridor follows the eastern slopes of the Great Dividing Range surrounding the Sydney Basin. The nearest point of this corridor to the Project is the Hawkesbury River to the north.

The locality of the Project does not form a component of any corridors mapped for the Great Eastern Ranges Initiative. However it is likely that habitat present in the locality would contribute "stepping stone" corridor value between Royal National Park and the Hawkesbury River.



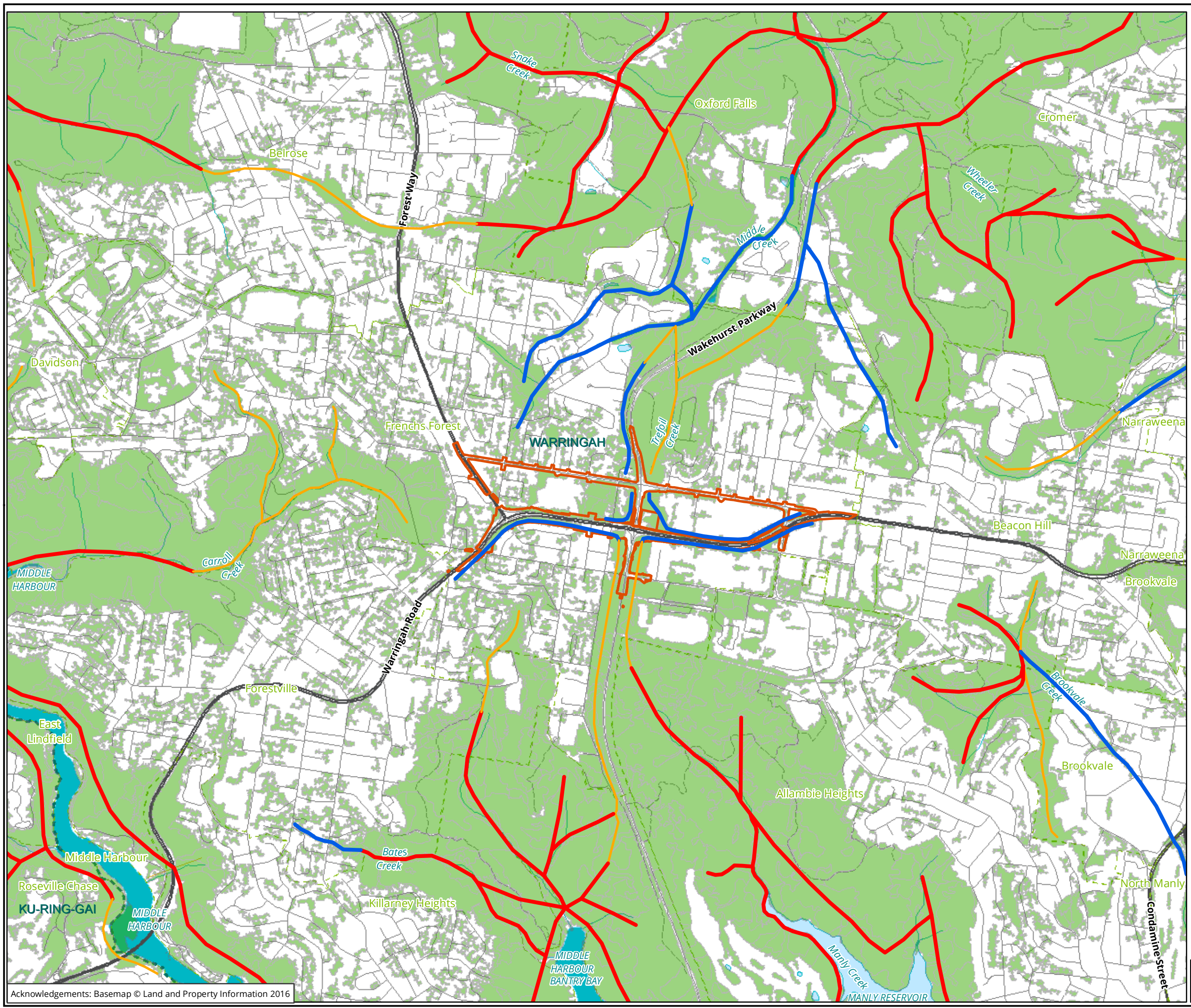
## 2.4 Barriers to dispersal

Barriers to dispersal comprise of physical or behavioural constraints which act as a barrier to habitat connectivity. Physical structures which form a barrier to dispersal comprise of major arterial roads, rail corridors, medium and high density residential development, largescale vegetation clearance and large tracts of water. Fauna behaviours which form a barrier to dispersal include aversion to noise and light, aversion to cleared or modified habitat, vulnerability to predation and migratory or dispersal cues (i.e. rainfall, seasonal, life history stage, reproductive cues etc.). Barriers within the Project area primarily comprise of:

- Warringah Road and Wakehurst Parkway which form major arterial roads within the locality.
- Cleared and/or modified habitat within areas which have been cleared for low density residential development and business parks.
- Light and noise pollution within the vicinity of suburban roads and urban development which may deter cryptic species.
- Interface between remnant bushland and urban areas or roadsides which may increase vulnerability to predation or parasitism.

Actions undertaken during the construction phase of the Project (including the widening of Wakehurst Parkway, Warringah Road and Frenchs Forest Road are unlikely to significantly increase existing barriers to fauna movement relative to those which currently occur adjacent to the road corridor. In addition, the removal of vegetation along existing roads for road widening will have some minor impact on the existing low connectivity values present along the eastern and western sections of Warringah Road and Frenchs Forest Road. The abovementioned barriers to dispersal have informed the creation of Figure 2 which displays current habitat connectivity values within the Project area and surrounding locality.





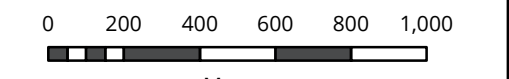
**Legend**

- Project footprint

**Connectivity Eco-4**

- High
- Moderate
- Low

**Figure 2: IS Eco-4  
Habitat connectivity**



Scale: 1:20,000 @ A3  
Coordinate System: GDA 1994 MGA Zone 56

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## 3 Road Risk Minimization Plan

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### 3.1 Fauna road risks

The construction of roads has had a significant effect on wildlife, most notably, the alteration of habitat and increased mortality from collision with vehicles. Ground dwelling fauna groups in particular, such as wallabies, possums, bandicoots, echidnas and lizards risk collision with traffic when navigating wildlife corridors. Road layouts and the physical attributes of the landscape can heighten this risk by concentrating and funnelling fauna into areas of high traffic frequency. Relative to the Project area, this process is evident as the width of vegetation adjoining Wakehurst Parkway narrows towards the intersection with Warringah Road.

Connectivity with the Project area is largely limited to linear bands of vegetation within the roadside corridors of Wakehurst Parkway and to some extent, Warringah Road. The roadside vegetation corridor along Wakehurst Parkway becomes quite narrow towards the intersection with Frenchs Forest Road as well as with Warringah Road which results in any fauna attempting to traverse the Project area in a north-south direction along Wakehurst Road being confronted by the physical barrier of Warringah Road (an arterial road comprising of eight lanes). This bottleneck acts as a barrier for groups of fauna such as reptiles as well as arboreal and ground-dwelling mammals.

