NSW Roads and Maritime Services

WOOLGOOLGA TO BALLINA | PACIFIC HIGHWAY UPGRADE

COASTAL EMU MANAGEMENT PLAN

Version 1.0

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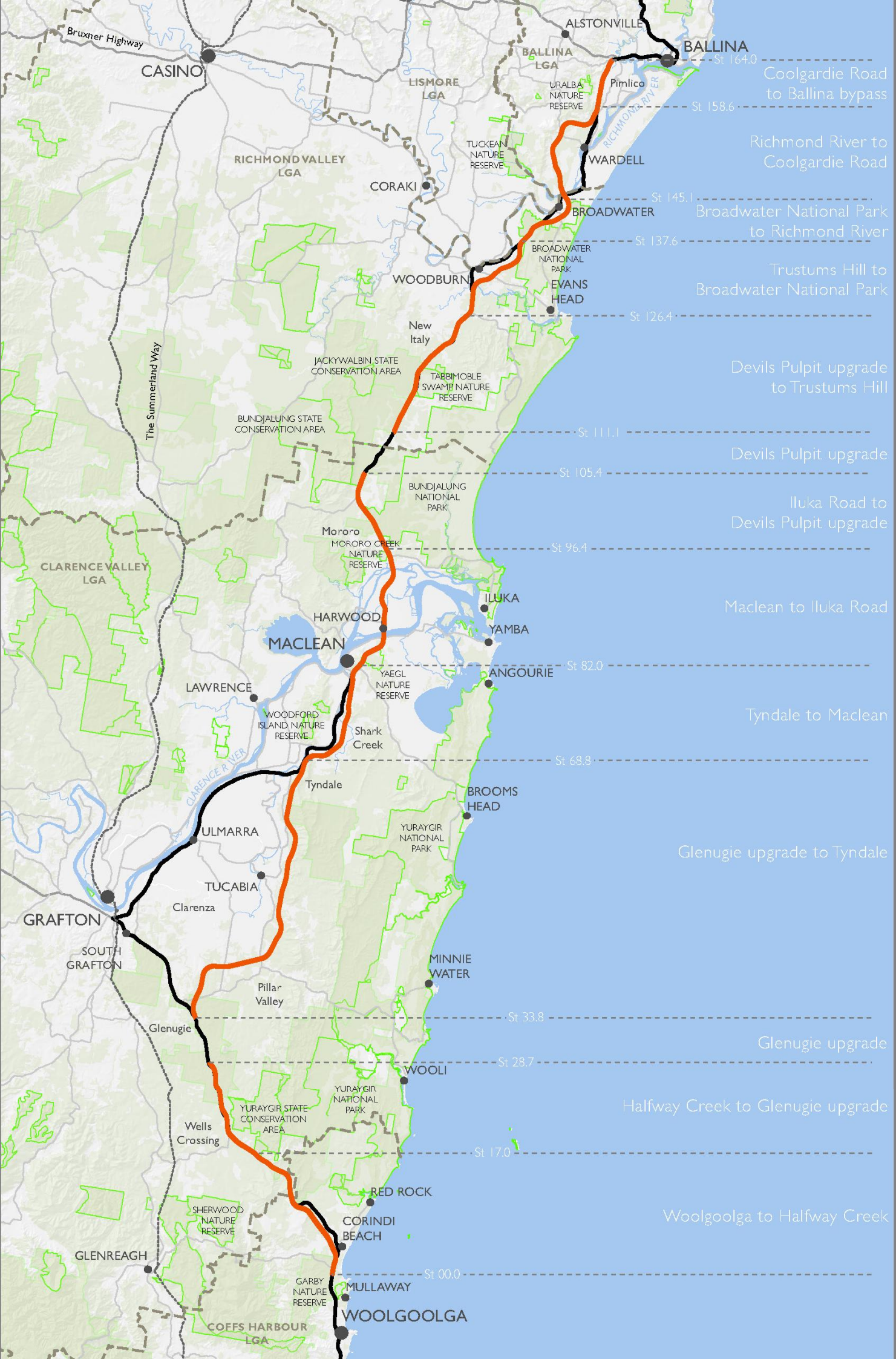
Bruxner Highway
CASINO
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Coolgardie Road to Ballina bypass
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LISMORE LGA
URALBA NATURE RESERVE
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TUCKEAN NATURE RESERVE
WARDELL
CORAKI
St 145.1
BROADWATER
Broadwater National Park to Richmond River
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St 137.6
BROADWATER NATIONAL PARK
Trustums Hill to Broadwater National Park
8
WOODBURN
EVANS HEAD
St 126.4
New Italy
JACKYWALBIN STATE CONSERVATION AREA
TABBIMOBLE SWAMP NATURE RESERVE
Devils Pulpit upgrade to Trustums Hill
7
The Summerland Way
BUNDJALUNG STATE CONSERVATION AREA
St 111.1
Devils Pulpit upgrade
St 105.4
BUNDJALUNG NATIONAL PARK
Iluka Road to Devils Pulpit upgrade
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Mororo
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HARWOOD
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MACLEAN
St 82.0
ANGOURIE
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LAWRENCE
WOODFORD ISLAND NATURE RESERVE
Shark Creek
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St 68.8
CLARENCE RIVER
Tyndale
BROOMS HEAD
YURAYGIR NATIONAL PARK
ULMARRA
Glenugie upgrade to Tyndale
3
TUCABIA
Clarenza
GRAFTON
SOUTH GRAFTON
MINNIE WATER
Pillar Valley
St 33.8
Glenugie
Glenugie upgrade
St 28.7
WOOLI
YURAYGIR NATIONAL PARK
YURAYGIR STATE CONSERVATION AREA
Halfway Creek to Glenugie upgrade
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Wells Crossing
St 17.0
RED ROCK
SHERWOOD NATURE RESERVE
CORINDI BEACH
Woolgoolga to Halfway Creek
1
GLENREAGH
St 00.0
GARBY NATURE RESERVE
MULLAWAY
WOOLGOOLGA
COFFS HARBOUR LGA

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1. Introduction

1.1 Project overview

NSW Roads and Maritime Services (Roads and Maritime) is seeking approval for the Woolgoolga to Ballina (W2B) Pacific Highway upgrade project (the project / the action), on the NSW North Coast. The approval is sought under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The location of the project is shown in the figure above.

Since 1996, both the Australian and NSW governments have contributed funds to the upgrade of the 664-kilometre section of the Pacific Highway between Hexham and the Queensland border, as part of the Pacific Highway Upgrade Program.

Both governments have a shared commitment to finish upgrading the highway to a four-lane divided road as soon as possible. The actual timing of construction, opening to traffic and completion is dependent on funding negotiations between the Australian and NSW governments. Assessments would be adjusted accordingly based on actual opening dates, for example noise and traffic predictions.

The project would upgrade around 155 kilometres of highway and represents the last priority (known as 'Priority 3' in the upgrade program) in achieving a four-lane divided road between Hexham and the NSW/Queensland Border. The project therefore forms a major part of the overall upgrade program and when constructed, would complete the four-lane divided road program.

The project would be jointly funded by the NSW and Australian governments.

The project does not include the Pacific Highway upgrades at Glenugie and Devils Pulpit, which are located between Woolgoolga and Ballina. These are separate projects, with Glenugie now complete and Devils Pulpit under construction. Altogether, these three projects would upgrade 164 kilometres of the Pacific Highway. The project does include a partial upgrade of the existing dual carriageways at Halfway Creek.

A more detailed description of the Woolgoolga to Ballina Pacific Highway upgrade is found in the Pacific Highway upgrade: Woolgoolga to Ballina Environmental Impact Statement prepared by Roads and Maritime in December 2012.

1.2 Purpose and objectives

This plan identifies the potential impacts of the upgrade on an endangered coastal emu (*Dromaius novaehollandiae*) population and outlines the most appropriate mitigation and monitoring actions to be undertaken to address the long-term survival of this species in the relevant areas of the W2B upgrade.

The objectives of the management plan include to provide:

- An effective coastal emu management plan with consideration to the concerns of key stakeholders.
- A summary of the locations where the endangered coastal emu population would be likely to be impacted by the project.
- Management and mitigation measures that would be implemented during pre-construction, construction and operation of the project to minimise impacts on the coastal emu population.
- A monitoring program to be implemented pre-construction and during construction and operation of the project to assess changes to habitat usage to identify if this is a result of the project and to monitor the effectiveness of the mitigation measures provided for these emus.
- Outline an adaptive management framework based on specific goals for mitigation, appropriate monitoring of the performance of these measures against the goals and the identification and implementation of corrective actions to improve mitigation where required. Where shortfalls from the mitigation and adaptive management are identified appropriate provisional and offset measures would be implemented.

1.3 Management structure and plan updates

Management structure

This species management plan provides a framework for any part of the proposed upgrade between Woolgoolga to Ballina. This plan would be updated during detailed design or pre-construction stage of any proposal that may affect threatened species relevant to this plan. The final management plan would be specific to the project section, stage, program of works or singular element of infrastructure which makes-up the overall Woolgoolga to Ballina upgrade. The plan would operate in conjunction with the Construction Environmental Management Plan (CEMP) and project specific flora and fauna management plan (FFMP), or may be incorporated into a wider framework that includes such plans.

Roads and Maritime would finalise this plan in consultation with the NSW Department of Planning and Infrastructure (DP&I) and NSW Office of Environment and Heritage (OEH).

General responsibilities for environmental management would be outlined in the CEMP and FFMP. Responsibilities for implementation of this plan have been described throughout and summarised in **Chapter 8**. Following approval of the plan, the construction contractor and the contractors ecologist engaged for the relevant project sections would be responsible to oversee implementation of the plan

Plan updates

The plan is intended to be a dynamic document subject to continual improvement. The management plan would be updated as required to meet the mitigation and management measures committed to in the EIS and PIR reports and any Condition of Approval (CoA) for the project. Prior to implementation, the plan would be updated following independent expert review to incorporate any necessary changes that arise from that review. The process for the update of the plan is illustrated in **Figure 1-1** below.

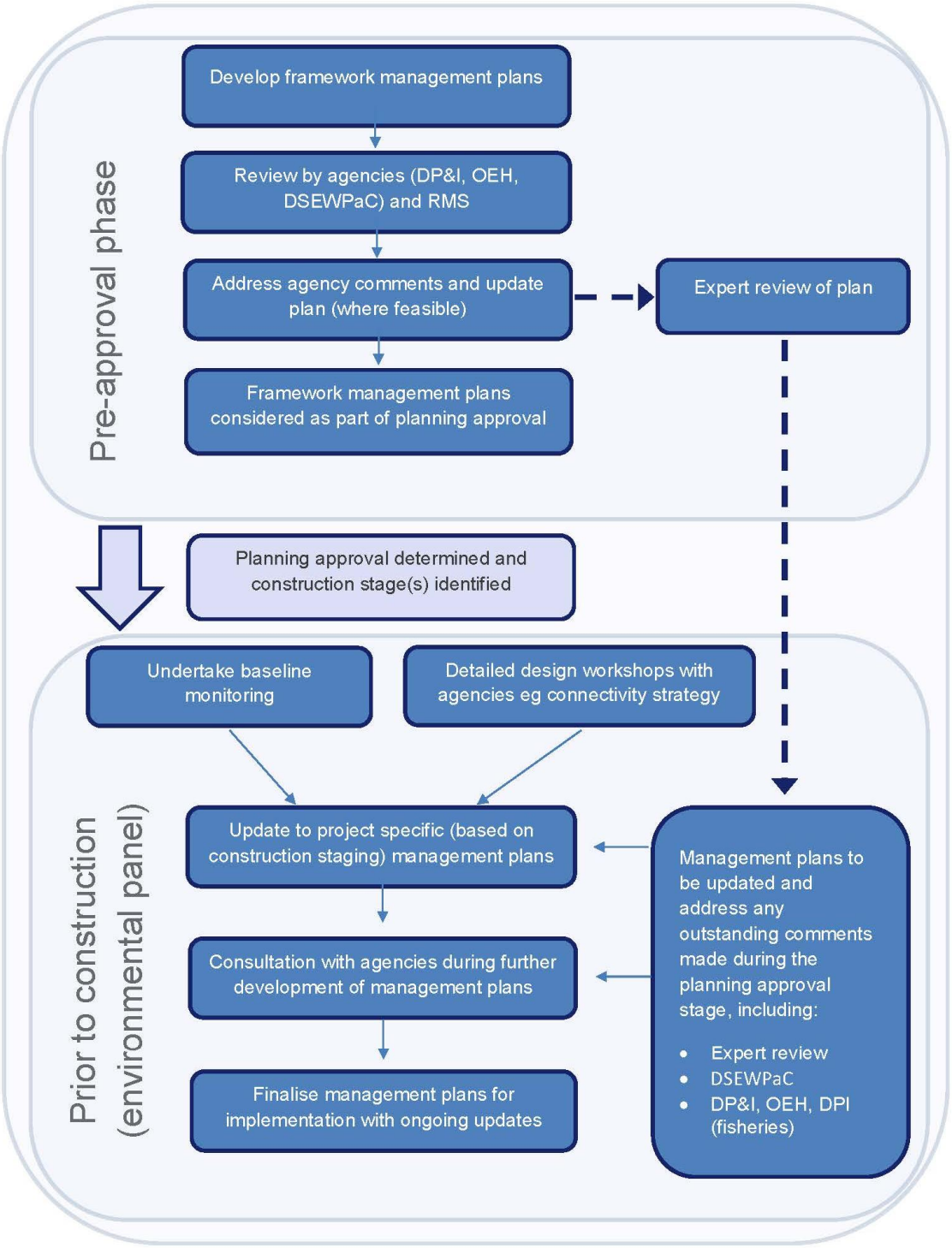
This plan identifies the general locations proposed for conducting monitoring and the methods, variables and timing of the proposed monitoring program. Details have been provided on the parameters for the selection of the final monitoring sites, both impact and control sites. It is not possible to pre-select the monitoring sites at this point in the planning and design process, as this requires consultation with affected landowners. The final selection of monitoring sites would be subject to further interrogation through the implementation of baseline surveys (refer to section 4.3.2) and confirmation of landowner access and would be presented in the first annual monitoring report with the intention of repeated sampling to be conducted at these locations.

1.4 Plan authors and peer review

This plan was prepared based on surveys, landowner interviews and the outcomes of a series of workshops held with OEH, specifically personnel involved with monitoring the coastal emu population over the last 10 years and wildlife carers experienced in handling wild emus. Other specialists consulted included researchers with experience in monitoring cassowaries in northern Queensland and Senior Veterinarian and wildlife handlers from Taronga Zoo.

The plan was prepared by Chris Thomson who is a Senior Ecologist with a Bachelor of Applied Science and Graduate Certificate in Natural Resources with seventeen years professional experience in the fields of ecology and natural resource management. He is experienced in the design and implementation of ecological monitoring programs, fauna surveys, threatened fauna management plans and ecological impact assessment. Chris has considerable experience assisting developing outcomes to meet project specific Conditions of Approval in relation to managing and monitoring impacts on biodiversity for large scale infrastructure projects. This includes the preparation and implementation of species specific management plans and monitoring programs. In particular Chris has comprehensive knowledge of fauna monitoring programs, having coordinated numerous targeted fauna surveys and monitoring programs throughout the Northern Rivers, Riverina, the ACT, Sydney region and the Hunter Valley.

Figure 1-1 Process to develop management plan



Chris has been conducting surveys and preliminary research on the Yuraygir coastal emu population over the past several years and associated with the Pacific Highway upgrade. This has involved extensive consultation with experts, local ecologists, rangers, wildlife carers and landowners with knowledge of the coastal emu population. Preliminary research has been conducted in collaboration with a range of scientists and experienced personnel and has included investigations into factors affecting emu-vehicle collisions in coastal areas and pilot studies investigating the use of anaesthesia procedures on emus, a trial on the use of GPS tracking technology for coastal emus and methods for collecting DNA samples from emus.

Expert review

An expert review of the plan was undertaken in August 2013 by Professor Stephen Davies. Stephen Davies has been a professional scientist since 1964 and has specialising in Ornithology. As well as an outstanding career as a CSIRO research scientist from 1964-84, Stephen has extensive experience as an academic, lecturing and developing courses in, for example, wildlife management, vertebrate biology, and land care revegetation. As president of Birds Australia, he produced the original Atlas of Australian Birds, a first for Australian ornithology.

Stephen has been the author on about 150 scientific publications, reports and books on Ornithology, this includes the primary author or contributor to four books about emus and seven peer reviewed scientific journal articles on emu biology and ecology.

Curriculum vitae which contains a list of published work on emu's for Stephen Davies is provided in Appendix A, and a copy of his review is provided as Appendix B. The recommendations provided in this review have been summarised in Table 1-1. The table also identifies how each of the recommendations have been addressed. Recommendations have been addressed in one of three ways:

- Adopted - plan updated.
- Adopted - plan to be updated prior to implementation.
- To be reviewed - recommendation to be reviewed further by Roads and Maritime prior to implementation.

