NSW Roads and Maritime Services

WOOLGOOLGA TO BALLINA | PACIFIC HIGHWAY UPGRADE

THREATENED FLORA MANAGEMENT PLAN

Version 1.0

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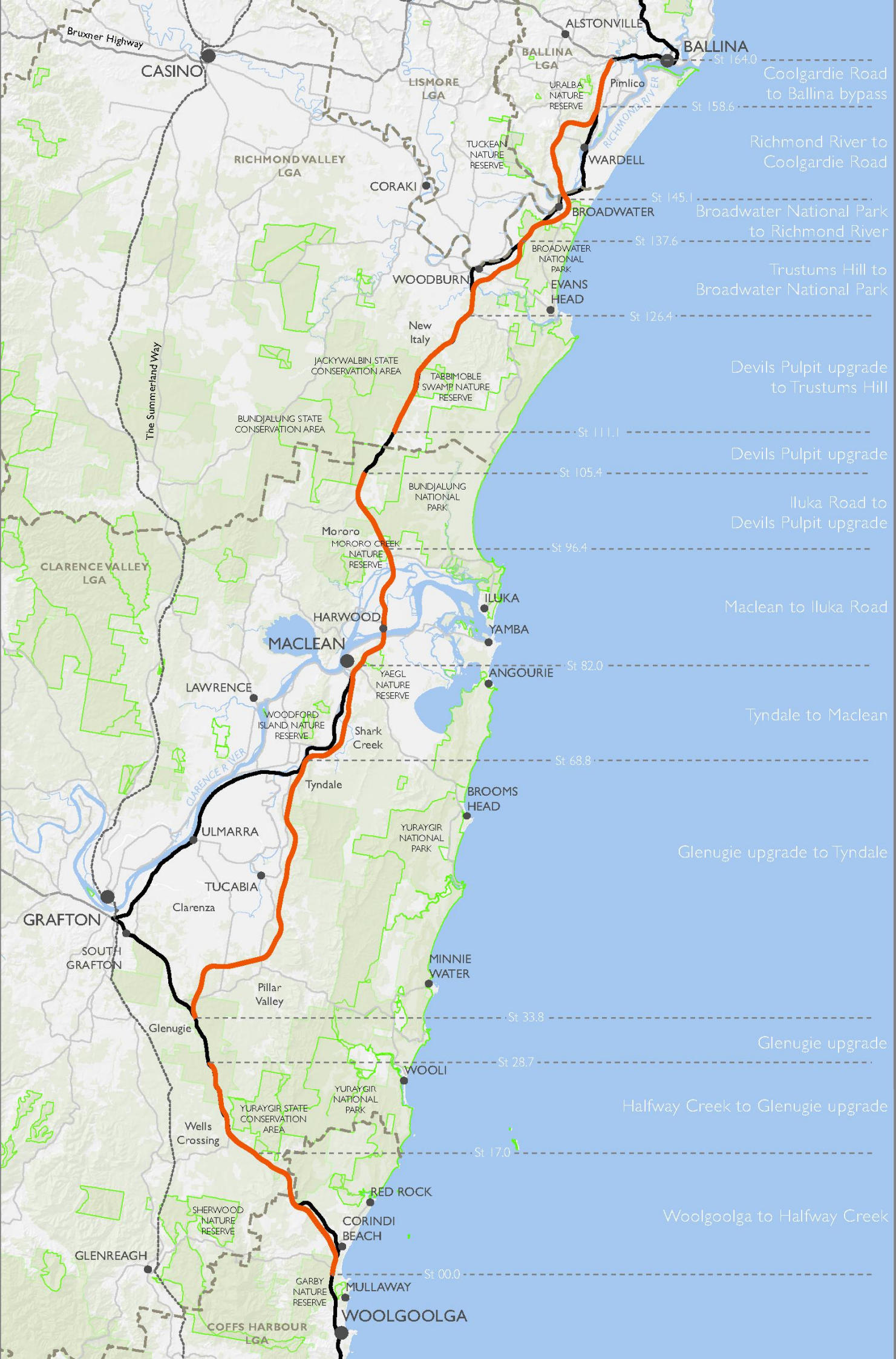
Bruxner Highway
CASINO
ALSTONVILLE
BALLINA
BALLINA LGA
St 164.0
Coolgardie Road to Ballina bypass
11
LISMORE LGA
URALBA NATURE RESERVE
Pimlico
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Richmond River to Coolgardie Road
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RICHMOND VALLEY LGA
TUCKEAN NATURE RESERVE
WARDELL
CORAKI
St 145.1
BROADWATER
Broadwater National Park to Richmond River
9
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
6
Mororo
MORORO CREEK NATURE RESERVE
St 96.4
CLARENCE VALLEY LGA
ILUKA
Maclean to Iluka Road
5
HARWOOD
YAMBA
MACLEAN
St 82.0
ANGOURIE
YAEGL NATURE RESERVE
LAWRENCE
WOODFORD ISLAND NATURE RESERVE
Shark Creek
Tyndale to Maclean
4
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
2
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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Glossary of Terms

Term	Definition
CEMP	Construction Environmental Management Plan
CoA	Conditions of Approval
Construction footprint	The direct area of the design alignment
DECCW	Department of Environment, Climate Change and Water (now known as OEH)
Direct impact	An impact that causes direct harm within the project boundary (i.e. clearing of vegetation)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (Now known as the Department of Environment)
DoPI	Department of Planning and Infrastructure
DPI	Department of Primary Industries
EP&A Act	Environmental Planning and Assessment Act 1979
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EIS	Environmental Impact Statement (Biodiversity Assessment Working Paper)
Ex-situ	Locations where plant populations would be translocated or revegetated in a new area.
FFMP	Flora and Fauna Management Plan
Indirect impact	An impact that causes harm outside of the project boundary as a result of a direct impact (i.e. edge effects, erosion etc.)
In situ	Locations where plant populations already exist and occur naturally in the landscape.
NSW	New South Wales
OEH	Office of Environment and Heritage
The Project (aka Project boundary)	Refers to the all the proposed works in all eleven sections which includes the construction footprint with a 10 metre construction buffer, ancillary and compound sites and design changes.
Roads and Maritime	Roads Maritime Services
S/PIR	Submissions / Preferred Infrastructure Report
Stochastic event	Natural phenomenon such as storms, fires, floods, droughts etc. (random event)
TFMP	Threatened Flora Management Plan (this plan)
Threatened species	Any organism listed as vulnerable, endangered or critically endangered under state and/or Commonwealth legislation.
TSC Act	Threatened Species Conservation Act 1995

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. However, 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 of the plan

This threatened flora management plan identifies the potential impacts of the upgrade on threatened plant species listed under the EPBC Act and NSW *Threatened Species Conservation Act 1995* (TSC Act) which were considered to be directly impacted or at greatest risk from the project. This plan does not include threatened rainforest plant species which are addressed in the *Rainforest Communities and Threatened Rainforest Plants Management Plan*.

This plan identifies the proposed mitigation measures to be implemented for threatened plants and a program for monitoring the effectiveness of these measures.

The objectives of the plan include providing:

- An effective threatened plant management plan with consideration to the concerns of main stakeholders.
- A summary of the locations where threatened plant populations may 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 threatened plant populations.
- A monitoring program to be implemented pre-construction and during construction and operation of the project the effectiveness of the mitigation measures proposed and inform an adaptive management approach.

1.3 Management structure and plan updates

Management structure

This plan provides a framework for any part of the proposed upgrade between Woolgoolga to Ballina that is of relevance to the subject species and specific locations. 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 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 (DoPI) and NSW Office of Environment and Heritage (OEH).

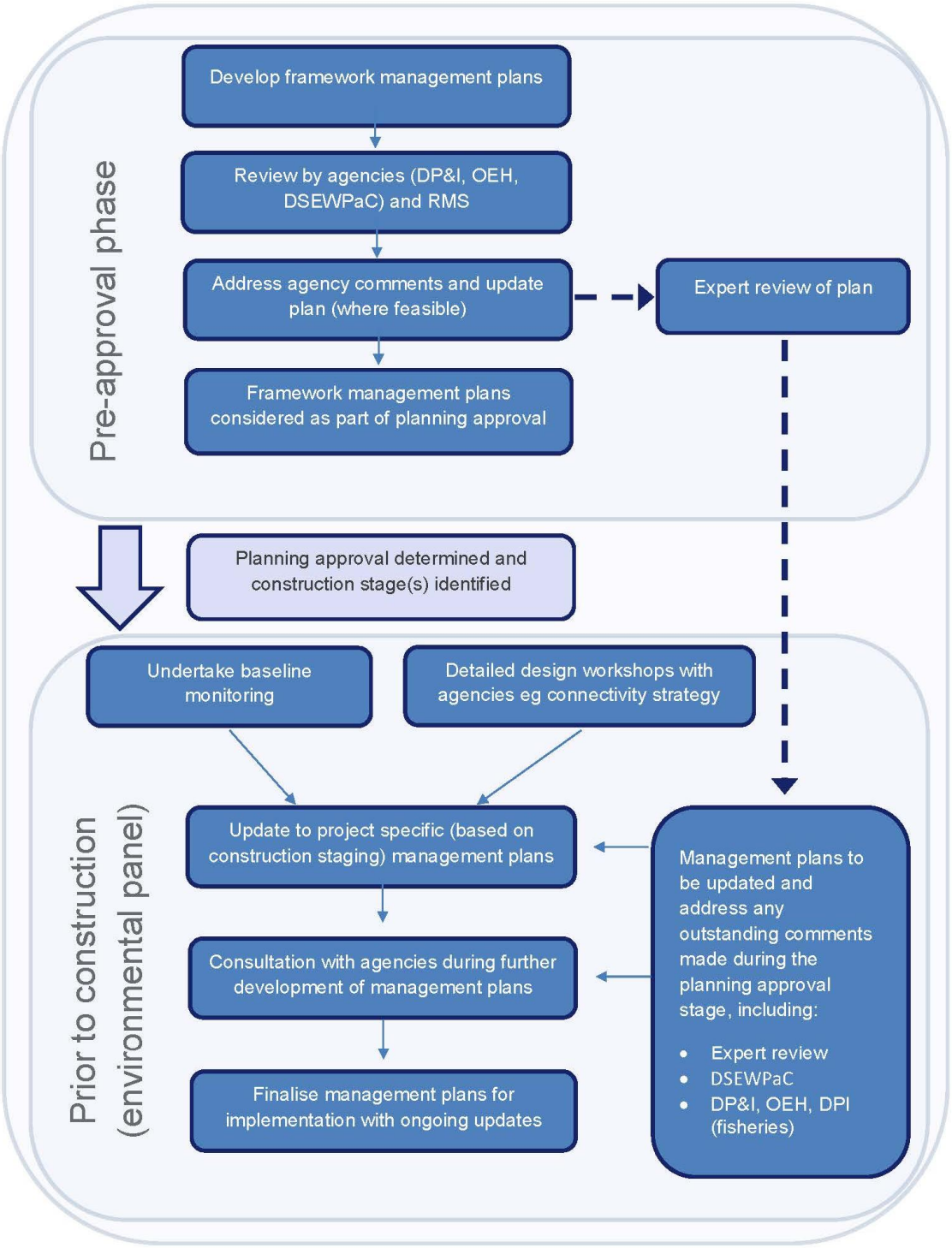
General responsibilities for environmental management would be outlined in the CEMP and FFMP. Responsibilities for implementation of this plan have been described throughout and summarised in Chapter 8. Following approval of the plan, the construction contractor and the contractors ecologists engaged 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 Environmental Impact Statement (EIS) and Preferred Infrastructure Report (PIR) 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 further consultation with adjacent landowners. The final selection of monitoring sites would be subject to further interrogation through the implementation of the targeted surveys (refer to section 4.3) 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.

Figure 1-1 Process to develop management plan



1.4 Plan authors and expert review

The biodiversity assessments technical lead was Chris Thomson (BAppSc, GradCertNatRes) with flora assessments led by Andrew Carty (SKM, BEnvSci, DipBushRegen). The flora assessment surveys were undertaken by the following people; Andrew Carty, Alex Callen (BEnvSci, DipBushRegen), Jon Carr (BEnvScMngt) and Lui Weber (BSc Hons). **Table 1-1** details the qualifications and experience of the authors of this plan.

Table 1-1 Authors qualifications and experience

Personnel	Qualifications	Experience
Chris Thomson	Bachelor of Applied Science and Graduate Certificate in Natural Resources	Chris Thomson has 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 highly experienced in the design and implementation of ecological monitoring programs, flora and fauna surveys, threatened fauna management plans and ecological impact assessment, having completed numerous studies for clients such as the Roads and Maritime and Department of Defence. Chris has considerable experience in the preparation and implementation of species specific management plans and monitoring programs.
Andrew Carty	Bachelor of Environmental Science, Certificate IV in Natural Area Restoration and Certificate II in Bush Regeneration	Andrew has a Bachelor of Environmental, Certificate IV in Natural Area Restoration and Management and Certificate II in Bush Regeneration. He has also completed the DECCW BioBanking Assessors Course. Andrew has over ten years experience specialising in botany and flora ecology. His experience includes flora and fauna field survey design and implementation, species identification, habitat evaluation and assessment, weed management and natural resource management. Andrew has comprehensive knowledge and experience with State and Commonwealth legislation regarding environmental impact assessment, threatened species protection and noxious weed management for Australia. Andrew has undertaken numerous projects throughout NSW for the Roads and Maritime Services including detailed biodiversity impact assessments, options assessments, offset strategies and ecological monitoring. Andrew is qualified to undertake BioBanking assessments in accordance with the NSW DECCW BioBanking assessment methodology. Andrew is licensed by the appropriate authorities to undertake flora and fauna investigations.
Kirsten Leggett	Bachelor of Science and, Graduate Diploma in Environmental Studies (Honours)	Kirsten Leggett has 13 years' professional experience in environmental management and has much experience in managing and co-ordinating ecological impact assessment projects and report writing.
Christine Corbett	Bachelor of Science	Christine Corbett has 16 years' professional experience and has undertaken ecological projects in most Australian states. She has done many ecological impact assessments and written reports for a wide range of projects. Christine has undertaken threatened flora surveys on roadsides and developed management and monitoring regimes for on-going protection of significant threatened species values.

Expert review

An expert review of the plan was undertaken in August 2013 by Dr Andrew Benwell. Andrew has more than 20 years professional experience in natural ecosystem management in NE NSW and SE Qld and is the Director of Ecos Environmental Pty Ltd which delivers a wide range of services dealing with the survey and management of flora and fauna. Expertise includes botanical survey, vegetation classification and mapping, preparation of plans on vegetation rehabilitation and restoration, threatened species translocation, weed management, monitoring and research. As well as preparation of planning documents and provision of advice. Ecos also implements ecological management works including bush regeneration and habitat restoration, threatened species translocation, broad-scale planting, weed removal, seed collection, plant propagation, ecological monitoring, auditing and research.

A curriculum vitae which contains a list of published or relevant work on threatened flora species for Andrew Benwell is provided in Appendix A and a copy of his review of the management plan is attached as Appendix B. The recommendations provided in this review have been summarised in Table 1-2. 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 1-2 Summary of recommendations from the expert review and how addressed in this plan

ID No	Section	Comment / Recommendation	How recommendation has been addressed in the plan
TFlMP1	Glossary	Include a glossary of terms at the front of the plan.	Adopted- plan updated
TFlMP2	1.2	This section doesn't describe the purpose and objectives of the plan. *Recommendation:* State the purpose and objectives of the W2B Threatened Flora Management Plan	Adopted- plan updated
TFlMP3	1.3	Not sure about the approach of a Framework TFMP and then stage-specific TFMPs. This may lead to a lot of duplication of reporting, increased 'green-tape' and significantly higher costs. Why not one threatened flora management plan for the whole project? The number of threatened species affected by the project is not particularly high.	To be reviewed prior to implementation
TFlMP4	1.3	Include rare species (such *Dicrocephala integrifolia*) as not listed under the TSC Act or EPBC Act in the Plan. Include the (TSC Act) endangered *Rotala tripartite* which was recorded in 2006 after completing the Iluka to Woodburn vegetation survey report	To be reviewed prior to implementation
TFlMP5	3.3	Bullet point to be reworded to ' targeted revegetation of disturbed areas adjoining in-situ threatened flora' Include this into the objectives/goals.	Adopted- plan updated
TFlMP6	4.3.2	Translocation proposal is best considered as part of a larger offsets strategy for threatened flora that includes direct offsets. *Recommendations*: • Include a general discussion of translocation including its purpose and objectives, the different types of translocation, history of use, general outcomes, reasons for failure etc as an introduction to the Translocation Strategy. • Include a discussion of the purpose and potential benefits (and risks) of translocation in the context of direct impact and loss of threatened species individuals (see WC2U TFMP). • Translocation would not be factored into offset formulae. • Translocation receival sites would be located outside the project boundary, in disturbed sections of offset land. • Translocation would be conducted to prevent declines in population numbers of threatened species in the vicinity of W2B upgrade (note – without translocation in some form there would be a net loss of individuals due to the project). • The introduction of threatened species to receival sites (i.e. translocation) would be designed in a comparative experimental fashion where practical to learn more about species ecology and translocation technology. • Include a section on the selection/allocation of receival	Adopted- plan updated

ID No	Section	Comment / Recommendation	How recommendation has been addressed in the plan
		sites.	
TFlMP7	5.3.5	Roads and Maritime has not developed standard weed management procedures that are implemented during construction as part of FFMP and targeted to in-situ threatened flora. *Recommendation*: Maintenance of in-situ threatened flora sites, which would involve weed removal and revegetation if required, be conducted as a package and implemented by a bush regenerator with local experience, rather than by the landscape architect or general weed control contractor.	To be reviewed prior to implementation.
TFlMP8	4.3.5	Tub-grinder mulch not be spread around in-situ threatened flora sites.	Adopted- plan updated
TFlMP9	General	The six mitigation measures listed to address this issue are all forms of translocation, although the way it is written might suggest otherwise. For example, "seed collection for establishment of threatened species on offset sites" is translocation. The three core mitigation measures for direct loss are: 1. Avoidance of impact where possible, including during the detailed design stages (ie. 85% and 100% detailed design) 2. Translocation – compensatory introduction to offset/receival sites, salvage transplanting to offset/receival sites, relocation to a nearby site with matching habitat, population enhancement to promote long-term population viability and so on. 3. Offsets – e. g. acquire and protect threatened flora habitat, improve threatened species habitat elsewhere etc.	Adopted-plan updated
TFlMP10	General	Move SMART principles to the start of the plan and consider throughout; clarify 'adaptive management'.	Adopted- plan updated
TFlMP11	4.3.1	Update table with: Arthraxon hispidus – Dec. to May Cyperus aquatilis - Jan to June Maundia triglochinoides – spring, summer, autumn Melaleuca irbyana – all year	Adopted- plan updated.
TFlMP12	4.3.1	For non-aquatic threatened species, the indirect impact zone would be defined as within 10m of the edge of clearing. For aquatic species and shade-requiring species such as the two orchids occurring on the project, the indirect impact species would be 20m.	To be reviewed prior to implementation
TFlMP13	4.3.2	Include a general discussion of translocation including its purpose and objectives, the different types of translocation, history of use, general outcomes, reasons for failure etc as an introduction to the Translocation Strategy. * this point is about the same issue as point 6.	Adopted- plan updated.
TFlMP14	4.3.2	Second last paragraph about "translocation trials" may need to be reworded as 'trial' indicates a preliminary or test translocation to be conducted before the full translocation, which I don't think was intended(?) Suggest including > translocation may be considered feasible for a threatened species that has not been translocated before if its ecological requirements, growth-form attributes and propagation characteristics indicate that translocation employing a certain method has a reasonable chance of success<	Adopted- plan updated.
TFlMP15	*4.3.2*	*Recommendation:* Include a section on the selection/allocation of receival sites.	Adopted- plan updated.
TFlMP16	4.3.3 and Table 4-	Change title to Threatened plant propagation, or Seed/cutting collection and propagation The requirements specified in some paragraphs would be	Adopted- plan updated.

ID No	Section	Comment / Recommendation	How recommendation has been addressed in the plan
	2	clearer in dot point format. What about a more general intro to this section – how does propagation fit into the overall process of translocation? 2nd paragraph– replaced stoned with stored. 3rd paragraph – suggest using dot point format. Table 4-2 Arthraxon hispidus Flowering Period – March-May; Seed collection – May-June. 6th paragraph – Some (not many) threatened species are difficult to germinate…… The use of cuttings may also be required if seed is not available for collection or does not propagate well.	
TFlMP17	4.3.3	Include a section on indirect management of genetic diversity.	Adopted- plan updated.
TFlMP18	Table 4-3	Set out this experimental initiative more clearly.	Adopted- plan updated.
TFlMP19	4.3.3	p.20, reword 3rd paragraph. See also results of previous threatened flora translocation projects for the Pacific Highway upgrade.	Adopted- plan updated.
TFlMP20	4.3.3	p. 20, last paragraph – Suggest change wording to: >Propagation of the threatened species would only be done by qualified/ experienced nurseries or plant propagators, and only disease free tubestock would be introduced to the receival sites.	Adopted- plan updated.
TFlMP21		Put seed propagation first Replace "bog method" with >saturated soil medium method< 2nd dot point, suggest change to >would be transplanted to 120mm tubes, or super tubes depending on the species, and grown on until at least 40cm tall. In the case of fast growing species this may take 9-12 months, for slower growing species 18 months or more… 3rd dot point – suggest change wording to >planted out when at least 40cm tall and after hardening off……	Adopted- plan updated.
TFlMP22		Provide more detail on the revegetation sub-plan – ie. what, where, how and when.	Adopted- plan to be updated prior to implementation.
TFlMP23	Table 4-5	3rd goal, Corrective action, suggest rewording to – Delay construction until seeds and propagules have been collected >only if they cannot be collected elsewhere in the local area including outside the construction zone.<	To be reviewed prior to implementation
TFlMP24	5.2	1st dot point – Suggest >zero mortality due to direct physical damage during construction. "No notable increase in the abundance of weeds" should be a separate dot point. 2nd dot point – this dot point implies that translocation would be carried out during construction? Salvage transplanting is normally carried out pre-construction. Propagation may start pre-construction or during construction. Last dot point – Water quality and >soil quality< managed in accordance with the CEMP. Non-aquatic threatened plants may be threatened by changes to soil quality, including erosion and sedimentation.	Adopted- plan updated.
TFlMP25	5.3.3	Suggest including >Sensitive Area Plans (Maps)< as a separate heading. SAPs are important for identifying where threatened flora are located for day to day management of the project. They should be kept up to date and clearly show the locations of in-situ and to-be-translocated threatened flora with their identification numbers.	Adopted- plan updated.
TFlMP26	5.3.1	"including risks to threatened frogs" – what are they?	Adopted- plan updated.