### 3.2 Fauna corridors

A fauna corridor comprises of a linear expanse of vegetation which contains the physical and structural attributes contains moderate to high quality habitat, is wide enough to contain core areas of undisturbed habitat and possesses the structural attributes which are amenable to target fauna species. Main fauna corridors within the Project Area include:

- Wakehurst Parkway (north-east): A corridor which spans from Frenchs Forest Road along Trefoil Creek (moderate connectivity) heading in a north-east direction (low connectivity) until linking with Red Hill Reserve (high connectivity).
- Wakehurst Parkway (north-west): A corridor which spans from the north-east side of Frenchs Forest Road along Trefoil Creek (moderate connectivity) until linking with Middle Creek (low connectivity) and heading in a north-west direction until joining with Garigal National Park (high connectivity). This fauna corridor connects beneath Wakehurst Parkway via Trefoil Creek.
- Wakehurst Parkway (south-east): A corridor which spans from the south east side of Warringah Road to approximately 50 metres south of Aquatic Drive (moderate connectivity) head in a south-east direction towards Manly Creek Reservoir (high connectivity).
- Wakehurst Parkway (south-west): A corridor which spans from the south-west side of Warringah Road heading in a south-west direction adjacent to Wakehurst Parkway (moderate connectivity) until joining with the southern extent of Garigal National Park (high connectivity).
- Small patches of vegetated land dotted throughout the Project area and surrounding locality provide low levels of connectivity to avifauna throughout the area. These small patches act as stepping stones linking the southern and northern Wakehurst Parkway Corridors and acting as a conduit for fauna when moving between the southern and northern ends of Garigal National Park.

The inclusion of fauna corridors which connect beneath existing roads in the Project area fulfils Condition B19 (SSI-6434). Habitat connectivity within the Project area and surrounding locality is displayed in Figure 2.

### 3.3 Target fauna species

Roadkill data reviewed in the Project EIS indicates that fauna killed by vehicle strike within the Project area commonly include ground dwelling mammals such as Swamp Wallaby *Wallabia bicolor*, Short-beaked Echidna *Tachyglossus aculeatus* and Long-nosed Bandicoot *Perameles nasuta* as well as arboreal mammals including Common Brushtail Possum *Trichosurus vulpecula* and Common Ringtail Possum *Pseudocheirus peregrinus*. The WCRMS seeks to cater for these target fauna species by using data derived from prior fauna surveys to inform the design and location of fauna road furniture according to their habitat, species movement patterns and distributions.

#### 3.3.1 Fauna survey results

All of the species listed in Section 3.3 above have been recorded within the Project area (SMEC 2015). The distribution of these species within the Project are outlined below:

- Swamp Wallaby: recorded in vegetated areas bounding Wakehurst Parkway, north and south of Warringah Road.
- Common Brushtail Possum: recorded in vegetated areas bounding Wakehurst Parkway, north and south of Warringah Road.
- Common Ringtail Possum: recorded in vegetated areas bounding Wakehurst Parkway, north and south of Warringah Road.
- Short-beaked Echidna: recorded in the vegetated areas on the eastern side of Wakehurst Parkway, north of the intersection with Frenchs Forest Road.
- Long-nosed Bandicoot: recorded in vegetated areas bounding Wakehurst Parkway, north and south of Warringah Road.

#### 3.3.2 Species movement patterns

All of the species listed as occurring within the Project area possess species specific movement patterns which govern how likely they are to use roadside vegetation corridors as well as directly cross roads within the Project area and surrounding locality. The movement patterns of species listed in Section 3.3 are as follows:

- Swamp Wallaby: roadside corridors form adequate habitat for this species which are habituated to the roadside interface and are able to utilise the increased foraging resources (increased cover of grasses and juvenile vegetation) present within the roadside environment (Ben-Ami & Ramp 2013; Ramp et al., 2014). The Swamp Wallaby will avoid traversing roads if possible but may inadvertently come into contact with traffic when forced via dispersal or when avoiding predation (Ben-Ami & Ramp 2013; Ramp et al., 2014).
- Common Brushtail Possum and Common Ringtail Possum: roadside corridors are utilised for movement by these arboreal mammals which will traverse the road at points which exhibit continuous canopy cover (Russell et al. 2013). In areas where canopy is patchy or absent, both species of possum will be forced to cross using electricity lines or on foot (Russell et al. 2013). Prior studies have determined that the majority of possum fatalities will tend to occur in areas which form the bushland-urban interface (Russell et al. 2013).
- Short-beaked Echidna: roadside corridors form dispersal habitat for juveniles who are moving out of their natal range to establish new territory in nearby suitable vegetation (Abensperg-Traun 1991). Echidnas are slow moving and will often succumb to traffic when forced to traverse roads.
- Long-nosed Bandicoot: roadside corridors form marginal habitat for the Long-nosed Bandicoot whose presence is not commonly recorded in the areas of modified vegetation which exist along the

roadside interface (Bennett 1990). Bandicoots will traverse the roadside corridor only when moving between patches of vegetation forming suitable habitat and will not take up permanent residence in these areas (Bennett 1990).

### 3.3.3 Threatened species

The potential movement patterns of following locally recorded threatened species have been considered when determining the mitigation measures outlined in Section 3.5 and the Wildlife Connectivity Plan in Section 4:

- Rosenberg's Goanna *Varanus rosenbergi* (Vulnerable TSC Act)
- Spotted-tailed Quoll *Dasyurus maculatus* (Vulnerable TSC Act; Endangered EPBC Act)
- Southern Brown Bandicoot (eastern) *Isoodon obesulus obesulus* (Endangered TSC Act; Endangered EPBC Act)
- Koala *Phascolarctos cinereus* (Vulnerable TSC Act; Vulnerable EPBC Act)
- Eastern Pygmy-possum *Cercartetus nanus* (Vulnerable TSC Act)

## 3.4 Fauna crossing hotspots

While roadkill has been recorded consistently along the length of Wakehurst Parkway to the north and south of the Project area, a 'hotspot' has been identified approximately two kilometres north of the intersection with Frenches Forest Road (SMEC 2015). Swamp Wallabies, Brushtail and Ringtail Possums and Long-nosed Bandicoot are the most recorded species which have suffered vehicle strike at this location (SMEC 2015). A further hotspot has been identified on Wakehurst Parkway approximately two kilometres to the south of the intersection with Warringah Road, this time with Swamp Wallabies, Brushtail and Ringtail Possums being the most recorded species as described in the report titled; The impact of roads on Swamp Wallaby populations on Sydney's Northern Beaches (Ramp et al., 2014). Monitoring of any fauna which have died as a result of road kill over the duration of the Project will be conducted in accordance with the Road Kill Monitoring Plan (Biosis 2016).

## 3.5 Mitigation measures

All fauna management measures have been chosen in accordance with Condition B19 (SSI-6434) in regards to consideration of their effectiveness to mitigate impacts to the targeted species including their ability to maintain or improve connectivity and movement pathways, reduce the risk of mortality for threatened species and are located according to the specific requirements of target species.

The Project Scope of Works and Technical Criteria (SWTC) provides recommendations for fauna crossings and fauna fencing as measures for the Project to mitigate impacts on fauna. The objectives of providing these measures are to:

- Maintain or improve on existing habitat connectivity values of Warringah Council's "Priority 1 Vegetation Corridor" (over the intersection of Wakehurst Parkway and Warringah Road) at suitable locations within the Project.
- Restrict or direct fauna movement at other locations to minimise road mortality and traffic incidents.

### 3.5.1 Locations of fauna fencing and fauna crossings

Fauna fencing and fauna crossing locations and frequency have been selected according to the ecological requirements of target species outlined in Section 3.3 to ensure risks associated with road crossing is minimised. The current proposed locations for fauna fencing and fauna crossings for the Project are displayed in Figure 3. These locations have been determined based on the Project SWTC as well as recommendations provided by Biosis (2015).

There are no practical options for establishing safe fauna passage crossing Frenchs Forest Road East and Warringah Road, for the following reasons:

- Works required to upgrade the existing culvert (a small pipe) to a fauna friendly underpass would be expensive and impractical.
- The canopy on the north side of Frenchs Forest Road East is too low to provide north/south connectivity for arboreal fauna via a rope bridge crossing.
- The overall habitat connectivity gains provided by a fauna crossing beneath or above Frenchs Forest Road would be limited as there is no viable option to provide a fauna crossing north/south across Warringah Road, which is a substantial barrier to fauna movement further to the south.

### 3.5.2 Fauna road furniture

Two types of fauna crossings comprising of the following fauna road furniture are currently proposed for the Project. These are:

- Box culverts – Provide passage beneath roads for small, medium and large terrestrial fauna and some arboreal fauna.
- Rope bridge crossings – Provide passage above roads for small to medium arboreal fauna.