Table 1-1 Summary of recommendations from the expert review and how addressed in this plan

ID No	Recommendation	How recommendation would be addressed
CeMP1	It would benefit the monitoring program to fly (about 400 feet above the ground) one or two hour surveys over the flood plain and along the coast in the pre- and post-breeding seasons to complement the land–based monitoring.	Adopted- plan updated.
CeMP2	Emus can be controlled by normal rabbit proof fencing with three barbs on top, giving a total height of 1.3 metres. There is no need to have solid fencing as in emu farms, but a vehicle track along the fences will help emus to move along it. I recommend that an exclusion fence of similar design be used along the alignment.	Adopted- plan to be updated prior to implementation

2. Coastal Emu population

2.1 Background

The *Coastal Emu population in the NSW North Coast Bioregion and Port Stephens Local Government Area* is listed as endangered population under the NSW *Threatened Species Conservation Act,* 1995.

The coastal emu population currently consists of three sub-populations, all in northern NSW, the largest located south of the Clarence River and two smaller populations north of the river. Since the listing on the TSC Act in 2002, information on the size and distribution of two sub-populations as well as the clustering of records has expanded. This has largely occurred due to the efforts of a small number of land managers from OEH: National Parks and Wildlife Service (NPWS) coordinating annual community-based surveys. This information has been used to augment the established scientific data on habitat preferences, diet and current population threats presented in this section. Details on breeding locations are not known, only some movements during breeding and non-breeding periods.

Table 2-1 describes the current status of the three documented sub-populations and their proximity to the project.

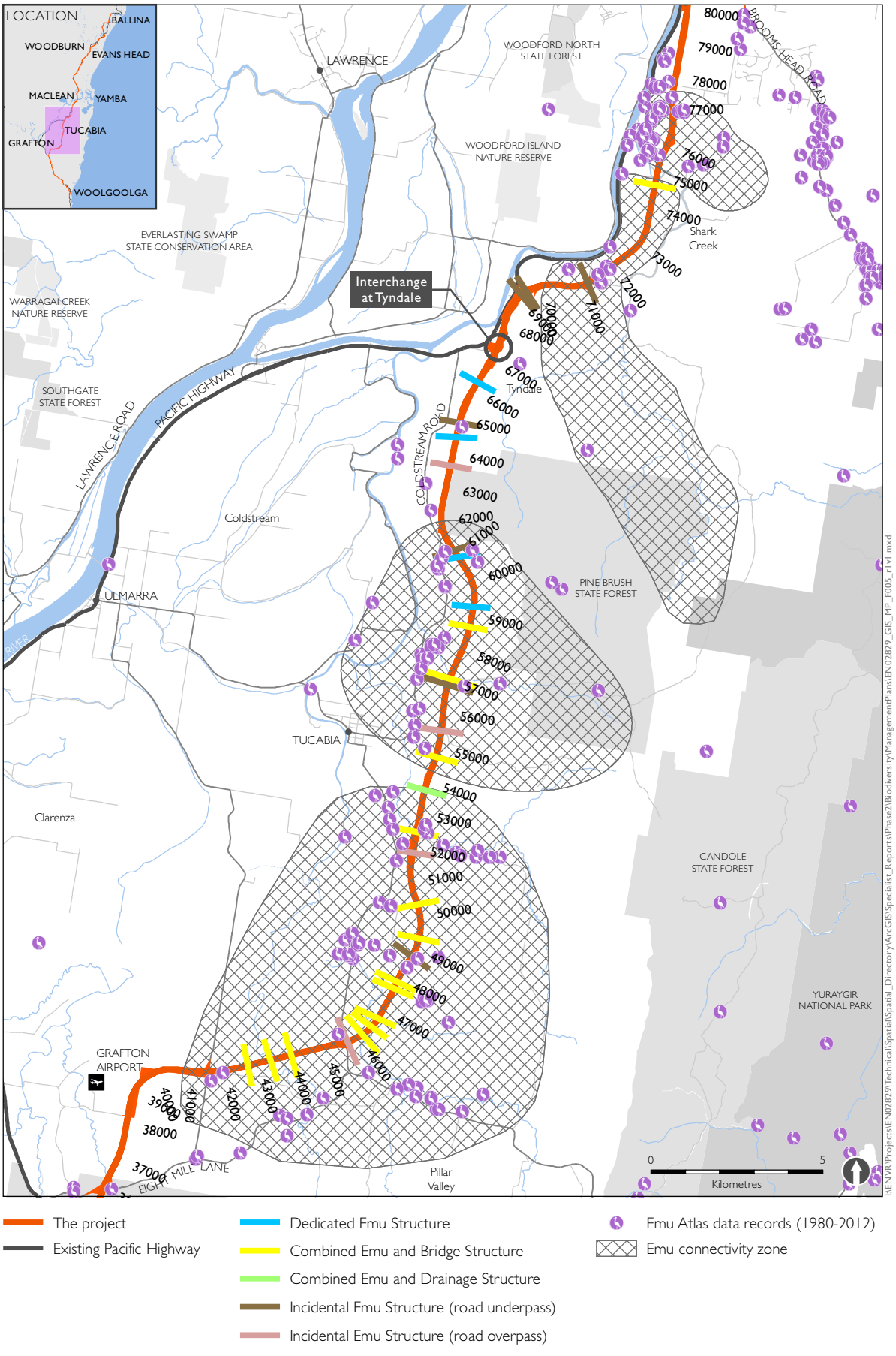
Table 2-1. Details of three described sub-populations in the mid-north coast (source NPWS annual survey results 2002-2012)

Sub-population and range	Predicted sub-population size	Intersection with project corridor
Yuraygir sub-population: South of the Clarence River including Yuraygir National Park and surrounding landscape such as Clarence River floodplain north to Gulmarrad-Maclean, and south to Red Rock through low hills and floodplain.	Largest group estimated at between 80-120 individuals from counts over the last 10 years.	The range and habitat of this sub-population intersects with proposed Sections 3 and 4 of the upgrade.
Bundjalung sub population: North of the Clarence River, largely over Bundjalung National Park from Iluka to Evans Head.	Smallest population, only 20 birds estimated in 2006. No emus counted in 2010-2013 censuses, current population unknown and considered possibly extinct.	Not directly affected.
Bungawalbin sub-population: North of the Clarence River and south of the Richmond River. Ranges over Bungawalbin Nature Reserve and National Park, main camp and surrounds.	Estimated at < 60 birds.	Not directly affected, existing highway may be a barrier to connectivity with Bundjalung sub-population.

This plan focuses on the larger Yuraygir sub-population which occupies the coastal strip of Yuraygir National Park to the east of the project, as well as, surrounding contiguous areas in the Sandon and Brooms Head area in the north to Minnie Waters and Red Rock in the south and Tucabia, Tyndale and Shark Creek to Pillar Valley and the lower Clarence River wetlands in the west.

Figure 2-1 below shows the location of the Emu records and connectivity structures in relation to the project.

Figure 2-1 Emu records and connectivity structures



2.2 Existing knowledge

2.2.1 Social groups and range

Knowledge on group movements and their range for the Yuraygir sub-population were based on interpretation and discussion of the annual emu census results from NPWS land managers (Gina Hart NPWS and Matt Clarke formerly NPWS *pers comm.*) and interviews with long-standing property owners in the Pillar Valley, Tucabia and Tyndale area. The anecdotal data suggests that the population is divided by a number of social groups that show fidelity to particular areas and habitat that support important pre and post-breeding life-cycle events. The degree of relatedness and interaction between the groups is not known. The assumptions regarding site fidelity by apparent sub-groups discussed below has not been rigorously investigated.

The majority of the sub-population is centred on Yuraygir National Park including Station Creek to Red Rock, Wooli, Diggers Camp, Minnie Waters, Sandon, Sandon River, Brooms Head, Wooloweyah, James Creek and Taloumbi. These groups range over a considerable distance from the project corridor to the east, north and south with the exception of an additional two groups, which have been predicted to be impacted by the project between the Glenugie Upgrade and Maclean (Sections 3 and 4 of the project). The latter groups include:

1. One ranging within the area south of Tucabia from the Coldstream River wetlands in the west to Pillar Valley and Yuraygir National Park in the east (Section 3 of the project).
2. A second group that is largely found on the agricultural land and forests between Pine Brush and Candole State Forest in the south, Tyndale Swamp and north to Shark Creek and Green Hill and the cane farms around Shark Creek including Byrons Lane and McIntyres Lane at Tyndale (includes portions of Section 3 and 4 of the project).

These two groups frequently access floodplain wetlands and creeks such as Chaffin Swamp and Pillar Valley Creek. They utilise modified agricultural habitats during pre- and post-breeding activities in spring and summer with the cane fields frequently occupied by adult males raising young. There is limited evidence suggesting that nesting occurs above the floodplain further east of the project corridor, for example Chaffin Hill and may extend to the eastern foothills of the Sommervale Range. There has been no reported nesting within the project corridor, however potential habitat occurs and nests have been found in cane fields in other parts of their range (Kerry Cranney pers.comm).

Congregations of emus reportedly occur in mid-autumn to winter prior to nesting and at this time social flocks of breeding birds are often observed in floodplain and agricultural paddocks (Plate 1). The occurrence of such groupings indicates that the birds may travel reasonable distances, as most emu sightings at other times are usually of solitary adults, or of birds in small family groups (Plate 2).

Plate 1. Congregation of breeding Emus in grazing land (pre-nesting)

Plate 2. Small Emu family grazing in sugar cane paddocks (post-breeding)

2.2.2 Breeding

Anecdotal information on breeding activities suggests that breeding occurs in four broad areas:

1) Station Creek to Red Rock River (south).
2) Wooli - Diggers Camp - Minnie Water - Sandon River (central).
3) Brooms Head - Sandon River - Candole State Forest - Wallaby Lane (north).
4) Pillar Valley around Chaffin Hill and Whites Hill in the western edge of their range (west).

The first three of these areas are in the eastern part of their range within 10 kilometres of the coast and several kilometres from the project. Breeding is evidenced by the presence of young chicks in winter and anecdotal evidence of nest sites in these locations. The full extent of areas used for breeding is not known, as breeding localities have only been identified based on family groups with striped chicks in July to September. These observations may be also skewed as they correlate to coastal villages, public lands and roads where there are more opportunities for viewing emus and their behaviour.

Based on anecdotal evidence, there are no confirmed breeding sites west of the project in the low-lying flood prone areas, and the limited observations of nest sites being reported to the east of the project in higher elevated lands. In the absence of comprehensive surveys it should be assumed that nesting habitat would also be isolated. Emu nests have been located in cane fields in other parts of their range near Brooms Head (Kerry Cranney pers.comm) and there would be potential for birds to nest in cane fields around Shark Creek (Section 4 of the project).

2.2.3 Habitat use

To support the life-cycle activities of feeding and drinking, breeding and nesting, the emus appear to depend on a mosaic of vegetation types including both natural and modified habitats. This includes open forest, heath, woodland, agricultural land (grazing and cropping land), grasslands and wetland fringes. Open paddocks, grazing land and crops are important habitats during both the pre-breeding phase, as social groups gather in these locations, and post-breeding phases for rearing young.

2.2.4 Diet and water requirements

There has been limited study on the diet and water requirements of coastal emus, albeit for an earlier dietary study on the Bungawalbin sub-population (McGrath and Bass 1999). Studies on Emus in open plain habitats in Western Australia indicate that at all times the birds are semi-nomadic, keeping in touch with variation in availability of food (Davies 1978; 1984). Emus are omnivorous relying on insects, seeds, fruits and succulent vegetation (Dawson *et al* 1983) which may include both native and exotic plant species in coastal areas (McGrath and Bass 1999). In any locality in a particular time of year emus exhibit clear food preferences (Davies 1976) a factor which is associated with the typical sporadic and seasonal occurrences of fruits and seeds and this may partly explain their semi-nomadic behaviour and need to travel long distances to access available food sources. In their study of emus in arid landscapes Dawson *et al* (1983) recorded regular daily movements of 10-12 kilometres in autumn and 18 to 25 kilometres in summer reflecting the spatial availability of food. The daily movements and length of travel of the coastal emus is not known however genetic data taken from across the sub-populations range indicates that there is considerable mixing between groups.

The emu's ability to transport many large seeds over long distances could prove an important link between fragments of remnant vegetation by helping to maintain the genetic mix in plant communities (McGrath and Bass 1999). Information obtained from landholder surveys in the Pillar Valley, Tucabia and Tyndale area indicate that the birds regularly feed on crops, in particular soy beans and lablab beans as well as young growth on burnt grass or soft wetland plants. Emus have been observed eating fruit from Bangalow Palm, Native figs and Inkweed and seeds from native sedges and gramminoids (*Gahnia* and *Lomandra* spp.).

The water requirements of adult emus do not appear high but intake may be limited by the size of the simple gut, resulting in a relatively high frequency of drinking, once per day and occasionally twice per day during hot summer conditions (Dawson *et al* 1983). Drinking rarely occurs during incubation. These data may support the hypothesis that the floodplain wetlands and creeks are critical to emu movements due to the regular supply of water, and the fact that they would be important year round, but particularly in the warmer months.

Evidence in western populations suggests that emus show a high fidelity to particular watering sites which may include artificial dams (Dawson *et al* 1983).

2.2.5 Movements

Emus are semi-nomadic moving in response to the availability of food and water resources. Seasonal access to frequented habitats may be via regular but broad movement pathways across the landscape. Prior to the EIS, there has been no study on the movements of the Yuraygir sub-population in the Clarence Valley and data on movements was based on observations collected as part of the NPWS annual survey. Further work for the EIS looked at targeted scat and feather collections as part of a genetic study as well as anecdotal information from landowner interviews. From the collation of all this data several main emu movement areas were assumed based on regular sightings at the same locations and include:

- Pillar Valley across Wooli Road at Whites Bridge (Pillar Valley Creek) and also south towards Coldstream Wetlands (Section 3 of the project). Congregations of emus have been reported several times on the western side of Tucabia Road around Whites Bridge.
- Sommervale Flats and Tyndale Swamp north to Shark Creek (east and west side of the creek) and north and south of Byrons Lane (Sections 3 and 4 of the project)
- Brooms Head to Green Hill and McIntyres Lane (Section 4 of the project).

The incidence of broad movement pathways suggests that any crossing structures targeting this species need to be closely spaced with multiple structures needing to cover a broad distance. Emus are often observed moving along vehicle tracks and frequent lightly wooded areas and clearings through forest and woodland particularly where they provide access through dense forest and heath, such areas may provide suitable locations for crossing structures or additions to crossing structures.

A pilot study was conducted by Roads and Maritime to determine if GPS-based telemetry data logging devices could be successfully used for monitoring emu movements and secondly to trial a field-based anaesthesia procedure for sedation and handling of emus so that devices could be attached. A secondary objective was to gain insight into the movements and behaviour of captive-reared emus released into the wild population. The data provided insight into the movements of captive-reared and released emus and identified and confirmed threats to their survival including encounters with barbed wire fencing and wild dogs. Monitoring showed wide dispersal, the use of clearings in remnant vegetation and farm land as well as natural habitat, with movements often associated with fence lines.

2.3 Population decline and threats

The decline of the coastal emu population is attributed to contracting range and fragmentation of sub-populations due to land development, agriculture and fires (NPWS 1995). Other threats include attack and predation from wild dogs, as confirmed from the radio-tracking study and collisions with vehicles. Over 60 road fatalities have been reported for the coastal emu population in the last 10 years. Other threats include:

- Risk of local extinction due to small population size and isolation.
- Clearing and fragmentation of habitat for agriculture and urban development.
- Burning of habitat at too frequent intervals.
- Disturbance of nesting birds and predation of birds and young by foxes, dogs and feral pigs.
- Deliberate killing by poisoning and shooting.

The current evidence suggests that the Bundjalung sub-population may have succumbed to a combination of these threats, exacerbated by intense wildfires.

There is no published information on the frequency of vehicle-collisions with emus. In their review of reported animal collisions between 1996 and 2005 throughout western NSW, Ramp and Roger (2008) identify 30 incidents involving emus. Within the range of the coastal emu population on the mid north coast, the NPWS and Clarence Valley WIRES group have logged 60 emu vehicle-collisions between 2000 and 2010 on local roads in the Minnie Waters, Clarence Valley and Iluka areas as a result of fatal collisions with vehicles.

The instances of vehicle collisions with emus in the Clarence Valley can be put into two categories: either, (a) the widespread instances of irregular road kill of single birds, or (b) localities where both multiple road kills occur (usually several chicks from a family group) and/or emus are killed on a regular (annual) basis.

A study of emu-vehicle collisions was reported in the EIS and found emu road-kill sites were typically:

- Where mature forest was present along the roadway (within 10 metres of mature comprising 6-50 per cent canopy cover), as opposed to cleared landscapes and open farmland.
- On single lane dirt roads or larger sealed rural roads.
- Where there was no fence between the forest edge and the road.
- Where there was vegetation two metres or taller within five metres of the edge of the road.

The road speed limit, adjacent speed limits, road gradient, type or condition of paddock fences, shrub and groundcover were identified to not be influential in typical emu road-kill locations.

3. Potential impacts and management approach

The following chapter provides a brief overview of the potential impacts to the coastal emu population with reference to the more detailed impact assessment presented in the EIS Biodiversity Working Paper. It describes the potential impacts to the species at specific locations along the upgrade and during the pre-construction, construction and post-construction (operational) stages of the project. The mitigation approach presented in the EIS and documented in **Chapters 4** to **Chapter 6** of the management plan target the predicted impacts.