ID No	Section	Comment / Recommendation	How recommendation has been addressed in the plan
TFIMP27	5.3.5	2nd paragraph – take out Quassia sp. Moonee Creek, generally occurs on slopes.	Adopted- plan updated.
TFIMP28	5.3.6	Revegetation and habitat maintenance around in situ threatened flora should be a bush regeneration task, not part of the broad-scale landscaping	Adopted- plan updated.
TFIMP29	5.3.6	Incorporate the use of salvaged topsoil seedbank in the revegetation of disturbed areas around in-situ threatened flora sites.	Adopted- plan updated.
TFIMP30	5.3.7	Weed management. During construction?	Adopted- plan updated.
TFIMP31	5.3.8	Install shade cloth screening along the edge of vegetation containing low growing, in-situ threatened species such as *Lindsaea incisa* for dust protection and to maintain microclimate.	Adopted- plan to be updated prior to implementation
TFIMP32	6.2	Main goals. Suggest that the goals be numbered. First goal/row – suggest the goal be set at zero mortality for physical damage during construction. Other projects have shown this is quite achievable. Any mortality due to direct physical damage is not acceptable, as the principle contractor may be prosecuted by EPA. There are two goals in the one sentence – put the weeds one as a separate goal. Proposed mitigation measures – include SAPs (see 5.3 above) Second goal/row – Proposed mitigation measures, suggest reword to include >undertaken at times, into suitable habitat and using appropriate methods< that maximise the chance of plant survival…… Monitoring timing/frequency – give the specific monitoring interval – e.g. 1st year – 3-monthly Performance thresholds – suggest change to >All plants identified for translocation have been translocated Corrective action – tubestock would be propagated anyway as part of population enhancement (for most species). Third goal/row Suggest reword as >revegetation and habitat management requirements for areas adjoining in-situ threatened flora prepared in a separate scoping sub-plan< or make into a separate goal. Employ specialist bush regenerator to implement.	Adopted- plan updated Adopted- plan updated To be reviewed prior to implementation
TFIMP33	5.4	Include measures to guard against illegal orchid collecting.	To be reviewed prior to implementation
TFIMP34	5 and 6	Both sections 5 and 6 of the plan concern the management of in-situ (roadside) threatened flora. At least 50% of the framework TFMP appears to deal with in-situ threatened flora from various angles. Is this the most efficient way to approach management of threatened flora? Translocation is arguably more important and technically difficult to implement, so you would expect it take up at least as much space as management of in situ threatened flora…?	Adopted- plan to be updated prior to implementation
TFIMP35	6.3	Refine the specification of performance thresholds. The goal for weeds is less than 5% weed cover at in-situ threatened flora sites at the end of the monitoring program.	Adopted- plan updated
TFIMP36	6.0	Provide more detail on the revegetation sub-plan – ie. what, where, how and when.	Adopted- plan to be updated prior to implementation
TFIMP37	6.0	Clarify the monitoring schedule, including the frequency of monitoring in each year (1-8?), specify the monitoring interval (e.g. year 2, 6-monthly….), for each aspect of the	Adopted- plan to be updated prior to implementation

ID No	Section	Comment / Recommendation	How recommendation has been addressed in the plan
		TFMP being monitored, and type of data to be recorded. Clarify and revise the description of performance thresholds	
TFlMP38	6.3.3	6.3.3 Weed management. This is repeating a previous section	To be reviewed prior to implementation
TFlMP39	6.4 and Table 6-1	Clarify and revise the description of performance thresholds as described above – set out clearly.	Adopted- plan to be updated prior to implementation
TFlMP40	6.0	What about monitoring of the translocation work?	Adopted- plan updated
TFlMP41	6.5	Objectives to be clearer set out in dot point format, checking wording.	Adopted- plan updated
TFlMP42	6.6	In-situ populations. For what species will the project really survey and collect "details on the distribution and abundance of threatened species immediately adjacent to the project" (2nd sentence) – ie outside the project boundary?	To be reviewed prior to implementation
TFlMP43	7.1	Methods, timing, intensity and duration The first paragraph needs to be reworded. Until what mitigation measures have proven successful? Describe how they would be assessed as having succeeded. How long are the 3 consecutive monitoring periods?	Adopted- plan updated
TFlMP44	7.2	Describe for what species and where this monitoring would be applied	Adopted- plan updated
TFlMP45	7.3	Translocation Why all the detail about monitoring in-situ threatened flora and nothing about monitoring the translocations?	Adopted- plan updated
TFlMP46	7.5	Performance measures and corrective actions – Table Same comments as the performance tables above.	Adopted- plan updated

2. Threatened plant populations

2.1 Identification

Populations of fifteen non-rainforest threatened plant species have been confirmed within the project or adjacent to the project and therefore may be indirectly impacted. These are listed in **Table 2-1** along with their status under the EPBC Act and the TSC Act. These species collectively form the basis of this management plan. After the initial EIS Biodiversity assessment, the species list was changed slightly in light of the findings of supplementary surveys, completed in April 2013. The locations of these threatened non-rainforest species are displayed over numerous figures from the Biodiversity Assessment Working Paper (Roads and Maritime 2012) and *Supplementary Biodiversity Assessment* (Roads and Maritime 2013).

The figures in **Appendix B** also show the location of these species. A profile of each threatened plant species to be impacted by the project can be found in **Appendix C**.

Table 2-1 Threatened plant species addressed in the management plan

Species	Common name	Status EPBC Act	Status TSC Act
Angophora robur	Sandstone Rough Barked Apple	V	V
Arthraxon hispidus	Hairy Joint Grass	V	V
Cyperus aquatilis	Water Nutgrass	-	E
Eucalyptus tetrapleura	Square-fruited Ironbark	V	V
Eleocharis tetraquetra	Square-stemmed Spike-rush	-	E
Grevillea quadricauda	Four-tailed Grevillea	V	V
Lindsaea incisa	Slender Screw Fern	-	E
Maundia triglochinoides	Maundia	-	V
Melaleuca irbyana	Weeping Paperbark	-	E
Oberonia titania	King of the Fairies Orchid	-	V
Olax angulata	Square-stemmed Olax	-	V
Phaius australis	Southern Swamp Orchid	E	E
Prostanthera cineolifera	Singleton Mint Bush	V	V
Prostanthera palustris	Swamp Mint Bush	V	V
Quassia sp. Moonee Creek	Moonee Quassia	E	E

Note: E – endangered and V- vulnerable.

2.2 Existing knowledge

Chapter 3 describes the potential impacts to each species, as detailed in the EIS, Biodiversity working paper and also the *Supplementary Biodiversity Assessment* (Roads and Maritime 2013). The local distribution and abundance of the threatened plants, as well as, the section where the species occurs is shown in **Table 2-2**.

Table 2-2 Threatened plant species distribution and location within the project

Species	Notes on distribution and population size	Project section / station (km)
Angophora robur	• The eastern subpopulation in the project is estimated to comprise about 125,000 individuals occurring over 1,489 hectares. • The known regional distribution including the northwest and southwest subpopulations is estimated at around164,000 individuals based on survey data and atlas records occurring over around 1,946 hectares of habitat • The entire predicted distribution is estimated at about 782,000 individuals occurring over around 9,300 hectares. • The population within and adjacent to the project represents the known eastern distribution of the species.	Section 3 and 4 Station: 44.6 to 69.0
Arthraxon hispidus	• Several populations between Coolgardie Road and Lumley's Lane (Section 10). • The known area of occupation of the species is 21.3 hectares.	Confirmed Section 10, possibly occurs in Sections 8, 9 and 11. Station:154.4-155.1, 156-156.5, 156.9-158.6, 160.7-161.2, 162.6-162.7
Cyperus aquatilis	• The species was recorded at six locations in Sections 6 and 7 in 2007 in low to moderate abundance. During further surveys (January 2012), it could only be located in Mororo State Forest, where a relatively large population (around 80 plants) was previously recorded. Similarly, locations of this species recorded in winter 2005 where found not to support the species during summer 2006, suggesting the distribution and abundance of the species is highly variable and dependant on numerous factors such as habitat disturbance, flooding events, seed dispersal and climatic conditions. • Other records in the study include a grazed paddock area south of Jacky Bulbin Road (around 18 plants), a disturbed drainage line north of Glencoe Road (nine plants) and several locations where only 1-3 individuals were recorded including at Tabbimoble Floodway No. 2. Most of the occurrences recorded during summer 2006 were associated with boggy access tracks that had recently been disturbed by tractors or other vehicles. Recent field surveys found there was little evidence of disturbance in the locations previously surveyed in 2007, and growth of other *Cyperus* spp. and grasses may have limited the germination of the species in these areas.	Section 1,2,6 and 7 Station:6.1, 24.7, 99.1-99.4, 102.7-103, 113.3, 114.8-114.9
Eleocharis tetraquetra	• Occurs on edges of ponds and in riffle habitats between ponds along several creek lines at Corindi Creek. • Population number difficult to determine due to growth habit of this species. • It was recorded in around 11 different locations in moderate to high abundance.	Section 1 Station: 5.6-6.7
Eucalyptus tetrapleura	• Several known populations near the existing Pacific Highway in Section 2. The population extends into the surrounding private properties and state forest including Wells Crossing Flora Reserve. The population is estimated at 1,213 individuals near the project, comprising around 14.5 hectares of known habitat. • The total local population is estimated to comprise approximately 159,629 individuals	Section 2 Station: 22.4-32.5
Grevillea quadricauda	• *Grevillea quadricauda* was recorded in the project at two different locations in Section 3. • It occurs in moderate abundance in the project comprising two subpopulations around 1.4 kilometres apart.	Section 3 Station: 59.3-59.5 and 60.9

Species	Notes on distribution and population size	Project section / station (km)
	• One of these subpopulations is very small occurring in partially cleared disturbed habitats consisting of eight individuals and the other is a larger population consisting of at least 200 individuals which extend to the east up slope of the project.	
Lindsaea incisa	• A total of five populations were found along the edges of drainage swales with sandy soils. • Large population extending into the boundary on the western side of the highway opposite Lemon Tree Road in Section 2. • Small patch 12 metres upstream to the east of the project on an elevated area in the centre of Halfway Creek in Section 2. • Moderate sized population found along swampy edges of a trail north of Bostock Road in Section 3. • Large population 20 metres downstream to the west of the project near Tucabia in Section 3. • Large population extending into the project in Mororo State Forest in Section 6. • Population numbers difficult to determine due to growth habit of this species. It was recorded in moderate to high abundance.	Section 1, 2, 3 and 6 Station: 17.6, 17.9, 22.5, 55.9, 60.3, 98.5-99.4
Maundia triglochinoides	• This species has been confirmed at 15 locations of which 11 are within the project. • Relatively large populations were recorded in swamp forest near Cassons Creek and medium sized populations along an unnamed drainage line north of Casson Creek in Section 1 • Large populations in Halfway Creek and Wells Crossing, Section 2. • Moderate to large populations in the Coldstream River, Chaffin Creek, unnamed tributaries south of Bostock Road, near Tallowwood Lane and east of Tucabia Road in Section 3. • Small to moderate populations in Section 7 at Tabbimoble Floodway Number 1 and 2, and several tributaries that cross the highway north of New Italy.	Section 1, 2, 3 and 7 Station: 4.8-4.9, 5.7, 20.6-20.7, 22.3-22.5, 43.3, 52.5, 55-55.1, 58.7-58.9, 61.9-62.1, 64.4, 110.5-110.6, 111, 115.4, 121.7-121.9, 122.4
Melaleuca irbyana	• Confirmed within the project at New Italy (Section 7) and adjacent to the project at Pillar Valley (Section 3). • The population at New Italy contains around 800 individuals comprising 250 trees (greater than 3 metres high) and 550 saplings and suckers, occurring over an area that extends north-south for around 200 metres and east-west for 100 metres.	Section 3 and 7 Station: 120.8-121.2
Olax angulata	• One individual has been recorded in the project north of Halfway Creek at Section 2.	Section 2 Station: 23.6
Oberonia titania	• A small population of *Oberonia titania* was recorded to the east of the construction footprint in Section 10 during 2010 and it was also recorded east of the corridor in Section 7 but could not be relocated during surveys in 2012. • In Section 10, it was mainly recorded growing on the small rainforest tree (*Trochocarpa laurina*) and several plants were also recorded growing on moss and lichens on Bangalow Palm (*Archontophoenix cunninghamiana*) and Brush Kurrajong (*Commersonia fraseri*) in an area of swamp sclerophyll forest with rainforest elements.	Section 10 Station: 152.4
Phaius australis	• Recorded east of the project in Section 9. • Individuals are approximately 50 to 120 metres from the edge of the construction footprint.	Section 9 Station: 144.5-144.6
Prostanthera cineolifera	• Occurs at a single location on Tabbimoble Creek south of Tullymorgan Road. Inhabits a narrow belt of deep, sandy soil along Tabbimoble Creek.	Section 7 Station:101.6-101.9
Prostanthera	• Recorded approximately 470 metres east of the project footprint	Section 7

Species	Notes on distribution and population size	Project section / station (km)
palustris	in wallum swamp habitats in Section 7. • Grows in poorly drained sandy soils, subject to extended waterlogging, in wet shrubland to heathland.	Station:116.4
Quassia sp. Moonee Creek	• Occurs along a rocky drainage line and surrounding rocky slopes in Section 1. A total of 899 stems and 2 clusters were recorded (details in the supplementary report).	Section 1 Station: 8.3-8.5

2.3 Threats

In general all these threatened plant species are threatened by:

- Habitat loss.
- Fragmentation from land clearing.
- Weed invasion particularly in edge effected areas.
- Stochastic events.
- Habitat alteration and other disturbances.

The threatened plant species covered in this management plan are being directly or indirectly impacted by the Woolgoolga to Ballina Pacific Highway upgrade project. The aim of this management plan is to minimise the severity and duration of potential threatening processes, particularly for the remaining individuals which would be in close proximity to the project.

3. Potential impacts and management approach

This chapter provides a brief overview of the potential impacts to the threatened flora species with reference to the more detailed impact assessment presented in the 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 6 of the management plan target the predicted impacts.

3.1 Potential impacts associated with the project

Fifteen non-rainforest threatened plant species would potentially be directly or indirectly impacted by the project. Seven of these species have moderately large populations occurring within or adjacent to the project (*Angophora robur, Arthraxon hispidus, Eucalyptus tetrapleura, Grevillea quadricauda, Melaleuca irbyana, Quassia species Moonee Creek* and *Maundia triglochinoides*). The remaining species have isolated individuals or small, localised populations within or near the project. Information on impacts to threatened species has been updated and informed by the results of the supplementary surveys undertaken in April 2013.

Direct impacts include removal of individuals and their associated habitat. Some populations directly impacted occur as small isolated populations (i.e. *Lindsaea incisa*), whilst other populations impacted are widely spread throughout the surrounding locality (i.e. *Angophora robur*).

The remaining individuals of these threatened flora populations in close proximity (up to 50 metres) to the project would potentially be subject to indirect impacts including edge effects and altered hydrological regimes. Where new edges have been created through areas of habitat there would be potential for edge effects such as changes to the amounts of light, moisture, wind and humidity in adjacent habitats potentially resulting in altered habitat conditions including weed invasion and altered habitat structure. Changes to hydrological regimes including the amount and quality of surface and groundwater entering habitats adjacent to the project would also be a potential threat to the remaining individuals downslope of the project. The known distribution and abundance of the threatened flora populations and discussion of impacts to each population are discussed in **Section 2.2** and **Chapter 4**.

3.1.1 Direct impacts

Of the fifteen threatened non-rainforest plants identified, thirteen of these species would be directly or indirectly impacted (refer to **Table 3-1**). The remaining two species are located outside of the project.

Table 3-1 Impacts to threatened non-rainforest plants

Species	Total estimated population identified in the project	No. of individuals or area impacted by the project
Angophora robur (Sandstone Rough Barked Apple)	125,076 individuals	7,056 individuals
Arthraxon hispidus (Hairy Joint-grass)	21.3 hectares	5.5 hectares
Cyperus aquatilis (Water Nutgrass)	114 individuals	112 individuals
Eleocharis tetraquetra (Square-stemmed Spike-rush)	11 population clusters	6 population clusters
Eucalyptus tetrapleura (Square-fruited Ironbark)	159,629 individuals	1,213 individuals
Grevillea quadricauda (Four-tailed Grevillea)	218 individuals	7 individuals

Species	Total estimated population identified in the project	No. of individuals or area impacted by the project
Lindsaea incisa (Slender Screw Fern)	2.7 hectares	0.4 hectares
Maundia triglochinoides (Maundia)	3.2 hectares	0.2 hectares
Melaleuca irbyana (Swamp Tea Tree)	800 individuals	514 individuals
Oberonia titania (King of the Fairies Orchid)	370 individuals	0 individuals/hectares
Olax angulata (Square-stemmed Olax)	1 individual	1 individual
Prostanthera cineolifera (Singleton Mint Bush)	5,000-8,000 individuals	250 individuals
Prostanthera palustris (Swamp Mint Bush)	Unknown number of individuals	0 individuals
Quassia sp. Moonee Creek (Moonee Quassia)	899 stems	136 stems

3.1.2 Indirect impacts

Apart from the direct impacts to the threatened plants detailed above, a number of indirect impacts also have the potential to impact remaining plants in close proximity to the project during construction or operation including:

- Accidental impact to threatened plants outside the project during construction.
- Increased potential for incursion of invasive weeds and subsequent habitat degradation.
- Increased light and exposure, wind speed and frequency and temperature, as well as changes in soil conditions at patch edges leading to a potential degradation of habitat.
- Changes to hydrological and nutrient regimes impacting the integrity of remaining patches. Changes may result from alterations made to creek alignments and from the operating road runoff.
- Lowering of the water table leading to changes to understorey floristic and possible canopy dieback.
- Spread of pathogens during construction.

3.2 Detailed design considerations

During detailed design there would be further opportunities to avoid and minimise impacts to *in situ* populations through:

- Avoiding or minimising vegetation removal wherever possible.
- Final planning for construction compounds and stockpile sites to be placed in cleared or disturbed parts of the selected ancillary facility sites.
- When locating water quality treatment measures, consideration would be given to the competing environmental requirements of minimising impact to native vegetation, particularly where there could be threatened plant species, and also wildlife corridors and potential fauna habitat.

3.3 Mitigation and monitoring

To maintain consistency with the overarching biodiversity management framework, developed for the project, the following objectives would be implemented for the mitigation of impacts to threatened flora species:

- Maintain and protect existing biodiversity in general and listed species and communities in particular, as a priority, wherever possible.

- Maintain water quality and hydrological flow regimes.
- Minimise the loss of native vegetation.
- Minimise pollution and degradation.
- Offset unavoidable/ residual impacts to significant biodiversity.

The biodiversity management framework includes a mitigation strategy, a monitoring strategy and an offsets strategy for residual impacts on biodiversity. Each strategy informs the development of the next strategy. The Mitigation Strategy includes the project-specific CEMP, the FFMP (prepared as a component of the CEMP) and individual threatened species management plans. The monitoring strategy includes the Ecological Monitoring Program as well as species-specific monitoring set out in the threatened species management plans.

A number of measures to mitigate and monitor the impact of the project on threatened flora during construction and operation of the project were suggested in the EIS (Biodiversity Working Paper). In general these measures related to:

- Provision of exclusion fencing to protect *in situ* threatened plants populations
- Management of indirect impacts to these *in situ* populations during construction.
- Water quality, erosion and sediment control.
- Weed management.
- Targeted revegetation of disturbed areas adjoining *in situ* threatened flora.

While translocation is not a mitigation measure; this plan describes an approach to translocation of threatened plants directly impacted by the project. This will include a feasibility assessment in line with the project offset strategy followed by translocation trials. These measures would be outlined in a separate translocation strategy (Refer to Section 4.3.2)

This management plan details the parameters and methods for monitoring the effectiveness of the proposed mitigation measures for threatened flora as part of an adaptive management program.

The measures to be taken to mitigate potential impacts and monitor the success of the mitigation strategies for non-rainforest threatened flora have been set out in detail in the following sections.

3.4 Effectiveness of mitigation measures

A summary of the mitigation measures and an evaluation of their effectiveness, based on past experience with other highway upgrades, are described in **Table 3-2** below.