Table 4 provides a complete summary of fauna crossings currently proposed for the Project. All fauna crossing locations and designs have been prescribed based on the results of ground surveys.

**Table 4 Summary of proposed fauna crossings**

Number	Location	Type	Specifications	Recommended in SWTC	Recommendation
1	Wakehurst Parkway (south of the Project boundary)	Rope bridge	Single span rope bridge. Located at point of minimum canopy separation across road.  Support poles to be located approximately same distance from road as adjacent canopy tree trunks.	Yes	As per SWTC. Single span structure proposed, as there is no option for a central support pole to be located in a median strip.
2	Wakehurst Parkway (Curl Curl Creek).	Box culvert	Minimum 1800 millimetres height and 2400 millimetres width (Table 2).	Yes	As per SWTC with multi cell configuration to be considered in design

Number	Location	Type	Specifications	Recommended in SWTC	Recommendation
3	Wakehurst Parkway (Curl Curl Creek).	Rope bridge	<p>Located at point of minimum canopy separation across road.</p> <p>Support poles to be located approximately same distance from road as adjacent canopy tree trunks.</p> <p>Support poles to be located on outside of fauna fencing (i.e. opposite side from road).</p>	Yes	As per SWTC. Single span structure proposed, as there is no option for a central support pole to be located in a median strip.
4	Wakehurst Parkway (north of Frenchs Forest Road)	Rope bridge	<p>Located at point of minimum canopy separation across road.</p> <p>Support poles to be located approximately same distance from road as adjacent canopy tree trunks.</p> <p>Support poles to be located on outside of fauna fencing (i.e. opposite side from road).</p>	Yes	
5	Wakehurst Parkway (north of Frenchs Forest Road)	Rope bridge	<p>Located at point of minimum canopy separation across road.</p> <p>Support poles to be located approximately same distance from road as adjacent canopy tree trunks.</p> <p>Support poles to be located on outside of fauna fencing (i.e. opposite side from road).</p>	Yes	
6	Aquatic Drive, (Curl Curl Creek)	Box culvert	Minimum 1800 millimetres height and 2400 millimetres width (Table2).	No	Additional to SWTC



### 3.5.3 Box culvert design

The SWTC proposes construction of a Box Culvert beneath Wakehurst Parkway along Curl Curl Creek. A fauna friendly culvert at this location will allow terrestrial fauna to move between the two large areas of vegetation to the east and west of Wakehurst Parkway. A multi-cell culvert will facilitate fauna movement during different flow scenarios of Curl Curl Creek. Upgrade of north/south culvert beneath Aquatic Drive will facilitate continued safe north/south movement of terrestrial fauna.

Table 5 provides recommended specifications for all box culvert fauna underpasses within the Project.

**Table 5 Box culvert specifications**

Feature	Specification
<b>Dimensions</b>	<p>Minimum 1.8 metre height (as per SWTC). Preferably 3 metres or greater height where possible to increase suitability as a fauna passage.</p> <p>Minimum 2.4 metre wide (as per SWTC). Preferably 3 metres or greater width where possible to increase suitability as a fauna passage.</p>
<b>Fauna structures</b>	<p>Raised fauna paths to be incorporated into box culvert design. Paths to be constructed along one side of Trefoil Creek (Crossing 7a) and Curl Curl Creek (Crossing 2 and Crossing 6). The path should provide terrestrial fauna a dry passage from one side of the carriage way to the other and should be positioned in the one in two year flood zone or higher.</p> <p>A raised walkway in the form of a pole railing or ledges on the bridge abutment is recommended to facilitate the movement of small ground-dwelling mammals including rodents and dasyurids (Bond and Jones 2008).</p> <p>Several (2 to 3) recesses should be included in the internal roof of the box culverts to provide supplementary roosting habitat for microbats.</p> <p>Logs (including those containing hollows), rocks, leaf litter and refuge pipes should be scattered throughout the underpass (where practical) and/or placed near the culvert entrances. These should be fastened to the substrate to ensure microhabitats aren't washed away in flood events.</p>
<b>Substrate</b>	<p>Natural substrates such as dirt. Could be concreted to ensure underpass doesn't wash away in flood events however a natural substrate should be allowed to settle providing a near-natural environment.</p>
<b>Vegetation at entrance</b>	<p>Where possible, natural vegetation cover should be retained at the entrances to box culverts to provide protection for species using the underpass (particularly from introduced predators). Where no natural vegetation occurs, low-lying dense vegetation cover that doesn't obstruct the view of the habitat or horizon on the far side of the underpass should be planted using locally occurring native plant species.</p>
<b>Fencing at entrance</b>	<p>Proposed fauna fencing throughout the Project should be modified at the entrances of box culverts to guide fauna to the crossing structures. Guide fencing should also be incorporated to the north of Trefoil Creek to direct fauna towards Crossing 7a. Given that the area supports populations of macropods,</p>

Feature	Specification
	the guide fences are recommended to extend at least 75 metres either side of the underpass with the last 10 to 15 metres of the fence angled in towards the entrance.

### 3.5.4 Fauna fencing

Fauna fencing should be designed to ensure fauna is not directed into roads. Fauna fencing should be finished by linking back to existing fencing where possible (e.g. existing boundary fencing) or should be directed 45 degrees away from roads to allow fauna to disperse instead of creating a focal crossing point (Figure 3).

Section 1.11 and Attachment 7 of the SWTC provides recommendations for the design and specifications of fauna fencing to be constructed within the Project area. The designs and specifications provided are generally consistent with current best practice and should therefore be adopted for construction and installation of fauna fencing for the Project.

Fauna fencing is to be installed at key locations along Wakehurst Parkway (in accordance with the SWTC), including:

- Wakehurst Parkway to Frenchs Forest Road (East).
- Wakehurst Parkway to Frenchs Forest Road (West).
- Warringah Road to Aquatic Drive (East).
- Warringah Road to Aquatic Drive (West).
- Aquatic Road (South).

Further information regarding the designs, specifications and considerations for the installation of fauna fencing within the Project area can be found in Appendix 1 and the ERFFCDL report (Biosis 2015) and Section 4.2 below.





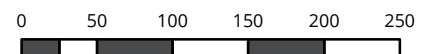
Figure 3: Indicative fauna fence locations



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Ballarat, Brisbane, Canberra, Melbourne,  
Newcastle, Sydney, Wangaratta & Wollongong

Acknowledgements: Imagery (c) Nearmap 2014  
Topo (c) NSW Land and Planning Information (2015)

Matter: 21345  
Date: 18 December 2015,  
Checked by: CAC, Drawn by: LH, Last edited by: Iharley  
Location: P:\21300s\21345\Mapping\21345\_F1\_FaunaManagement



Metres  
Scale 1:5,000 @ A3  
Coordinate System: GDA 1994 MGA Zone 56





## 4 Wildlife Connectivity Plan

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### 4.1 Wildlife connectivity objectives

The Project benchmark habitat connectivity values are described in Section 2.3. These benchmark values have been used to determine the following habitat connectivity objectives to qualify for Level 2 Eco-4 credits on completion of the Project. Habitat connectivity objectives for the Project include:

- Ensure with 50% or greater probability that current moderate connectivity levels can be maintained along the northern section (east and west side) and southern section (east and west) of Wakehurst Parkway on completion of the Project. This is to be achieved by minimising vegetation clearing for the Project, protecting vegetation in adjacent areas, applying post-construction revegetation within the Approved Construction Footprint and installation of fauna crossings.
- Ensure with 50% or greater probability that current low connectivity levels between the eastern and western sections of the corridor along both sides of Warringah Road can be enhanced by 20% or greater on completion of the Project. This is to be achieved through revegetation and rehabilitation within the Approved Construction Footprint and installation of fauna crossings. Revegetation

Revegetation to enhance the connectivity of existing roadside corridors has been prescribed for the following sections of the Approved Project Footprint according to the ULDR (AECOM 2015) and the *Northern Beaches Hospital Connectivity and Network Enhancement Zone 2000 – Stage 2 – Detailed Design Landscape Works (DDLW)* (Roads and Maritime Services 2016):

- Extensive revegetation is to occur on the site located below the ground detention tank on the corner of Warringah Road and Fitzpatrick Avenue.
- Revegetation of the roadside interface along the northern side of Warringah Road, opposite the intersection with Hilmer Road.
- Revegetation of the roadside interface along the southern side of Warringah Road, adjacent to the intersection with Bantry Bay Road.
- Revegetation of the roadside interface along the southern side of Warringah Road at the intersection with Wakehurst Parkway (includes revegetation of both sides of Wakehurst Parkway) including the revegetation of all traffic islands/median strips.
- Revegetation of the roadside interface along the southern side of the Warringah Road.
- Revegetation of the roadside interface and associated median strips of Wakehurst Parkway immediately south of the intersection with Warringah Road as well as both sides of Aquatic Drive.