3.1 Potential impacts associated with the project

Loss of habitat, fragmentation and barrier to movements

The population consists of small numbers of emus that occupy a broad landscape mosaic of both natural and modified habitats. Being predominantly nomadic, non-breeding birds move from place to place without regard to season or direction and depend on resources that occur rarely at the same site. A continuity of resources can be ensured only if birds are able to locate successive favourable areas that are often spatially separated (Davies 2007). In areas where environmental conditions are regular, the movements of emus can appear regular but the birds are still influenced by the same suite of behaviour patterns as are birds in environments that are less consistent (Davies 2007).

Based on the distribution of emu records for the Pillar Valley to Shark Creek group, the evidence suggests that the relatively stable environmental conditions associated with the floodplain wetlands and swamps of the Coldstream River, Chaffin Swamp, Champions Creek, Pillar Valley Creek, Tyndale Swamp and Shark Creek including the associated agricultural land, support reliable food and water resources, both spatially and temporally. These habitats account for observed movements in the pre and post breeding life-cycle periods of birds. The wetlands are currently contiguous with the forest and heath communities to the east of the floodplain via relatively natural and modified habitats, albeit for a network of smaller roads, such as the Tyndale-Tucabia Road, continuing to the coastal lands of Yuraygir National Park and surrounds.

The project in the eastern extent of the lower Clarence floodplain (Section 3 and 4 of the project) would effectively skirt around the Coldstream wetlands, eventually crossing Pillar Valley Creek, Chaffin Creek, Champions Creek and Shark Creek and therefore introduce a physical barrier for emus accessing these important wetland habitats from the east.

Therefore, the impact to the population from the project would include the direct removal, fragmentation and isolation of important habitat. This factor combined with the increased risk of vehicle strike associated with the project, adding to the existing mortality from vehicle strike on local roads, has potential to have significant long-term impacts associated with a cumulative reduction in the population leading to loss of viability. The project would have the greatest impact on the group ranging the Pillar Valley to Tyndale area. The degree of relatedness and interaction of this group to the other identified groups extending to the coast is not known.

Impact of fences

Fauna exclusion fencing is used effectively on other Pacific Highway upgrades for a range of fauna, however there has been no study into the effects of using this fence type on wild emus and it is unknown if the currently used fauna exclusion fence design would be effective in directing emus to crossing locations.

Based on discussions with property owners in the region emus are known to pass easily through rural three strand wire fences including barbed wire stock fences. Although, captive-reared emus released into the wild have difficulty negotiating barbed wire fences. There is also anecdotal evidence to suggest that emus have trouble finding open gates in paddocks suggesting it is difficult to distinguish between wire fences and openings and this may affect their movements.

The provision of exclusion fencing on the project would reduce the number of crossing points needed for emus by channelling birds to the designated crossing points. However, there are issues with placing fences in flood prone areas and as is the case near some bridge crossings and also issues preventing cattle exiting private properties but allowing emus to cross through fences to facilitate natural movements to habitat east and west of the project.

The fences should also incorporate vertical gaps that are intended to allow emus 'trapped' in the carriageway to run along the fence and be directed through the gap. Given there has been no monitoring of the fencing it is unclear whether the vertical gaps would be effective. It would be possible for the birds to walk along a fence until they come to a break in it, rather than use the underpass structure, although this needs to be tested. An appropriate emu fence is yet to be designed and properly assessed for efficacy.

3.2 Detailed design considerations

A number of factors were considered in identifying the key connectivity zones for emus and the types of crossing structures incorporated into the concept design for emus, with the aim of developing these further at the detailed design stage. The factors considered in located and sizing structures included:

- The known distributional range of the Yuraygir sub-population, including all known records of sightings and anecdotal evidence provided by rangers from OEH and land owners.
- The distribution of known habitats and in particular the location of the floodplain wetlands and connectivity of the surrounding landscape to these.
- The body size of the emu standing to 2 metres (bridges were raised to accommodate emu movements rather than minimum hydrology requirements and would not be lowered).

Detailed design in Sections 3 and 4 of the project would consider the appropriate design and location of emu exclusion and directional fencing taking into consideration flood prone areas and the need for escape gates should emus become trapped in the road reserve and strategic emu revegetation measures. Consideration would also be given to fence design around bridges design to exclude domestic stock from exiting a property boundary but allowing emus to pass through and continue to the road crossing point.

It is currently proposed to use the standard 'floppy-top' fauna fence in combination with other a trial of measures in flood prone land which may include wide densely vegetated strips in the road reserve in combination with rural fencing. Given the possibility for emus to enter the road corridor over the life-time of the project, strategic escape points or gates would be required. In some locations boundary stock fencing would be required parallel to bridges that have been targeted as underpass crossing points for emus. Detailed design of purpose built emu gates or openings would need to be trialled to monitor their effectiveness and the results used to adapt fence structures if proven ineffective.

3.3 Mitigation and monitoring

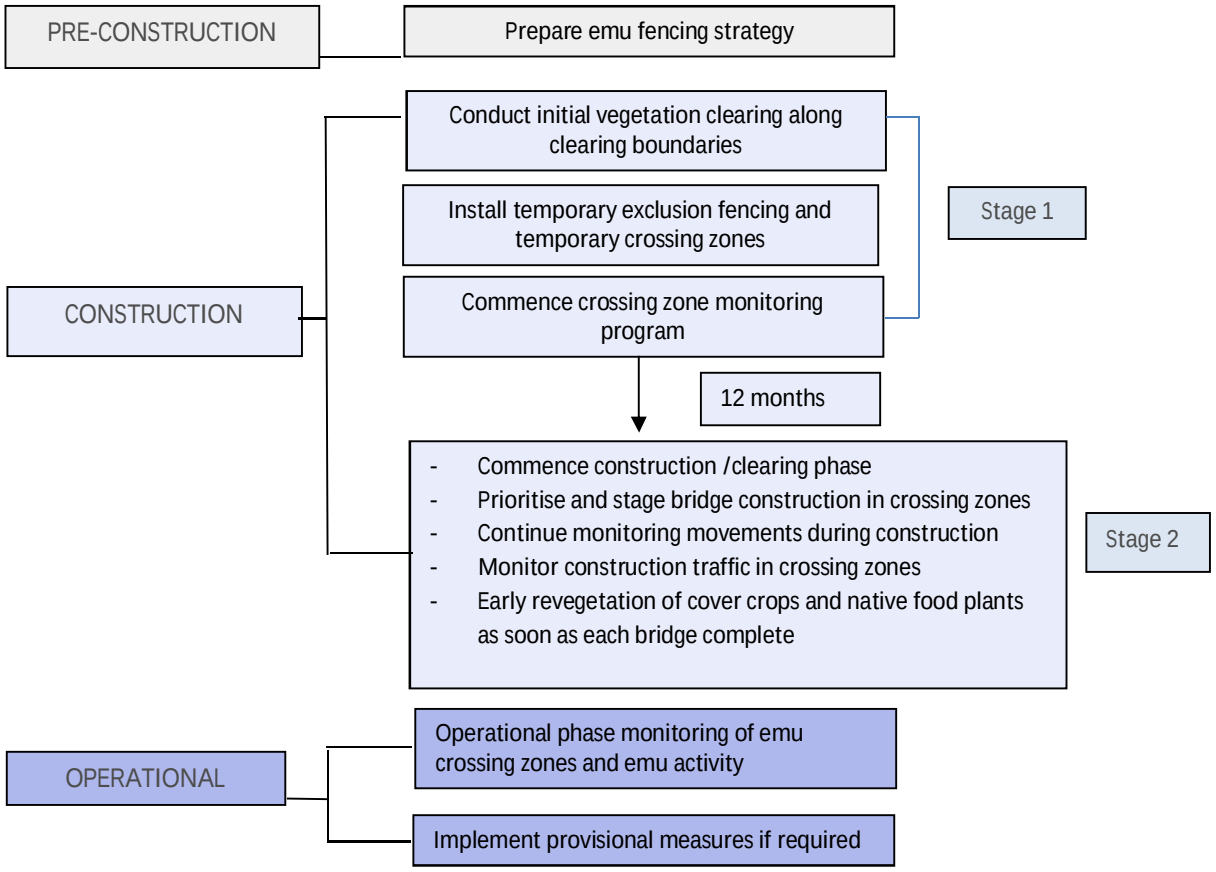
A number of measures to mitigate and monitor the impact of the project on emus during construction and operation of the project were identified in the EIS Biodiversity Working Paper. In general these measures related to:

- A targeted connectivity strategy.
- Provision of exclusion fencing, including physical and planted directional fencing.
- Avoiding impacts to emu habitat outside the road footprint during construction.
- Developing an emu find procedure for dealing with emu encounters during construction.
- Providing and trialling attractants to emu crossing points including food plants and other measures
- Re-establishment of emu habitat at approaches to emu crossing structures.
- Develop a monitoring program to monitor impacts on the population and the effectiveness of mitigation measures and incorporate adaptive management actions where impacts are noted.

As a minimum the design of emu targeted crossing structures and fencing would be based on the design principles outlined in the EIS and the process for managing emu connectivity requirements described in the Biodiversity Connectivity Strategy. This includes a comprehensive monitoring program and the inclusion of precautionary options.

The proposed approach to management of potential impacts to the emu population throughout the pre-construction, construction and operational phases is illustrated in **Figure 3-1** below. The management plan addresses these issues in more detail in the following chapters.

Figure 3-1. Proposed staging of management measures



3.4 Effectiveness of mitigation measures

Crossing structures and fencing

Providing continued access to the floodplain wetlands is considered critical to the survival of the emu population as is preventing road fatalities on the future highway. In theory access can be provided via appropriately placed and adequately sized crossing structures (i.e. bridges and culverts) in addition to exclusion fencing, which should also act as directional fencing leading to the crossing structures. However, there would be a risk in this approach in that it relies on efficacy of these mitigation measures when there is no current scientific evidence to indicate that wild emus are capable of finding and using crossing structures or can be directed by fencing. In the absence of scientific certainty the benefit of providing crossing structures remains to be proven. There is a need to collect evidence to improve our confidence in this as a mitigation strategy adequately prediction can be made regarding the impact of the project on the Yuraygir sub-population. This includes a comprehensive monitoring program and the inclusion of precautionary options if the crossing structures and fences are proving to be ineffective.

Fauna exclusion fencing has been used effectively on other Pacific Highway upgrades, however there has been no study into the effects of fencing on wild emus and it is unknown if the currently used design would be effective in directing emus to crossing locations. Exclusion fence monitoring would be implemented during pre-construction and continue during construction and operation, further details are provided in **Chapter 7**. Typical chain mesh 'fauna fence' would be used in strategic areas however may not be appropriate in flood prone areas and where stock fences are more practical. Additional mitigation may include fauna fences on batter slopes.

Other measures to prevent emus from entering the road corridor may include gabion walls or electric fences where rural stock fencing is used. Escape gates would be designed in the exclusion fencing to allow emus trapped in the road corridor to escape.

For consideration, in the emu husbandry industry minimum guidelines for fence design are typically 1.9 metre high chain mesh fences, gate openings are a minimum of two metres in width and fences to corral emus can incorporate hessian or shade cloth along the mesh to prevent emus from seeing through as this assists in calming and herding animals (Agricultural and Resource Management Council of Australia and New Zealand 2003). This information suggests that the standard floppy-top fence or similar tall chain mesh fence may be suitable for preventing emus from entering the road corridor and that shade cloth be used on the fence for a suitable distance either side of a crossing location to assist emus to find the structure however this approach would be trialled and monitored.

General measures

A summary of the proposed emu specific mitigation measures and evaluation of their effectiveness based on past experience with other highway upgrades is described in **Table3-1**.

Table 3-1. Mitigation measures and evaluation of their effectiveness

Issue	Mitigation measure	History of success	Effectiveness rating
Emus are curious of new activities and may enter the construction area.	Exclusion fencing to exclude emus from the construction corridor.	Temporary and permanent exclusion fencing used on all Pacific Highway upgrade over the last 10 years.	Moderate, monitor success and implement corrective actions.
	Develop and implement an emu finds procedure.	Procedure has been developed by Roads and Maritime for unexpected finds such as threatened species, and has been adopted as part of the CEMP for multiple projects.	Unknown, monitor success and implement corrective actions.
	Pre-clearing and clearing procedures.	A standard procedure has been developed by Roads and Maritime and documented in the Biodiversity Guidelines for Construction (RTA 2011). The guidelines were developed in consultation with the NSW Office of Environment and Heritage (OEH), NSW Department of Primary Industries (DPI) (Fisheries), biodiversity specialists and Roads and Maritime staff including project managers, construction personnel and designers. Consultation was facilitated through a number of workshops carried out in 2009. These procedures have been developed using knowledge gained from a long history of upgrades on the Pacific highway and other road projects in NSW.	High
Potentially lengthy disruption to emu movements during construction.	Provide access for emus crossing corridor during construction and stage construction through priorities at bridge sites.	Bridges have been prioritised on other projects and this is a feasible approach. Traffic control used on all upgrades by Roads and Maritime to account for local traffic and screening of construction areas. This same method could be adapted for emus.	Unknown, monitor success and implement corrective actions.
Impact to emu habitat outside the construction zone.	Identify exclusion zones and limits of clearing. Revegetation of lands adjacent to the corridor post construction.	Standard procedures have been developed by Roads and Maritime and documented in the Biodiversity Guidelines for Construction (RTA 2011). The guidelines were developed in consultation with the NSW Office of Environment and Heritage (OEH), NSW Department of Primary Industries (DPI) (Fisheries), biodiversity specialists and Roads and Maritime staff including project managers, construction personnel and designers. Consultation was facilitated through a number of workshops carried out in 2009. These procedures have been developed using knowledge gained from a long history of upgrades on the Pacific highway and other road projects in NSW.	High
Domestic dogs brought on site by contractor could lead to dog attack.	CEMP to document dog policy.	A standard policy used successfully on all highway upgrade by Roads and Maritime.	High
Emu-vehicle collisions on the highway.	Permanent exclusion fencing and escape gates or escape points.	Permanent fauna exclusion fencing has been used on multiple sections of the Pacific highway to exclude fauna and direct to crossing points. Not been used before for emus.	Unknown, monitor success and implement corrective actions.

Emu-vehicle collisions on the highway.	Maintenance of fences, gates and crossings.	Roads and Maritime routinely conducts maintenance on exclusion fencing along the Pacific Highway both as a standard procedure and in response to a breach in the fence or speight of fauna road kills.	High
Highway creates a barrier to emu movements and access to known habitats, or isolates proportion of the population.	Targeted crossing structures including large arches and raised bridges.	Targeted crossing structures for other fauna have been used on multiple projects in Australia and overseas with high level of success. Raised bridges have been used successfully by cassowaries in north Queensland, however never before targeted at emus.	Unknown, monitor success and implement corrective actions and provisional measures.
Emus attracted to rubbish, or unfamiliar objects around the construction site such as plastic and shiny things.	Waste managed in accordance with procedures in the CEMP.	Roads and Maritime have developed standard procedures for waste management on construction sites as part of the CEMP process with a long history of success as reported in auditing reports	High
Water supply for emus contaminated during construction.	Water quality managed in accordance with procedures in the CEMP.	Roads and Maritime have developed standard procedures for water quality management on construction sites as part of the CEMP process with a long history of success as reported in auditing reports.	High
Increased noise and dust during construction impacting on emu movements and behaviours.	Dust and noise managed in accordance with procedures in the CEMP.	Roads and Maritime have developed standard procedures for water quality management on construction sites as part of the CEMP process with a long history of success as reported in auditing reports.	High
Potential for increased wild dog attack at concentrated crossing zones.	Wild dog control.	Roads and Maritime does not conduct wild dog control. Roads and Maritime would engage with stakeholders involved with predator control to identify actions to assist in minimising attacks as required.	High

3.5 Adaptive management approach

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

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

- **S**pecific.
- **M**easurable.
- **A**chievable.
- **R**esults-based.
- **T**ime-based.

The monitoring program is also adaptive in its approach and details of the proposed monitoring program is described in **Chapter 7** which includes monitoring:

- Change in emu activity in proximity to the project and to the east and west of the project, the methodology includes a Before-After-Impact-Control (BACI) approach.
- The use of crossing zones and crossing structures during pre-construction, construction and during operation of the project.
- The effectiveness of roadside fencing at excluding emus from the road corridor and directing emus to crossing zones.
- The success of emu habitat revegetation.

3.6 Proposed provisional measures

The connectivity strategy provided in the EIS outlined the proposed process for managing emu connectivity requirements. This included monitoring the performance of the connectivity measures against SMART goals as described above. Further information on the proposed monitoring program is provided in **Chapter 7** of this plan.