Table 3-2 Mitigation measures and evaluation of their effectiveness for threatened flora

Issue	Mitigation measure	History of success	Effectiveness rating
Impacts to threatened flora to be retained in situ within the project boundary outside the construction footprint.	Determine extent of threatened flora populations to be directly impacted. Identify and maintain exclusion zones and limits of clearing. Weed management near retained threatened flora Erosion and sediment control Pre-clearing and clearing procedures.	Standard procedures have been developed by Roads and Maritime and documented in the Biodiversity Guidelines (RTA 2011). The guidelines were developed in consultation with OEH, NSW Department of Primary Industries (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. Protection of threatened plant populations in situ has been used successfully on multiple upgrades of the Pacific Highway and other major highways in NSW. Recent examples include Glenugie, Tintenbar to Ewingsdale and Sapphire to Woolgoolga, however the associated mitigation measures go back over at least 15 years on other upgrades. Construction and operational monitoring has been reported for numerous threatened flora species and reported on survival, resilience and recruitment of species such as Quassia species Moonee Creek. Where mortalities are reported these are included in an adaptive management framework.	High
Impacts from weeds around retained *in situ* threatened plant populations' incursion of invasive weeds.	Weed management procedure developed and implemented to control weeds. Revegetation of areas disturbed by construction to minimise weeds. Top soil management.	Roads and Maritime has developed standard weed management procedures that are implemented during construction and are reported as part of the FFMP process. This includes pre-clearing surveys to identify weeds and noxious species and map their location for on-going monitoring and control during construction. Operational monitoring of weeds is conducted around in situ populations of threatened plants and control undertaken where required. Weed monitoring during construction is a routine procedure for road upgrades with a long history of success in NSW. Reporting for on-going weed impacts and controls around threatened plants adjacent to the road have varied greatly in their success. The results suggest they are reliant on persistent effort, with on-going follow-up actions until such time as the population is proven to remain viable. Roads and Maritime has undertaken revegetation of disturbed areas successfully on a number of road projects. Roads and Maritime have also successfully managed top soil for reuse as part of the landscaping and revegetation management.	Moderate, monitor against performance and implement weed management actions

Issue	Mitigation measure	History of success	Effectiveness rating
Direct loss of threatened plants during construction.	Avoidance of impact where possible (during the detailed design stages) Translocation is a management option which may involve: - Translocation strategy developed to identify suitable plants and locations, translocation of plants out of areas of direct impact. - Establishment of translocation population in appropriate areas away from construction. - Seed collection from threatened plant species as appropriate, for establishment of ex-situ populations on offset sites. - Establishment of ex-situ populations from seed and cutting material collected from impact areas (or other sites) to offset sites. - Maintenance of translocated threatened flora population/s. Revegetation of appropriate sites with germinated/struck seedlings. Offsetting or acquiring compensatory habitat to protect and/or improve threatened flora habitat.	The procedures used depend on the species and Roads and Maritime typically follows industry best practice as reported in *RTA Seed Collection QA Specification R176* and the *Florabank Guidelines and Model Code of Practice* (www.florabank.org.au) and the Nursery Industry Accreditation Scheme Australia (NIASA) Best Management Practice Guidelines - 4th Edition, updated 2010. Propagation and replanting of threatened plant species and translocation of threatened plants may be done in conjunction with offset requirements and has not been done often by Roads and Maritime as a general construction procedure. However Roads and Maritime have successfully translocated the following threatened flora species included in this plan on the following projects: - Hairy Joint Grass: Ballina Bypass and T2E projects. - Linsaea incisa: Sapphire to Woolgoolga project. - Melaleuca mirbyana: Glenugie upgrade. Roads and Maritime has also successfully translocated a number of other threatened plants not included in this plan, as such they have not been detailed in this table. Translocation is not seen as a mitigation measure and would be trialled for other species if required as a condition of approval with on-going monitoring to be conducted to measure the success.	Moderate, monitor against performance and implement contingencies where required.
Populations of threatened flora adversely impacted by changes to the water quality within and immediately adjacent to the project.	Water quality managed in accordance with procedures in the CEMP.	Roads and Maritime has successfully used water quality controls across a number of Pacific Highway projects. Procedures for water quality management on construction sites have been developed in accordance with the Blue Book principles and form part of the CEMP process.	High

3.5 Adaptive management approach

This plan includes 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.

Details of the proposed monitoring program are described in **Chapter 7** and include monitoring retained in-situ threatened plants, translocated sites and revegetation areas adjacent to threatened plants.

4. Pre-construction management measures

4.1 Potential impacts during pre-construction

There is an opportunity to protect threatened flora species within and close to construction areas through implementation of pre-construction management measures. There is potential for accidental impact to threatened plants when locating ancillary facility sites including heavy vehicle access as part of pre-construction planning.

4.2 Main goals for management

- Threatened plants within and in close proximity to the project to be retained (in situ) would be identified, mapped and marked prior to commencement of construction.
- Threatened plants translocation strategy completed for relevant project sections.
- Seeds and other propagation material to be collected from threatened plants prior to clearing works.
- Identify exclusions zones prior to construction commencing including corridor and ancillary sites and access roads.

4.3 Management measures

4.3.1 Targeted surveys

Targeted surveys for threatened plants would be required pre-construction to collect comprehensive up to date data on the location and number of threatened plants within the project, mark plants, collect baseline data and inform the development of the translocation strategy (refer to **Section 4.3.2**). The optimum time to undertake these surveys have been indicated in **Table 4-1**.

Table 4-1 Optimum targeted survey timing for threatened flora

Species	Optimum survey time
Angophora robur (Sandstone Rough Barked Apple)	Throughout the year
Arthraxon hispidus (Hairy Joint-grass)	December - May
Cyperus aquatilis (Water Nutgrass)	January - June
Eleocharis tetraquetra (Square-stemmed Spike-rush)	Throughout the year
Eucalyptus tetrapleura (Square-fruited Ironbark)	Throughout the year
Grevillea quadricauda (Four-tailed Grevillea)	Throughout the year
Lindsaea incisa (Slender Screw Fern)	Throughout the year
Maundia triglochinoides (Maundia)	Spring, summer and autumn
Melaleuca irbyana (Swamp Tea Tree)	Throughout the year
Oberonia titania (King of the Fairies Orchid)	Autumn and spring
Olax angulata (Square-stemmed Olax)	Throughout the year
Prostanthera cineolifera (Singleton Mint Bush)	September - October
Prostanthera palustris (Swamp Mint Bush)	February -June
Quassia sp. Moonee Creek (Moonee Quassia)	Throughout the year

The targeted surveys would also enable the accurate mapping of the distribution and abundance of threatened species immediately adjacent to the project and would also assist in the identification of potential revegetation or translocation sites in consultation with landowners and as part of the project offset strategy.

All targeted surveys would be undertaken by a licensed and appropriately experienced ecologist and would involve:

- A review of the EIS and working paper to confirm the threatened plants that are known from or could potentially occur in and adjacent to the project up to 50 metres form the construction zone. Plants beyond 20 metres may be used as controls for on-going monitoring.
- Field survey to identify and mark threatened plants within the project and immediately adjacent to the project (subject to property access).
- Recording the location of all threatened plants found during the field survey including GPS co-ordinates, identification number, plant height and other relevant details.
- A habitat condition assessment for ongoing monitoring of change in habitat for *in situ* populations.

As noted above, the data collected during the targeted surveys would be used to inform the detail design and monitoring program. For example, this data would be overlaid on the project design to identify if the threatened plants would be directly or indirectly impacted. Directly impacted relates to individuals located within the clearing limits/construction zone. Indirectly impacted relates to non-aquatic species located within 10 metres and aquatic species (and shade-requiring species) located within 20 metres of the clearing limits/construction zone. Threatened plants to be retained *in situ* include those individuals located within the project but outside the clearing limits/construction zone. The monitoring program proposed is expected to determine the extent of indirect impacts.

As such, this information would be used to update the construction management measures and monitoring program outlined in the following sections including existing habitat to be protected and the location of threatened flora exclusion fencing. These surveys would also inform the development of a project specific translocation strategy.

4.3.2 Translocation strategy

Translocation is defined as the ‘deliberate transfer of plant material from one area to another for conservation purposes’ (ANPC 2004). Its purpose in this project is to apply different translocation techniques on development impacts where declines in threatened species population numbers and genetic diversity are to be avoided. Techniques aim to establish a salvaged population (transplanted and propagated individuals) and compensate conservation efforts.

A separate translocation strategy would be prepared prior to construction for each section of the project. The overall objective of threatened plant translocation is to establish populations that are self-sustaining over the long term. There is no guarantee of translocation success and it should be viewed as a last resort. It is vital for the target species to recover and reproduce in a functioning habitat which requires detailed planning and long term commitment to monitoring (ANPC 2004). Translocation would be undertaken for threatened species that have suitable life history traits where translocation may a viable option. This would be carried out with a feasibility assessment designed to comparatively research environmental characteristics to measure translocation success of receival sites and the ecological needs of a species.

It should be noted that translocation receival sites would be located outside of the project boundary, in disturbed areas of offset land or compensatory habitat. Translocation would not be factored into offset formulae, but rather aim to achieve a no net loss in local plant populations being impacted by the project. A receival site would selected upon inspection of any land that meets species specific habitat requirements and may be selected on Roads and Maritime owned properties, designated offset sites or private landowner land.

The translocation strategies for each section of the project would be informed by the targeted surveys. The following outline of a translocation strategy has been adopted from other Pacific Highway upgrade projects. Examples include the:

- Warrell Creek to Urunga Upgrade: Threatened Flora Management Plan, Ecos Environmental Pty Ltd, December 2012.
- Translocation strategy for Maundia triglochinoides as part of the Pacific Highway upgrade, Kempsey to Eungai, Parsons Brinkerhoff, April 2006.

The translocation strategy would generally follow the framework and issues of consideration set out in the ANPC (2004) *Guidelines for Translocation of Threatened Plants Australia* and would include the following information shown below.

Translocation feasibility assessment would include:

- An assessment of the feasibility of translocating the threatened plants details in this management plan. This assessment would be based on a review of translocation experience for individual threatened plants and involve the assessment of the benefits and risks of translocation for each threatened plant. Specifically this assessment would determine whether any threatened plants located within the clearing limits/construction zone could be successfully translocated, or propagated and planted into, an appropriate receiving site, preferably outside the road reserve, within an offset site or on private property (in consultation with landowners). For this to happen, a number of factors would be considered and would be documented in the feasibility assessment for each of the subject threatened plants including:
    - Species life history traits and population dynamics (e.g. timing, pollinators etc.).
    - Known distributional range, suitable habitat and potential recipient sites.
    - Type of translocation (e.g. re-stocking, re-introduction, introduction, conservation introduction).
    - Propagation potential (e.g. seed, cuttings, grafting, mycorrhizal associations, genetic etc.).
    - Survival rates and expectancy.
    - Cost and commitment of physical transfer and long term monitoring and management.
    - Contingency options (back-up options in case of failure).
    - Detail and confirmation of appropriate recipient sites.
- Detail the habitat, population dynamics, transplanting and propagation potential and recovery plan requirements for each threatened plant to be translocated. This would allow for suitable receiving sites to be identified to optimise the successful of the translocated individuals.

Translocation planning would include:

- Detail the translocation approach including a description of the methods to be used to salvage the threatened plants for translocation, how receiving sites would be selected and where they would be located, and the resources required for the translocations. This would include development of a translocation procedure that outlines the machine and manual transplanting, and pruning requirements. Mechanical transplanting would usually be required for established tree species whereas manual transplanting would be sufficient for shrubs and smaller plants.
- Describe the proposed propagation procedure for threatened plants within the translocation receival sites to enhance the translocated population and provide back-up individuals to replace mortalities potentially incurred during transplanting. Propagation would also assist in increasing the long term population persistence of the threatened plants by establishing larger initial populations. Individuals would be propagated from seed or cuttings collected from the local threatened plant populations.
- A description of post-translocation actions including:
    - Maintenance activities such as weed control and bush regeneration.
    - Habitat restoration requirements if translocation receiving sites include disturbed or degraded vegetated areas.

  - Research and experimentation review and reporting requirements, for example where translocation and/ or propagation has not be undertaken previously for threatened plant species a trial translocation and/or propagation may be required. Details of the trial methods, timing etc would need to be outlined in the translocation strategy.
  - Monitoring requirements to document the establishment and survival of translocated and propagated plants. Monitoring would provide data to allow an assessment of the success of the translocation undertaken. The monitoring requirements are detailed in **Chapter 7**.
- An implementation schedule summarising the translocation program requirements pre, during and post-construction.

Translocation may be considered feasible for a threatened species that have not been translocated before if its ecological requirements, growth-form attributes and propagation characteristics indicate that employing a certain translocation method has a reasonable chance of success.

The location, size and suitability of receiving sites would require further consideration as part of the offset and revegetation strategies.

4.3.3 Seed/cutting collection and propagation

Methods of propagation (such as seed and cutting) for plant translocation allow activities to collect a good genetic base from local populations of subject threatened species that would establish a viable population size.

Seed collection and propagation of threatened plant species would be applied to replace those populations directly lost as a result of construction. The seed collection and propagation activities would aim to raise individual threatened species as tubestock suitable for the re-introduction activities and to offset any potential die-off incurred as a result of construction near *in situ* populations, at translocated sites and for compensatory planting in offset areas.

Seed collection would be initiated at the earliest possible time in order to collect a suitable density of seeds prior to clearing. Experienced, licensed seed collectors would carry out all seed collection and may involve collecting seed up to 12 months in advance of any clearing works. Seed would need to be collected and stored before clearing works begin.

It is important to consider genetic factors in the short term seed collection activities for securing long term resilience and persistence of translocated populations. Poorly selected genetic material can lead to population inbreeding, depression, and reduction or lose of genetic flexibility to evolve with changing environments. To maintain genetic diversity, indirect genetic management would be required in the form of a species genetic study or determining genetic variability through species habitat type and geographic position that can indirectly measure differences between populations.

Seed collection would be undertaken within the local population, where possible and would involve:

- Collected seed stored for future use on the project to provide contingency for low survival rates of planted tubestock if required,
- Seed collection, storage and propagation should follow recognised guidelines, in particular *RTA Seed Collection QA Specification R176* and the *Florabank Guidelines and Model Code of Practice* (www.florabank.org.au).
- Seed collection would need to target fruiting periods of threatened plants which generally occurs in spring and summer.

Table 4-2 outlines the ideal seed collection period for each threatened plant.

Table 4-2 Optimum periods for threatened flora seed collection

Species	Flowering period	Seed collection
Angophora robur	December-May	December-May
Arthraxon hispidus	March-May	May-June
Cyperus aquatilis	October-February	February-May
Eleocharis tetraquetra	October-February	January-April
Eucalyptus tetrapleura	August-October	November-December
Grevillea quadricauda	August-September	September-November
Lindsaea incisa	Spore capsules appear in November-February	March-June
Maundia triglochinoides	October-March	March-May
Melaleuca irbyana	October-February	December-March
Oberonia titania	March-May and October-November	May-June and November-December
Olax angulata	October-November	October-December
Prostanthera cineolifera	September-October	November-December
Prostanthera palustris	February-June	February
Quassia sp. Moonee Creek	November-December	March-April

If seed resources from the immediate site area are not available or sufficient, additional seed may need to be collected from other areas within the region. Suitable seed collection sites need to be identified to ensure adequate genetic diversity within the plant seed collected and the compatibility of the conditions of the receiving site.

Some threatened plant species are difficult to germinate, and when germination does happen, would take several years to be of suitable size to plant out. The use of cuttings may also be required if seed is not available for collection or does not propagate well. The potential loss of some genetic diversity in the first generation would be offset by the numbers of individuals restored into the environment. Cuttings would be taken from the greatest number of parent plants as possible to ensure some genetic variation in the second generation. The processes of seed collection and storage are outlined in **Table 4-3**.

Table 4-3 Seed collection, storage and propagation methods

Process	Method
Seed collection	▪ Seed should be collected from as many as possible, widely spaced, healthy parent plants (not diseased) across the extent of the population. ▪ The aim would be to collect as much varied genetic material as possible, therefore seed should be collected from plants that are less likely to cross-pollinate (i.e. spaced more than 500 metres apart). ▪ Isolated plants should be avoided where possible. ▪ Small sections of branches supporting unopened mature capsules should be collected. ▪ Sustainable collection techniques would be employed with no more than 20 per cent of the total seed crop on any plant collected, and the amount of vegetation removed would be minimised. However, plants to be totally removed could be excluded from this collection process. ▪ Secateurs would be used to remove small sections of branches supporting capsules. (Australian Tree Seed Centre and Mortlock 1999a; Mortlock and the Australian Tree Seed Centre 1999b)
Seed storage	The basic requirements for good storage include the following: ▪ Seed collected only from fruit that is fully mature. ▪ Seed is well dried and cleaned.

Process	Method
	▪ Storage should be in airtight containers at a constant temperature. ▪ Accurate record keeping should be implemented including collection data and location. (Mortlock 1998a)
Seed trials	Seed trials would be undertaken with seed grown plants in commercial potting mix and a mix containing the natural soil type from the site. Transplanting to the natural soil type would be carried out when seedlings are about 15 cm tall. Tree seedlings would be grown on until at least 40 cm tall, shrub species 30 cm tall, before introduction to the receival site. Herbaceous species should be robust and healthy before introduction. All tubestock would require a hardening off period (i.e. adjustment to outdoor conditions) prior to planting. The trial would aim to examine: ▪ The effect of the potting medium on growth and establishment of plants in the field. ▪ As an additional comparison, half of each of the above treatments would be planted with and without slow release fertiliser to study the effect of fertiliser addition on performance. This would provide useful information for future management and mitigation of this species assessing the effect of nursery soil medium and fertiliser application on the survival and establishment of propagated plants introduced to the wild, as these factors are currently poorly understood. ▪ A proportion of each of these treatments would be planted in each of the different 'habitats' deemed to be suitable on site adjacent to the highway including slopes and riparian areas and sediment basins.

Transplanting to the natural soil type should be carried out when the site is available and free from construction activities. The seedlings should also be mature enough for replanting and planted at a time that is optimal for their survival i.e. in spring or summer.

Threatened plant species would not be planted in the road reserve. Planting of threatened plants would be targeted at planting in other Roads and Maritime land acquired as part of the offset strategy.

A number of propagation methods have been assumed for threatened plants to improve results based on typical genus or family propagation success and are recommended during trails (Ralph 2009 and ANPS 2009). The processes of propagation are outlined in **Table 4-4**.

Propagation of threatened species would only be done by qualified nurseries or plant propagators, under appropriate quarantine conditions, with appropriate threatened species approvals. There would be risks of introducing pathogens to the seedlings, or transferring pathogens from propagules. Only disease free tubestock would be introduced to receival sites.

Table 4-4 Propagation methods

Process	Method
Seed propagation	▪ Germination from seed is generally the most cost effective and efficient method which produces populations with greater genetic diversity compared to other propagation methods. Some species may require special pre-treatment such as soaking, washing, stratification, scarification and smoke. The 'saturated soil medium method' may be required for most sub-aquatic and wetland species, where the pot containing the seeds is placed into a saucer of water until germination occurs, which results in moisture reaching the seeds by capillary action and ensures that the seeds do not dry out (ASPSA 2006). ▪ Seeds would be propagated in seedling trays of standard seed propagation mix (e.g. pine bark fines, cracker dust, sand, vermiculite, slow release fertiliser). When about 1 cm tall the seedlings would be transplanted to 120 millimetre tubes, or super tubes depending on the species, and grown on until at least 40 centimetres tall. In the case of fast growing species this may take 9-12 months, for slower growing species18 months or more. It would be likely that larger propagated plants would have higher survival rates. ▪ Most of the seedlings would be planted out in the field when they reach 40 centimetres tall and after hardening off. If revegetation activities have been delayed some plants may need to be grown on further and potted into larger pots.
Cutting propagation	Cuttings should be collected from as many parent plants as possible. The aim of cutting propagation would be to provide effective backup to the principle form of propagule collection, through seed collection. However, due to recognised limitations of seed collection and propagation, cuttings maybe required to provide revegetation material.

4.3.4 Exclusion zones

An exclusion zone is a designated “no go” area that clearly identifies and would be appropriately fenced to prevent damage to native vegetation and in situ populations of threatened plants, and to prevent the distribution of pests, weeds and disease. Exclusion zones can also be used to define clearing limits. The location and type of exclusion fencing to be used would be included in the CEMP and informed by the targeted surveys marking and mapping of threatened plants. Further detail on exclusion zone establishment and maintenance can be found in the *Biodiversity Guidelines* (RTA 2011).

The relevant protocols for exclusion zones include:

- Exclusion zones to be identified and marked out prior to clearing works considering threatened species mapped by the targeted surveys.
- Exclusion zone fencing would be placed outside the tree protection zone (drip zone) and in accordance with Australian Standard AS 4970-2009 Protection of trees on development sites.
- Appropriate signage would be erected to inform personnel about the purpose for the fencing. Signage needs to be clearly visible from a distance of 20 metres and be consistent in wording i.e. Exclusion Zone or Environmental Protection Zone.
- All construction materials or equipment outside the exclusion zone should be stored in accordance with Australian Standard AS 4970-2009 Protection of trees on development sites i.e. outside of the tree drip line.
- All exclusion zones would be marked on a site plan used for construction with an aerial image underlay.
- Indicate on the site plan construction stations or distance markers where the exclusion zones would be located.
- Exclusion zones would be clearly labelled on the site plan, including the type of fencing to be used and installation and maintenance requirements.

Exclusion zones would be delineated with temporary fencing. The type of temporary fencing used may vary depending on the number of plants being protected and the sensitivity of the site. Fencing options may include (but are not limited to) the following:

- Highly sensitive sites – chain wire fencing.
- Permanent protection required – stock fencing or similar.
- Temporary fencing of specific small areas – Para-web material and start pickets.
- Larger areas – capped star pickets and reflective spinning tape (helicopter tape).
- Delineation of low risk intrusion areas – earth bunding, mulch berms, sediment fencing or flagging tape.

Ancillary facilities sites have been considered in the EIS and included siting facilities within cleared areas and disturbed vegetated areas. Stockpiles and laydown areas, as well as, roads would need to be identified in the field and include appropriate fencing such as exclusion fencing near threatened plants.

4.3.5 Weed management

Guide 6: Weed management of the Biodiversity Guidelines: protecting and managing biodiversity on RTA project (RTA 2011) provides the requirements for weed management on all Roads and Maritime projects. The *Introductory Weed Management Manual* (Natural Heritage Trust 2004) also provides guidance for developing weed management plans.

In summary, Guide 6 requires a site weed assessment to be undertaken prior to construction for each staged section of the project. Data collected during the assessment would be used to develop a weed management plan, which would include details on the weed monitoring. The requirements of the weed management plan would be incorporated into relevant plans for the project (eg landscape management plan, CEMP or work method statements).

A separate weed management plan would be developed for each staged section of the upgrade, as part of the CEMP to provide guidance for preventing or minimising the spread of noxious and environmental weed species during pre-construction, construction and operation. The plan would outline weed management measures to be implemented during construction.

In general, weed management plans include descriptions and mapping of major weed infestations identified during pre-clearing surveys, with appropriate management actions outlined to be implemented for each infestation. The details in the weed management plans would most likely vary for each section of the project but should include:

- Type and source of the weed/s.
- Weed management priorities and objectives.
- Sensitive environmental areas within or adjacent to the site.
- Location of weed infested areas.
- Mechanical weed control methods such as slashing or mowing, as well as a range of herbicides to avoid the development of herbicide resistance.
- Measures to prevent the spread of weeds.
- Appropriate placement of tub grinder mulch that avoids being spread around retained *in situ* threatened flora sites.
- A monitoring program to measure the success of weed management.
- Communication strategies to improve contractor awareness of weeds and weed management.

Details on monitoring the performance of weed management, as well as, corrective actions to be implemented in instances of change from performance measures are provided in **Chapter 7**. This provides a consistent measure to be included in all weed management plans for threatened plants.

General weed monitoring during construction and operation would be reported as detailed in the weed management plans and ecological monitoring program requirements.

4.4 Performance thresholds and corrective actions

The environmental planning measures for threatened flora species that are to be completed prior to the commencement of construction are outlined in **Table 4-5**.