The creation of the revegetation landscape plans within the ULDR (AECOM 2015) and the DDLW (Roads and Maritime Services 2016) will benefit wildlife connectivity through establishment of vegetation leading to connectivity structures.

### 4.2 Fencing Strategy

Section 1.11 of the SWTC provides recommendations for the design and specifications of fauna fencing to be constructed within the Project area. Biosis has recommended a series of revisions to the fauna fencing strategy within the ERFFCDL report (Biosis 2015). The following areas are currently designated for installation of fauna fencing:

- **Wakehurst Parkway:** Between approximately 100 metres north of Trefoil Creek and Frenchs Forest Road. Fencing extends for a short section east along Frenchs Forest Road.
- **Wakehurst Parkway (east):** Between Warringah Road and Aquatic Drive. Extends for short sections east along Warringah Road (south side) and Aquatic Drive (north side). Gaps and funnelling in fencing at proposed locations for two fauna culverts.
- **Wakehurst Parkway (west):** Between Warringah Road and opposite Aquatic Drive. Extends for a short distance west along Warringah Road (south side). Gap and funnelling in fencing at proposed location for one fauna culvert.
- **Aquatic Drive (south):** From Wakehurst Parkway extending approximately 100 metres west. Fencing extends for a short section south along Wakehurst Parkway (east side). Gap and funnelling in fencing at proposed location for one fauna culvert.

Further information regarding design, specifications and considerations for the installation of fauna fencing within the Project area can be found in Appendix 1 and the ERFFCDL report (Biosis 2015).

### 4.3 Actions, responsibilities and timing

The following table (Table 6) describes the actions to be undertaken to ensure the fulfilment of this WCRRMS including personnel responsible, timing, report requirements and performance parameters.

**Table 6 Wildlife connectivity and road risk minimization actions, responsibilities and timing**

Refer to	Action	Description	Timing of action	Reporting	Responsibility	Performance Parameters / Assessment Criteria
<b>Retention and protection of native vegetation</b>						
<b>Flora and Fauna Management Sub Plan</b>	Protection of vegetation to be retained within and adjacent to the Approved Construction Footprint that currently provides habitat connectivity.	Delineate and install protective measures (e.g. exclusion fencing) of vegetation for retention within and adjacent to the Approved Construction Footprint.	Prior to the commencement of vegetation clearing and construction.	Pre-clearing assessment requirements are detailed in the Flora and Fauna Management Sub Plan . The following information should be recorded during each vegetation clearing event: Survey date. Time. Surveyors. Location and extent of vegetation clearance, including photo-point monitoring. Location and photographs of protective fencing and signage. Discussion of the effectiveness of those methods employed. If there is any deterioration or damage to protective fencing and signage and if maintenance is required.	Environment Manager	The performance of pre-clearing and clearing procedures will be assessed against: <ul style="list-style-type: none"> <li>• Successful removal of intended vegetation without accidental damage to vegetation proposed for retention.</li> <li>• Data collation and reporting of these measures.</li> </ul> Assessment criteria: <ul style="list-style-type: none"> <li>• Avoid impact to vegetation marked for protection to ensure &gt;50% probability that current moderate habitat connectivity will be maintained along the northern and southern sections of Wakehurst Parkway.</li> <li>• Avoid impact to vegetation marked for protection to ensure &gt;50% probability that current low habitat connectivity will be maintained between the east and west sections of Warringah Road including the east and west side of Wakehurst Parkway in the vicinity of the FYJV Site Compound, when combined with planned rehabilitation works post-construction along this corridor.</li> </ul> Reporting regarding vegetation clearance to be prepared and provided to relevant stakeholders as per Project Condition of Approval parameters/requirements.
<b>Flora and Fauna Management Sub Plan</b>	Monitoring of vegetation clearance in areas adjacent to ecologically sensitive areas or vegetation to be retained.	Following the installation of protective fencing and signage, on-going monitoring is to be undertaken as per Appendix A of the FFMP (Biosis 2016) to ensure that vegetation to be retained continues to provide low, moderate or high degrees of habitat connectivity.  A final post construction assessment is to be undertaken to determine any off site impacts to retained vegetation.	Monitoring of vegetation clearance to be undertaken: <ul style="list-style-type: none"> <li>• 1. On a weekly basis during construction by the on site environmental officer.</li> <li>• Immediately after construction by the on site environmental officer.</li> </ul>	Techniques, timing and responsibilities for monitoring of vegetation clearance are detailed in the Flora and Fauna Management Sub Plan. The following documentation is to be recorded following each monitoring event: Survey date. Time. Surveyors. Location and extent of vegetation clearance, including photo-point monitoring. Location and photographs of protective fencing and signage. Discussion of the effectiveness of those methods employed. If there is any deterioration or damage to protective fencing and signage and if maintenance is required.	Environment Manager/ Project ecologist	The performance of pre-clearing and clearing procedures will be assessed against: <ul style="list-style-type: none"> <li>• Successful removal of intended vegetation without accidental damage to vegetation proposed for retention.</li> <li>• Data collation and reporting of these measures.</li> </ul> Assessment criteria: <ul style="list-style-type: none"> <li>• Avoid impact to vegetation marked for protection to ensure &gt;50% probability that current moderate habitat connectivity will be maintained along the northern and southern sections of Wakehurst Parkway.</li> <li>• Avoid impact to vegetation marked for protection to ensure &gt;50% probability that current low habitat connectivity will be maintained between the east and west sections of Warringah Road including the east and west side of Wakehurst Parkway in the vicinity of the FYJV Site Compound, when combined with planned rehabilitation works post-construction along this corridor.</li> </ul> Reporting regarding vegetation clearance and groundwater/water quality to be prepared and provided to relevant stakeholders as per Project Conditions of Approval parameters/requirements.