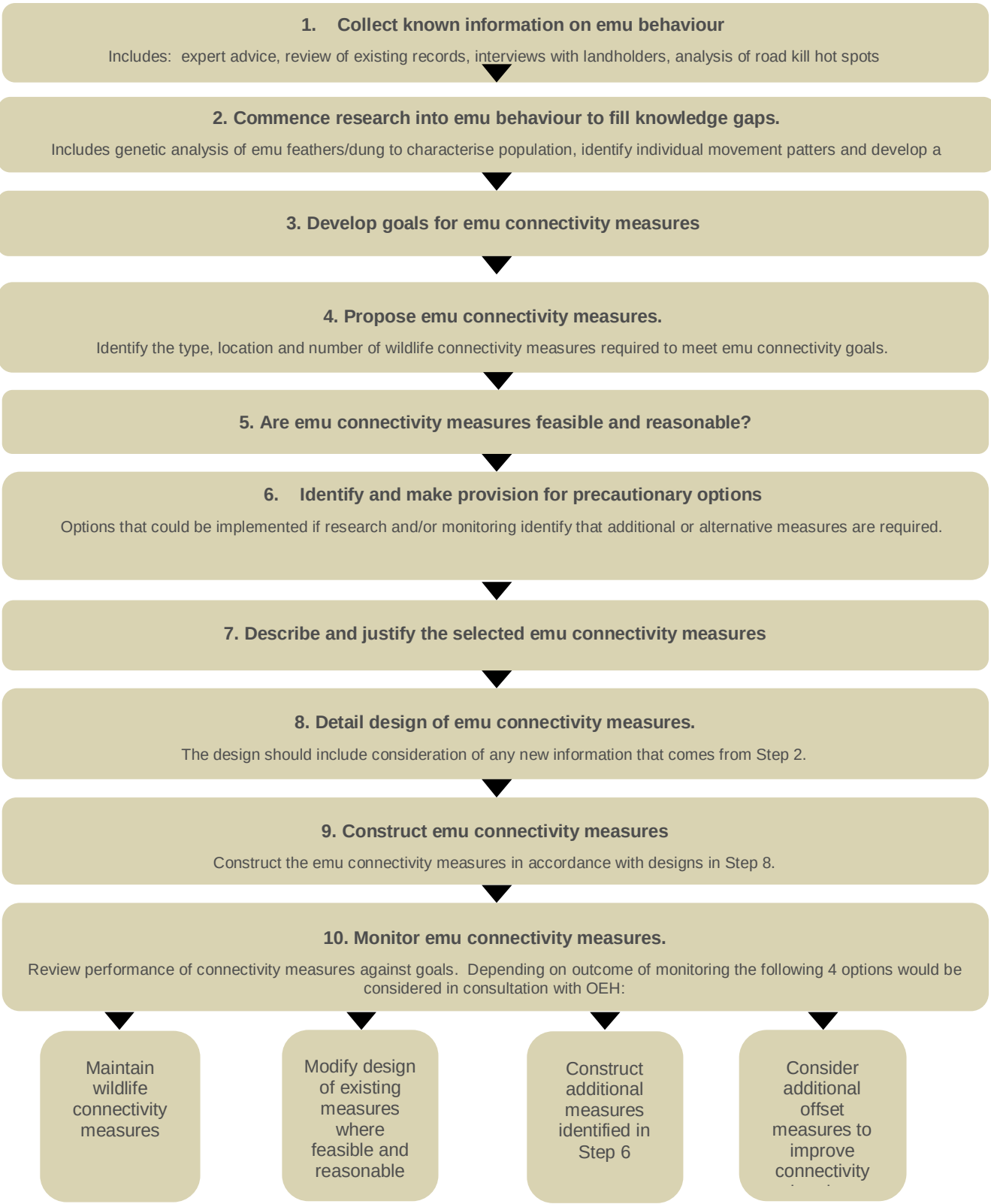
If during the operational phase emus are found to be unable or unwilling to use designated crossing structures provisional options would be developed that could be implemented if research and/or monitoring identify that additional or alternative measures are required.

Depending on the outcome of the monitoring of crossing structures the following four options would be considered in consultation with OEH:

- Maintenance of the existing connectivity measures.
- Modification of the design of existing measures where feasible and reasonable.
- Construction of additional measures.
- Consideration of additional offset measures to improve connectivity elsewhere.

The location of additional measures is still to be decided based on further inputs from the monitoring program and discussions with the agencies, It is noted for now to include an additional structure somewhere between Wooli Road and Sommervale Road in Section 3, subject to further population monitoring.

Figure 3-2. The process for managing emu connectivity requirements



4. Pre-construction management measures

4.1 Potential impacts during pre-construction

- Location of infrastructure within ancillary facility sites including heavy vehicle access may impact on emu habitat, movements, foraging and behaviour.
- Dog attacks to occur inadvertently by bringing domestic dogs onto the worksite.
- Loss of connectivity and access to important habitats during pre-construction.

4.2 Goals for management

- No damage to emu nests in Section 3 and 4 of the project.
- No damage to emu habitat outside of designated work areas within an ancillary facility in Section 3 and 4 of the project during the pre-construction planning.
- No emu deaths from domestic dog attack on the project.
- Emu fencing strategy completed prior to construction commencing.

4.3 Management measures

Details on the site specific mitigation measures for emus to be implemented during the pre-construction phase are detailed here and summarised in **Table 4-1** along with performance thresholds and corrective actions.

4.3.1 Prepare an Emu fencing strategy

The objective of the fencing strategy for Sections 3 and 4 of the project is to develop a strategy for excluding emus from the construction corridor and directing emus to crossing zones as part of earlier education of emus to use crossing zones. The plan would be completed and implemented 12 months prior to construction as discussed in **Chapter 5**. The plan would provide detail on fence types, and specific locations for fencing including fencing at crossing zones perpendicular to the construction corridor. It has been proposed to install temporary fencing at a minimum 12 months prior to construction of Sections 3 and 4 of the project to allow time for emus to become accustomed to crossing areas prior to the bridges being built.

The radio-tracking study proved that emus can sustain injuries from barbed wire fences. The fencing strategy would look to reduce the amount of barbed wire on boundary/stock fences. Current fencing strategy sees a likely fence design having concrete posts, chicken wire, three barbs at top adopting feedback from peer review of the plan. In areas of arboreal crossing zones, the fencing would exclude use of barbed wire on the top strand.

The strategy would focus on temporary fencing during construction and permanent fencing during operation including design and placement of escape points or gates if emus become trapped in the road corridor and also strategic vegetation such as attracting plants at the entrance to crossing points and screening plants to buffer emus from entering the road corridor in flood-prone areas and direct then to escape points.

Temporary fencing would be installed around exclusion zones to indicate the limits of clearing and to prevent emus from entering the construction corridor. Temporary fencing type would be selected in accordance with the Roads and Maritime Biodiversity Guidelines – Guide 2 Exclusion Zones (RTA 2011). For emus it is recommended that temporary fencing include barrier mesh and shade cloth or similar material, be a minimum of two metres in height.

Temporary fencing would be replaced at the end of construction with permanent emu exclusion fencing in significant locations in project (Sections 3 and 4), identified by the detailed design. These would be located at a minimum across much of Sections 3 and 4 with the exception of flood prone areas and along either side of the emu crossing structures to direct emus to key crossing points.

Exclusion fencing would avoid blocking access to waterways and artificial dams which represent potential emu watering points.

Monitoring of crossing points would begin prior to construction and is discussed in **Chapter 7**.

Fauna fencing trial assessment of flood velocities

A trial of fauna fencing would be undertaken prior to construction of the project in Pillar Valley to assess the effect of fencing on the movement of fauna across the project.

As fencing would be installed prior to construction of the project, an assessment has been undertaken to assess potential flood velocities through the fencing in the absence of the project embankment. The inability of fencing to withstand these velocities has the potential to compromise the trial.

The modelled flood velocities across the project during existing conditions were assessed. Modelling results for the two year ARI flood (see **Appendix B**) show that flood velocities through the proposed fenced areas (ie around the project boundary, excluding bridge openings) are predominantly less than 0.5 metres per second, with small localised areas experiencing velocities of up to one metre per second.

Results for the 100 year ARI flood (see **Appendix B**) show that flood velocities through these areas are much higher, with most fenced areas experiencing velocities of greater than 0.5 metres per second, and some localised areas experiencing velocities of up to, and exceeding, two metres per second.

The velocities expected for the two year ARI event are relatively low, and are not considered to present a risk to the operability of the trial. Velocities of greater than two metres per second which may be experienced in the 100 year ARI flood may damage or push over fences and require reinstallation. given that the trial is expected to be in place for no longer than one year and the probability of the 100 year ARI flood occurring in this year is low (about one per cent), the flood risk to fencing due to high velocity flows is considered to be low.

4.3.2 Baseline surveys

Baseline surveys for the coastal emu would be undertaken pre-construction to inform the detailed design and monitoring program. Survey data would be used to inform the detailed design and proposed mitigation measures and possible provisional measures. The baseline surveys would be conducted as described in Section 7.2.

4.3.3 Identify exclusion zones

An exclusion zone is a designated ‘no-go’ area that is clearly identified and appropriately fenced to prevent damage to native vegetation and fauna habitat. This procedure is documented in the CEMP and conducted along the entire construction corridor for all threatened species and endangered ecological communities.

Habitat exclusion zones and limits of clearing in section 3 and 4 would include consideration of emu habitat, which may include natural and modified habitats and potential sources of water. These zones would be established during the on-ground survey of the road corridor and the commencement of construction to ensure that these activities do not remove protected and roadside vegetation in emu habitat areas.

The identification of exclusion zones may be staged with a priority for early works sites and then remaining areas of the construction corridor. Survey personnel would be inducted to ensure they do not encroach outside the limits of clearing.

4.3.4 Identify sensitive ancillary areas and access roads

The siting of ancillary areas including stockpiles and construction infrastructure would be planned and sited in cleared areas and disturbed vegetation to avoid impacts to vegetation contained within the boundaries of the ancillary site. This would occur across all ancillary sites for each stage of the project and would be documented in the CEMP. The procedure would consider avoiding direct and indirect impacts to emu habitat in Sections 3 and 4 of the project.

4.3.5 Dog policy

The CEMP would include a policy that no domestic dogs are to be brought onto the site during pre-construction and construction activities. All construction personnel to be inducted as part of CEMP.

4.4 Performance thresholds and corrective actions

Table 4-1 below summarises the pre-construction environmental planning measures for coastal emus that would be completed prior to the commencement of construction.

Table 4-1. Mitigation measures, performance measures and corrective actions

Main goals for mitigation	Proposed mitigation measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if deviation from performance thresholds
Emu fencing strategy completed prior to construction commencing.	Detail location of temporary and permanent emu fencing, encourage use of crossing points and direct emus from the road corridor.	Emu fencing strategy to be completed and implemented 12 months prior to construction commencing on Section 3 and 4 of the project.	Temporary fences not in place 12 months prior to construction.	Delay construction until fencing strategy complete and temporary fencing in place.
No damage to emu nests in Section 3 and 4.	Pre-clearing process.	Report results in the CEMP/EMS.	Emu nest found.	Inform planning and procedures for the staged habitat removal.
No damage to emu habitat in Section 3 and 4 outside road corridor.	Identify exclusion zones.	Identify clearing limits prior to survey and clearing works to mark and flag exclusion zones. Follow-up inspection after surveying road corridor .	Damage to habitat reported outside limits of clearing in Section 3 and 4.	Supplementary revegetation of disturbed habitat and monitor recovery for period of 12 months.
No damage to emu habitat outside designated ancillary facilities and access.	Construction related infrastructure to be planned and sited within cleared or disturbed areas of the ancillary site. Particularly away from water sources and movements areas.	Detailed plans to be prepared showing the proposed location of construction related infrastructure and signed off prior to commencement of construction.	Plans show facilities located in vegetated areas or outside limits of clearing.	Amend locations if needed until all habitat is shown to be avoided.
No emu deaths from contractors domestic dogs on the project.	CEMP to document policy that prohibits dogs being brought onto the construction site.	Ongoing during construction.	Domestic dog found on site and connected with construction personnel.	Any breach in policy to be reported to EMR and contractors warned and if further breaches would be removed from the project.

5. Construction management measures

5.1 Potential impacts during construction

- Impacts during clearing of vegetation.
- Emus entering the construction corridor and becoming trapped in the corridor.
- Emu-vehicle collisions with construction traffic.
- Loss of connectivity and access to important habitats during construction.
- Disturbance and degradation to adjoining emu habitat.
- Ingestion of wire or plastic waste.
- Contamination or isolation of water supplies used by emus.
- Dust and noise impacting on movements and habitat use.

5.2 Goals for management

- No injuries to emus during clearing of vegetation.
- No injuries to emus during construction as a result of emu-construction vehicle collisions.
- No change in pre-construction emu movements across the construction corridor.
- No damage to emu habitat within exclusion zones in Section 3 and 4 of the project during construction.
- Domestic waste managed in accordance with the CEMP.
- Dust and noise managed in accordance with the CEMP.
- Water quality managed in accordance with the CEMP.
- Cover crops established within 3 months of completion of each bridge constructed in emu crossing zones in Section 3 and 4 of the project.
- Methods for rehabilitation of emu habitat adjacent to the road would be documented in the landscape design.

5.3 Management measures

In order to minimise impacts to emu movements across the project during construction and to educate emus to use crossing zones prior to construction commencing, it is proposed to stage the construction and placement of infrastructure. This staging approach is illustrated in **Figure 5-1** below.

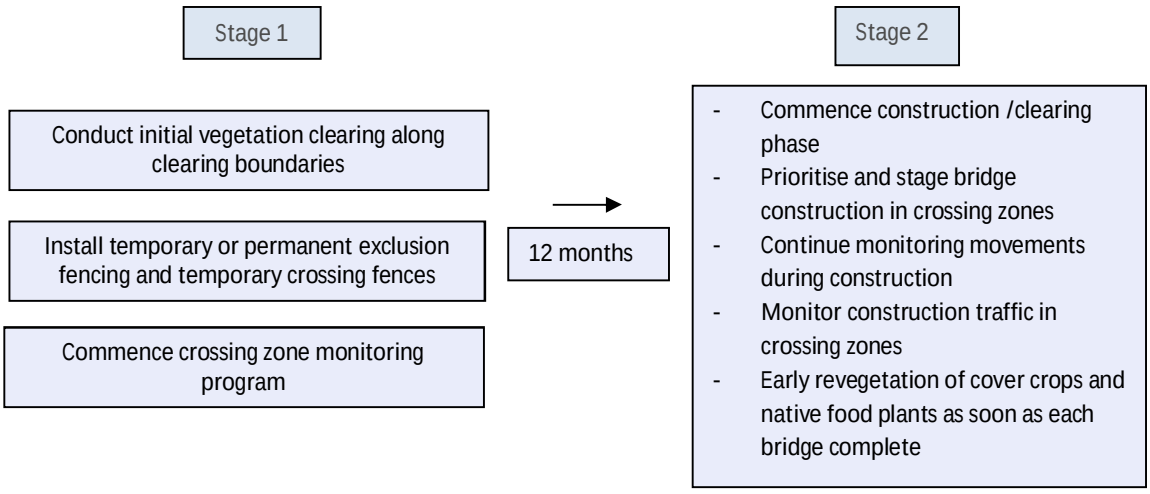


Figure 5-1. Staging of construction and placement of infrastructure

5.3.1 Pre-clearing surveys

The pre-clearing process provides a final check for emu nests in the construction corridor prior to the commencement of construction. This may occur at early works sites as a priority and later across the construction corridor according to the priority stages of the upgrade to be determined. The pre-clearing process targets all fauna habitat and is a requirement of the CEMP. Searches of emu activity and emu nests would form a part of this process, and is particularly relevant in Sections 3 and 4 of the project. The results of the pre-clearing process would inform planning and procedures for the staged habitat removal process and have been documented as part of the EMS process.

5.3.2 Implement emu exclusion fencing strategy

The goal of early construction of exclusion fencing in Section 3 and 4 of the project would be to maintain connectivity during construction and educate emus to use crossing zones at least 12 months prior to construction commencing. In addition emus are curious animals and would readily investigate new activities in their home range. For this reason having the fence in place at the start of Stage 2 of construction would be necessary to prevent emus from entering the construction corridor at any period.

5.3.3 Staging of construction

Given a potential lengthy construction period for Stages 3 and 4 of the project, the project must make available a number of opening options during construction. Staging is proposed to ensure that emus will have continued opportunities to cross the construction corridor during the construction phase. The objectives are firstly to identify crossing zones by establishing fencing prior to construction and then to maintain functional crossing zones during construction so that at any one time there would be at least one or multiple crossings open.

The first stage of construction would involve identifying clearing limits and removing vegetation along clearing lines followed by installation of either temporary or permanent fencing in places identified by the fencing strategy prior to the commencement of construction. As emus should be allowed the opportunity to cross the construction corridor during the construction period at designated emu crossing zones this will involve placing temporary fencing perpendicular across the construction corridor and maintaining these during the construction phases. **Figure 5-1** shows an example diagram of a crossing zone which represents one of the several bridge locations to be constructed in Sections 3 and 4.

During construction of a bridge(s), this crossing zone would be closed using temporary fencing until completion of the bridge at which point the permanent fencing would be tied into the bridge and plantings completed and the zone open. As there are multiple bridges, construction of these would be staged over time so that there would always be active crossing zones available during construction. It will be important to prioritise rehabilitation of emu crossing zones as soon as a bridge construction is completed.

As it is expected that construction traffic will need to pass through crossing zones on a regular basis, this would occur via controlled vehicle crossing areas (refer Figure 5-1 for example diagram). Controlled access involves speed reduction and erection of emu warning signs as well as the use of temporary gates to be closed outside of construction times to prevent emus entering the construction corridor along the haul road.