Table 4-5 Mitigation measures and performance thresholds for threatened flora during pre-construction

Main goals for mitigation	Proposed mitigation measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if deviation from performance thresholds
Threatened plants within and in close proximity to the project to be retained (in situ) would be identified, mapped and marked prior to commencement of construction.	Pre-construction targeted surveys of threatened plants, to identify threatened plants for retention *in situ*, translocation and seed collection. Identification of exclusion zones and clearing limits. Construction related infrastructure to be planned and sited within cleared or disturbed areas of the ancillary site. Targeted surveys conducted if necessary.	Targeted surveys to occur pre-construction (in the optimum season for the threatened plant species) to inform the detailed design. Baseline data collected during the targeted surveys to inform the mitigation measures and monitoring program prior to construction commencing. Detailed plans to be prepared showing the proposed location of construction related infrastructure and approved prior to commencement of construction.	Targeted survey not undertaken prior to construction in the optimum season for the threatened species. Damage to threatened plant habitat reported outside limits of clearing associated with ancillary facilities and access roads.	Delay construction until targeted surveys have been undertaken. Revegetation of disturbed habitat and monitoring of recovery.
Threatened plants translocation strategy completed for relevant project sections.	Targeted survey findings used to develop the threatened plants translocation strategy.	Pre-construction.	Translocation strategy not completed prior to construction.	Delay construction until translocation strategy has been completed.
Seeds and other propagation material to be collected from threatened plants prior to clearing works.	Targeted survey findings used to collect seeds and plant material to preserve the local gene pool and replant in offset areas.	Pre-construction.	Seeds collection and plant material collection not undertaken prior to clearing works.	Delay construction until seeds and propagules have been collected, only if they cannot be collected elsewhere in the local area including outside the construction footprint.
Identify exclusions zones prior to construction commencing including corridor and ancillary sites and access roads.	Identification of exclusion zones informed by targeted surveys.	Identification of exclusion zones informed by targeted surveys and identified and approved y construction clearing limits prior to clearing works to mark and flag exclusion zones. Follow-up inspection after surveying road corridor.	Exclusions zones not identified and approved prior to construction.	Delay construction until exclusions zones have been identified and approved.

5. Construction management measures

5.1 Potential impacts during construction

- Machinery moving around threatened plants has the potential to cause damage to the threatened plants directly or by allowing materials to fall on them.
- Machinery moving around threatened plants has the potential to impact threatened plants indirectly by compacting soil around the plants and compacting roots and changing water infiltration in these areas, introducing and/or spreading weeds, contaminating the soil and/or water and generating dust that could coat plants.
- There would also be potential for the loss of those individuals proposed to be translocated through an incomplete or inadequate translocation processes.

5.2 Main goals for management

- Zero mortality of threatened plants from *in situ* populations due to a direct physical damage during construction and no loss of threatened plants directly adjacent to the project.
- No notable increase in the abundance of weeds within threatened plant habitat during monitoring of *in situ* populations.
- Adequately planned translocation carried out such that it maximises the chance of survival of the translocated plants.
- The landscaping design includes details on revegetation requirements for areas adjacent to threatened plants and translocation/offset areas.
- Dust managed in accordance with the CEMP.
- Water quality and soil quality managed in accordance with the CEMP.

5.3 Management measures

5.3.1 Work method statements

Work method statements would be prepared for specific activities that pose particular environmental risks, including risks. Work method statements would ensure sound environmental practices are implemented to minimise the risk of environmental incidents or system failures, in accordance with the CEMP.

Work method statements covering activities with the potential to impact on threatened plants would address all relevant management measures and be prepared in consultation with agencies, Roads and Maritime and the relevant project environmental manager prior to the commencement of identified activities.

5.3.2 Induction and training

Induction and training would be conducted with all contractors and other staff that would be working in the areas of known and potential threatened flora species habitat and distribution within the project. This training would identify threatened flora species habitat, crossing zones and key threats. The importance of following the clearing, translocation and rehabilitation protocols would be made clear for any personnel that require access to the site.

5.3.3 Sensitive Area Plans (SAPs)

SAPs are important for identifying where threatened flora species are located for day to day management of the project. A map (GIS format) would be prepared clearly showing sensitive locations of *in situ* populations and proposed translocated flora (with identification numbers) and be kept up to date.

5.3.4 Clearing requirements

Clearing requirements are provided in the *Biodiversity Guidelines Guide 1* (Roads and Traffic Authority (2011)), and would also be detailed in the FFMP. The following clearing requirements apply to threatened plant species:

- All threatened plants identified for translocation would be translocated prior to clearing works being undertaken, as outlined in the translocation strategy.
- All threatened plants identified to be retained at the edge of the clearing limits/constriction zone (*in situ*) would be protected during construction.
- Where individual threatened plants occur on the edge of a planned clearing zone and the clearing cannot be avoided, pruning of the trees or cutting tree trunks and leaving stumps in the ground, to regrow or sucker from the base, would be done where possible.
- All relevant construction staff would be made aware of the presence of individual threatened plants and populations of threatened species and the importance of protecting and avoiding impacts to individuals during construction.
- Only individual plants marked with flagging tape colour-coded for removal would be removed.
- In the event of an unexpected discovery of a threatened and/or rare plant species, the construction staff are to follow the *Unexpected threatened species finds procedure.* If the plant individual or population is a new species discovery it will need to be added to the final TFMP.

5.3.5 Sedimentation fencing

Detailed site specific erosion and sediment control plans would be prepared as part of the CEMP for each section of the project. Locations for sediment fencing would be identified using a risk based approach to determine the likelihood of sediment encroaching into *in situ* threatened plant locations. Appropriate sediment fences would be erected where works are on or adjacent to sloped areas, riparian areas, wetlands and run off could occur to prevent local run-off directly impacting threatened plants.

These details would be further designed on a site specific basis as part of the CEMP following the outcomes of the pre-construction surveys. These measures would be important in maintaining the current condition of threatened plant habitats, particularly wetlands, swamps and creek lines which support *Maundia triglochinoides*, *Cyperus aquatilis*, *Eleocharis tetraquetra* and *Arthraxon hispidus.*

Sedimentation fencing would be monitored weekly during construction and repaired if damaged or filled with trapped sediment.

5.3.6 Revegetation

The landscape design would provide specific details for the re-establishment of native vegetation within areas disturbed by construction, such as batters and bare areas to provide protection for *in situ* threatened species. Methods for topsoiling, seeding, planting and weed control would be in accordance with the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA 2011).

The design would contain specific revegetation measures adjacent to threatened plant locations to ensure these sites are adequately buffered with fast growing native species to prevent weeds becoming dominant. The designs would contain a maintenance schedule for three years; the first year (timing) is described in the operational section.

Revegetation would commence immediately upon completion of the construction activities within each section of the project or may commence earlier in the construction period if applicable.

Revegetation maintenance would be planned in consultation with a sub-contractor who possesses the following skills:

- Experienced in identification of the local flora and particularly subject threatened species, so that damage to individuals of threatened species and native species in general does not occur during maintenance activities (these plants will be monitored).
- Experienced with using bush regeneration and planting to restore and maintain threatened flora habitat.

Salvaged topsoil would be ideal to top-dress revegetation areas on disturbed roadsides. Remaining in situ threatened flora populations would benefit from weed/rhizome free topsoil salvaged from any existing weed free forest topsoil. This is an effective measure to reduce the level of weed invasion into ecologically sensitive areas.

Details on monitoring the performance of the revegetation as well as corrective actions to be implemented in instances of change from performance measures are provided in **Chapter 7**.

5.3.7 Weed management

Weed management would be undertaken according to the weed management plan. Refer to the weed management plan for details.

5.3.8 Dust management

Dust impacts would be managed in accordance with the CEMP including dust suppression measures. Depending on rainfall, threatened plant habitat patches retained in close proximity to the project may require periodical wash down, to remove dust if accumulation becomes excessive. Corrective measures would be adopted where a significant impact is noted and may include the addition of tall shade cloth screening installed around low growing species and *in* situ populations such as *Lindsaea incisa* to provide dust protection and maintain microclimate. The presence of dust on threatened plants would be monitored as part of the plant health monitoring as outlined in Chapter 7.

5.4 Performance thresholds and corrective actions

The construction environmental planning measures for threatened flora species, and corrective actions if the measure deviates from the performance criteria are outlined below in **Table 5-1**.

Table 5-1 Mitigation measures, performance thresholds and corrective actions during construction phase

Main goals for mitigation	Proposed mitigation measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if deviation from performance thresholds
Zero mortality of threatened plants from *in situ* populations (for physical damage during construction) and no loss of threatened plants directly adjacent to the project. No notable increase in the abundance of weeds within threatened plant habitat during monitoring of *in situ* populations.	Implementation of the Roads and Maritime clearing protocol. Clearing areas identified and approved within the clearing protocol. Exclusion zones fenced off, fencing checked regularly, faults rectified. Induct all construction staff at the commencement of construction works. Induct new staff as appropriate. Development and implementation of the weed management plan. Up to date SAPs.	Clearing areas identified and approved prior to clearing activities being undertaken. Exclusion zone fencing monitored at least monthly, faults rectified as soon as noticed. During construction as Ecological Monitoring Program.	Clearing commenced prior to clearing areas being marked out and approved. Exclusion zone fencing remains intact. Maintain exclusion fencing for life of construction works. No direct damage to threatened plants. Noxious and environmental weeds reported in areas adjacent to threatened plants. Spread of noxious and environmental weeds into properties adjoining the project noted in monitoring activities.	Delay construction until clearing areas has been marked out. Stop construction in the area of the fencing breach until exclusion fencing has been repaired. Investigate why breach in fencing occurred and implement corrective actions as required to prevent reoccurrence. Review the weed management maintenance schedule and update as required. Implement appropriate weed measures as required.
Adequately planned translocation carried out such to maximise the chance of survival of the translocated plants.	Salvage and planting of identified plants for translocation undertaken at times, into suitable habitat and using appropriate methods that maximise the chance of plant survival prior to clearing.	At the optimal time of year for species prior to clearing works commencing. Once salvaged, plants would need to be monitored throughout the construction phase at least three times a year (summer, autumn, spring).	All plants identified for translocation have been translocated.	Ample reserves of species tube stock would be available to supplement and enhance population.
The landscaping design includes details on revegetation requirements for areas adjacent to threatened plants and translocation/offset areas.	Revegetation and habitat management requirements included in the landscape design for areas adjacent to threatened plants. Specifically includes revegetation maintenance planned in consultation and implemented by experienced bush regenerators for in situ populations.	Developed prior to clearing.	Landscape design not developed prior to clearing.	Delay clearing activities until the landscape design has been developed and includes details of revegetation requirements adjacent to threatened plants.
Dust managed in accordance with the CEMP.	Dust impacts would be managed in accordance with the CEMP including dust suppression measures. Tall shadecloth screening installed on edge of construction footprint to protect low growing threatened flora.	Dust suppression would be implemented in accordance with the CEMP. Depending on rainfall, rainforest patches retained in close proximity to the alignment may require periodical	No dust related exceedances recorded from the dust monitoring within sections with threatened plants. No loss of plant condition recorded during the plant health monitoring as a result of dust impacts.	Review dust suppression procedures and update as required. Adequate dust suppression and wash down of threatened plants implemented as soon as possible.

Main goals for mitigation	Proposed mitigation measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if deviation from performance thresholds
		wash down, to remove dust if accumulation becomes excessive. Monitoring of dust on plants considered as part of plant health monitoring.		
Water and soil quality managed in accordance with the CEMP.	Adequate water quality controls installed surrounding retained threatened plants. Procedures for maintenance and monitoring of water quality included in the CEMP.	Water quality controls would be monitored as a minimum weekly throughout the construction period and directly after storm events.	No significant breaches of water quality controls recorded. No loss of ecological condition recorded from the plant health monitoring particularly from altered water quality.	Review adequacy of the water quality controls and implement appropriate corrective actions. Review monitoring procedures for water quality controls and implement appropriate corrective actions.

6. Operational management measures

6.1 Potential impacts during operational phase

- Degradation of retained threatened plant populations and habitat from edge effects.
- Degradation of aquatic threatened plants associated with reduced water quality.

6.2 Main goals for management

- Zero mortality of retained in-situ threatened plant populations has survived during construction and for three consecutive monitoring periods post-construction and 80 per cent survival of tree, shrub and herbaceous perennials after five-eight years.
- At least 90 per cent of the plants planted as part of the revegetated areas have survived after the first year and 80 per cent after three consecutive monitoring events.
- Less than five per cent weed cover at retained in situ threatened flora sites (end of monitoring program) and less than 30 per cent weed cover at other revegetation areas.

6.3 Management measures

6.3.1 *In situ* threatened plants/populations

Ongoing mitigation for *in situ* plants/populations would be undertaken for three consecutive monitoring events or until mitigation measure has been proven to be successful. Maintenance activities would include watering if necessary, removal of damaging debris after storms, plantings to replace mortalities, removal of bags and stakes (if used) when the plants overtop them, maintenance of mulch cover and weed control as necessary. Refer to the **Chapter 7** for the *in situ* and translocation monitoring requirements.

Species may differ in resilience, longevity and sensitivity to disturbance. Plant health may seasonally fluctuate in its natural environment depending on the species (e.g. orchids and shade loving species would need more attention to buffering disturbances). These factors would need to be considered when monitoring decline thresholds over any given monitoring event and a valid comparison to control sites would be useful, particularly for *Arthraxon hispidus* and *Maundia triglochinoides*.

6.3.2 Revegetation areas

Ongoing maintenance of revegetated areas adjacent to threatened plants/populations would be undertaken as detailed in the revegetation plan. Maintenance activities would include watering if necessary, removal of damaging debris after storms, plantings to replace mortalities, removal of bags and stakes (if used) when the plants overtop them, maintenance of mulch cover and weed control as necessary.

The recommended monitoring and maintenance schedule for the revegetation areas adjacent to threatened plants 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	3 months	Weeds and grass controlled within 2 metres of planting locations,

Monitoring	Timing	Maintenance
Mulching and fertilising of plants		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 and grass 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 and grass 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 and grass controlled within 2 metres of planting locations, all plants mulched and fertilised.

6.3.3 Weed management

Weed management would be undertaken as part of the Roads and Maritime ongoing maintenance of landscaped areas. Weed control measures would be implemented for *in situ* plant/population and revegetated areas adjacent to threatened plants. Refer to the relevant project section weed management plan developed for further details on weed management.

The monitoring program would monitor weeds adjacent to in situ populations with corrective actions to be implemented if the abundance of weeds is above the performance thresholds. Monitoring and performance measures are provided in **Chapter 7**.

As noted in **section 4.3.2**, weed control for translocation sites would be included in the translocation strategy.

6.4 Performance thresholds and corrective actions

The operational environmental planning measures for threatened flora species and corrective actions if the measure deviates from the performance criteria are detailed below in **Table 6-2**.

Table 6-2 Mitigation measures and performance thresholds for threatened flora during highway operation phase

Main goals for mitigation	Proposed mitigation measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if deviation from performance thresholds
Zero mortality of retained in-situ threatened plant populations has survived during construction and for three consecutive monitoring periods post-construction and 80 per cent survival of tree, shrub and herbaceous perennials after five-eight years.	Weed management plan.	Threatened plant health monitoring and weed monitoring to occur as per Chapter 7.	More than a 20 per cent decline for *in situ* threatened plants over one monitoring event (depending on species specific seasonal fluctuations).	Review weed schedule. Identify potential threats and implement corrective actions and modify monitoring as necessary.
At least 90 per cent of the plants planted as part of the revegetated areas have survived after the first year and 80 per cent after three consecutive monitoring events.	Regular maintenance activities such as watering, mulching, weed control and supplementary plantings as required as per the landscape design.	Revegetation areas would be managed as per the landscape design. Maintenance activities such as weed management and mulching would be undertaken where identified as being required from the monitoring.	Monitoring and maintenance activities not being undertaken. More than 90 per cent of roadside plants have died after first year and more than 80 per cent have died after five monitoring events.	Review and update maintenance methods as required. Identify any other potential threats and implement corrective actions as required. Any failed areas would be reinstated. Ongoing monitoring and maintenance undertaken until plant health and/or ecological condition of habitat has been maintained over five years.
Less than five per cent weed cover at retained in situ threatened flora sites (end of monitoring program) and less than 30 per cent weed cover at other revegetation areas.	Weed management plan.	As per weed management plan.	An increase in weed coverage by 10% or weed coverage more than 30% in revegetation areas.	Review weed maintenance program and update as required.

7. Monitoring program

Monitoring would be undertaken to determine the effectiveness of mitigation measures and would specifically focus on *in situ* threatened plants/populations and weed monitoring. The monitoring program would be reviewed and updated as required following the targeted surveys and development of the translocation strategy.

7.1 Objectives

Monitoring would provide reliable information such that sound conclusions can be drawn in relation to the management of threatened plants. Monitoring would be undertaken during the pre, during and post-construction until such time as the management measures have proven to be effective. The overall monitoring objectives include:

- Evaluating the success of the mitigation measures.
- Further understanding the propagation and translocation requirements of individual threatened plant species.

7.2 *In situ* populations

As noted in **section 4.3.1** targeted surveys would be undertaken to collect comprehensive up to date data on the location and number of threatened plants within the project. These surveys will also include details on the distribution and abundance of threatened species immediately adjacent to the project. The baseline data collected during these surveys would be used to update the monitoring program. During the targeted surveys control and species specific monitoring locations would be identified.

Retained *in situ* threatened plants within the project would be monitored during and post-construction until the mitigation measures have been proven successful for three consecutive monitoring periods. A particular focus would be to identify any changes in health and condition which require management actions for remediation.

7.2.1 Methods, timing, intensity and duration

Monitoring of retained *in situ* threatened plants would be undertaken biannually (in autumn and spring) during construction and then annually post-construction during and post-construction until the mitigation measures presented in this plan have been proven successful for three consecutive monitoring periods. Following this period a review of the monitoring would be undertaken to identify if further monitoring is required.

Monitoring would include the documentation of the following information, as a minimum:

Identification

- Genus, species and subspecies.
- Identifier – unique plant number.
- Location – location; easting, northing & description.

Plant condition

- General condition – score on a scale of 0 to 5, where 0 is dead and 5 is excellent.
- Leaf condition – healthy/unhealthy, colour, vigour.
- Flower/fruit – flower/fruit presence.
- Length of new shoots – average length of new shoots (estimate) and abundance of new shoots (counts or basic scale).
- Disease symptoms – evidence of disease (including presence / absence of Myrtle Rust, Cinnamon Fungus).
- Recruitment.

- Evidence of any other damage or disturbance.

Site conditions

- Plant community type.
- Canopy cover.
- Mid-storey cover.
- Ground-layer cover and composition.
- Weed abundance and composition.
- Recruitment of canopy and mid-storey species.
- Climatic events (e.g. drought, flood, unusually cold winter temperatures etc.).
- Maintenance carried out – when and what kind of maintenance carried out at the site since the last monitoring.
- Any other ecological impacts.

Suitable control sites would be identified during the targeted surveys for selected *in situ* threatened plants. Baseline data would be collected at these control sites as part of the targeted surveys.

Control sites would comprise areas of threatened flora populations and their habitat that is remote from the impacts associated with the project. Control sites should be located in relatively natural habitats with limited disturbance and threatening processes. Suitable locations may comprise known threatened flora populations outside of the edge affected area which would be generally > 50 metres from the road corridor. Suitable control sites would be located prior to construction during the targeted surveys. Baseline data would be collected at these locations as part of the targeted surveys.

The purpose of the control site is to monitor natural variation within populations and habitats which are not attributable to the impacts associated with the project. This natural variation may be from prevailing climatic conditions such as droughts and floods, widespread insect attack (i.e. dieback for lerps, locust plagues) and other natural phenomenon. Control sites provide a basis for determining if the source of potential impacts to a threatened species and their habitat are from the project or due natural events unrelated to the project.

A summary of the *in situ* threatened plant monitoring data collected, as well as, an assessment of the effectiveness of protective measures and recommendations would be included in the annual monitoring report.

7.3 Monitoring translocation sites

The plan defers measures regarding translocation until after the preparation of a translocation feasibility assessment. At this stage there is no detail on which plants will be translocated to which locations and this detail will follow preparation of the strategy and consultation with landowners. The monitoring of translocated plants would be described in the translocation strategy. Monitoring would record the results of the translocation process and document the establishment and survival of translocated and propagated plants. Translocation monitoring would follow similar methods as *in situ* populations that include the collection of plant identification, plant condition and site condition data. Data would allow an assessment of the success of the translocation undertaken.

7.4 Habitat condition

The weed management plan would outline weed management measures to be implemented during construction, while the ecological monitoring program outlines weed monitoring measures to be implemented post-construction across the project. The noxious weeds and environmental weed infestations monitored during construction would inform the operational weed monitoring locations. Refer to the relevant weed management plan and the translocation strategy for weed monitoring requirements within the project pre, during and post-construction. This plan outlines weed monitoring to be conducted within the *in situ* populations and adjacent to the road reserve.

7.4.1 Selection of monitoring locations

Monitoring would be undertaken where revegetation has been undertaken adjacent to threatened plants and also within threatened plant populations and remnant areas to evaluate the success vegetation establishment within these areas.

7.4.2 Methods, timing, intensity and duration

After the first year of maintenance of revegetation, annual monitoring of revegetated areas adjacent to threatened plants would be undertaken using the BioBanking assessment methodology (DECC, 2008) to evaluate the progress of revegetation against benchmark data for the target vegetation community. These tasks would be integrated into the landscape design for the specific project section. Optimal survey time per species has been outlined in **Table 4-1** of **Section 4.3.1**.

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

Revegetation criteria for the site-based attributes would be developed, derived from benchmark data for the target vegetation community.

Monitoring of revegetation areas would occur until success of the revegetation has been achieved for three consecutive monitoring periods.

The following information would be collected during monitoring:

- 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.

The success or otherwise of the revegetation areas would be reported in the annual monitoring report.

7.5 Performance measures and corrective actions

Performance thresholds and corrective actions for threatened plants are outlined in Table 7-1.

Table 7-1 Performance thresholds

Performance thresholds	Corrective actions
At least 80 per cent of retained *in-situ* threated plants have survived during construction and for three consecutive monitoring periods post-construction and 60 per cent survived after five years.	Review mitigation measures used to protect retained *in situ* threatened plants if a decline in plant health has been observed during construction. Review the weed schedule and update as required. Propagate stored seed and replace threatened plants. Review water quality and modify water controls as required. If a decline in plant health has been observed during operation review for potential threats and implement corrective actions and additional monitoring as necessary.