Refer to	Action	Description	Timing of action	Reporting	Responsibility	Performance Parameters / Assessment Criteria
<b>Flora and Fauna Management Sub Plan</b>	Retention and protection of local habitat connectivity values identified by Northern Beaches Council – Warringah.	<p>Retention and protection of vegetation along either side of the northern and southern sections of Wakehurst Parkway, directly adjoining Garigal National Park which provides "moderate to high" connectivity value within The Northern Beaches Council - Northern Beaches LGA.</p> <p>Retention and protection (where possible) of vegetation between the east and west sections of Warringah Road including the east and west side of Wakehurst Parkway in the vicinity of the FYJV Site Compound that provides "low" connectivity value within the Northern Beaches Council - Northern Beaches LGA.</p> <p>Achieved through delineation and protective measures as described above.</p>	Prior to the commencement of vegetation clearing and construction.	Reporting requirements as detailed in the Flora and Fauna Management Plan.	Environment Manager/ Project ecologist	<p>The performance of pre-clearing and clearing procedures will be assessed against:</p> <ul style="list-style-type: none"> <li>• Successful removal of intended vegetation without accidental damage to vegetation proposed for retention.</li> <li>• Data collation and reporting of these measures.</li> </ul> <p>Assessment criteria:</p> <ul style="list-style-type: none"> <li>• Avoid impact to vegetation marked for protection to ensure &gt;50% probability that current moderate habitat connectivity will be maintained along the northern and southern sections of Wakehurst Parkway.</li> <li>• Avoid impact to vegetation marked for protection to ensure &gt;50% probability that current low habitat connectivity will be maintained between the east and west sections of Warringah Road including the east and west side of Wakehurst Parkway in the vicinity of the FYJV Site Compound, when combined with planned rehabilitation works post-construction along this corridor.</li> </ul> <p>Reporting regarding vegetation clearance and groundwater/water quality to be prepared and provided to relevant stakeholders as per Project Condition of Approval parameters/requirements.</p>
<b>Replacement of tree hollows</b>						
<b>Nest Box Management Plan</b>	Offset loss of hollow-bearing trees.	Provide artificial roost and breeding habitat for hollow-dependent fauna to ensure that the loss of hollow-bearing trees will not result in a reduction in habitat connectivity values resulting from clearing of vegetation for the Project.	To be implemented prior to vegetation clearing.	<p>Pre clearance advice prior to vegetation clearing and construction, and post-clearing and construction advice on completion of all required Ecological supervision/inspections.</p> <p>Monitoring in accordance with the Nest Box Strategy (Biosis 2016b).</p>	Environment Manager/ Project ecologist	In accordance with the Nest Box Strategy (Biosis 2016b).
<b>Retention of Red-crowned Toadlet Habitat</b>						
<b>Red-crowned Toadlet Management Plan</b>	<p>Offset loss of shelter habitat for Red-crowned Toadlet.</p> <p>Promote dispersal through installation of culverts.</p>	Ensure that impacts of the Project on known or potential Red-crowned Toadlet breeding and dispersal habitat will not result in a reduction in habitat connectivity values for this group.	To be implemented prior to and during construction.	<p>Pre clearance advice prior to vegetation clearing and construction, and post-clearing and construction advice on completion of all required Ecological supervision/inspections.</p> <p>Monitoring accordance with the Red-crowned Toadlet Management Plan.</p>	Environment Manager/ Project ecologist	In accordance with the Red-crowned Toadlet Management Plan.



Refer to	Action	Description	Timing of action	Reporting	Responsibility	Performance Parameters / Assessment Criteria
<b>Retention and enhancement of habitat connectivity</b>						
ERFFCDL	Minimisation of mortality of terrestrial fauna crossing roads	Installation of fauna exclusion fencing along sections of the Project to minimise vehicle strike.	As per the Ecological Monitoring Plan.	As per the Ecological Monitoring Plan.	Environment Manager/ Project ecologist	In accordance with the Ecological Monitoring Plan.
ERFFCDL	Minimisation of mortality of terrestrial fauna crossing roads	Installation of fauna passages to culverts beneath roads to facilitate movement of terrestrial fauna between patches of habitat.		As per the Ecological Monitoring Plan Section.	Environment Manager/ Project ecologist	In accordance with the Ecological Monitoring Plan.

## 5 Maintenance, monitoring and evaluation

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### 5.1 Maintenance

Regular (bi-annual) inspections will be undertaken of all fauna road furniture for signs of damage and/or impediment. All maintenance requirements will be undertaken by a suitably qualified contractor. Maintenance actions, responsibilities and timing are outlined in Table 7.

Maintenance requirements for nest boxes installed for the Project are outlined in the Project NBMP (Biosis 2016b).

### 5.2 Monitoring

#### 5.2.1 Monitoring objectives

Regular monitoring of measures put in place to increase wildlife connectivity and reduce road risk for fauna species is an essential component of successful implementation of this Plan, and required to ensure adaptive management measures provide flexibility in the management of these measures.

Monitoring actions outlined in Table 7 below have been developed with regard to the following objectives:

- Mitigation measures installed to reduce road risk continue to function as designed.
- Actions to provide wildlife connectivity are auditable and continue to progress towards targets.
- Revegetation has achieved the objective of maintaining connectivity.

#### 5.2.2 Monitoring actions, responsibilities and timing

Actions required to ensure that the objectives outlined above are achieved on completion of the Project are addressed in the following Project documents:

- Flora and Fauna Management Sub Plan (FFMP) (and sub-reports)
- Urban Design and Landscape Report
- Ecological Monitoring Plan
- Bandicoot Monitoring Plan
- Red-crowned Toadlet Management Plan
- Vegetation Management Plan

In addition to these documents, Table 7 below provides details of specific actions required for the monitoring of the success of road risk minimisation and improvement to wildlife connectivity, as well as responsibilities and timing for each of these actions. These actions are planned to enable the maintenance and/or enhancement of benchmark habitat connectivity values throughout the landscape during and post construction for the Project.

The Project is seeking credits for Eco-4 Habitat connectivity under the IS Rating Scheme. Adhering to the actions outlined in this document and further detailed in Table 6 will facilitate maintaining or enhancing “Moderate or Low” benchmark habitat connectivity in the locality for the Project to be eligible for Level 2 Eco-4 credits.

### 5.3 Adaptive Management

Adaptive management and continual improvement to the WCRMS will be achieved through implementation of recommendations from ongoing monitoring and reporting as outlined in 5.2.2. As specified in the IS Rating Tool, the WCRMS needs to provide "a set of performance indicators that will be measured at least every three years". The WCRMS shall therefore be reviewed every three years to ensure that all efforts to maintain or enhance habitat connectivity remain effective.

Adaptive management shall aim to achieve the following:

- Identify opportunities to improve habitat connectivity management and outcomes.
- Review the Wildlife Connectivity Strategies listed in Section 4.1.
- Monitor and document the outcomes of any corrective measures.
- Re-evaluate achievement of Wildlife Connectivity objectives following implementation of corrective measures.

**Table 7 Monitoring actions, responsibilities and timing**

Action	Description	Timing of action	Reporting	Responsibility	Performance Parameters / Assessment Criteria	Adaptive management
<b>Monitoring functionality of road furniture</b>						
Inspect fauna crossings for damage and/or impediment	Undertake regular inspections of all: <ul style="list-style-type: none"> <li>• Rope bridge for damage to ropes and webbing</li> <li>• Rope bridge supports for damage/vandalism</li> <li>• Underpasses for debris/rubbish either dumped or brought in via stormwater</li> <li>• Underpasses for weed infestations</li> <li>• Underpasses for use by people for shelter</li> </ul>	During construction and defects liability stage. Annually during construction.	Status reports provided to asset owner.	Environment Manager during construction and defects liability stage.  Asset owner post construction.	Fauna crossings remain in good repair through to life of the manufacturer's warranty.  Fauna crossings remain in good repair for life.  Impediments to fauna are removed regularly and access / functionality is maintained for life.	Results of monitoring inspections are provided to asset owner and corrective actions are undertaken.  Repetition of damage or reduction in functionality to fencing or crossings is flagged in annual reports and mitigation measures developed to target the source of the damage.

Action	Description	Timing of action	Reporting	Responsibility	Performance Parameters / Assessment Criteria	Adaptive management
Inspect fencing for damage	Undertake regular inspections of all fauna fencing for: <ul style="list-style-type: none"> <li>Holes, gaps or other damage that would allow fauna access through the fencing.</li> <li>Fallen trees and/or large branches that would provide fauna access up and over the fence.</li> </ul>	Six monthly	<ul style="list-style-type: none"> <li>Results of the surveys including condition of each fauna crossing.</li> <li>Location of any damaged fencing and/or fallen woody debris.</li> <li>Potential cause of damage to crossing/fencing.</li> <li>Recommendations for corrective actions.</li> <li>Discussion of the results including effectiveness of mitigation measures.</li> <li>Recommendations for future monitoring.</li> </ul>	Asset owner.	Damage to fauna fencing is repaired as damage becomes apparent.  Any areas of repeat damage are recorded and mitigation measures are developed to prevent re-occurrence.	