5.3.4 Vegetation clearing and emu find procedures

Before clearing commences, ensure that the pre-clearing process as reported in **Chapter 4** would be complete.

Clearing of vegetation would be to ensure that construction works do not go beyond the approved clearing limits in Sections 3 and 4 of the project.

Clearing procedures would be outlined in the CEMP and FFMP, and would be undertaken in accordance with *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA 2011), in order to minimise impacts on flora and fauna in general.

An ecologist would be present during the clearing works in Sections 3 and 4 of the project and if an emu is encountered during clearing works the Roads and Maritime unexpected finds procedure would be followed.

In the case of the emu a suggested framework would include cease work and employ options for ensuring the safety of the animal. This may include repairing any breeches in exclusion fence before work recommences, or opening the exclusion fence and buffer the area until the emu leaves. A nominated ‘vet-on-call’ to be contacted immediately to facilitate response if an emu is found injured.

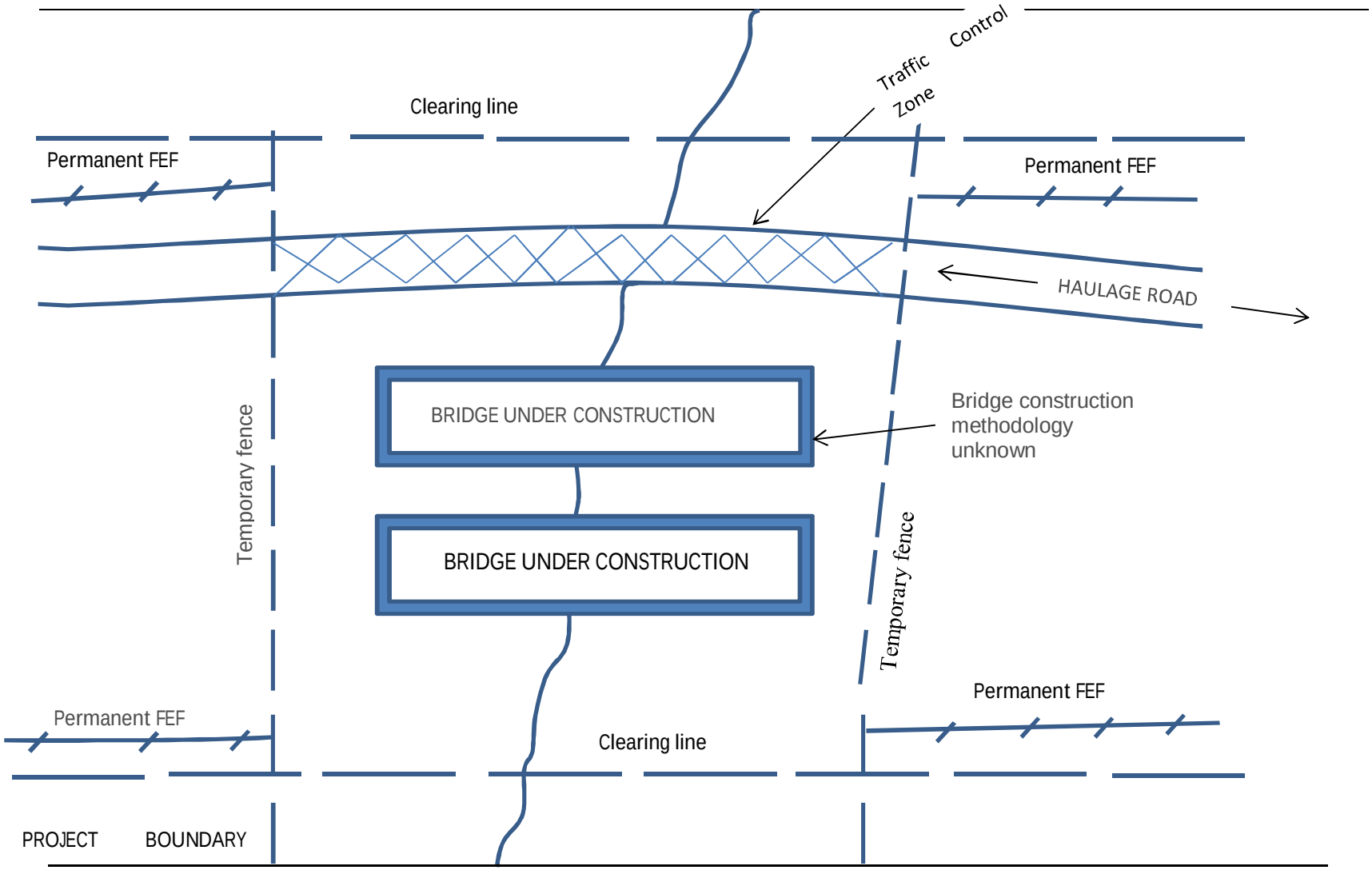


Figure 5-1. Diagrammatic representation of fencing strategy outcomes for crossing zones and haulage routes

5.3.5 Managing emu-vehicle collisions

A licensed ecologist would be present on site during all vegetation clearing and habitat removal activities to redirect emus that may be encountered as discussed above with reference to the unexpected threatened species find procedure.

Following the clearing works and throughout the remainder of the construction period, any observations of emus in the construction corridor would also follow the unexpected threatened species find procedure (RTA 2011). All vehicles are to remain within the designated construction corridor at all times.

In the case of the emu work would cease and options considered for ensuring the safety of the animal. This may include repairing any breeches in exclusion fencing before work recommences. Details of the incident would be reported included the number of emus present, time of day, location and likely entry point from the exclusion fence.

All construction vehicles are to comply with the speed limits set out in the CEMP and to remain within the designated construction corridor.

Given the likely increased traffic on local roads during the construction period due to construction traffic getting to the site, emu awareness signs would be erected on local roads in potential road kill areas to make motorists aware of the potential for emus to cross the road.

5.3.6 Targeted emu crossing structures

The specific structures for emus would be located in the between chainage 36500 and 66500 (Section 3 and 4 of the project) and include:

- Raised bridges with a minimum height of 3.6 metres to provide targeted crossing points for emus to the Coldstream, Shark Creek and Tyndale wetlands via dry passage retained along both banks of the channel.
- A minimum bank width of 4 metres would be retained in emu habitat / crossing areas to allow emus to walk between an abutment and the creek edge.
- Raised arch structures in emu connectivity zones.
- Purpose built exclusion fencing strategically located in areas surrounding the crossing structures to direct emus and to prevent emus from entering the highway corridor.

5.3.7 Permanent emu exclusion fencing

Permanent exclusion fencing would progressively replace temporary fencing during construction and completed by the end of construction. The fence type and design would be documented in the emu fencing strategy, and consider issues such as flooding and directing emus to crossing zones.

5.3.8 Revegetation of emu crossing zones

Emus prefer to be able to see well ahead of them, ideally a kilometre, so it would be important to have clear, straight leads up to the crossing points and equally important to shield these routes from as much traffic noise, light and movement as possible. Opportunities for trialling construction of dirt tracks would be considered on private land and discussed with landowners. This has evolved from the satellite tracking work which found emus regularly travel along roads and clearings through bushland, and the intention would be to direct emus to crossing points. These tracks could link up with existing tracks, or run parallel to the highway or linking with regular movement pathways. The location of tracks will be informed by the monitoring work documented in **Chapter 7** and depend on negotiation with adjacent landowners.

Revegetation of emu crossing zones (where these have been intersected by the project on Roads and Maritime owned land) would commence immediately on completion of construction activity and to be staged to avoid lengthy disruption to emu movement along the corridor. The aim would be to have an established cover crop within three months of the completion of each bridge.

The revegetation of these areas would include ground cover crops such as soybean, oats, lablab or rye grass to be used initially on disturbed ground around the approaches to the bridges to attract emus to the crossing zone as these represent known food plants. As these are non-native species, sterile cover crops would be used and these areas would be monitored and progressively replaced with native food plants as discussed. This could also be done in the early staging works and documented in the emu fencing strategy.

Where possible, revegetation near crossing zones would commence early during construction in areas that are not expected to be impacted further during construction activities.

Open walking tracks or unsealed vehicle tracks may be incorporated under bridges in densely forest areas as an added attractant for emus to find the crossing structure. This would not be required in open landscapes with clear line of sight.

5.3.9 Emu specific revegetation

The landscape design would be developed to provide specific details for the re-establishment of native vegetation on batters, cut faces, surrounding sediment basins and other areas disturbed during construction including approaches to emu connectivity structures and riparian corridors. Methods for topsoiling, seeding and planting would be in accordance with the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA 2011).

The plan would provide due consideration to the landscape requirements of emus which would include natural vegetation and plant types known to be used by emus. This would include revegetation around crossing structures targeted at emus by ensuring that the height and density of vegetation does not obscure the structure and provides a clear open line of sight and revegetation in disturbed areas adjacent to Sections 3 and 4 of the project.

The following specific measures would be implemented during construction:

- Roadside plantings in emu habitat (Section 3 and 4 of the project) would not be within the first 10 metres of the road edge unless there is fauna exclusion fencing in place or as part of the exclusion barrier. In particular, common landscape species such as Lomandra and Dianella spp. would not be used in roadside landscaping as they represent food plants for emus and may attract them to the road edge.
- Final landscape plantings under dedicated and combined bridges in emu crossing zones (Section 3 and 4 of the project) including the approaches to the crossing are to use native grasses or low ground covers suitable to the location and avoid dense plantings of trees and shrubs including low trees such as Acacia or Casuarina. This is to leave the opening and line of sight clear.
- Revegetation in roadside areas disturbed during construction needs to restore the original habitat type at each location. This refers to rehabilitating either the original open forests or swamp forest community or restoration of modified agricultural landscapes which are also known to be used by emus.

Details on monitoring the performance of the revegetation are provided in **Chapter 7**, along with corrective actions.

5.3.10 Managing domestic waste

Wire and plastic, food scraps and other potentially ‘attractive’ items for emus would be managed in accordance with the waste and refuse protocols of the CEMP.

5.3.11 Managing water quality

Implement procedures for maintenance of water quality included in the CEMP including sediment and erosion control measures. These measures would be critical to maintaining water quality in important emu watering areas. These procedures include:

- Controlled access to watercourses by construction workers and vehicles.

- All refuelling and maintenance to be undertaken in designated bunded areas away from overland flow paths and low-lying areas.
- Specific measures for water detention basins, including appropriate discharge where necessary.

5.3.12 Minimising dust and noise

Dust and noise impacts would be managed in accordance with the CEMP including dust suppression measures and construction noise limit measures.

5.4 Performance thresholds and corrective actions

Table 5-1 below summarises the construction environmental planning measures for coastal emus that would be completed prior to the commencement of construction.

Table 5-1. Mitigation measures, performance measures and corrective actions

Main goals for management	Management measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if performance threshold reached
No injuries to emus during clearing of vegetation.	• Documented procedure for clearing of vegetation. • Documented procedure for emergency management if emu is encountered during clearing works. • Procedure developed in consultation with WIRES and NPWS. • Project ecologist evaluate situation and approach on each occasion.	• Monitored daily during the clearing works. • Outcome of emu management procedure reported in EMR for review.	Emu injured during clearing works.	Stop clearing works and consult with emu specialists or NPWS. Update emergency procedure and toolbox talks.
No injuries to emus from collisions with construction vehicles.	• All vehicles to stay within the construction corridor and no entry into exclusion zones. • Comply with construction vehicles speed limits designated in the CEMP. • Implement a daily inspection of emu crossing zones and fence integrity.	• Monthly fauna incident log to be maintained as per FFMP. • Daily exclusion fence monitoring.	Emu injured during construction.	Stop construction and conduct evaluation of exclusion fence strategy and traffic control procedures as appropriate.
No damage to emu habitat within exclusion zones in Section 3 and 4 during construction.	• Implement the emu fencing strategy prior to construction. • Fencing to be erected concurrently with clearing procedure in Section 3 and 4.	• Audit fencing outcomes prior to commencement of construction. • Monthly monitoring of exclusion fence and protection zones as part of FFMP	Breach in exclusion zone by construction vehicle of personnel.	Supplementary revegetation of disturbed habitat and monitor recovery for period of 12 months.
No change in pre-construction emu movements across the construction corridor.	• Adopt emu fencing strategy • Construction infrastructure and access tracks located to avoid lengthy interruption to emu movements . • Avoid extended activities in or adjacent to known emu habitat, watering points or crossing zones.	• Daily – monitor construction activities to ensure compliance with emu management plan. • Daily – monitor construction activities to ensure continued access for emus to water supplies and foraging habitat in line with fencing strategy.	After four construction monitoring events there is a demonstrated change from pre-construction emu movements across the project corridor.	Re-evaluate and revise monitoring methodology. Revisit fencing strategy and staging approach for crossing zones and change if practical.
Dust and noise managed in accordance with the CEMP	Implement relevant procedures from the CEMP.	Measures to be undertaken in response to weather and construction conditions.	Monthly reports as part of CEMP including updates on dust and noise control measures.	Increase the frequency of dust and noise measures.
Domestic waste managed in accordance with the CEMP.	Implement waste management procedures from the CEMP.	Ongoing, clean-up of all construction sites to remove potentially hazardous items includes a general daily clean-up of construction areas and rubbish removal	Event based reporting according to CEMP.	Review staff training and waste management training as necessary.

Water quality managed in accordance with the CEMP	Implement water quality procedures from the CEMP.	Weekly and event based monitoring of water quality and erosion controls.	CEMP	Review water and erosion management procedures as necessary.
Cover crops established within 3 months of completion of the bridge construction in Section 3 and 4.	Implement revegetation and rehabilitation to commence immediately on completion of construction activity completion and to be staged to avoid lengthy disruption to emu movement corridors.	Comply with landscape plans performance criteria as regards planting success and revegetation monitoring.	Event based, incident reporting in CEMP	Dead plantings (>30%) to be replaced with equivalent species and maintained until established.
Methods for rehabilitation of emu habitat adjacent to the road is documented in the landscape design.	● Roadside plantings in emu habitat (Section 3 and 4) avoid emu food plants to prevent emus being attracted to road edges. ● Landscape plantings under emu crossing zones in Section 3 and 4 to use native grasses or low ground covers suitable to the location and avoid dense plantings of trees and shrubs. ● Revegetation in roadside areas disturbed during construction to restore the original habitat type at each location.	Final audit of the landscape design.	Evidence of emu specific revegetation to be captured in the landscape design.	Update landscape design accordingly.

6. Operational management measures

6.1 Potential impacts during operational phase

- Degradation of emu exclusion fence and escape points leading to emu-vehicle collisions and road death or emus being trapped in the road corridor.
- Degradation of emu revegetation areas.
- Wild dogs targeting emus at designated crossing zones.

6.2 Goals for management

- Zero or reduced rate of reported emu deaths on the highway in Section 3 and 4 of the project after 10 years.
- Maintain habitat revegetation areas on Roads and Maritime owned land in Section 3 and 4 of the project post-construction until performance threshold has been met.
- Zero or reduced rate of reported deaths from dog attacks in vicinity of crossing structures in Section 3 and 4 of the project in years 1-5.

6.3 Management measures

6.3.1 Maintenance of exclusion fences and escape points

The Roads and Maritime would conduct maintenance of exclusion fencing and escape points in emu habitat areas and under emu crossing structures to maintain the integrity of the these structures for the life-time of the project. This would include inspections of the fence and structures as part of the standard maintenance requirements at the site for the life-time of the project.

Monitoring would also be conducted in response to observations and reports of emu road kills in the vicinity of exclusion fencing and emu crossing structures. Monitoring would be conducted for five years initially and the need for further five year monitoring periods would be reviewed at the end of this period. The work to be commissioned would include repair of any breaches in the exclusion fence, the slashing of overgrown vegetation that breaches the fence and the removal of large debris or vegetation from arch structure entrances and below bridges.

Conduct fauna mortality surveys with focus on emus in known emu habitat areas and report as per monitoring program discussed in **Chapter 7**.

6.3.2 Maintenance of habitat revegetation

Inspection, monitoring and maintenance of emu habitat revegetation areas would be specified in the landscape design. The recommended monitoring and maintenance schedule for the revegetated areas in the first year is outlined in **Table 6-1**.

Table 6-1 Monitoring and maintenance schedule first year

Monitoring	Timing	Maintenance
Site preparation	Commencement	Weeds and grass controlled within 2 metres of planting locations.
Watering weekly	First month	No plants wilting or with dried foliage.
Monitoring weeds and plant health	3 months	Weeds not smothering plants, plants healthy with active growth, replanting required if plant survival not at required percentage.
Weed control Mulching and fertilising of plants	3 Months	Weeds and grass controlled within 2 metres of planting locations, all plants mulched and fertilised.

Monitoring weeds and plant health	6 months	Weeds not smothering plants, plants healthy with active growth, replanting required if plant survival not at required percentage.
Weed control Mulching and fertilising of plants	6 months	Weeds controlled within 2 metres of planting locations, all plants mulched and fertilised.
Monitoring weeds and plant health	9 months	Weeds not smothering plants, plants healthy with active growth, replanting required if plant survival not at required percentage.
Weed control Mulching and fertilising of plants	9 months	Weeds controlled within 2 metres of planting locations, all plants mulched and fertilised.
Monitoring weeds and plant health	12 months	Weeds not smothering plants, plants healthy with active growth, replanting required if plant survival not at required percentage.
Weed control Mulching and fertilising of plants	12 months	Weeds controlled within 2 metres of planting locations, all plants mulched and fertilised.