At least 90 per cent of the roadside plants have survived after the first year and 80 per cent after five years.	Review and update maintenance methods as required. Identify any other potential threats and implement corrective actions as required. Any failed areas would be reinstated. Ongoing monitoring and maintenance undertaken until plant health and/or ecological condition of habitat has been maintained over five years.
An increase in weed coverage by 10% or weed coverage more than 30% in revegetation areas.	Review weed maintenance program and update as required.

The above performance and corrective actions would be reviewed and updated following the targeted surveys and development of the translocation strategy.

7.6 Evaluation, project review and reporting

7.6.1 Responsibility

The contractor employed to undertake the threatened plants monitoring for each component would be responsible for reporting and evaluating the monitoring information collected.

7.6.2 Adaptive management

If monitoring results indicate a substantial decline in the health or number of individuals as per the performance criteria, adaptive management measures would be implemented. These measures would be recommended by a qualified ecologist in monitoring reporting for each species and may include (but would not be limited to) the following:

- Active weed control to minimise competition.
- Watering of plants whilst young to promote establishment.
- Replacement of planted individuals of species that have a survival rate below the thresholds listed above.
- Replacement of retained individuals that have not survived due to edge effects associated with the project.
- Reporting losses and underlying reasons in the monitoring reports.

7.6.3 Timing

Reporting would be undertaken as detailed in **Section 7.3**, **7.4** and **7.6**. During construction this would generally include biannual reports and annual reports post-construction. These reports would outline the results of the monitoring undertaken including the success or otherwise of the mitigation measures.

A final report would be prepared at the conclusion of the monitoring program. This report would incorporate all the methods and results of the monitoring and recommend any provisional measures (if deemed necessary) to facilitate the long-term survival of the threatened plants within the project.

8. Summary table and implementation schedule

An overall example summary of the actions proposed in the above plan is provided in **Table 8-1**. 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.

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

No.	Task	Responsibility	Pre-construction	Construction	Operation				
					Year 1	Year 2	Year 3	Year 4	Year 5
1. Pre-construction									
1.1	Targeted surveys	Ecologist and design team	X						
1.2	Translocation strategy	Ecologist	X						
1.3	Seed collection and propagation	Contractor	X	X					
1.4	Exclusions zones	Contractor	X	X					
1.5	Weed management	Contractor	X						
2. Construction									
2.1	Work method statements	Contractor		X					
2.2	Induction and training	Contractor		X					
2.3	Clearing requirements	Roads and Maritime		X					
2.4	Sedimentation fencing	Ecologist		X					
2.5	Revegetation	Contractor		X					
2.6	Weed management	Contractor		X					
2.7	Dust management	Contractor		X					
3. Operation									
3.1	*Insitu* threatened plants/populations	Roads and Maritime			X	X	X	X	X
3.2	Revegetation areas	Roads and Maritime			X	X	X	X	X
3.3	Weed management	Roads and Maritime			X	X	X	X	X
4. Monitoring program									
4.2	In situ populations	Roads and Maritime, Ecologist		X	X	X	X	X	X
4.3	Habitat conditions	Roads and Maritime Contractor	X	X	X				
4.4	Evaluation and reporting	Roads and Maritime, Ecologist			X	X	X	X	X

9. References

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Department of Environment and Climate Change (2007). *Translocation Policy and Procedures*. Draft Report prepared by the Department of Environment and Climate Change.

Parsons *Brinkerhoff (2006) Translocation strategy for Maundia triglochinoides as part of the Pacific Highwau upgrade, Kempsey to Eungai*, April 2006.

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Sinclair Knight Merz (2010) *Pacific Highway Upgrade Glenugie*, Construction Management Strategy for *Melaleuca irbyana*, NSW.

Appendix A – Dr Andrew Benwell CV

CURRICULUM VITAE

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Qualifications

Diploma of Horticulture
Victorian College of Agriculture and Horticulture, Burnley 1978

Bachelor of Arts with Honours (Biogeography)
Department of Geography and Planning, University of New England 1995

Doctor of Philosophy (Plant Ecology)
University of New England 2004

Selected Project Experience

Translocation Plan for threatened and rare flora on the Tintenbar to Ewingsdale Upgrade of the Pacific Highway, plan implementation and monitoring, for NSW Roads and Maritime Services. 2011-2013

Rainforest restoration plan and implementation for six hectares of lowland subtropical rainforest on the Tintenbar to Ewingsdale threatened flora translocation site, for Roads and Maritime Services. 2011-2013

Tree hollow survey, nest box plan, installation and monitoring, for the Tintenbar to Ewingsdale Upgrade of the Pacific Hwy, for Roads and Maritime Services. 2011-2013

Seed collection for the Mt Annan Botanical Gardens seedbank project. 2011-2013

Banora Point Upgrade Ecological Monitoring Program (Bush Hen, Microchiropteran Bats, Mitchells Rainforest Snail, Threatened Plant Species, EECs), for the Banora Point Upgrade Alliance and Roads and Maritime. 2011-2013.

Vegetation investigations and expert witness for Tweed Shire Council in the matter of Gales Holdings vs Tweed Shire Council in the NSW Supreme Court. 2011.

Impact Minimisation Strategy for threatened flora on the Tintenbar to Ewingsdale Upgrade of the Pacific Highway, the NSW Roads and Maritime Services. 2011

Monitoring of Plant Species Composition in Burnt and Unburnt Frontal Dune Vegetation in Bundjalung National Park during Aerial and Ground Spraying of Bitou Bush (Chrysanthemoides monilifera subsp. rotundata) 2002-2011. Reports to the NSW National Parks and Wildlife Service. 2002-2011.

Translocation Plan for Arthraxon hispidus on the Tintenbar to Ewingsdale Upgrade of the Pacific Highway, report to the RTA. 2010.

Monitoring and research on the threatened species Euphrasia sp. aff bella at The Pinnacle, Border Ranges National Park, for Department of Environment Climate Change and Water. 2010-3

Preparation of Research, Management and Translocation Proposal for Arthraxon hispidus (Hairy Joint Grass) and implementation of the translocation, for the Ballina Bypass Alliance. 2009-2010

Translocation Plan, implementation and monitoring for the threatened species Rough-shelled Bush Nut (Macadamia tetraphylla), Arrow-head Vine (Tinospora tinosporoides) and Ball Nut (Floydia praealta), for the Ballina Bypass Allliance. 2009-2010

Cutting collection and propagation of the endangered plant Spiny Gardenia (Randia moorei) for the Hinze Dam project and Gold Coast City Council 2008-2010.

Hutley Road EIS – Vegetation Survey. Report to SMEC Australia. 2009

Mitigation Strategy for the Threatened Species Arthraxon hispidus (Hairy Joint Grass) on the Tintenbar to Ewingsdale Upgrade of the Pacific Highway. Report to the RTA. 2009

Osprey monitoring, weed management planning and landscaping advice on the Bonville Deviation Project, for Abigroup/Bilfinger Berger Australia. 2009

Pre-clearing Flora Survey, Weed Management Strategy, Targeted Bush Hen Survey and Ecological Monitoring Strategy - Banora Point Upgrade of the Pacific Highway, for the Banora Point Upgrade Alliance. 2009.

Translocation of Threatened Plant Species for the Ballina Bypass Project: Monitoring Report 1. Report to the Ballina Bypass Alliance. 2009

Targeted survey for threatened flora, assessment of translocation feasibility, Salvage Translocation Plan and management strategy for in situ threatened flora on the Sapphire to Woolgoolga Upgrade of the Pacific Highway, Report to the RTA. 2009

Maintenance, rehabilitation and monitoring of threatened species translocation areas for the Brunswick Heads to Yelgun Upgrade of the Pacific Highway, for the RTA. 2005-9

Environmental Audit of vegetation reinstatement at ten environmentally sensitive locations on the Southern Regional Water Pipeline between Ipswich and the Gold Coast. Report to the Southern Regional Water Pipeline Alliance. 2008

Vegetation Map and Flora Survey of the Nature Conservation Trust property at Banyabba north of Grafton. Report to the Nature Conservation Trust. 2008

Preparation of Seven-part Tests and Translocation Plans for Spiny Desmodium (Desmodium acanthocladum), Fragrant Myrtle (Austromyrtus fragrantissima) and Rough-shelled Bush Nut (Macadamia tetraphylla) in relation to proposed bridge reconstruction works in the Lismore City Council area. Reports to Lismore City Council. 2008.

Maintenance, rehabilitation and monitoring of three threatened species translocation areas for the Bonville Bypass project, for Abigroup Contractors P/L. 2006-8

Investigation of the condition of vegetation communities and the tolerance of plant species to variation in groundwater and soil chemistry at the tunnel section of the Tugun Bypass in NSW. Report to the Pacific Link Alliance. 2007

Tugun Bypass Translocation Project for Threatened and Rare Plants: Monitoring Report 1. Report to the Pacific Link Alliance. 2007

Targeted surveys for the rare forest ecosystems Craven Grey Box and Grey Box-Grey Gum for the Department of Environment and Conservation. 2007

Flora survey, Translocation Plan and plan implementation, for the Bonville Upgrade of the Pacific Highway, for Abigroup Contractors P/L. 2007-6

Translocation of the Great Barred Frog (Mixophyes iteratus) from Pine Creek on the Bonville Upgrade of the Pacific Highway, for Abigroup Contractors P/L. 2007.

Targeted Vegetation Survey of Floodplains and Lower Slopes on the
Far North Coast – 120 full floristic plots, data analysis and interpretation, and report review for DEC 2008-2006

Botanical survey, revegetation planning and seed collection for the South East regional water pipeline (Ipswich to the Gold Coast), for Southern Regional Water Pipeline Alliance 2007-2006

Plan of Management for Habitat Compensation Blocks A & E Cobaki Broadwater, co-authored with Ben Lewis, for the Tugun Bypass Alliance. 2007.

Flora and fauna survey and assessment report on proposed compensatory habitat lands for the Bonville Bypass project, for the RTA. 2007

Translocation Plan for Threatened and Rare Flora for the Tugun Bypass Project and implementation of works, Pacific Link Alliance. 2006

Vegetation Issues On Two Route Options Involving The Summerland Way (Grafton to Casino) And Connection Back To The Pacific Highway (Casino-Lismore-Byron Bay). Report to the NSW Roads and Traffic Authority. 2006

Monitoring of Roadside Threatened and Rare Plants on the Brunswick Heads to Yelgun Pacific Highway Upgrade, for Abigroup Contractors P/L. 2006

Vegetation Survey and Management Recommendations for Upgrade of Water Mains Supply Brunswick Heads, for Rous Water. 2006

Ecos Environmental P/L (2006). Vegetation Survey of the Preferred Route for The Upgrade of the Pacific Highway Between Sapphire to Woolgoolga. Report to Connell Wagner P/L.

Vegetation survey of the Tarong Energy Corp site at Glen Wilga, Chinchilla, for Parsons Brinckerhoff Australia. 2005

Vegetation survey of the Tarong Energy Corp ash dam extension site at Nanango, for Parsons Brinckerhoff Australia. 2005

Peer Review of Phase 1 & 2 of the Woodburn to Ballina Upgrade of the Pacific Highway, for Hyder Consulting, on behalf of the Roads and Traffic Authority. 2005.

Vegetation Management Plan for the Tugun Bypass project, for the Pacific Link Alliance (SMEC and Abigroup). 2005

Rainforest restoration on two compensatory habitat sites for the Brunswick Heads to Yelgun highway upgrade, for the Roads and Traffic Authority. 2005

Translocation Plan for Threatened Plants on the Alstonville Bypass, for the Roads and Traffic Authority. 2005.

Monitoring of Translocated and Roadside Threatened Species on the Yelgun to Chinderah Highway Upgrade (Year 4), for Abigroup Contractors P/L 2005.

Toowoomba City Remnant Vegetation Survey, for Toowoomba City Council. 2005-2004

Botanical survey and vegetation map of the Redland Bay South Development Site, for the Australian Koala Foundation on behalf of Redland Bay Southpark Corporation Pty Ltd and Medallist Development Pty Ltd. 2004.

Translocation Plan for threatened flora on the Brunswick Heads to Yelgun Pacific Highway Upgrade and implementation of works, for the Roads & Traffic Authority. 2005-2004

Management Plan for the threatened grass Arthraxon hispidus at Koala Beach Estate, Tweed Shire, and plan implementation, for the Australian Koala Foundation on behalf of the Ray Group P/L. 2005-2000.

Vegetation mapping and botanical surveys of the Tugun Bypass route, Gold Coast, for Parsons Brinckerhoff Australia Pty Ltd, Brisbane. 2004-2.

Management Plan for the endangered Smooth Davidsonia on a proposed rural tourist facility at 904 The Pocket Road, Byron Shire, for Pocket Mountain Retreat Pty Ltd. 2004.

Vegetation Rehabilitation Plan, advice and supervision of works at Emigrant Creek Dam, for Rous Water 2004.

Monitoring and analysis of the distribution of the endangered Square-stemmed Spike Rush, for the NSW Department of Environment and Conservation 2004-2000.

Survey and Management of Terrestrial and Aquatic Flora and Fauna at Emigrant Creek Dam, report to Rous Water 2003.

Vegetation Regeneration and Landscape Plan for Community Titles development at Lot 2 Main Arm Road via Mullumbimby, for Leon Rubinstein. 2003.

Management plan for the Endangered Plant Rusty Green-leaved Rose Walnut (Endiandra muelleri subsp. bracteata) on Stage 3 of the Koala Beach Estate, Tweed Shire and plan implementation, for the Australian Koala Foundation on behalf of the Ray Group P/L. 2002

Survey and Management Plan for threatened plants on power line corridors in Byron Shire, report to Country Energy. 2002.

Review of Environmental Factors for emergency water supply works at Howards Grass (Lismore) & Middleton Way (Dorroughby), report to Rous Water. 2002.

Threatened species survey and mapping and rehabilitation advice for a floodplain rainforest remnant on Cudgera Creek impacted by proposed upgrade of Cudgera Creek Road, report to PES (RTA). 2002.

Vegetation survey of Stages 5, 6 & 7 Koala Beach Estate, Pottsville and Eight Point Tests for Threatened plants Endiandra muelleri subsp. bracteata, Arthraxon hispidus and Archidendron hendersonii, report to the Australian Koala Foundation on behalf of the Ray Group P/L. 2002

Flora, Fauna and Habitat Survey of Marshall's Ridge, North Ocean Shores, report to Greenfields Mountain P/L. 2002.

Flora survey and vegetation mapping of route options for the Sapphire Beach to Woolgoolga section of the Pacific Highway Upgrade, for Connell Wagner P/L. 2002.

Development Application - Boundary Fencing Billinudgel Nature Reserve and Greenfields Mountain P/L and associated Environmental Assessments (acid sulphate soils, aboriginal heritage, flora and fauna), prepared for the National Parks and Wildlife Service, Tweed Office. 2001

Flora and fauna survey and Revegetation Concept Plan for the proposed Dunoon Dam Site, prepared for Rous Water. 2001.

Design of monitoring program and collection of baseline data for the 'Brunswick Saltmarsh Monitoring Program', for Sinclair Knight Merz and the RTA. 2001

Flora and fauna survey of 'Harris Creek' (Gresford) and 'Hiddenvale' (Dungog), two properties in the Hunter Valley Region. Report to National Parks and Wildlife Service, Coffs Harbour. 2001

Flora surveys and rehabilitation proposal for ex-logging roads in Toonumbar, Yabbra and Tooloom National Parks, for Kyogle sub-district for the NSW National Parks and Wildlife Service. 2001

Flora survey and Eight Point Test for an occurrence of Endiandra muelleri subsp. bracteata on Stage 2 of the Koala Beach Estate, Pottsville, for the Australian Koala Foundation on behalf of the Ray Matrix P/L. 2001

Translocation, monitoring and habitat rehabilitation for nine species of Threatened rainforest tree, shrub and vine flora on the Yelgun-Chinderah section of the Pacific Highway upgrade, for Abigroup Contractors P/L and the NSW Roads and Traffic Authority. 2000-2001.

Flora Environmental Control Plan - Yelgun-Chinderah Pacific Highway Upgrade, report to Abigroup Contractors P/L and the NSW Roads and Traffic Authority. 2000.

Landscaping, Revegetation and Rehabilitation Environmental Control Plan for the Yelgun-Chinderah Pacific Highway Upgrade, report to Abigroup Contractors P/L and the NSW Roads and Traffic Authority. 2000.

Weed Control and Vegetation Clearing Environmental Control Plan for the Yelgun-Chinderah Pacific Highway Upgrade, report to Abigroup Contractors P/L and the NSW Roads and Traffic Authority. 2000.

Botanical survey and vegetation map of Nymboida National Park, for the NSW National Parks and Wildlife Service, Northern Tablelands Region. 1999-2000

Monitoring of the threatened species Eleocharis tetraquetra at Boambee, for RTA and the NSW National Parks and Wildlife Service. 2000-2001

Publications and Discussion Papers:

2013. Ballina Bypass Arthraxon hispidus (Hairy Joint Grass) Translocation Project. Discussion Paper presented at the 2013 Australian Network for Plant Conservation translocation workshop at the University of the Sunshine Coast.

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2007. Response of Rock Outcrop and Fringing Vegetation to Disturbance by Fire and Drought. Australian Journal of Botany 55 (7) 735-748.

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1999. Species Recovery Plan for *Corchorus cunninghamii.* Prepared for the NSW National Parks and Wildlife Service.

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1998. Species Recovery Plan for *Angiopteris evecta*. Prepared for the NSW National Parks and Wildlife Service.

1998. Species Recovery Plan for *Allocasuarina defungens*. Prepared for NSW National Parks and Wildlife Service.

1996 (co-author). Estimation of the Pre-1750 Forest Type Distribution for the Northern Study Area. Prepared for RACAC by the NSW National Parks and Wildlife Service.

1995. Interim Procedure for the Protection of High Conservation Value Examples of Inadequately Conserved Forest Types in North Eastern NSW. Report to the National Parks and Wildlife Service.

1994. (key contributor) Flora of North-east NSW Forests. North East Forests Biodiversity Report No.4. NSW National Parks and Wildlife Service.

Appendix B – Dr Andrew Benwell - expert

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18/9/2013

WOOLGOOLGA TO BALLINA PACIFIC HIGHWAY UPGRADE
THREATENED FLORA MANAGEMENT PLAN Version 3.0 August 2013.

Prepared by: NSW Roads and Maritime Services, Aurecon and Sinclair Knight Merz

Reviewed by: Dr Andrew Benwell (ECOS Environmental Pty Ltd)

Reviewed for: Sinclair Knight Mertz

Point No.	Section/Table Number	Comment
1	Not included	Glossary of terms – e.g goal, objective, in-situ, direct impact, indirect impact, translocation, revegetation, threatened species, performance threshold, offset, project boundary, receival site, donor site etc. *Recommendation*: include a glossary of terms at the front of the TFMP
2	1.2 Purpose and objectives	This section doesn't describe the purpose and objectives of the plan. The dot points give the contents of the plan (?) *Recommendation:* state the purpose and objectives of the W2B Threatened Flora Management Plan
3	1.3 Management structure	Not sure about the approach of a Framework TFMP and then stage-specific TFMPs. This may lead to a lot of duplication of reporting, increased 'green-tape' and significantly higher costs. Why not one threatened flora management plan for the whole project? The number of threatened species affected by the project is not particularly high. There were a similar number of threatened plant species on BH2Y. (Most of the comments below would relate to a single plan or multiple plans)
4	2. Threatened plant populations	What about non-listed rare species? There is at least one very rare species on W2B which are worthy of being treated in the same fashion as threatened species. Recommendation: Include rare species not listed under the TSC Act or EPBC Act in the W2B TFMP, such as Dicrocephala integrifolia, thought to be extinct in NSW until rediscovered in 2006 near Woodburn. (Justification - NPWS (1998). The Threatened Vascular Flora of North-

Point No.	Section/Table Number	Comment
		Eastern NSW. Inventory, Assessment and Conservation. NSW National Parks and Wildlife Service.) Also include the endangered species Rotala tripartita (TSC Act) recorded opposite Jackybulbin Rd in 2006 after completing the Iluka to Woodburn vegetation survey report.
5	Last dot point	Suggest this point be reworded > <u>targeted revegetation of disturbed areas adjoining in-situ threatened flora</u> *Recommendation:* Incorporate the above into objectives/goals.
6	3rd para from bottom of 3.3	This paragraph states that translocation is not a mitigation measure. Reading the agency comments, DSEWPAC and EPA also have this view, but not DoPI. My personnel view is that when conducted for development, translocation is a mitigation measure, although not an offset. The ANPC (2004) guidelines for translocating threatened species recognise different forms of ameliorative translocation. Approaching translocation as a form of offset is problematic, because the results of a translocation cannot be predicted with confidence, particularly with respect to long-term goals, as discussed in the WC2U TFMP. Some threatened flora translocations have been relatively successful in the short-term, but many have failed or the outcomes are uncertain. Most threatened flora translocations are essentially experimental. Often failures are due to problems with implementation that can be corrected or trialled again using a different method, hence the importance of monitoring and documentation of methods and results. The reviewer agrees with DSEWPAC that a translocation proposal is best considered as part of a larger offsets strategy for threatened flora that includes direct offsets. Roads and Maritime has taken this approach on previous Pacific Hwy upgrade projects such as BH2Y, Tugun and Bonville, where both compensatory habitat containing threatened species and translocation contributed to the offset package. *Recommendations*: • Include a discussion of the purpose and potential benefits (and risks) of translocation in the context of direct impact and loss of threatened species individuals (see WC2U TFMP). • Translocation would not be factored into offset formulae. • Translocation receival sites would be located outside the project boundary, in disturbed sections of offset land. • Translocation would be conducted to prevent declines in population numbers of threatened species in the vicinity of W2B upgrade (note – without translocation in some form there would be a net loss of individuals due to the project). • The introduction of threatened species to receival sites (i.e. translocation) would be designed in a comparative experimental fashion where practical to learn more about species ecology and translocation technology. * Note - points 6 and 14 are really about the same issue and can be merged.
7	Table 3-2 Mitigation measures and evaluation of	Col. 1 Suggest replace " Impacts to threatened flora outside the construction (exclusion) zone" with >Impacts to threatened flora to be retained in-situ within project boundary outside the construction zone<

Point No.	Section/Table Number	Comment
	effectiveness	Col. 2 first point – the word "*in situ*" seems redundant if flora is directly impacted Col. 3 third point – Suggest replace "Weed management near threatened populations" with <u>Weed management near retained threatened flora</u>
8	Table 3-2 – second issue	Maintenance of in-situ threatened flora sites is best carried out as a package including weed control and revegetation. This would be applied to a specified area surrounding each in-situ threatened flora site, and possibly important sites outside the project boundary but directly adjoining it. This work should be planned in consultation with and implemented by a bush regeneration/habitat restoration sub-contractor, rather than by the landscape architect or general weed control sub-contractor. The personnel doing this work need to be:- (i) experienced in identification of the local flora and particularly the subject threatened species, so that damage to individuals of threatened species and native species in general does not occur during maintenance activities (these plants will be monitored). (ii) experienced with using bush regeneration and planting to restore and maintain threatened flora habitat. Roads and Maritime has not developed standard weed management procedures that are implemented during construction as part of FFMP and targeted to in-situ threatened flora. *Recommendation*: Maintenance of in-situ threatened flora sites, which would involve weed removal and revegetation if required, be conducted as a package and implemented by a bush regenerator with local experience, rather than by the landscape architect or general weed control contractor.
9	Issue not addressed	Clearing/tub grinder mulch applied in revegetation areas adjoining threatened species has the potential to interfere with native species regeneration and encourage weed growth There should be more information available about how recent projects have managed this issue and what the outcomes were – e.g. the Glenugie Upgrade and Devils Pulpit. *Recommendation:* Tub-grinder mulch not be spread around in-situ threatened flora sites.
10	Table 3-2 third issue (direct loss of plants during construction)	The six mitigation measures listed to address this issue are all forms of translocation, although the way it is written might suggest otherwise. For example, "seed collection for establishment of threatened species on offset sites" is translocation. The three core mitigation measures for direct loss are: 1. Avoidance of impact where possible, including during the detailed design stages (ie. 85% and 100% detailed design) 2. Translocation – compensatory introduction to offset/receival sites, salvage transplanting to offset/receival sites, relocation to a nearby site with matching habitat, population enhancement to promote long-term population viability and so on. 3. Offsets – e. g. acquire and protect threatened flora habitat, improve threatened species habitat elsewhere etc.
11	3.5 Adaptive management approach	This section describes the management approach in general rather than adaptive management. It doesn't really address adaptive management.