Action	Description	Timing of action	Reporting	Responsibility	Performance Parameters / Assessment Criteria	Adaptive management
Assess road kill frequency	<p>Roadkill monitoring transects are to include areas in the vicinity of fauna crossing and fences, and will record incidence of roadkill.</p> <p>Council data on roadkill will be sought and included in monitoring reports.</p>	<p>Monthly monitoring prior to construction, during construction, and for up to 12 months of operational phase.</p> <p>Monitoring of Council data is to be undertaken bi-annually on an ongoing basis.</p>	<p>Brief roadkill monitoring reports are to be produced following each roadkill monitoring session, with the findings to be submitted in annual reporting to the Secretary and relevant Council, or as otherwise agreed by those agencies shortly after the clearing operations have been completed. The following information will be collected:</p> <ul style="list-style-type: none"> <li>• Date.</li> <li>• Transect number.</li> <li>• Individual roadkill (to species if possible).</li> <li>• Time of day.</li> <li>• GPS waypoint of each individual.</li> <li>• Assessment of Council data.</li> <li>• Patterns and any relationship to fauna crossing/fencing.</li> </ul>	<p>Environment Manager with operational phase monitoring requirements to be determined post-construction.</p>	<p>No increase in the frequency of roadkill encounters during assessments.</p> <p>No new species encountered during construction phase when compared to baseline data.</p> <p>No correlation to locations of fauna crossings and an increase in roadkill.</p>	<p>Increases in road kill occurrence and/or hot-spots at fauna crossing sites are to be highlighted in monitoring reports and potential reasons investigated and mitigation measures developed.</p>



Action	Description	Timing of action	Reporting	Responsibility	Performance Parameters / Assessment Criteria	Adaptive management
<b>Monitoring success of corridor improvement</b>						
Assess success of revegetation and rehabilitation works	<p>As described in <i>Northern Beaches Hospital Vegetation Management Plan – Stage 1 and 2</i> (Biosis 2016), including assessment and documentation of:</p> <ul style="list-style-type: none"> <li>Survival rate of installed plants, and requirements for supplementary planting, and maintenance requirements.</li> <li>Occurrence of weed species and requirements for vegetation management.</li> <li>Results of quadrat and photo monitoring.</li> </ul>	<p>Vegetation management undertaken as part of corridor improvement is to be included in VMP monitoring events.</p> <p>Briefly:</p> <p>0-12 months: 1 visit / 2 months</p> <p>12-24 months: 1 visit / 6 months</p> <p>&gt;24 months: annual for 5 years post construction</p>	<p>Status reports at the end of each monitoring event are to provide a summary of:</p> <ul style="list-style-type: none"> <li>The details of works carried out.</li> <li>The status of supplementary planting works and the degree of compliance with performance criteria.</li> <li>The nature of any corrective or adaptive management actions that have been taken, or which are proposed, in respect of non-compliance with the specified performance criteria.</li> </ul>	Environment Manager with operational phase monitoring to be determined post-construction.	<p>Minimum 80% survival rate of installed plantings at 12 months from time of installation.</p> <p>Minimum 10% exotic species foliage projective cover (FPC) at 12 months from commencement of works.</p> <p>Minimum &lt;5% exotic species foliage projective cover (FPC) at 36 months from commencement of works.</p>	<p>Adaptive weed control techniques are to be applied based on results of primary and secondary works.</p> <p>Assisted regeneration techniques such as soil scarification, smoke-water treatments or pile burns are to be trialled should native regeneration be lacking.</p>

## 6 Conclusion

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Through the completion of the various actions prescribed within this WRRMS across the suggested timeframe it is envisaged that the Project will adequately achieve the objective of maintaining and/or enhancing habitat connectivity values throughout the landscape during and post construction for the Project.

Maintaining and/or enhancing habitat connectivity will ensure that habitat corridors in the locality will continue to function as viable pathways for fauna passage and facilitate genetic exchange. The resilience of biodiversity in the locality is largely dependent on the long-term viability of these habitat corridors.

Achieving the goal of maintaining or enhancing habitat connectivity values, as well as security of offsets, ensures that the Project is eligible for credits under the Level 2 IS tool "Eco-4 – Habitat connectivity" category.

Table 3 outlines the relevant documentation providing which together are equivalent to a Biodiversity Management Plan. These documents form evidence to support application for Eco-4 credits for the Project. Based on the requirements specified in the IS Rating Tool, the Project should be eligible for Level 2 Eco-4 Habitat connectivity credits.

The "moderate" connectivity along the northern section (east and west side) and southern section (east and west) of Wakehurst Parkway will be maintained (with >50% probability). The "low" habitat connectivity between the eastern and western sections of the corridor along both sides of Waringah Road will be maintained or enhanced by > or = 20% (with > 50% probability). This will be achieved through a combination of the following:

- Minimising vegetation clearing for the Project.
- Protecting vegetation in adjacent areas.
- Applying post-construction revegetation and rehabilitation in accordance with the UDLP using indicative species for Duffys Forest EEC within the Approved Construction Footprint along Wakehurst Parkway and Waringah Road revegetation using indicative species for Duffys Forest EEC within the Approved Construction Footprint along Wakehurst Parkway and Waringah Road.
- Installation of fauna crossings, fauna fencing and next boxes.

In closing, the production and enactment of the WRRMS has fulfilled FYJVs obligations under Stage 1 Condition of Approval B4 (SSI-6434) and Stage 2 Condition of Approval B13 (SSI-6622).