6.3.3 Wild dog control

Predators can exploit the channelling function of the fence by hunting near the entrance to the underpass or overpass (Harris et al. 2010). Monitoring of dog activity would be conducted as part of the crossing structure monitoring program (refer Chapter 7). Should underpass monitoring in Section 3 and 4 of the project demonstrate wild dogs to be an issue for emu movement through the crossing zones, the Roads and Maritime would engage with the Northern Rivers Catchment Management Authority, NSW Office of Environment and Heritage (Parks and Wildlife Grafton), and Rural Lands Protection Board (North East) and adjacent landowners.

6.4 Performance thresholds and corrective actions

Table 6-1 below summarises the operational environmental planning measures for coastal emus and corrective actions if the measure deviates from the performance criteria.

Table 6-1. Mitigation measures, performance measures and corrective actions

Main goal	Mitigation / control measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if deviation from performance criteria
Zero or reduced rate of emu deaths on the highway in section 3 and 4 after initial five years.	• Periodic monitoring and maintenance of exclusion fencing for the life-time of the project. • Slashing weeds near fences and repair breaches in fence or replace broken fences.	• Conduct emu mortality surveys as per Chapter 7. • The program would include inspections of the fence and structures as part of the standard maintenance requirements at the site for the life-time of the project. • Monitoring would also be conducted in response to observations and reports of emu road kills in the vicinity of exclusion fencing and emu crossing structures. Monitoring would be conducted for five years initially and the need for further 5 year monitoring periods will be reviewed at the end of this period.	• Emu death reported in Section 3 and 4 within operational years 1-5.	• Locate and repair faulty exclusion fence within 3 days of emu death being reported.
Maintain habitat revegetation areas on Roads and Maritime owned land in Section 3 and 4 post-construction until performance threshold has been met.	• Follow designated maintenance plan.	• As per designated maintenance plan.	• Planned activities not conducted as per schedule.	• Review maintenance activities and update as required.
Zero or reduced rate of reported deaths from dog attacks in vicinity of crossing structures in Section 3 and 4 in years 1-5.	• Conduct ongoing monitoring at crossing zones as per methods in Chapter 7.	• Monitor dog presence and emu-dog kills as part of ongoing crossing structure monitoring program.	• Emu death near crossing zone attributed to dog attached as evidenced by dog activity (as per methods in Chapter 7).	• Engage with stakeholders involved with predator control and identify actions to assist in minimising attacks.

7. Monitoring program

The monitoring program would consist of following the progress of the coastal emu sub-population that has been identified in proximity to the project in Section 3 and 4 between Chainage 36500 and Chainage 66500 focused on emu activity, crossing zones and potential habitat near the road.

The methodologies selected and described herein have been informed by two pilot studies in addition to other road monitoring programs adopted for cassowary populations in Queensland. The first pilot project looked at the development of molecular assays to investigate the feasibility of using emu DNA derived from scats and feathers to identify the movements of individual animals and ultimately population size. The process of extracting DNA and developing a molecular approach was successful using tissue samples and large feather samples collected from road-killed birds, however was less successful with extracting DNA from scats and smaller feather samples which were the most widespread and readily available in the field. The field methodology involved walking transects to locate emu scats and feathers. A positive outcome from the pilot study was that the method of finding feathers and scats was found to be a feasible approach to mapping and locating emu activity.

The second pilot study investigated GPS-based monitoring of emus by trialling GPS satellite transmitters on captive-reared and released coastal emus. The pilot demonstrated that emus can be safely anaesthetised and handled with minimal stress and that spatial and temporal movements of emus can be monitored across a range of habitats using GPS data loggers. The pilot study found that the cuff attachment used for the tracking device on the upper leg caused rubbing and superficial abrasion of the skin. Further trials are required using different cuff attachments and smaller devices. A method of capturing and anaesthetising wild emus in the study area has not been trialled and is required before this monitoring technique can be considered further.

7.1 Objectives

Monitoring is to provide reliable information such that sound conclusions can be drawn in relation to the management of the species. The overall monitoring objectives include to:

- Further understand habitat usage and the movements and activity of emus near the road corridor.
- Evaluate the success of mitigation measures (crossing structures and exclusion fences and habitat revegetation).

The monitoring can be refined, subject to progress against the above matters. In order to fulfil these objectives a number of ecological variables would be monitored, with each variable discussed below.

7.2 Emu activity monitoring

7.2.1 Transect survey

Emu activity would be monitored east and west of the project in Sections 3 and 4 during the pre-breeding and post-breeding periods. Congregations of emus reportedly occur in the pre-breeding season mid-autumn to winter (April to June) and post-breeding activities would occur in spring and summer (September to January).

The primary objective is to accurately locate, measure and map all emu sign e.g. footprints, bird sightings, droppings, and feathers from a number of established transects. Based on monitoring conducted to date for the EIS and pilot studies, although sightings of individual birds are the most certain evidence of occurrence, footprints and droppings and feather samples were also found to be common signs of emu presence in the study area. Hence the program would employ a combination of camera monitoring and direct searches for emus and signs of their presence.

The program intends to compare the 'before' construction data with 'during' and 'after' construction data and the impact sites with control sites. Surveys would commence in the pre-construction phase in autumn and spring with two monitoring sessions per season conducted as the baseline survey (i.e. two surveys pre-breeding and two survey post-breeding) to get maximum baseline data prior to the exclusion fencing going into place. The timing for monitoring activities is to coincide with the months is indicated in **Table 7-1**.

Table 7-1 Timing of monitoring activities

	J	F	M	A	M	J	J	A	S	O	N	D
Pre-construction 2013												
Pre-construction 2014												
Pre-clearing (fenced) 2015												
Construction and operational monitoring times												

Exclusion fencing installed
Clearing commences

It is proposed to implement the fencing strategy immediately after completion of the pre-construction baseline surveys, further monitoring would then continue with the fence in place over a 12 month period and then through the remainder of the construction period. Subsequent monitoring during construction and post-construction would be conducted as per the schedule above in autumn and spring each year with operational monitoring subject to performance review after a period of 7 years.

The monitoring program would be adaptive and the timing of surveys and location of transects may change according to the results of the surveys. Performance indicators, thresholds and corrective actions for this component of the monitoring program are discussed in **Section 7.2.2**.

The monitoring program would focus activities near identified crossing zones or known emu activity areas in Section 3 and 4 of the project and would be divided into search areas based on knowledge gained from the EIS and information from previous surveys and land owner interviews.

Up to six search areas would be identified across the range of the emu population and up to five transects employed in each search area (total 30 transects). The location of impact transects would be dependent on liaison with property owners and would be finalised in consultation with landowners and subject to change depending on the results of initial pilot surveys. Some transects would be positioned along fence lines to locate feathers caught on barbed wire, as the DNA pilot study found this technique to be effective at locating emu activity and some along dirt tracks where present to assess use by emus. A number of transects were established at impact and control sites for the DNA pilot study conducted for the EIS and up to 65 per cent of these yielded results of emu signs. It is proposed to revisit these sites through discussion with property owners, and assess the potential to include these in the ongoing monitoring program (**Table 7-2**). All search areas and transects would be recorded and mapped for repeat surveys and transects described below are subject to change.

The survey would involve searches for emus and their signs, along the designated transects, using a combination of camera monitoring stations and active searches for signs of emus. A description of the attributes used to record data on emus and their sign are described in **Table 7.3**. In addition to this two to three remote cameras would be positioned along each transect to record passing emus. Cameras would be movement activated and remain continuously active, with data downloaded at each subsequent survey period, and batteries replaced.

Note it is proposed to commence soft soil treatments in the area from Tyndale to Maclean from July 2014. As there is no emu mitigation measures proposed in this location, it is not critical to complete the four baseline surveys in this location prior to commencing this activity however some pre-construction surveys would occur. Emu activity monitoring in this location would focus on monitoring emu presence to the west of the project corridor (during soft soil pre-loading, construction and operation) to assess whether emus become trapped to the west of the project or are able to use the gaps proposed for access roads and cane drains. Additional transects to those listed in Table 7-1 are to be added to the Shark Creek area and associated with the cane fields either side of the project corridor between station 69.0 and 75.0 to account for the soft soil treatment areas as described previously.

Table 7-2 Indicative locations and details of monitoring transects

Transect Code	Location	Site detail	Transect Start Location		Transect End Location	
			Easting (GDA)	Northing (GDA)	Easting (GDA)	Northing (GDA)
1B	Track off Brooms Head Rd	Control	531397.572	6728262.735	-	-
1BH	Brooms Head Rd	Control	-	-	-	-
1C	Track off Brooms Head Rd	Control	532365.033	6727875.259	-	-
1D	Track off Sandon River Rd	Control	530822.037	6724227.713	530237.645	6724142.814
1E	Track off Sandon River Rd	Control	530226.881	6724140.688	530632.276	6723877.047
1F	Track off Sandon River Rd	Control	550544.961	6848576.785	-	-
1G	Point off Sandon River Rd	Control	530682.83	6722693.78	-	-
1H	Paddock off Brooms Head Rd	Control	524334.50	6734220.47	-	-
1S	Sandon River Rd	Control	530640.504	6723935.812	530856.954	6724210.996
2A	Track off Tallowood Lane	Impact	512967.00	6721394.00	513875.00	6721843.00
2D	Easement off Wooli Rd	Impact	511498.00	6715109.00	511333.00	6715655.00
2H	Bostock Rd	Impact	512256.00	6718354.00	513140.00	6717913.00
2I	Somervale Rd	Impact	512221.00	6719791.00	514029.00	6719778.00
2L	Mitchels Rd	Impact	511393.00	6713523.00	511520.00	6712078.00
3C	Tip Trail	Impact	522973.00	6703880.00	524297.00	6704491.00
3D	Off Minnie Water Rd	Control	527322.00	6706018.00	526964.00	6765822.00
3DW	West of easement, Sth of Min.Water Rd	Control	526240.00	6705126.00	526476.00	6705554.00
3E	Easement Nth of Minnie Water Rd	Control	528243.00	6706503.00	527337.00	6706050.00
3F	Bookrems Walk	Control	527500.00	6700205.00	528200.00	6701140.00
3G	Diggers Camp Rd	Control	527501.00	6700226.00	524437.00	6701735.00
4A (day 1)	Shark Creek	Impact	-	-	-	-
4A (day 2)	Shark Creek	Impact	518087.123	6732847.187	-	-
WL	251 Wallaby Lane	Control	-	-	-	-
2B	Access @ end of Michels Rd	Impact	51552.00	6712074.00	512456.00	6711132.00
2V	Coldstream Rd	Impact	513258.00	6728399.00	513093.00	6727435.00
2L	Mitchels Rd	Impact	511391.00	6713519.00	511449.00	6712096.00
2K	Fence South off Bostock Rd	Impact	512427.00	6718339.00	512407.00	6718228.00
2M	Fence South off Bostock Rd	Impact	512971.00	6718238.00	512967.00	6718154.00
2Q	Fence south off Somervale Rd	Impact	512829.00	6719654.00	512803.00	6719447.00
2J	Near intersection of 8 mile/Wooli Rd	Impact	510034.00	6709307.00	509499.00	6709358.00
2I	Somervale Rd	Impact	512221.00	6719791.00	514029.00	6719778.00

Table 7-3 Description of attributes used to record data on emus and their sign during transect surveys

Emu sign	Primary attribute	Secondary attribute	Tertiary attribute
Scats	Age of scat ● Very fresh – Dropping wet and sometimes "steaming". ● Fresh – Dropping has a thin dry outer layer but is still very wet underneath. ● Recent – Dropping dry but wet at centre and base. ● Old – Dropping still maintains its shape but has weak structure, and completely dry throughout. ● Very old – Dropping lack structure or baked hard, very dry and deteriorating, consists of exposed seeds or could be germinating.	Size of scat Small (<12 cm diameter) Large (<12 cm diameter)	Contents of scat.
Footprint	Social structure ● Solitary bird – no chick prints accompany adult footprints or no group structuring. ● Family group – chick prints accompany the adult print. Including number of chicks if discernible from footprints. ● Social group – multiple adult footprints indicating gathering of emus prior to breeding.	Footprint quality – footprints to be measures from tip of middle toe to back of heel. ● High quality – tip of toenail and back of heel are clearly defined; scale imprints are often visible; print is on relatively flat survey and not spread into mud. ● Low quality – tip of toe nail and edge of heel no clearly identified, obscured by vegetation, or smudged.	Length of each measured print in mm and direction of travel.
Feathers	Age of feather ● Fresh – Feather moist and bends without interaction. ● Old – feather stiff and dry or deteriorating.	Direction of travel.	Strand on fence (bottom. middle or top).
Sightings	Social structure ● Family group – adult male and number of chicks. ● Independent adult – adult plumage and size. ● Independent sub-adult – sub-adult plumage or black-head, small size.	Sex ● Male. Tail droops below body line, smaller than fully grown female, with or without chicks. ● Female – Tail small and does not droop below body line; larger than male when fully grown; without chicks.	Any distinguishing face or body markings, injuries, unusual gait.

7.2.2 Aerial survey

In Western and South Australia aerial surveys have been effective in counting Emus when flown at about 400 feet above the ground. The peer reviewer has suggested that it would benefit the monitoring program to fly one or two hour surveys over the flood plain and along the coast in the pre- and post-breeding seasons to complement the land–based monitoring.

As such an initial aerial survey pilot is proposed to determine the effectiveness of this technique. If successful this monitoring technique would continue in conjunction with land-based survey at four times per year and may contribute as a research action as part of the project offset strategy.

The success of this technique has not been tested and therefore performance thresholds are currently not proposed and may be included following review of the monitoring methods and outcomes of the pilot study.

7.2.3 Performance thresholds and corrective actions

The objectives of the mitigation measures are to minimise the impacts of habitat loss and fragmentation and the barrier affect created by the project to maintain the long-term viability of the emu population in the locality. The status of the emu population adjacent to the project would be measured and reported following each monitoring event. Performance thresholds and corrective actions are identified in Table 7-4.

Table 7-4. Performance thresholds and corrective actions for emu movement monitoring

Performance thresholds	Timing and corrective actions
• Greater than 15% decline in emu activity between impact and control areas and before and after data. • No evidence of emu flocks congregating in the study area in pre-breeding periods or evidence of breeding through sightings of chicks and sub-adults.	• Emu activity would be compared with the baseline data at the end of each monitoring period during the construction phase. Regular evaluation and review would be conducted at the end of each monitoring period. • If decline noted in the first 12 months of the post-construction (operational) monitoring, review and modify the monitoring program, to consider more intense monitoring or different techniques and monitoring locations. • Review transects locations and cross reference with performance monitoring of the emu crossing structures and fencing strategy. • Investigate emu habitat adjoining the highway and consider improving habitat condition and connectivity. • If decline still noted after a further 12 months operational monitoring (2 years operation) engage with OEH and consider provisional measures. • Further monitoring of provisional measures would be planned at this stage.

7.3 Monitoring effectiveness of crossing structures

7.3.1 Methods, timing, intensity and duration

The monitoring program would be designed to compare a range of crossing types with controls to determine their effectiveness and inform management decisions, this would include:

- Structure type (raised bridges, versus arch structures).
- Landscape type (cover crops, versus native plantings versus open landscape).
- Attractant type (tethering shiny twirls, versus cleared tracks versus no attractants).

Monitoring of emu crossing structures will be undertaken using a combination of techniques deployed at set monitoring periods, as described below.

- **Remote surveillance cameras:** stationed at different locations on the structure depending on the situation. For example given the length of the bridges targeted at emus (i.e. up to 400 metres long) camera stations would include attachment to the bridge underside and mounted cameras on poles at ground level to obtain alternative side views. Camera would operate continuously during the

monitoring period with batteries replaced and data downloaded every 14 days in both pre-breeding phase (mid-autumn to late winter) and post-breeding phase (spring-summer).

- **Transect surveys**. As per methodology and timing described in **Section 7.2** (i.e. three monthly during construction and six monthly after construction). Survey to search for emu and dogs scat, tracks and feather surveys and direct emu sightings. Transects would be established at all crossing zones including targeted bridge and arch structures. At bridge sites transects would run parallel to streams on either side of the stream bank with variable transect length depending on land ownership and access. Data would be collected from the entrance or inside the crossing structure or below the bridge. Searches to be undertaken when installing and checking sand plots (i.e. four consecutive mornings per monitoring period). Transects would be established prior to commencing the first monitoring period and reported and mapped in the first monitoring report.
- **Sand plots** established on either end of the structure for a period of four consecutive days per monitoring period. Sand plots, at least one metre wide, would be established in different locations depending on the structure type for example in the arch and culvert structures it would be possible to place these across the entire width of the structure. For bridges, these will be placed at intervals below the bridge, generally along banks areas and avoid stream beds. The sand tracks would be monitored on each morning for emu and dog tracks and then raked clean.
- **Mortality survey**: Survey of the emu exclusion fence for 250 metres either side of the structure to identify and report and breaches and report maintenance requirements. Survey of the north and southbound carriageway 500 metres either side of the crossing structure for emus hit by vehicles.