Point No.	Section/Table Number	Comment
		Do SMART principles relate directly to the heading of adaptive management? Wouldn't they be better at the start of plan? My reference says 'R' is Relevant (ie choosing goals that matter; Is this worthwhile?), not Results-based. *Recommendation:* Move SMART principles to the start of the plan and consider throughout; clarify 'adaptive management'.
12	Table 4-1	Arthraxon hispidus – Dec. to May Cyperus aquatilis - Jan to June Maundia triglochinoides – spring, summer, autumn Melaleuca irbyana – all year
13	4.3.1 Targeted surveys	p.16 last line talks about identifying translocation sites in consultation with landowners (ie. private property), but p. 20, 2nd paragraph states planting of threatened plants (ie. translocation) would be "targeted at planting in other Roads and Maritime land acquired as part of the offset strategy"….? Selection of the receival sites is a separate task from targeted surveys. Site inspections would be needed to identify suitable receival sites. Targeted surveys are about identifying and marking where threatened species occur within the project boundary to advance planning for translocation and in-situ flora management. p.17, paragraph after dot points, first line – "…used to inform the detailed design, translocation strategy, revegetation measures for in situ threatened flora and monitoring program." In previous threatened flora MPs, the indirect impact zone was 10m from the edge of clearing/construction (see Sec. 3.3.7 of WC2U plan). Our monitoring of roadside threatened flora for the Pacific Hwy upgrade has shown that indirect impacts such as weed invasion along cleared forest edges is generally limited to <10m from the edge of clearing, given implementation of mitigation measures for protection of roadside threatened flora and habitat such as strict control on clearing, no tree felling into retained habitat, sed fencing etc. Increasing the indirect impact zone to 20m would significantly increase the monitoring load. If in some situations indirect impacts were likely to extend further, the indirect impact zone could be increased for that site. *Recommendation:* For non-aquatic threatened species, the indirect impact zone would be defined as within 10m of the edge of clearing. For aquatic species and shade-requiring species such as the two orchids occurring on the project, the indirect impact species would be 20m.
14	Suggest a section headed Translocation, before the Translocation Strategy	What is translocation? Translocation is defined as the "deliberate transfer of plants or regenerative plant material from one place to another, including existing or new sites or those where the taxon is now extinct." (ANPC 2004)….etc. Translocation is a means of maintaining or increasing the numbers of a threatened species when a direct loss occurs. Land offsets may have indirect benefits for threatened species, such as, a population may be protected that would have become degraded due to lack of restrictions

Point No.	Section/Table Number	Comment
		on land use, or a population may increase due to habitat rehabilitation provided as part of an offset package. Without translocation (i.e. salvage transplanting and/or addition of individuals by propagation/compensatory introduction) there may still be a net decline in threatened species populations due to clearing. There are different types of translocation including salvage transplanting and compensatory introduction, the two principle forms of translocation to be applied on the W2B project. *Recommendation:* Include a general discussion of translocation including its purpose and objectives, the different types of translocation, history of use, general outcomes, reasons for failure etc as an introduction to the Translocation Strategy. * this point is about the same issue as point 6.
15	Section 4.3.2 Translocation strategy	Suggest adding another paragraph >Translocation Plans would generally follow the framework and issues of consideration set out in ANPC (2004) "Guidelines for the Translocation of Threatened Plants in Australia" < Suggest putting the dot points under two headings - Translocation Feasibility Assessment and Translocation Plan. Translocation Feasibility Assessment applies to the first two dot point and sub-dot points. The TP applies to the other four dot points. Fourth dot point – " to enhance the translocated population (not site) Second last paragraph about "translocation trials" may need to be reworded as 'trial' indicates a preliminary or test translocation to be conducted before the full translocation, which I don't think was intended(?) Suggest including > translocation may be considered feasible for a threatened species that has not been translocated before if its ecological requirements, growth-form attributes and propagation characteristics indicate that translocation employing a certain method has a reasonable chance of success<
16	Issue not addressed – Selection of Receival Sites	This important decision could be described in more detail, including how such sites are identified, when and where. Would they be sited on offset land or other Roads and Maritime owned properties? How would receival site selection proceed in a planned and organised way? *Recommendation:* Include a section on the selection/allocation of receival sites.
17	Section 4.3.3 Seed collection and propagation	Change title to Threatened plant propagation, or Seed/cutting collection and propagation The requirements specified in some paragraphs would be clearer in dot point format. What about a more general intro to this section – how does propagation fit into the overall process of translocation?

Point No.	Section/Table Number	Comment
		2nd paragraph– replaced stoned with stored. 3rd paragraph – suggest using dot point format. Table 4-2 Arthraxon hispidus Flowering Period – March-May; Seed collection – May-June. 6th paragraph – Some (not many) threatened species are difficult to germinate…… The use of cuttings may also be required if seed is not available for collection or does not propagate well.
18	Issue not addressed	The Framework TFMP does not directly address the issue of managing genetic diversity. Section 4.2.4 and 4.2.3 of the WC2U TFMP provide some simple guidelines for maintaining genetic diversity. Why is it important? *Recommendation:* Include a section on indirect management of genetic diversity.
19	Table 4-3 Seed collection, storage and propagation methods	Seed trials (?). This is a trial comparing two different types of soil medium for growing seedlings/cuttings in pots – i.e. standard commercial propagation mix and the local natural soil type – and the effect of this on survival when the seedling/cutting tubestock are introduced to the field/receival site. (Propagation medium and field survival trials?) Suggest adding: Tree seedlings would be grown on until at least 40cm tall, shrub species 30cm tall, before introduction to the receival site. Herbaceous species should be robust and healthy. All tubestock would be hardened off for at least a month before planning out. The rest of the methods might be clearer in dot point format. *Recommendation:* Set out this experimental initiative more clearly.
20	4.3.3	p.20, reword 3rd paragraph. See also results of previous threatened flora translocation projects for the Pacific Highway upgrade.
21	4.3.3	p. 20, last paragraph – Suggest change wording to: >Propagation of the threatened species would only be done by qualified/ experienced nurseries or plant propagators, and only disease free tubestock would be introduced to the receival sites.
22	Table 4-4 Propagation methods	Put seed propagation first Replace “bog method” with >saturated soil medium method< 2nd dot point, suggest change to >would be transplanted to 120mm tubes, or super tubes depending on the species, and grown on until at least 40cm tall. In the case of fast growing species this may take 9-12 months, for slower growing species 18 months or more… 3rd dot point – suggest change wording to >planted out when at least 40cm tall and after hardening off……
23	4.3.5 Weed management	A lot of this section seems to apply to weed management for the general highway landscaping and revegetation, not specifically for management of in-situ threatened flora sites. The latter should be treated separately, not as part of the overall landscaping plan or weed management plan.

Point No.	Section/Table Number	Comment
		A more careful bush regeneration approach to weed management would generally be required at threatened flora sites. Suggest, once the targeted surveys are completed and threatened flora to be retained in-situ within 10m of the construction zone are identified, a sub-plan "Revegetation and Management of In-situ Threatened Flora Sites" be prepared. This would be short and consist essentially of a scope of works for each in-situ flora location. The two main measures to be applied would be revegetation of adjoining bare areas with appropriate native vegetation and/or weed control. This should be implemented separately from the general landscaping and weed management, inside a flagged off exclusion zone of agreed functional dimensions. *Recommendation:* Provide more detail on the revegetation sub-plan – ie. what, where, how and when.
24	4.4 Performance thresholds and corrective actions	Table 4-5 3rd goal, Corrective action, suggest rewording to – Delay construction until seeds and propagules have been collected >only if they cannot be collected elsewhere in the local area including outside the construction zone.<
25	5.2 Main goals for management (Construction management measures)	1st dot point – Suggest >zero mortality due to direct physical damage during construction. "No notable increase in the abundance of weeds" should be a separate dot point. 2nd dot point – this dot point implies that translocation would be carried out during construction? Salvage transplanting is normally carried out pre-construction. Propagation may start pre-construction or during construction. Last dot point – Water quality and >soil quality< managed in accordance with the CEMP. Non-aquatic threatened plants may be threatened by changes to soil quality, including erosion and sedimentation.
26	5.3 Management measures	Suggest including >Sensitive Area Plans (Maps)< as a separate heading. SAPs are important for identifying where threatened flora are located for day to day management of the project. They should be kept up to date and clearly show the locations of in-situ and to-be-translocated threatened flora with their identification numbers.
27	5.3.1 Work method statements	"including risks to threatened frogs" – what are they?
28	5.3.4 Sedimentation fencing	2nd paragraph – take out Quassia sp. Moonee Creek, generally occurs on slopes.
29	5.3.5 Revegetation	1st paragraph – disagree with this approach. Revegetation and habitat maintenance around in situ threatened flora should be a bush regeneration task, not part of the broad-scale landscaping. 2nd paragraph – maintenance should be for a minimum of three years. Specify the number of times per year. *Recommendation:* Revegetation and habitat maintenance around in situ threatened flora should be a bush regeneration task, not part of the broad-scale

Point No.	Section/Table Number	Comment
		landscaping.
30	Issue not addressed	What about a section on Topsoil Salvage and Re-use for Revegetation? Using topsoil seed bank salvaged from weed free areas of forest is potentially a far more effective method of revegetating disturbed areas and controlling weed invasion. There are major ecological and cost advantages to this widely used approach compared with hydromulching using commercially sourced native seed, tubestocking and uncoordinated use of salvaged topsoil. *Recommendation*: Incorporate the use of salvaged topsoil seedbank in the revegetation of disturbed areas around in-situ threatened flora sites.
31	5.3.6 Weed management	During construction?
32	5.3.7 Dust management	Tall shade cloth screening would be installed for low growing species to provide dust and microclimatic protection, as used for *Lindsaea incisa* on S2W. *Recommendation:* Install shade cloth screening along the edge of vegetation containing low growing, in-situ threatened species such as *Lindsaea incisa* for dust protection and to maintain microclimate.
33	Table 5-2 Mitigation measures, performance thresholds and corrective actions during construction phase.	Main goals. Suggest that the goals be numbered. First goal/row – suggest the goal be set at zero mortality for physical damage during construction. Other projects have shown this is quite achievable. Any mortality due to direct physical damage is not acceptable, as the principle contractor may be prosecuted by EPA. There are two goals in the one sentence – put the weeds one as a separate goal. Proposed mitigation measures – include SAPs (see 5.3 above) Second goal/row – Proposed mitigation measures, suggest reword to include >undertaken at times, into suitable habitat and using appropriate methods< that maximise the chance of plant survival…… Monitoring timing/frequency – give the specific monitoring interval – e.g. 1st year – 3-monthly Performance thresholds – suggest change to >All plants identified for translocation have been translocated Corrective action – tubestock would be propagated anyway as part of population enhancement (for most species). Third goal/row Suggest reword as >revegetation and habitat management requirements for areas adjoining in-situ threatened flora prepared in a separate scoping sub-plan< or make into a separate goal. Employ specialist bush regenerator to implement. Fourth goal/row - Dust Proposed mitigation measure – include tall shadecloth screening installed on edge of construction zone to protect low growing threatened flora.

Point No.	Section/Table Number	Comment
		Fifth goal/row – water quality. Suggest soil quality is included here for non-aquatic threatened flora.
34	Issue not addressed	Security measures for orchids and other collectable plants. *Recommendations:* Include measures to guard against illegal orchid collecting.
35	6 Operational management measures	Both sections 5 and 6 of the plan concern the management of in-situ (roadside) threatened flora. At least 50% of the framework TFMP appears to deal with in-situ threatened flora from various angles. Is this the most efficient way to approach management of threatened flora? Translocation is arguably more important and technically difficult to implement, so you would expect it take up at least as much space as management of in situ threatened flora…?
36	6.2 Main goal for management	Aren't these performance measures rather than goals? 1st dot point – how long are the "three consecutive monitoring periods"? As discussed above, the goal/performance threshold for direct physical damage (as defined by the TSC Act) during construction needs to be zero. Decline to 60% after five years indicates gradual attrition of the remaining in situ population – is this a good outcome? Suggest minimum 80% survival of tree, shrubs and herbaceous perennials after 5-8 years. Species-specific performance thresholds would be preferable to general thresholds, as species differ in resilience, longevity and sensitivity to disturbance. Shade-loving species such as orchids may need a lower threshold (and more attention to buffering). The threshold would have to modified for species that fluctuate seasonally, or from year to year – e.g. Arthraxon hispidus and Maundia – comparison with a control may be useful, although for a valid comparison, land-use at the control site and the in situ site would have to be the same, which will be difficult to control. If it cant be controlled effectively, is it worth having a quasi-control? *Recommendation:* Refine the specification of performance thresholds, as discussed above. *Recommendations:* The goal for weeds is less than 5% weed cover at in-situ threatened flora sites at the end of the monitoring program.
37	6.3 Management measures 6.3.1 In situ threatened plants/populations	Are all these interventions for in-situ threatened flora necessary? These are established, naturally occurring plants. Why would you water them? 100% survival can be expected for perennial trees, shrubs and herbs during the period of an average monitoring program. At the most, partial dieback of branches or stems may occur in some plants. How is debris from storms damaging to plants? They don't seem to meet SMART principles in the sense of being Relevant.
38	6.3.2 Revegetation areas	1st paragraph – this is the first mention of a "revegetation plan", which is more-or-less what I am suggesting above in 4.3.5. When would this plan be prepared? What would it contain? Suggest, once the targeted surveys are completed and threatened

Point No.	Section/Table Number	Comment
		flora to be retained in-situ within 10m of the construction zone are identified, a sub-plan "Revegetation and Management of In-situ Threatened Flora Sites" be prepared. This would be short and consist essentially of a scope of works for each in-situ flora location. The two main measures to be applied would be revegetation of adjoining bare areas with appropriate native vegetation and/or weed control. This should be implemented separately from the general landscaping and weed management, inside a flagged off exclusion zone of agreed functional dimensions. Include some information on the actual revegetation methods? The description of maintenance activities for revegetated areas needs attention. The purpose of maintenance is to ensure that tubestock become established and areas are revegetated successfully. If topsoil seedbank is used to revegetate, virtually no maintenance is required – a wide range of species will grow from the soil seedbank and if salvaged from weed free areas during clearing there should be very little or no weed regeneration. If areas are tubestocked, the main maintenance required is weed control. If tubestock are planted properly, additional watering would only be required if there is a long period of drought. Well grown-on, hardened off tubestock would be planted, mulched and marked with bamboo stakes for follow-up maintenance (i.e. weed control). Plastic planter bags are not necessary. Follow-up maintenance at specified time intervals to control competing growth is essential for a high tubestock survival rate. *Recommendation:* Provide more detail on the revegetation sub-plan – ie. what, where, how and when.
39	Table 6-1	I don't think all this monitoring is needed – the main thing is to have a clearly defined and appropriate maintenance schedule. Maybe 'site inspection checks' would be better than 'monitoring'. Monitoring implies data collection and reporting. Weekly watering in the first month is not be necessary unless in a period of drought, in which case you would delay planting. Only an initial watering is necessary if the plants are a good size and well hardened off. The table needs to be simplified. *Recommendation:* Clarify the monitoring schedule, including the frequency of monitoring in each year (1-8?), specify the monitoring interval (e.g. year 2, 6-monthly….), for each aspect of the TFMP being monitored, and type of data to be recorded.
40	6.3.3 Weed management	This is repeating a previous section
41	6.4 – Table 6-1: Performance thresholds and corrective actions	This table could be simplified. Suggest that columns 1 and 4 be merged and called 'performance goals' (apply to construction version of this table also) What are the performance goals specifically for the operational phase?

Point No.	Section/Table Number	Comment
		When does the operational phase start relative to the overall threatened flora management program? How long does the operational phase run for (approx.)? What is the interval between the three consecutive monitoring events? Col. 1 of the table is confusing – it includes goals (?) for "during construction" and "during the first year (this is not the operational phase) and 3 consecutive monitoring periods post-construction (operational phase?) and "after five years" As discussed above, the goal/performance threshold for direct physical damage (as defined by the TSC Act) during construction needs to be zero. Decline to 60% after five years indicates gradual attrition of the remaining in situ population – is this a good outcome? Suggest minimum 80% survival of tree, shrubs and herbaceous perennials after 5-8 years. Species-specific performance thresholds would be preferable to general thresholds, as species differ in resilience, longevity and sensitivity to disturbance. Shade-loving species such as orchids may need a lower threshold (and more attention to buffering). The threshold would have to modified for species that fluctuate seasonally, or from year to year – e.g. Arthraxon hispidus and Maundia – comparison with a control may be useful, although for a valid comparison, land-use at the control site and the in situ site would have to be the same, which will be difficult to control. Show construction and operation performance criteria in one table? *Recommendation:* Clarify and revise the description of performance thresholds as described above – set out clearly.
42	Monitoring program (no number)	What about monitoring of the translocation work?
43	6.5 Objectives	To be clearer set out in dot point format, checking wording.
44	6.6 In-situ populations	For what species will the project really survey and collect "details on the distribution and abundance of threatened species immediately adjacent to the project" (2nd sentence) – ie outside the project boundary?
45	6.6.1 Methods, timing, intensity and duration	The first paragraph needs to be reworded. Until what mitigation measures have proven successful? Describe how they would be assessed as having succeeded. How long are the 3 consecutive monitoring periods? The use of control sites is supported, but need to be careful the amount of monitoring doesn't become excessive. Suggest adding controls for certain species potentially sensitive to disturbance. Based on past experience, adverse impacts on in-situ threatened flora, given application of mitigation measures, is expected to be minimal for most species.
46	6.7 Habitat condition monitoring	Habitat condition at the in-situ sites is worth monitoring to some extent, but the habitat areas requiring management around most of the in situ threatened flora species is relatively small. Is the BioBanking Assessment Methodology appropriate at this scale? Habitat condition can be recorded effectively using a few simple quantitative measures and qualitative descriptors, plus photographs.

Point No.	Section/Table Number	Comment
		As mentioned above, the most important thing for in-situ flora site management, is a focused maintenance program involving weed control and revegetation, where required, implemented by appropriate personnel. Limited resources should be allocated to this work rather monitoring. *Recommendation:* Describe for what species and where this monitoring would be applied.
47	6.8 Translocation	Why all the detail about monitoring in-situ threatened flora and nothing about monitoring the translocations?
48	6.9 Performance measures and corrective actions – Table	Same comments as the performance tables above.

(a) Is the design of the monitoring project appropriate for the species?

Yes, the monitoring project describes what aspects of threatened flora management would be monitored (e.g. in situ threatened flora, translocation, habitat etc), which will address all subject threatened species.

A tabular summary of the monitoring design would be useful to clarify the main components of the monitoring project design.

(b) Is the frequency and timing of monitoring adequate?

As worded, some of the points in column 3 of Table 5-2 don't seem to relate to monitoring timing/frequency, such as "Clearing areas…..", "Dust suppression……" and "washdown of rainforest…" These are management actions rather than monitoring.

I have recommended that the plan includes specific information on the monitoring schedule, including monitoring intervals in each year for each aspect of threatened flora management being monitored – see my review comments.

(c) *Is the Management Plan clear on what basis the monitoring locations would be selected?*

There is no information about the how the monitoring locations would be selected – ie. where and how many.

(d) Are appropriate goals being set?

Yes appropriate goals are being set, although I have recommended some revision to these in my review comments, including (i) no mortality of in-situ threatened plants due to direct physical damage during clearing and construction; (ii) 80% of trees, shrubs and herbaceous perennials in the indirect impact zone surviving after 8yrs, and (iii) specific thresholds for some species such as Arthraxon and Maundia which have more potential to fluctuate in abundance due to other causes apart from construction.

(e) Are the mitigation and management actions sufficiently targeted for the species?

I have recommended some refinements to the mitigation and management actions in my review comments.

(d) Are the objectives, performance measures, corrective actions and thresholds for corrective actions in accordance with SMART principles?

Not always – see may review comments.

(e) Do the management measure objectives, performance indicators, thresholds and corrective actions link sufficiently to allow effective implementation?

Management measure objectives are generally not presented. Otherwise the performance indicators, thresholds and corrective actions link sufficiently to allow effective implementation.