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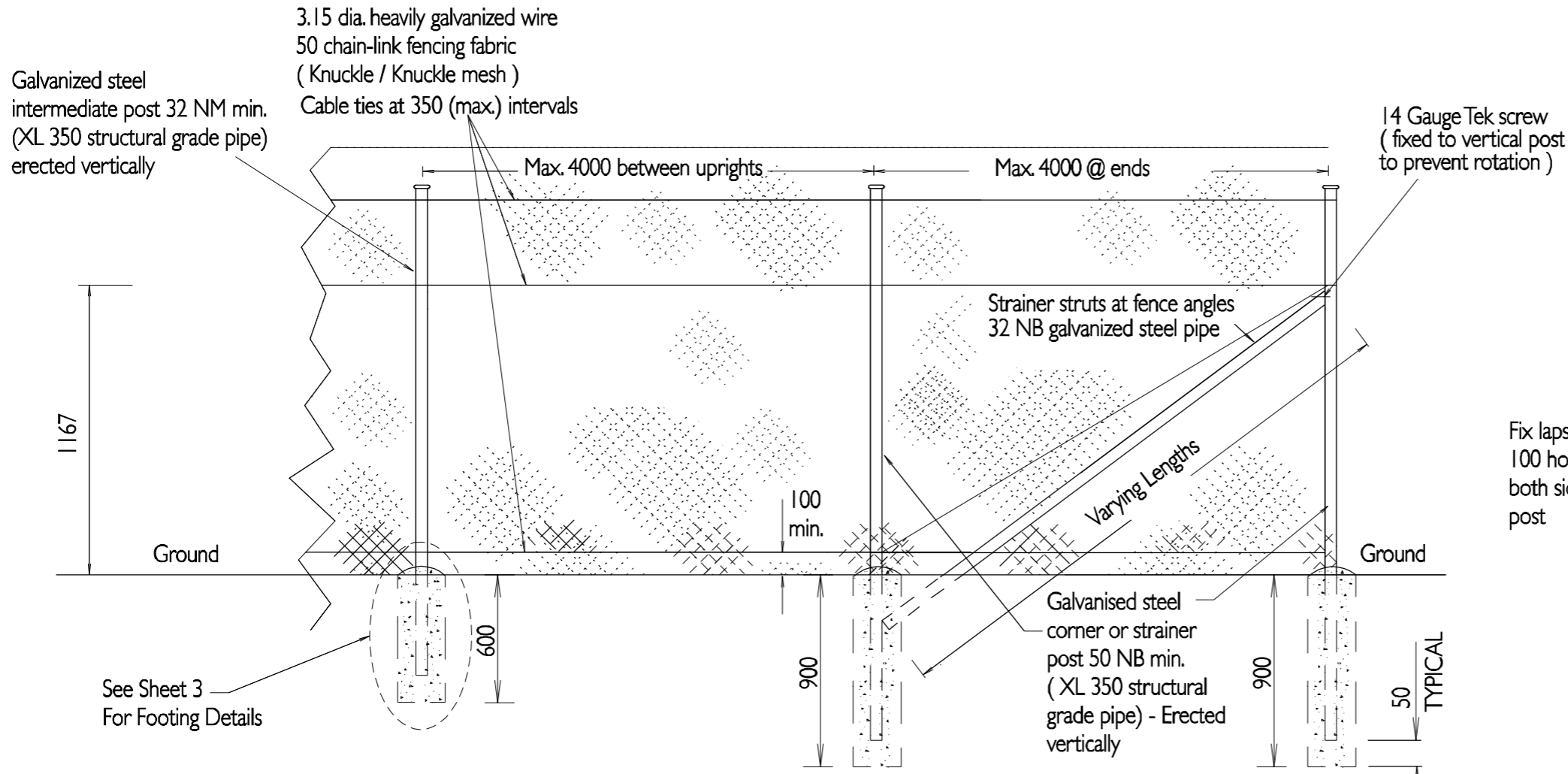
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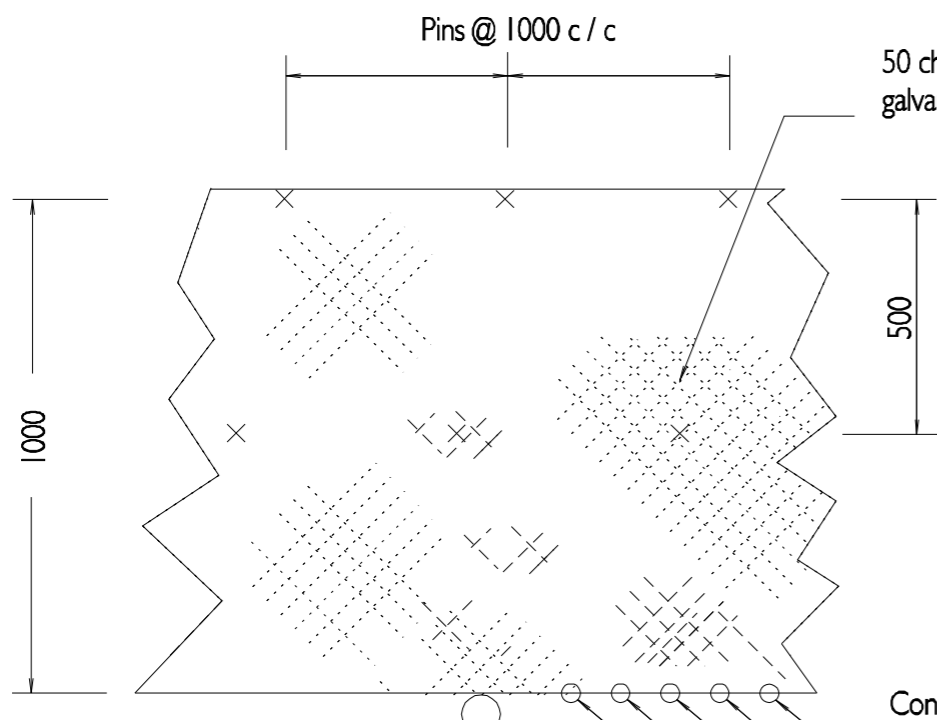
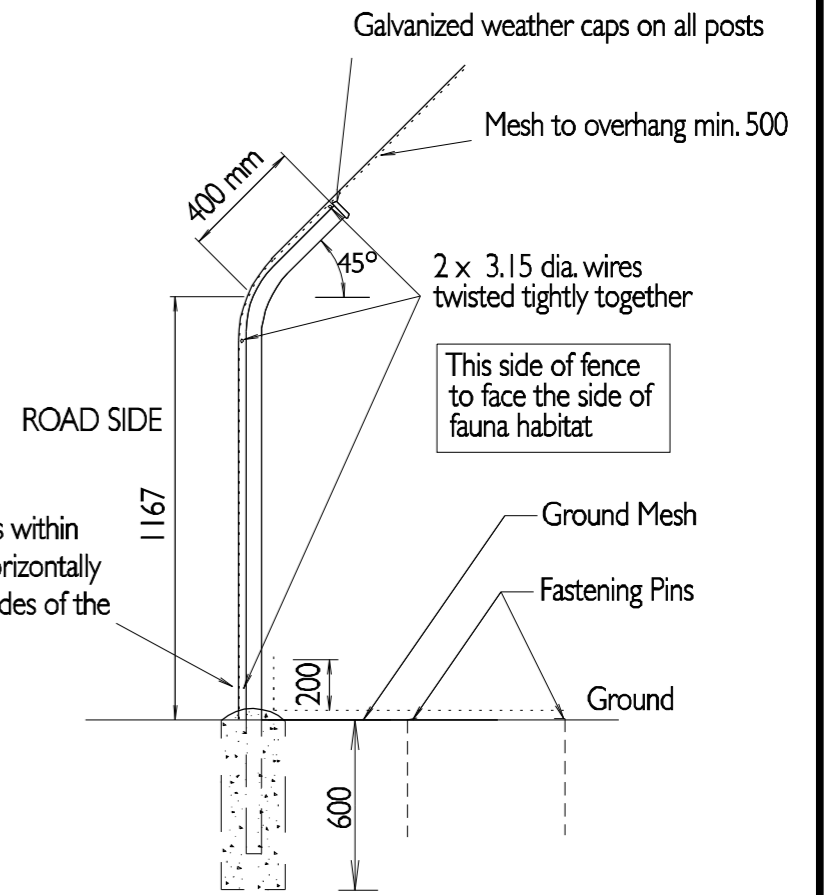
## Appendix 1 – SWTC Fauna fencing design

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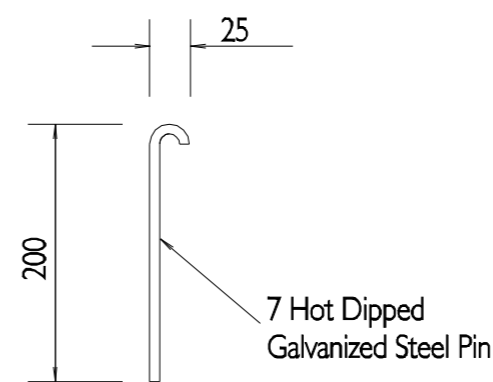
ELEVATION



GROUND MESH FIXING DETAIL

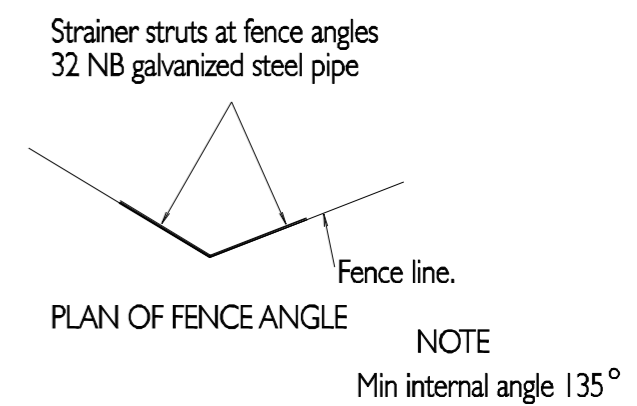
Connect 2.5 mesh to 3.15 mesh @ 210 centres and overlap

*Special requirements may apply to the erection procedures for fences installed near high voltage transmission lines. The relevant Electricity Authority should be contacted prior to the installation of the fence.*



FASTENING PIN DETAIL

NOTE  
For loose or sandy soils 350 (min.) galvanised fastening pins must be used



AMENDMENT DETAILS		DATE
Roads and Traffic Authority, NSW		
FAUNA EXCLUSION FENCE		
SCALE N.T.S	No. OF SHEETS 3	SHEET No. 1

DRAWING NUMBER  
**MD.R201.D02.A**

All dimensions are in millimetres unless otherwise shown.