The monitoring program would extend for five years post-construction of the crossing structures and consist of two monitoring periods per year timed to coincide with peak pre and post-breeding activities (i.e. mid-autumn to mid-winter to coincide with the breeding season and late summer when chicks are active). These periods would likely to represent peaks in emu movement, resulting in potentially higher rates of usage of connectivity structures and thus more robust data.

Emu crossing structure monitoring would commence at the start of the first monitoring period after construction. Monitoring would be undertaken for a period of five years post-construction to monitor the effectiveness of the emu crossing structures, after which time the need for further monitoring would be reviewed in consultation with OEH.

The monitoring program would integrate with the emu population monitoring program (**Section 6.2**) to assess emu activity in proximity to structures and identify crossing zones. Additional monitoring or provisional measures may be required in the event the monitoring data suggests that particular emu structure, landscape or attractant type is ineffective or some more effective than others.

7.3.2 Performance thresholds and corrective actions

Monitoring of the emu crossing structures would be undertaken to assess their effectiveness and inform the need for corrective or provisional measures. The main performance thresholds and corrective actions are outlined in Table 7-5.

Table 7-5. Performance thresholds and corrective actions for crossing structures monitoring

Performance thresholds	Timing and corrective Actions
• No evidence of east-west movements across the project corridor after 5 years post-construction. • Emus found on western side of the highway but no evidence of using crossing structures (i.e. isolation). • A single road fatality recorded on the highway in Section 3 and 4 of the project.	If no evidence noted after 3 years post-construction then: • Review the monitoring methods considering increasing frequency, intensity and duration or a different technique to ensure individuals using crossing structures are identified. • Check fauna exclusion fencing and fauna crossing structures for damage/blockage and rectify. • Investigate habitat adjoining the underpass/bridge. Consider improving habitat condition and connectivity. If no evidence noted after a further 2 years (total 5 years post-construction) then • Review location and type of crossing structures and fauna exclusion fencing and engage provisional measures as outlined in the EIS.
• A single dog attack reported in proximity to a crossing structure, through evidence of dogs reported on surveillance cameras, sand plots and a dead emu found.	• Engage with stakeholders involved with predator control and identify actions to assist in minimising attacks.

7.4 Exclusion fence monitoring

7.4.1 Methods, timing, intensity and duration

The objective of the emu exclusion fence in Sections 3 and 4 of the project is to exclude emus from the road corridor and direct emus to safe crossings in dedicated and combined underpasses. The fencing would be integrated into the underpasses to direct emus to habitat continuity. The emu fencing strategy would document details of the fence types, and locations and lengths.

Exclusion fencing and escape points or gates would be trialled and monitored to assess their effectiveness and inform the need for corrective actions. The fence would be required to meet the following objectives:

- Exclude emus from entering the roadway.
- Prevent injuries and death to emus from collision or entanglement with the fence.
- To act as a visual barrier to emus.
- To be resilient to flooding and debris.

Fence design would be further considered and trialled to determine the most effective fence. The following factors would need to be considered:

- Flood resistance.
- Maintenance.
- Performance as an exclusion fence to exclude emus.
- Stock proof.
- Location i.e. on boundary, within road reserve, on batter slope.
- Combined fauna fencing in lieu of property boundary fencing.
- Cost.

Given the possibility for emus to enter the road corridor escape gates or alternative escape points would also be used. In some locations boundary stock fencing would be required parallel to some bridges that are targeted as underpasses for emus. A hybrid fence/gate design with the purpose of enabling emus to pass and restrict cattle would be trialled to monitor the effectiveness.

A number of fence types and one-way gates would be trialled to assess their effectiveness including:

- Standard floppy-top fauna exclusion fence in non-flood prone areas.
- Standard floppy-top fauna exclusion fence with shade-cloth to act as a visual barrier.
- Glenugie style fence with increased height.

- A hybrid emu gate integrated into the rural boundary fence at emu crossing underpasses with the purpose of enabling emus to pass and restrict cattle.
- A one-way escape gate and directional fence to direct trapped emus off the roadway.

Monitoring cameras would be installed as a means of trialling the effectiveness of the fence and gate design. The number and locations of cameras and frequency and timing of the camera monitoring would be determined in the final management plan, and could be revised during the program in light of any additional information from the emu activity monitoring program.

Cameras would be attached to the fence at strategic locations to ensure sampling of a range of fence types. Cameras would be sensor activated and run continuously, with data collected at the three monthly monitoring periods.

7.4.2 Performance thresholds and corrective actions

Monitoring of the emu exclusion fences would be undertaken to assess their effectiveness and inform the need for corrective or provisional measures. The main performance thresholds and corrective actions are outlined in Table 7-6.

Table 7-6. Performance thresholds and corrective actions for exclusion fencing monitoring

Performance Indicator	Corrective actions
• Evidence of emus injured by exclusion fencing or gates. • Evidence of emus breaching the exclusion fencing system and entering the roadway. • Evidence that purpose built escape gates or escapes points are ineffective through the camera monitoring program.	• Review monitoring methods, considering further monitoring and assessment. • Modify the type of fence being breached. • Review monitoring data for all fence types to compare effectiveness and inform decisions around provisional measures. • Repair breach in fence within 5 days of identifying the problem

7.5 Emu habitat revegetation monitoring

7.5.1 Methods, timing, intensity and duration

The objective of the emu habitat revegetation is to restore the habitat surrounding the construction footprint and road boundary in Section 3 and 4 of the project to a high condition based on establishing different habitat zones. As emus are known to use both natural and modified habitats, the revegetation is aimed at restoring the original pre-construction condition of the vegetation.

After the first year of maintenance of emu revegetated areas (refer to **Section 5.3.7**), annual monitoring would be undertaken using the BioBanking assessment methodology (DECC, 2008) to evaluate the progress of revegetation against benchmark data for the target vegetation community. This method would only apply for natural revegetation areas and would be based on undertaken an initial 'benchmark' survey prior to construction. The restoration of modified agricultural landscapes would also be based on a benchmark survey although would be based on photo monitoring plots.

BioBanking is a site-based, quantitative and therefore repeatable assessment procedure that provides a numeric score of the condition of native vegetation. Permanent monitoring plots (100 metres x 50 metres) would be established in revegetation areas and assessed for nine site-based vegetation attributes as follows (note the attribute 'number of large trees with hollows' has been removed as revegetation will be from scratch):

1. Native plant species richness.
2. Native over storey cover.
3. Native mid-storey cover.
4. Native ground cover (grasses).
5. Native ground cover (shrubs).
6. Native ground cover (other).

7. Exotic plant cover.
8. Proportion of over-storey species occurring as regeneration.
9. Total length of fallen logs.

Revegetation criteria for the site-based attributes would be developed, derived from benchmark data by undertaking pre-construction surveys for the different vegetation communities and habitats present to the east and west of the project in Sections 3 and 4.

Monitoring of revegetation areas would commence one to two years after initial establishment and would occur annually (in Spring/Summer) for a period of five monitoring events post-construction or until success of the revegetation has been achieved against criteria. The following information would be collected:

- Record of treatments used, including topsoil source, soil treatment, seeding and planting rates and mixes.
- Photographs of the revegetation areas from permanent photographic points.
- BioBanking site-based vegetation attributes from permanent monitoring plots.
- Slope and erosion.
- Any failure of revegetation works.

7.5.2 Performance thresholds and corrective actions

The following table outlines the monitoring program, performance indicators and corrective actions if monitoring finds poor outcomes as measured by performance indicators. Performance indicators and corrective actions are identified in Table 7-7.

Table 7-7. Performance thresholds and corrective actions for emu habitat revegetation

Performance indicator	Corrective actions
Revegetation criteria not been achieved after 5 consecutive monitoring periods post-construction.	Undertake revegetation maintenance, i.e. replanting, fertiliser treatment, erosion control, weed control.

7.6 Evaluation, project review and reporting

7.6.1 Responsibility

The contractor employed to undertake the emu population monitoring would be responsible for evaluation and reporting of the monitoring program after each monitoring event. Monitoring needs to be proactive and rigorous

7.6.2 Timing

A report would be prepared at the end of each monitoring event to inform the adaptive management and monitoring program. Reports would be prepared by the contractor for distribution to Roads and Maritime and OEH and document the methods and results from each monitoring period.

7.6.3 Identify and implement provisional measures

The connectivity strategy provided in the EIS outlined the proposed process for managing emu connectivity requirements. This included monitoring the performance of the connectivity measures against goals.

If during the operational phase emus are found to be unable or unwilling to use designated crossing structures as per the performance measures outlined in this plan then provisional options would be developed. Depending on the outcome of the monitoring of crossing structures the following four options would be considered in consultation with OEH:

- Maintenance of the existing connectivity measures.
- Modify design of existing measures where feasible and reasonable.
- Construct additional measures.
- Consider additional offset measures to improve connectivity elsewhere.

8. Summary table and implementation schedule

Table 8-1 provides an overall example summary of the actions proposed in the above plan. It also identifies the person responsible for the actions and the estimated timing of the project.

The program schedule would be updating following a review of the approval and project timelines.

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Table 8-1: Summary table and implementation schedule of management plan.

No.	Task	Responsibility	Pre-construction	Construction	Operational				
					Year 1	Year 2	Year 3	Year 4	Year 5
1. Pre-construction management									
1.1	Prepare emu fencing strategy	Ecologist and design team	X						
1.2	Pre-clearing survey	Ecologist	X						
1.3	Identify exclusion zones	Contractor	X						
1.4	Identify sensitive ancillary areas	Contractor	X						
1.5	Develop dog policy	Contractor	X	X					
2. Construction management									
2.1	Develop emus finds procedure	Roads and Maritime		X					
2.2	Vegetation clearing procedure	Ecologist		X					
2.3	Designate temporary emu crossing zones and erect temporary exclusion fence	Contractor		X					
2.4	Prioritise construction of bridges to minimise disruption to emu movements	Contractor		X					
2.5	Install permanent exclusion fencing	Contractor		X					
2.6	Revegetation using cover crops at crossing zones	Contractor		X					
2.7	Emu specific revegetation in areas disturbed by construction including crossing zones	Contractor		X					
2.8	Managing domestic waste	Contractor		X					
2.9	Ongoing management of water quality	Contractor		X					
2.10	Ongoing management of dust and noise	Contractor		X					
3. Operational management									
3.1	Maintenance of exclusion fence and escape points	Roads and Maritime			X	X	X	X	X
3.2	Maintenance of habitat revegetation	Roads and Maritime			X	X	X	X	X
3.3	Predator control	Roads and Maritime			X	X	X	X	X
4. Monitoring program									
4.1	Emu activity monitoring	Ecologist	X	X	X	X	X review	X	X
4.2	Effectiveness of crossing structures	Ecologist		X	X	X	X review	X	X

No.	Task	Responsibility	Pre-construction	Construction	Operational				
					Year 1	Year 2	Year 3	Year 4	Year 5
4.3	Exclusion fencing monitoring	Ecologist		X	X	X	X review	X	X
4.4	Habitat revegetation monitoring	Ecologist		X	X	X	X		
4.6	Evaluation and reporting	Ecologist	X	X	X	X	X	X	X

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10. Acronyms and abbreviations

Acronym / Abbreviation	Description
DoPI	Department of Planning and infrastructure
OEH	The NSW Office of Environment
DSEWPaC	The Department of Sustainability, Environment, Water, Population and Community
Roads and Maritime	Roads and Maritime Service

Appendix A –Stephen Davies CV

from STEPHEN DAVIES

WATERS UPTON
MOUNT HELENA
WESTERN
AUSTRALIA

S.J.J.F. DAVIES - BIOGRAPHICAL DETAILS

Born	26th. April 1935 at Sydney, N.S.W.
Childhood	Mainly at Castle Hill, near Sydney, but with two years at Thursday Island, Queensland.
Education	The King's School, Parramatta, N.S.W. (1943-1952) and The Elms School, Colwall, Malvern, England (1948).
Undergraduate	Emmanuel College, Cambridge, 1953-1956. Graduated with 2.1 honours in Part II Zoology in 1956. I attended courses in Botany (2 years), Organic Chemistry (1 year) and Biochemistry (1 year). I attended a marine course at Bangor, Wales, in 1955, two bird biology courses at Oxford (1955,1956) and visited Swedish Lapland in 1955 as a member of the Cambridge Lapland Expedition 1955. Most of my vacations were spent with my uncle in rural Shropshire.
Post-graduate	I joined the Wildlife Survey Section of CSIRO in 1956 and studied the behaviour and ecology of Magpie Geese at Darwin 1956-1959. During and after those years I carried out a number of experimental studies on the behaviour of captive Magpie Geese. In 1959 I moved to Western Australia to begin studies of the pattern of movement of Emus in north-western Australia and of White-tailed Black Cockatoos in south-western Australia.
PhD Course	1961-1964 at the Sub-department of Animal Behaviour, Madingley, Cambridge, England under the supervision of Professor W.H. Thorpe, FRS, on studies of the behaviour of *Streptopelia* doves and their hybrids in captivity. I attended the 1961 (Germany) and 1963 (Holland) International Ethological Congresses and the Paris Symposium on Antarctic Biology in 1963. I assisted with the running of a freshwater biology course at Slapton Ley Field Studies Centre in 1963, and at Scolt Head Island in 1964. I visited Corsica on fieldwork in 1963. I visited Skolholm Island, Wales with a Ministry of Agriculture, Fisheries and Food field party to study rabbits in 1962.
1964-1975	With CSIRO, Division of Wildlife Research, continuing studies of the movement patterns of Emus, which led into studies of the environmental variables of the mulga zone, and studies of other arid zone organisms. Officer-in-Charge of the Helena Valley Laboratories of the Division 1969-1983, where a programme developed relating the ecology and behaviour of various bird species. I continued work on the behaviour of *Streptopelia* doves leading to the recognition of the critical relationship between the bird's display and its nest-building activities as a mechanism for the stimulation of ovulation in the hen. In 1966 I visited Macquarie Island with the Australian National Antarctic Research Expedition. In 1973 I was a member of the Australian delegation to the third US/Australian Workshop in Range Science at Tuscon, Arizona, U.S.A. In 1974 I was appointed to the Western Australian Wildlife Authority on whose committees I had served since 1971. I was a member of the Australian Committee of the 16th. International Ornithological Congress in Canberra in 1974 and of its Scientific Programme Committee. In 1975 I attended the Association of Animal Behaviour

meeting in Aberdeen, Scotland, and the British Ornithologists Union Conference at Wexford, Ireland, and inspected waterfowl conservation in Ireland.

1976-1998 Officer-in-Charge, CSIRO Helena Valley, until 1983. Director, Royal Australasian Ornithologists Union 1984-1989. Adjunct Professor, School of Environmental Biology, Curtin University of Technology from 1989, and concurrently, Adjunct Professor Environmental Science Murdoch University from 2003. Research Liaison Officer, Division of Environmental Science, Murdoch University, 1990-1999. Other RAOU offices: President , RAOU, 1975-1978; Chairman Research Committee 1975-1984; Fellow 1980; Chairman, WA Group of the RAOU 1970-1984. President, Gould League of WA, 1982-1983. President Royal Society of WA, 1983-1984. Patron, Avicultural Society of WA, 1979-1984. Member, International Ornithological Committee, 1974-1982. Member, Scientific Programme Committee, International Ethological Congress, 1983. Member Western Australian Wildlife Authority, 1974-1984. Member, Conservation Programme Committee of World Wildlife Fund Australia 1978-1984; Trustee 1984-1990; Goverrnor 2007 - present. One of three international speakers invited to "Birds and Man" Symposium in Johannesburg in April 1983. I visited the Percy Fitzpatrick Institute of African Ornithology and the Oudtshoorn district where I visited Ostrich farms and processing facilities. Chairman, Accreditation Panel, Degree of Master of Applied Science in Environmental Science, Western Australian Institute of Technology, January 1985. In November 1985 I was the non-government member of the Australian Delegation to the Third Consultative Meeting of the Japan-Australia Migratory Bird Agreement in Tokyo. from 1986 to 1993 I was a member of the Editorial Committee of the *Fauna of Australia* (ANPWS). In 1986-1987 I was Chairman of the Management Committee of the Ngangganawilli Community Emu Farm at Wiluna, WA. In 1986 I was appointed to the WA Department of Conservation and Land Management, Herdsman Lake Management Advisory Committee and have been Chairman since 1991. I attended and spoke at the International Ornithological Congress at Ottawa, Canada, in June 1986, and was appointed to the IOC Committee on Applied Ornithology, became a member of the Working Group on Birds as Indicators of Environmental Change and was appointed Chairman of that Working Group in 1998. Attended the IOC meeting in Vienna, Austria, in 1994. I was appointed by the Victorian Department of Conservation, Forests and Lands to the Review Committee on the Possession and Trade in Wildlife from 1987-1989. I was elected a Corresponding Member of the British Ornithologists Union in 1987-97. I was made an Honorary Member of the Emu Farmers Federation of Australia in 1989 and was Chairman of its Research and Information Committee 1995-8. I was appointed to the Board of Whiteman Park, WA in 1991. In 1992 99 I was elected to the national committee of the Australian Rare and Minority Breeds Association; vice-president 1993-99. I was a member of the WA Rhodes Scholarship Selection Committee in 1994-1996. Appointed to the WA Recovery Team for Carnaby's Cockatoo in 2003 and the WA and National Recovery Teams for Malleefowl in 2004.