(e) Has the Management Plan provided sufficient evidence where the proposed mitigation has previously been effective?

No, more evidence could be presented about 'history'. There is no information on the past effectiveness of translocation.

(f) Does the Management Plan describe and discuss contingencies, should the proposed measures be ineffective?

There are two references to contingencies in the TFMP. This aspect of the plan could be developed more.

(g) If we can't demonstrate mitigation proposed will be effective, can we demonstrate that corrective actions will be effective?

Corrective actions are a continuation of the mitigation in modified form so that implementation is more effective. Monitoring will determine if it is effective or not.

(h) Where there is no known research / evidence of the effectiveness of the specific measure proposed – have relevant alternative contingencies been committed to?

There are two references to contingencies in the TFMP. This aspect of the plan could be developed more.

(i) Have indirect impacts been addressed in the Management Plan, as relevant?

Yes the indirect impacts addressed in the MP are relevant.

(j) Are qualifications and experience of authors in subject field relevant?

Yes.

Yours faithfully

Dr. Andrew Benwell

Appendix C – Maps of threatened flora populations

Figure 2 -1 Location of threatened flora populations (section 1)

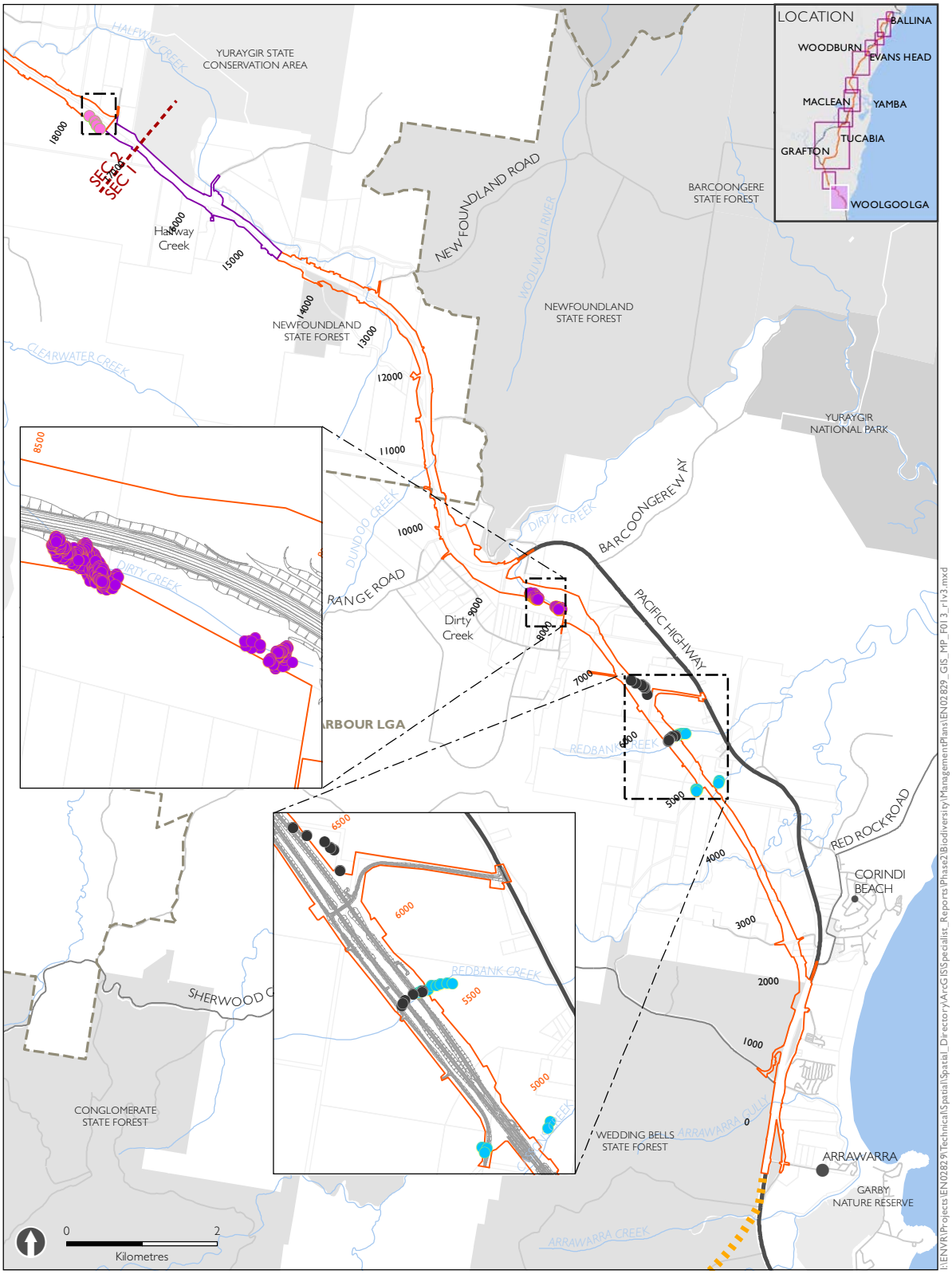


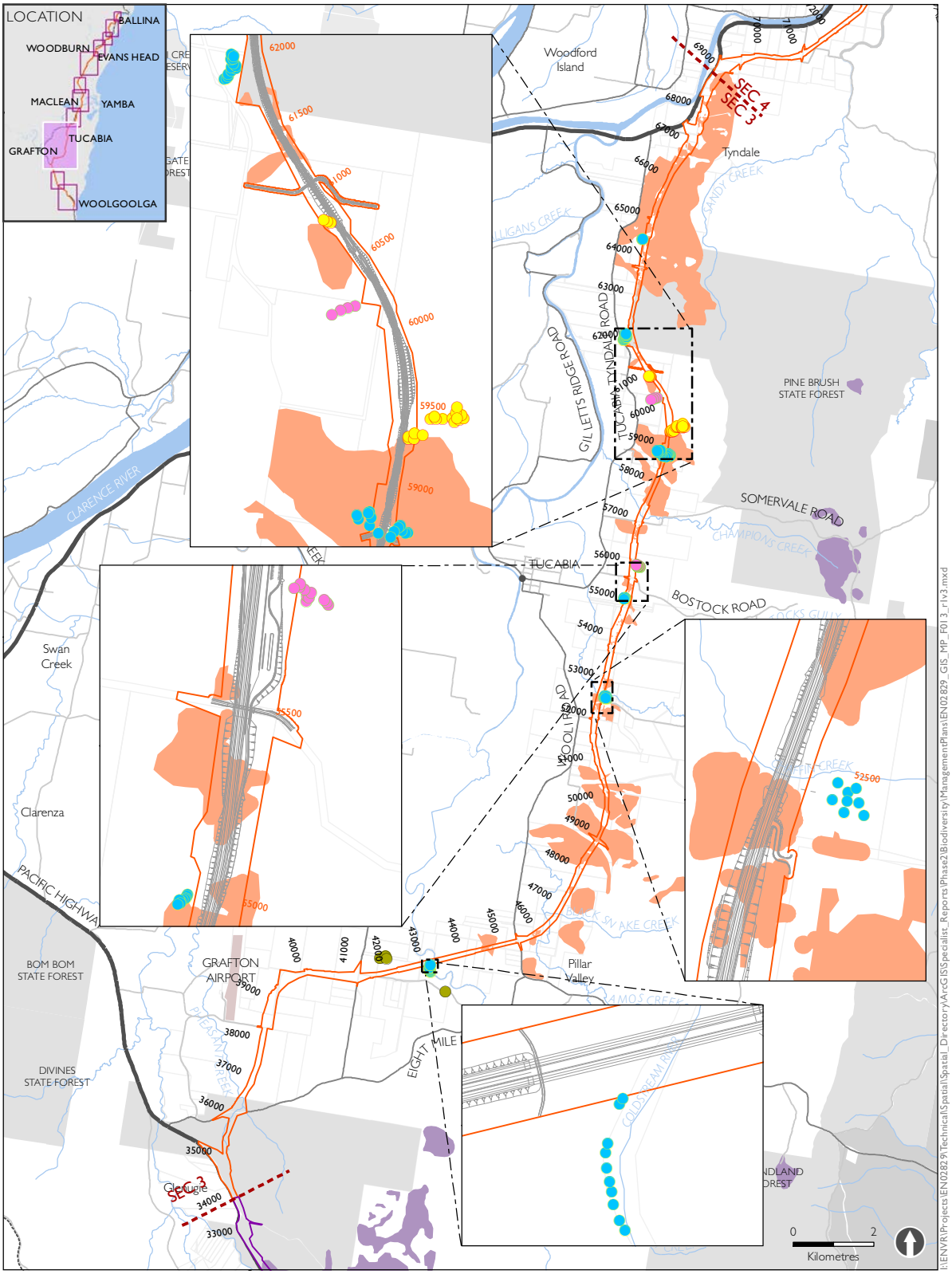
Figure 2 -2 Location of threatened flora populations (section 2)

The project
Upgrade completed to dual carriageway
Upgrade under construction

Threatened Flora

Oberonia titania
Prostanthera palustris
Cyperus aquatilis
Olax angulata
Quassia sp. Moonee Creek
Eleocharis tetraquetra
Melaleuca irbyana
Maundia triglochinoides
Lindsaea incisa
Grevillea quadricauda
Phaius australis
Prostanthera cineolifera
Arthraxon hispisdus
Eucalyptus tetrapleura
Angophora robur

Figure 2 -3 Location of threatened flora populations (section 3)



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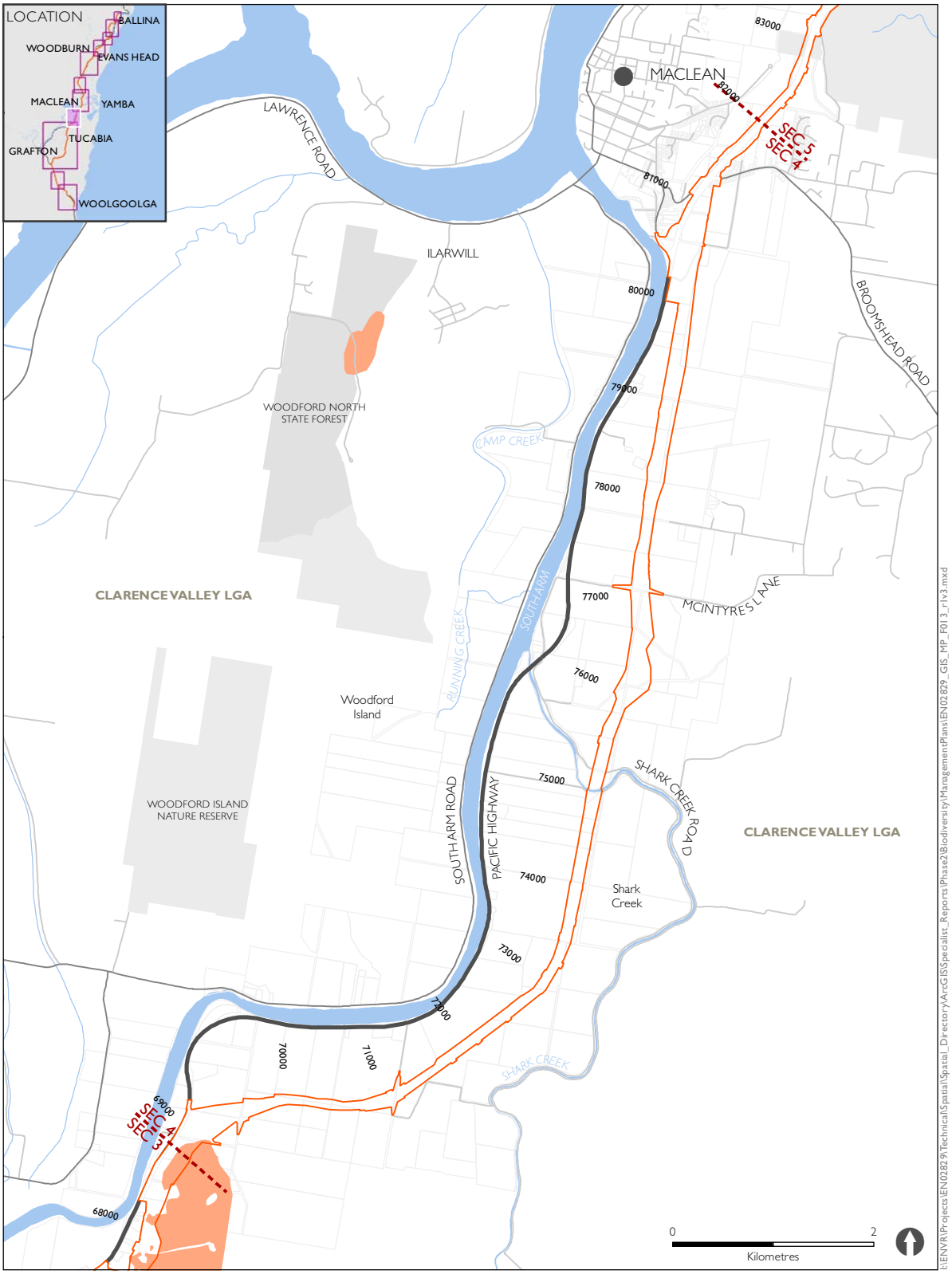
Eucalyptus tetrapleura
Angophora robur

Figure 2 -4 Location of threatened flora populations (section 4)



The project

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Threatened Flora

- *Oberonia titania*
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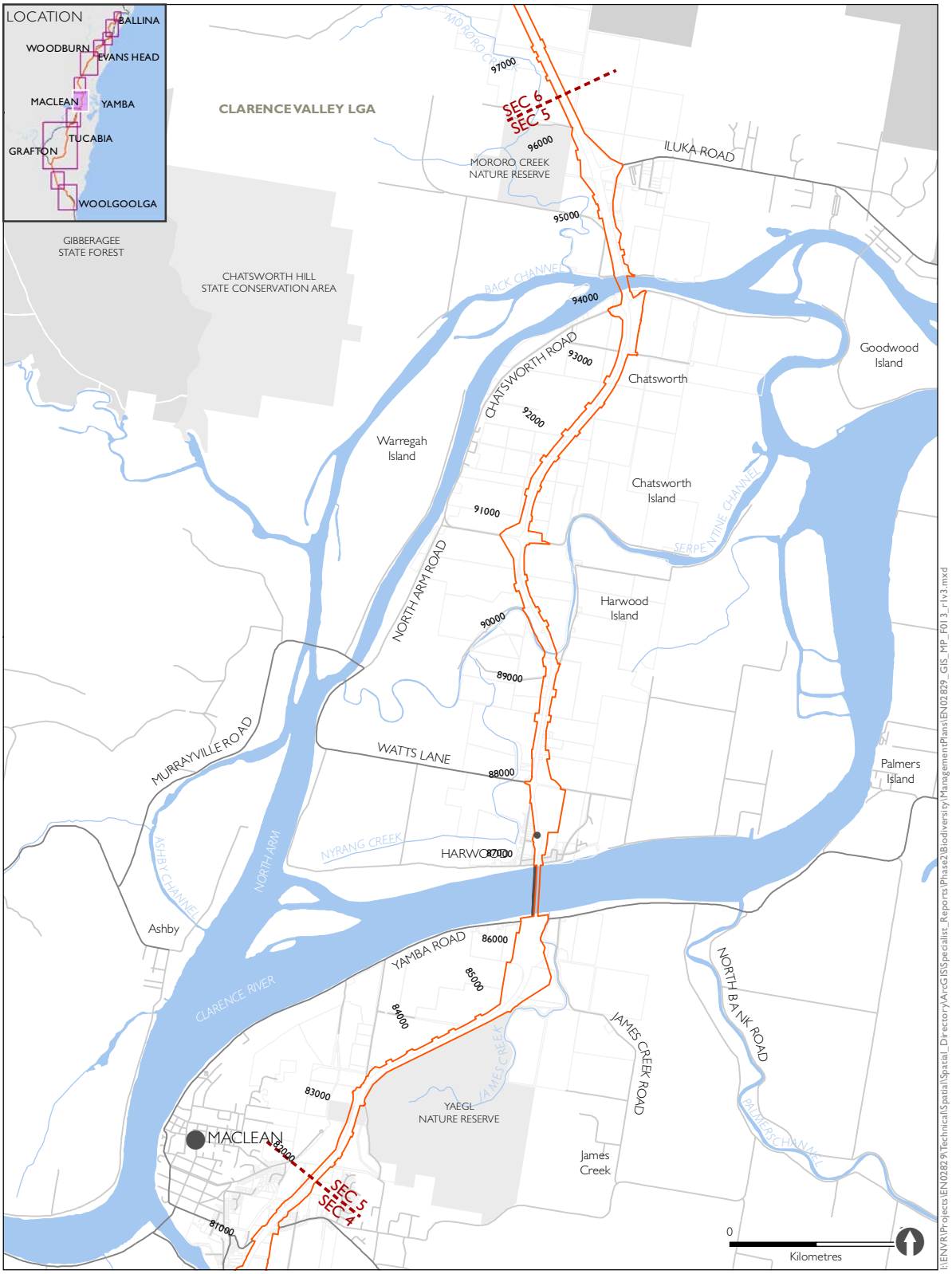
- *Angophora robur*

Figure 2 -5 Location of threatened flora populations (section 5)



The project

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Threatened Flora

- *Oberonia titania*
- *Prostanthera palustris*
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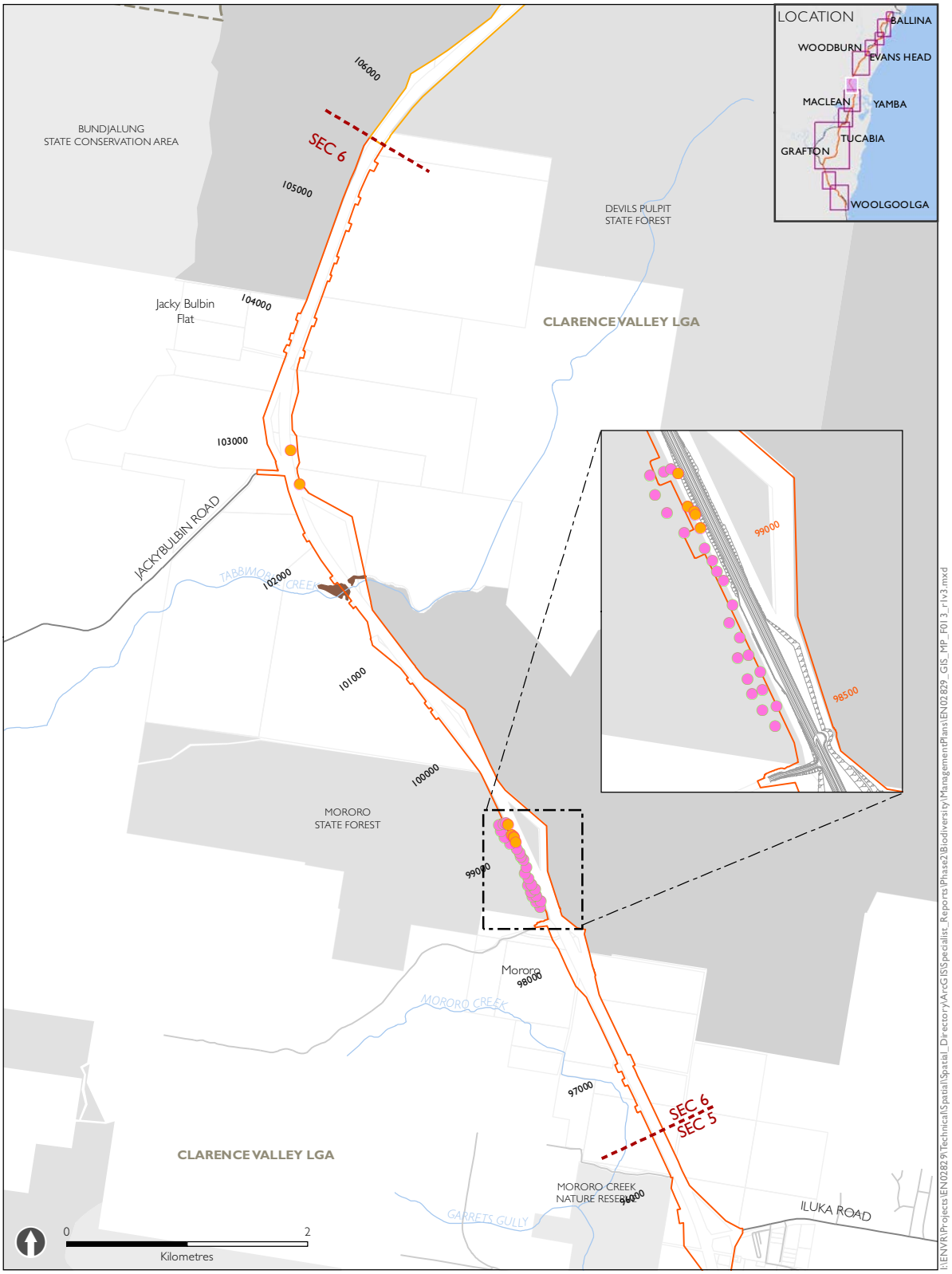
- *Angophora robur*

Figure 2 -6 Location of threatened flora populations (section 6)