First issued : July 2009

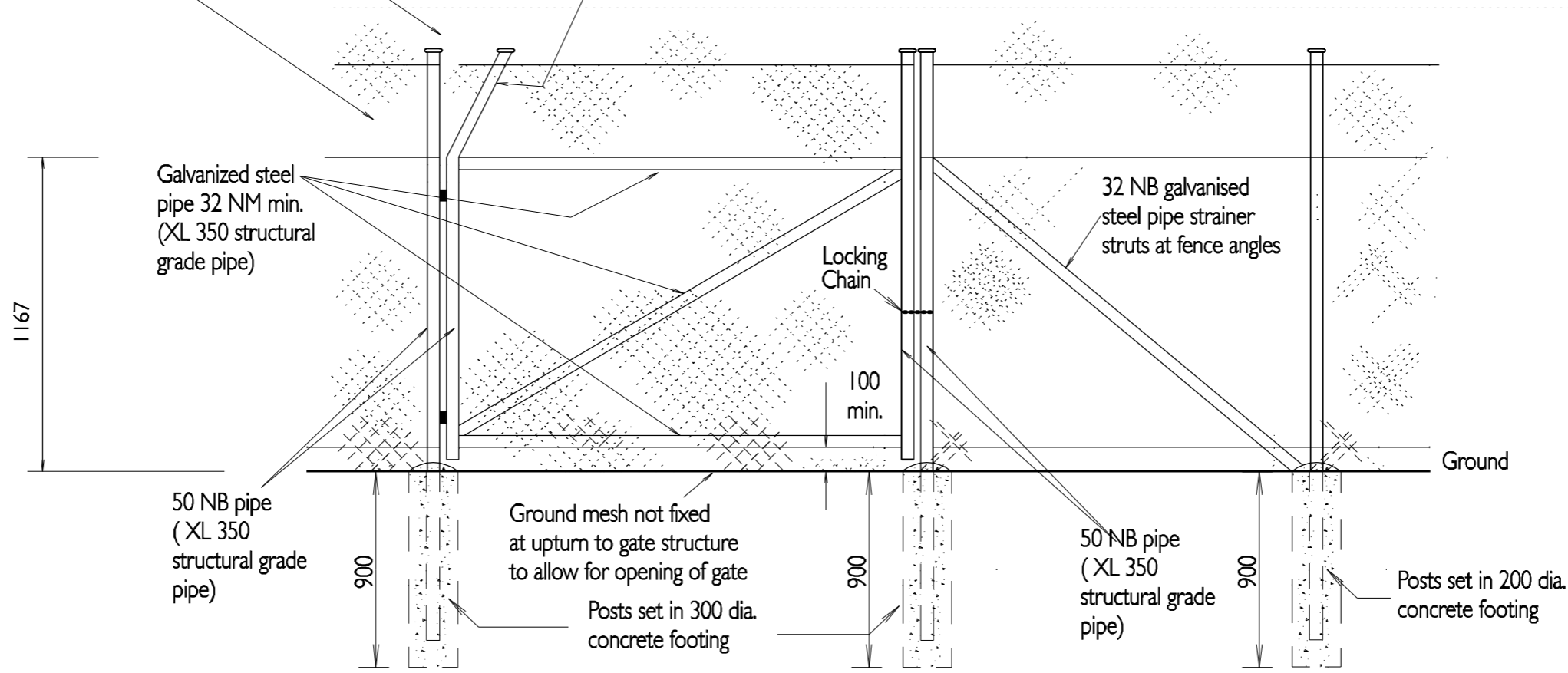


3.15 dia. heavily galvanized wire  
50 chain-link fencing fabric  
(Knuckle / Knuckle mesh)  
Cable ties at 350 (max.) intervals

Floppy top mesh  
continuous lapped  
(not Fixed)

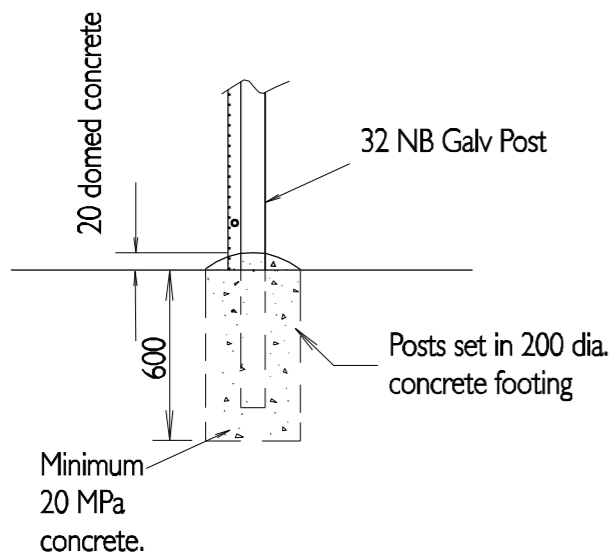
4000  
Crank to be angled to allow  
for opening of gate  
(hinge side only)

3000  
Hinges to be installed on either  
side to allow for correct  
opening

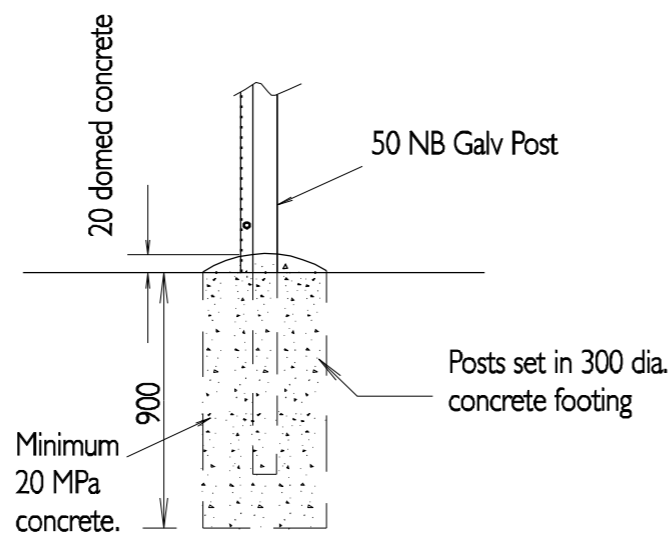


### MAINTENANCE GATE DETAILS

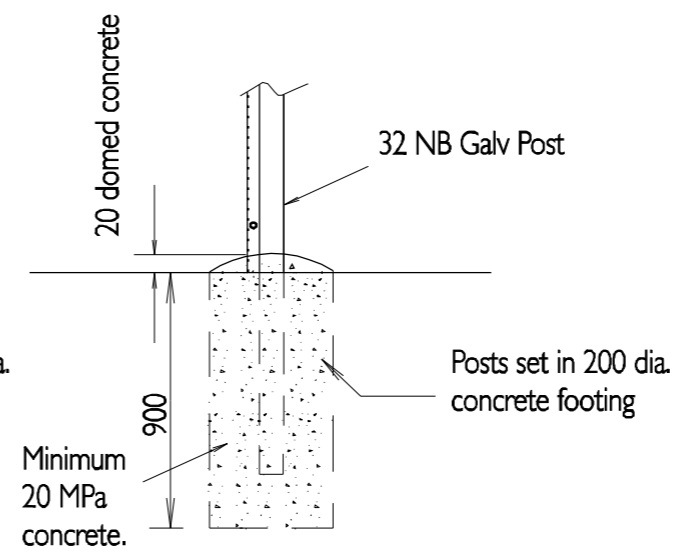
*Special requirements may apply to the erection procedures for fences installed near high voltage transmission lines. The relevant Electricity Authority should be contacted prior to the installation of the fence.*



INTERMEDIATE POSTS  
FOOTING DETAILS



STRAINER & CORNER  
POSTS FOOTING DETAILS



INTERMEDIATE POSTS  
FOOTING DETAILS  
AT LOW POINT

AMENDMENT DETAILS		DATE
Roads and Traffic Authority, NSW		
FAUNA EXCLUSION FENCE WITH GATE		
SCALE N.T.S	No. OF SHEETS 3	SHEET No. 3

DRAWING NUMBER  
**MD.R201.D02.A**

First Issued : July 2009

All dimensions are in millimetres unless otherwise shown.