Sc.D. I was admitted to the ScD. degree by Cambridge University in 1988.

Scholarships 1953-1956 Broughton and Forrest Exhibition from The Kings School, Parramatta, to Cambridge. 1961-1964 CSIRO Overseas Studentship to the Sub-department of Animal Behaviour, Cambridge.

Teaching From 1969-1972 I gave an annual course on Animal Behaviour to the honours school of the Department of Psychology in the University of Western Australia. From 1984 to 1988 I lectured in Wildlife Management at the School of Agriculture and Forestry, Melbourne University, and in 1986 gave two courses on Wildlife Management at Footscray College of Technical and Further Education (Victoria). In 1989 I contributed twelve lectures and six practicals to the 202 second year vertebrate biology course at Curtin University of Technology; from 1997 I have contributed six lectures and three practicals to this course. From

1991 I have been Course Coordinator for the Landcare Revegetation Unit of the Graduate Diploma in Landcare offered by Curtin University of Technology. I have given several series of extension lectures on animal behaviour and on birds for the University of Western Australia. I have demonstrated at the Murdoch University Ecology Camp from 1992, and lectured in Management of Aquatic Systems and Monitoring Fauna units. I have supervised 26 honours, 4 masters and 13 PhD students, all of whom have completed their degrees.

Valuations — I have been a registered valuer of Biological Material with the Cultural Gifts and Bequests Programs (and precursors) since 1985.

Consulting — Scientific Consultant to Iluka Resources Ltd Capel Wetlands Centre, since 1989. Ecological Consultant to Mundaring Christian School, 1992-1993. Ornithological Consultant to Government House, Perth, Grounds Maintenance Advisory Committee 1994-97. Prepared fauna survey reports for Cobra Station, Gascoyne (1984), Trickle Creek, Parkerville (1989), Koobabbie Farm, Coorow (1990) (this farm was runner-up in the Greening Western Australia, John Tonkin Award (private landholder) 1994). Conducted bird surveys at Kangaroo Hills and Calooli Timber Reserves, Coolgardie (CALM 1991), Innering Catchment (Carnamah LCDC, 1992), Western Reefs Mt. Farmer prospects (1995) and conducted biological survey of unmade road reserves in the Shire of Dumbleyung, 1993 (this survey was part of the winning entry in the Greening Western Australia John Tonkin Award (Local Government) 1994). Prepared a Management Plan for the Churchmans Bushland Association (Churchman Regional Open Space) 1996-98. Conducted weekend workshops on Wildlife on Farms at Birralee, Kukerin (1990), at Wybalena, Kojonup, (1990) and on Farm Dams at Tincurrin, 1992. Flora surveys of the Marchagee, Waddy Forest and Wilton Well Catchments for the National Heritage Trust 1999-2000. Conducted search for new populations of a rare plant *Chorizema humile* in WA in 2000 (CALM) Undertook a consultancy "Coast and Catchment" on Carnaby's Cockatoo for the Moore Catchment Council, 2001. Surveyed the vegetation structure and bird communities of the Latham Land Conservation District, 2001. Undertook biological survey of the Mullewa Land Conservation District, 2001-2002. Advice to the NSW Roads and Maritime Service on the realignment of the Pacific Highway around Grafton. December 2007. External Triennial Review of the Department of Environment and Conservation Ethics Committee, March 2011.

Hobbies Include breeding Shropshire sheep of which I have maintained a stud since 1969; I exhibit the sheep regularly in the Perth Royal Show and Wagin Woolarama.

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Appendix B – S. Davies expert review

REVIEW OF THE WOOLGOOLGA TO BALLINA / PACIFIC HIGHWAY UPGRADE
DRAFT COASTAL EMU MANAGEMENT PLAN – Version 0.3

by Stephen Davies

I have examined the Draft Coastal Emu Management Plan – Version 0.3 - prepared by NSW Roads and Maritime Services, Aurecon and Sinclair Knight Mertz, together with the notes from the telephone discussion of August 23, 2013, the Agency Comments on the Plan and the responses from the authors of the Draft Plan.

I consider the Plan is sound, thorough and workable.

Specifically:

1. Figure 2.1 illustrates a satisfactory number of crossing points for emus to pass between the flood plain and the coastal habitat.
2. The early construction of emu exclusion fencing, prior to the commencement of construction work, along the highway alignment except at emu crossing points is strongly endorsed (5.3.2).
3. The need to control vehicle and emu movement at crossing points during the construction phase in Zones 3 and 4 is necessary and practical (5.3.3).
4. Raised bridges with a minimum height of 3.6 metres will give satisfactory clearance for emus to pass through (5.3.6).
5. The provision of food for emus – soy beans and laplap – at the entrances to bridges is strongly endorsed (5.3.8).
6. Giving emus a clear view toward and through the bridges is important (5.3.8).
7. The methods of monitoring the movement of emus to and from the floodplain are acceptable (7.2; 7.3). but would be improved by some aerial monitoring (see below)

DETAILED COMMENTS ON THE PLAN

1.3 It is excellent that the plan is regarded as a dynamic document.

2.2 The Victorian road maintenance authority – I do not know its present name – has kept records of road kills of Emus on the Sturt Highway, and these should be available.

3.1 I agree about the importance of limiting vehicle strike.

Emus will locate open gates as they walk up and down fences. They do so on the 1000 km Emu Fence in Western Australia.

3.4 The Western Australian Emu fence directs Emus well, often for hundreds of kilometres. Stock fences will not deflect Emus.

5.3.2 I endorse this paragraph as Emus are well known to be inquisitive.

5.3.8 I endorse this paragraph, particularly the straight leads; traffic noise will be continual and this will be less disrupting than sudden bursts of noise. The early revegetation with known food plants, even though not native, is very sensible.

RCOMMENDATIONS

1. In Western Australia aerial surveys in a high-winged monoplane (Cessna 182 or 206) have been effective in counting Emus when flown at about 400 feet above the ground. Emus would be easily visible on the open flood plain and looking at the aerial photos of the open woodland of the W2B study areas 3 and 4 that show the projected flood levels in the plan document (Appendix B), Emus should be visible there too. It would benefit the monitoring program to fly one or two hour surveys over the flood plain and along the coast in the pre- and post-breeding seasons to complement the land–based monitoring. This

should indicate if shifts in the population do occur. There is an airport at Grafton and it is likely that a Cessna could be chartered there for a short flight.

2. Emus can be controlled by normal rabbit proof fencing with three barbs on top, giving a total hight of 1.3 metres. It works well in the Western Australian Emu Fence. From 350 Emus banded outside the fence only one was found inside the fence and that was thought to have been shot outside the fence but the address of the shooter was inside the fence. There is no need to have solid fencing as in emu farms, but a vehicle track along the fences will help emus to move along it. I recommend that an exclusion fence of similar design be used along the alignment. Further information can be obtained from Emily Lewis, WADFA Coordinator of the Esperance Emu Fence Extension Emily.Lewis@agric.wa.gov.au

SUGGESTIONS

1. There are various methods of catching wild Emus. That illustrated in Rowley (1974). Bird Life. Collins. p 256 is very effective but no longer practical with current OHS rules. A Western Australian sheep station Wogarno has devised a water trap that catches Emus, although it was built to catch goats. Their address is David and Lesley-Jane Campbell, Wogarno Homestead, P.O. Box 525, Mount Magnet 6638, Western Australia and the phone number is (08) 9963 5846. The e-mail is wogarno2@bigpond.com but I would suggest a phone call first. It may be worth seeking their advice.

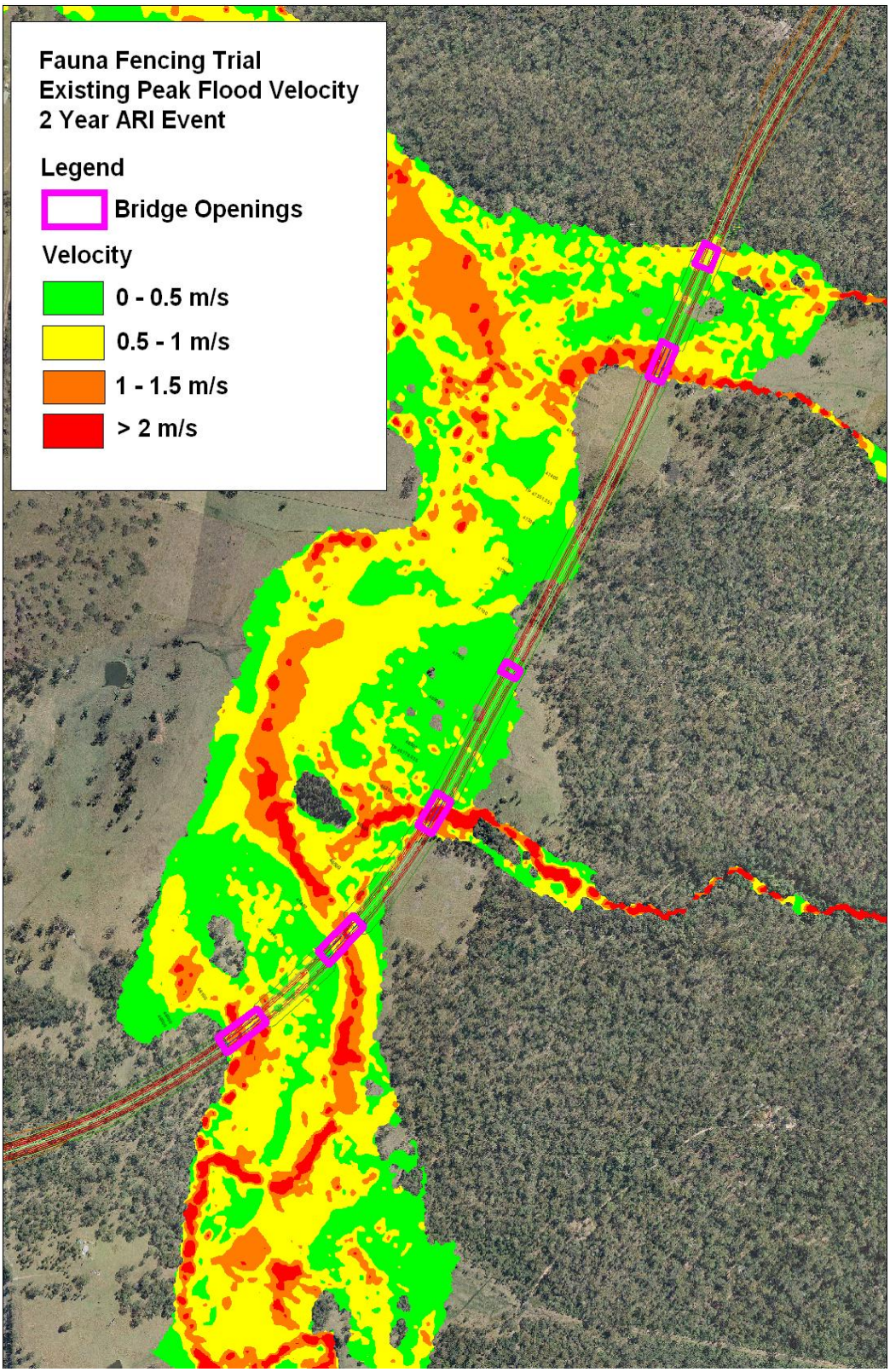
2. One general point relates to the whole approach taken by the plan, set out in 1.2 – Purpose and Objectives. In this it is stated that the plan "… outlines the most appropriate mitigation and monitoring actions to be taken to address the long-term survival of this species in the relevant areas of the W2B upgrade." The plan does this by dealing in detail with the means of ensuring that the emus are able to cross the new highway safely, but mentions only briefly aspects related to the breeding of the birds. Of the three coastal Emu populations in the area, one is already thought to be extinct, and both the others are estimated to be small, less than 60 birds and between 80 and 120 birds. In order to ensure the

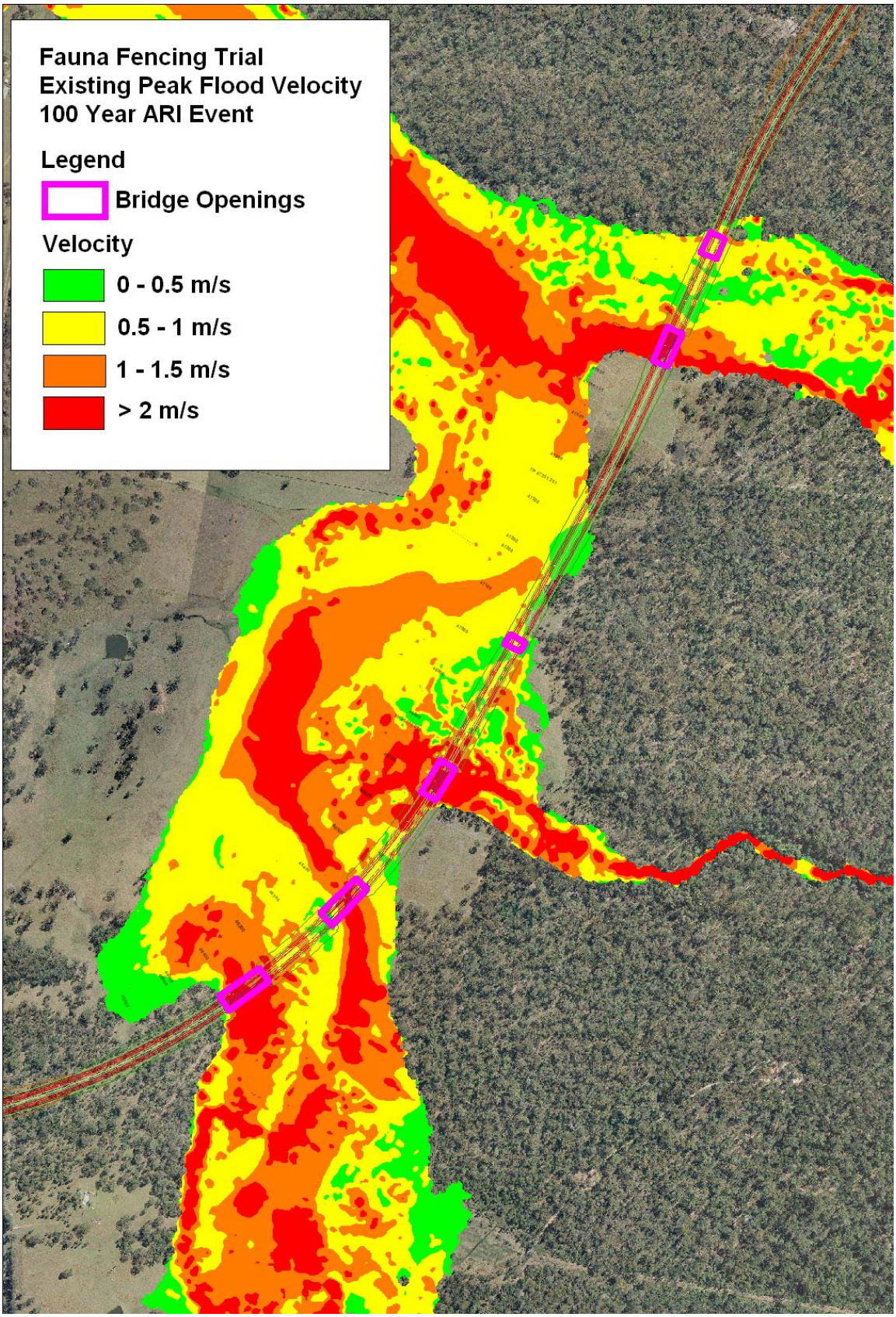
survival of the populations consideration should also be given to enhancing the breeding potential of the existing populations. The bird can produce large clutches and rear them successfully if the food supply during the pre-breeding period (January-March) is good and plenty of food is available for the chicks in their early weeks (July-August). It is particularly desirable that breeding should be successful during the construction and early operational phases of the project, when road casualties are likely to occur (over 60 have been reported in the last ten years (2.3 and 3.1), that is half the number of birds estimated in the largest surviving population). It may therefore be desirable to enhance the breeding potential of the surviving population by providing supplementary food for the birds in the suspected breeding areas during the pre-breeding and early chick periods. The birds are known to eat soy beans and laplap beans (2.2.4) and if weekly feeds of these cereals were provided in identified breeding areas it could greatly enhance the reproductive potential of the population.

It will be said that this introduces an artificial treatment to a natural population. From the Emu's point of view the whole situation is artificial, although fires undoubtedly occurred in pre European times, there were no roads, no vehicles and no substantial clearing in those days. The population can clearly adapt to artificial changes as nests have been found in cane fields (2.2.2). If the population is to survive this help may be of great benefit and a low additional cost compared with the engineering works proposed in the plan. It can be considered as an Off-set, the possible use of which is noted in the plan already (7.6.3).

3. It would be good if revegetation in roadside areas disturbed during construction contained native food plants that produce fruit such as figs (5.3.9).

Appendix C - Flood velocities in emu habitat areas




Fauna Fencing Trial
Existing Peak Flood Velocity
100 Year ARI Event
Legend
Bridge Openings
Velocity
0 - 0.5 m/s
0.5 - 1 m/s
1 - 1.5 m/s
> 2 m/s