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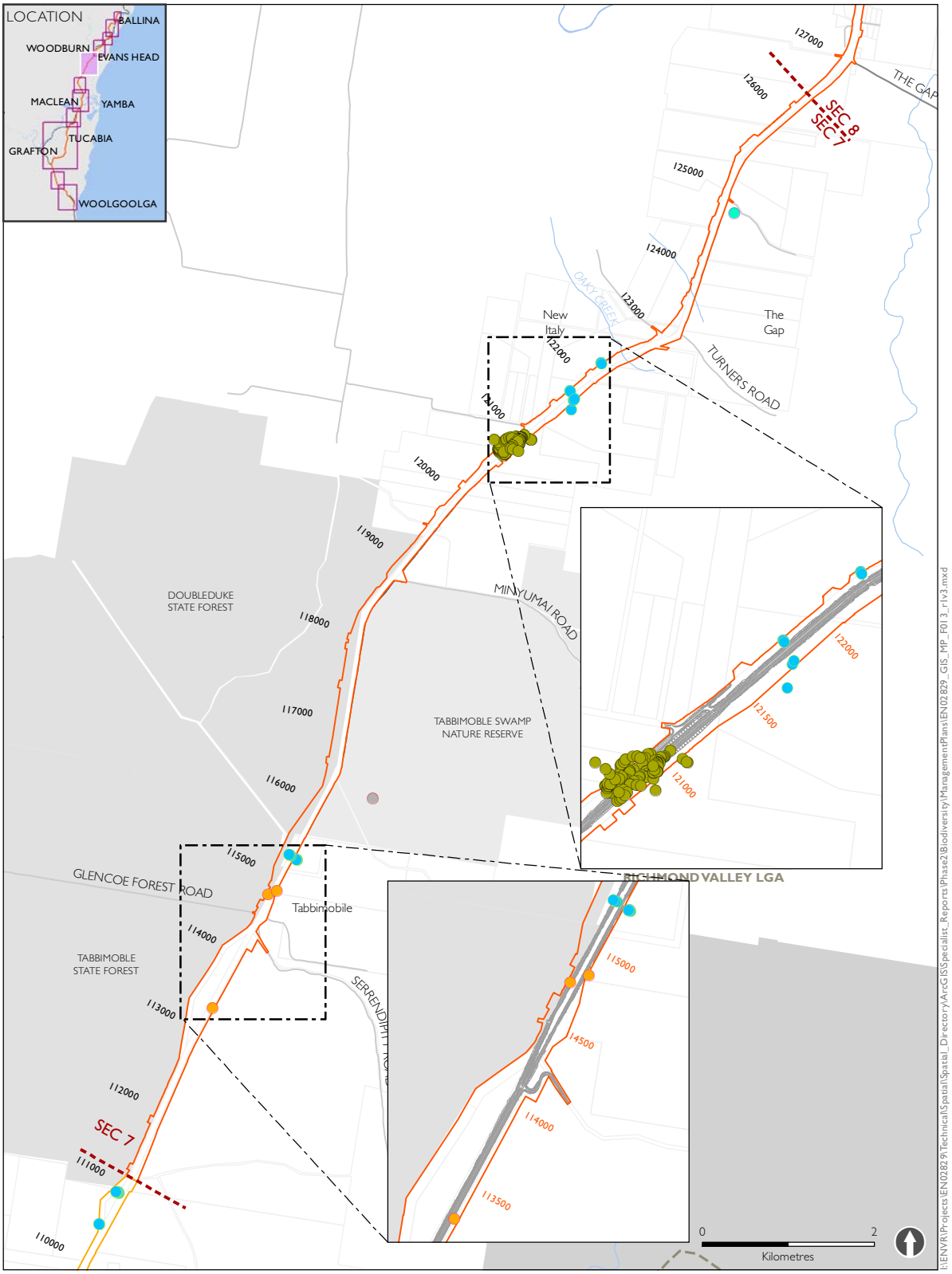
Eucalyptus tetrapleura
Angophora robur

Figure 2 -7 Location of threatened flora populations (section 7)



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Angophora robur

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Figure 2 -8 Location of threatened flora populations (section 8)

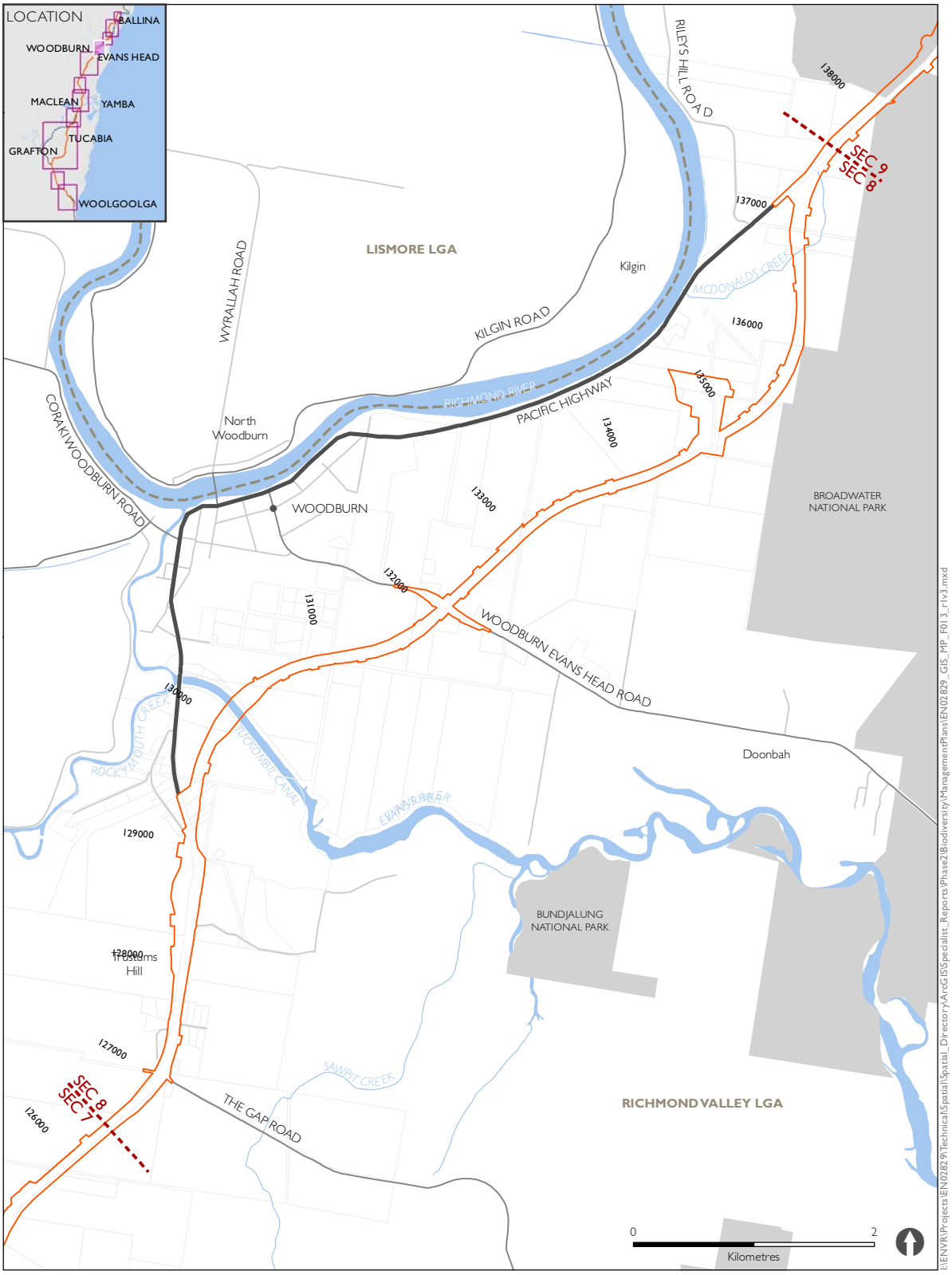

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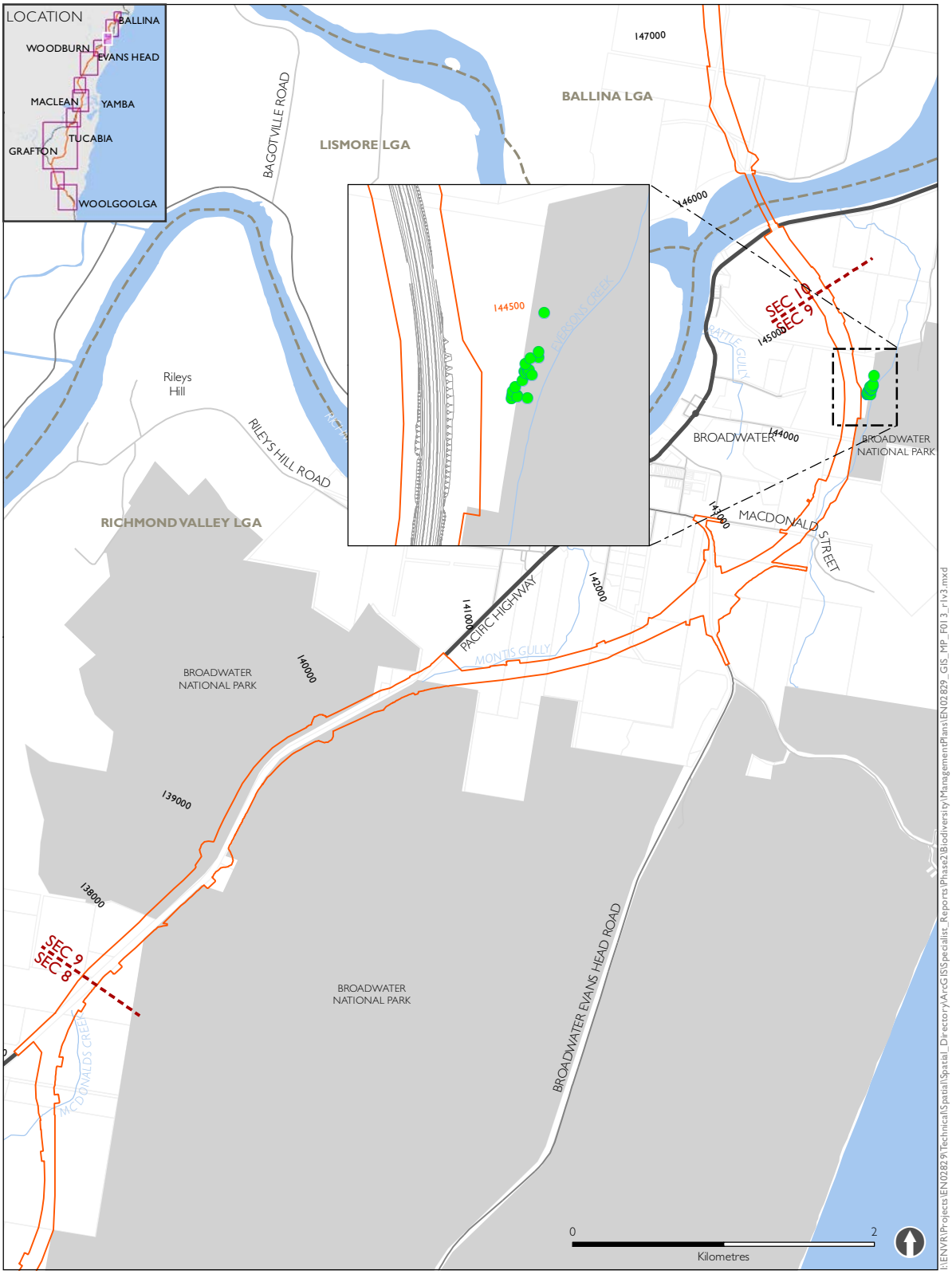
Figure 2 -9 Location of threatened flora populations (section 9)



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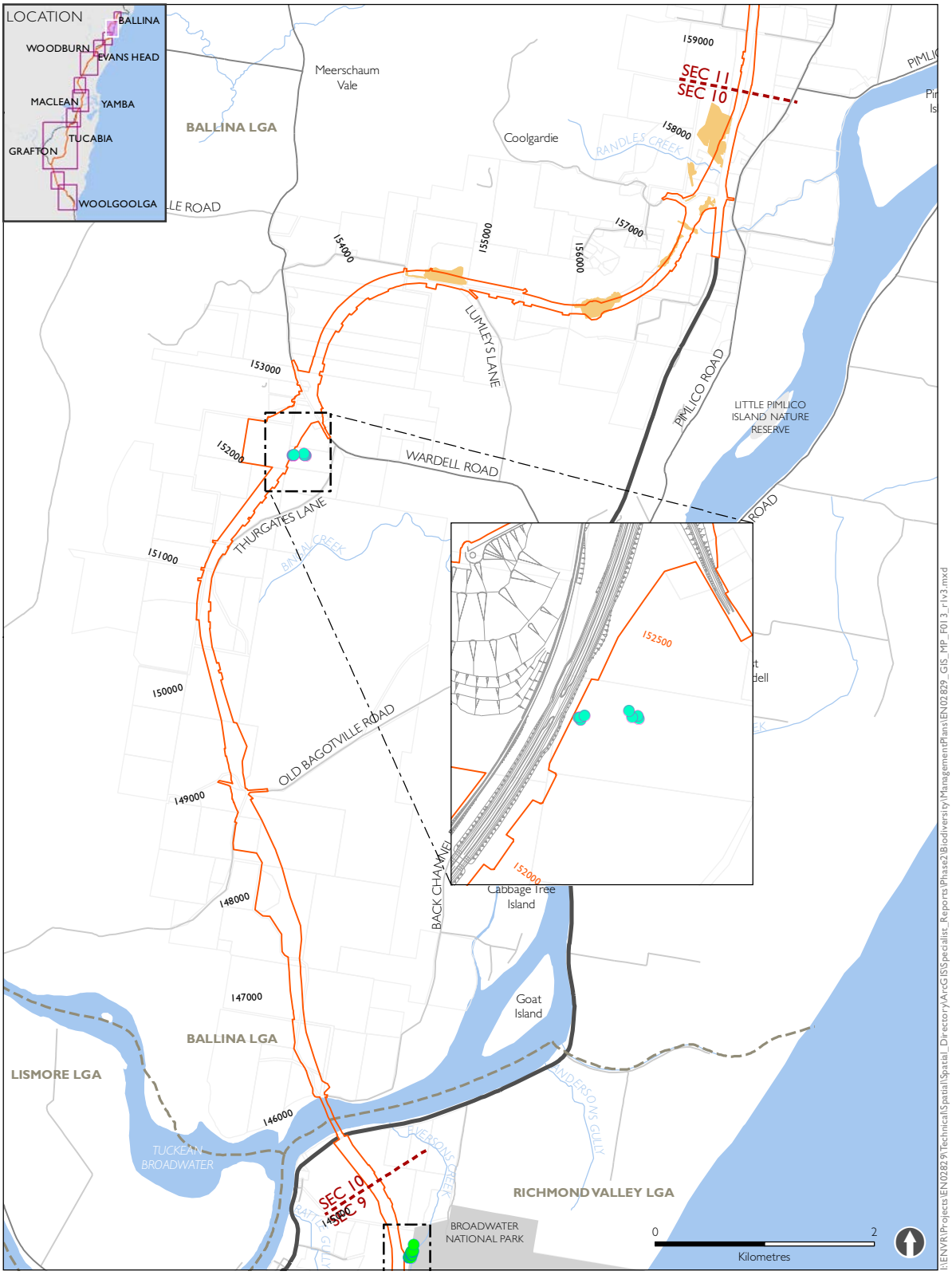
Angophora robur

Figure 2 -10 Location of threatened flora populations (section 10)



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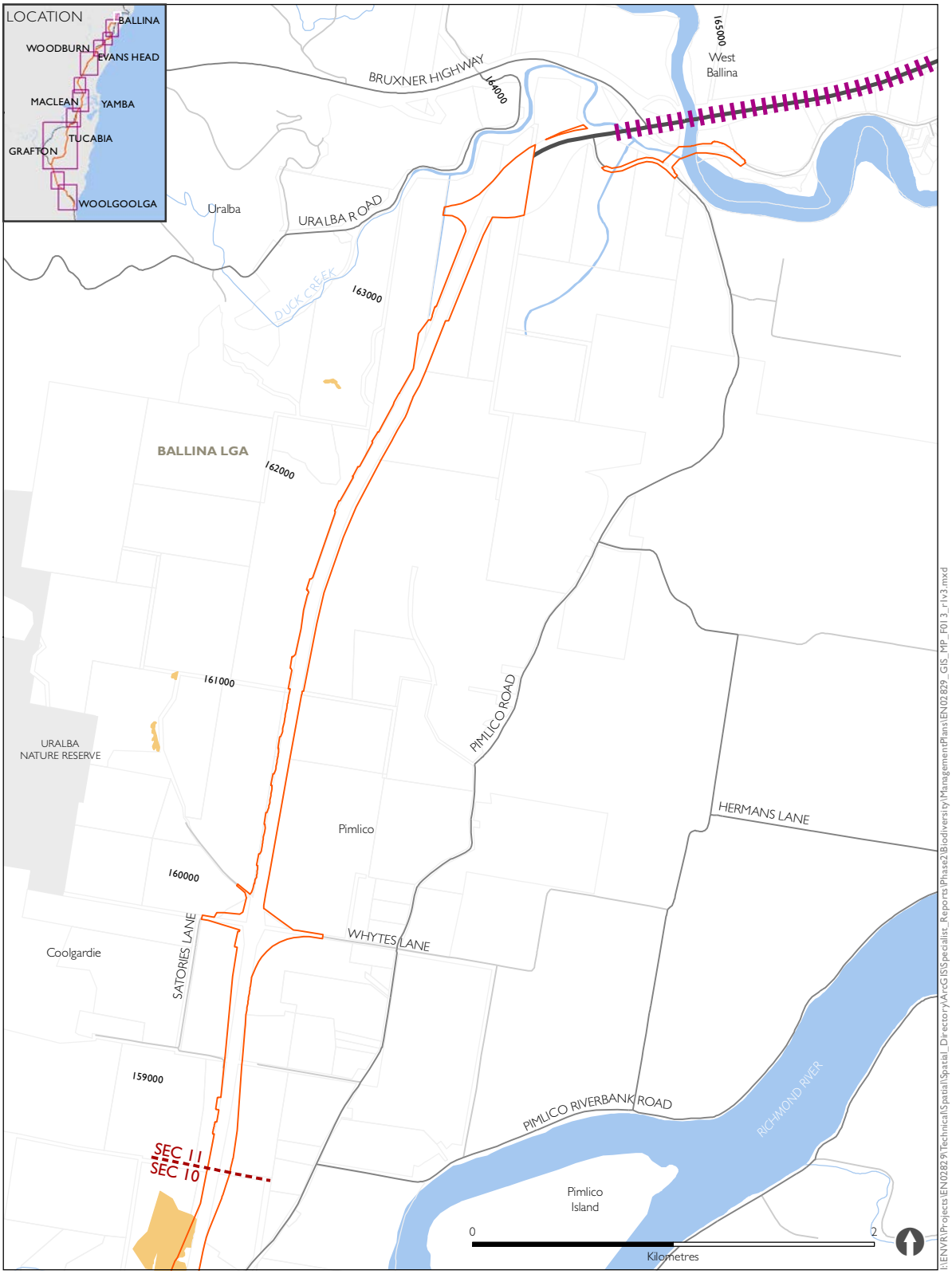
Eucalyptus tetrapleura
Angophora robur

Figure 2 -11 Location of threatened flora populations (section 11)



The project
Upgrade completed to dual carriageway
Upgrade under construction

Threatened Flora

Oberonia titania
Prostanthera palustris
Cyperus aquatilis
Olax angulata
Quassia sp. Moonee Creek
Eleocharis tetraquetra
Melaleuca irbyana
Maundia triglochinoides
Lindsaea incisa
Grevillea quadricauda
Phaius australis
Prostanthera cineolifera
Arthraxon hispisdus
Eucalyptus tetrapleura
Angophora robur

Appendix D – Species profiles

Sandstone Rough-barked Apple

(*Angophora robur*)

Source: http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10054

DESCRIPTION

Sandstone Rough-barked Apple is an, eucalypt-like trees with paired leaves and, often, gnarled limbs. It grows up to 10 m tall, and is smaller and more twisted than most angophoras. It has rough grey bark and is distinguished by its unusually large leaves, up to 18 cm long and 7.5 cm wide. The leaves may be rather bristly and are paler below. The white, clustered flowers are followed by large, ribbed fruits up to 1.6 cm long and wide

LEGISLATIVE STATUS

TSC Act: VULNERABLE; EPBC Act: VULNERABLE.

DISTRIBUTION

Occurs in a band from around Glenreagh, north-west of Coffs Harbour, to the Coaldale area north-west of Grafton, with an isolated occurrence farther west near Nymboida. It can be locally common

HABITAT

Dry open forest in sandy or skeletal soils on sandstone, or occasionally granite, with frequent outcrops of rock.

THREATS

- Clearing of habitat for development or agriculture.
- Too-frequent fires, which may suppress successful regeneration.
- Widening of roads.
- Timber harvesting in water quality, from sedimentation or pollution.

Hairy Joint Grass

(*Arthraxon hispidus*)

Source: http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10066

DESCRIPTION

Hairy Jointgrass is a creeping grass with branching, erect to semi-erect purplish stems. Leaf-blades are 2–6 cm long, broad at the base and tapering abruptly to a sharp point. Long white hairs project around the edge of the leaf. The seed-heads are held above the plant on a long fine stalk. This grass is considered to be a perennial but it tends to die down in winter

LEGISLATIVE STATUS

TSC Act: VULNERABLE, EPBC Act: VULNERABLE.

DISTRIBUTION

Occurs over a wide area in south-east Queensland, and on the northern tablelands and north coast of NSW, but is never common. Also found from Japan to central Eurasia.

HABITAT

Moisture and shade-loving grass, found in or on the edges of rainforest and in wet eucalypt forest, often near creeks or swamps.

THREATS

- Clearing of habitat for agriculture and development.
- Inappropriate fire regimes.
- Over-grazing by domestic stock.
- Competition from introduced grasses such as Paspalum and Kikuyu.
- Slashing or mowing of habitat.

Water Nutgrass

(*Cyperus aquatilis*)

Source: http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10197

DESCRIPTION

Sedge that appears as an annual during the wet summer period. It grows to 10 – 30 cm tall, and has weak triangular stems. The leaves are 1 – 3 mm wide and shorter than the flowering stem. The flower- and seed-head is made up of several branches radiating from the top of the stem. Each branch has one to eight flattened spikelets 3 mm wide with 10 – 30 green flowers. The seeds are three-sided nuts, whitish to pale brown.

LEGISLATIVE STATUS

TSC Act: ENDANGERED.

DISTRIBUTION

In NSW, known only from a few sites north from Grafton. Also occurs in Queensland, Northern Territory, Western Australia and New Guinea.

HABITAT

Grows in ephemerally wet sites, such as roadside ditches and seepage areas from small cliffs, in sandstone areas.

THREATS

- Clearing for agriculture or development.
- Browsing and trampling by stock.
- Damage to plants and habitat during road-works.

Square-fruited Ironbark

(*Eucalyptus tetrapleura*)

Source: http://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&photo=26&file=28/169/Eucalyptus_tetrapleura_0.jpg

DESCRIPTION

This tree may grow to over 30 m tall but is usually smaller than other ironbarks. The deeply furrowed bark is dark brown or black and extends to the small branches. It is more flaky than the typically hard bark of other ironbarks. Adult leaves are up to 20 cm long, curved and dull green on both sides. The four-angled buds have distinctively small caps that protrude at the end. The 1 cm long, conical or pear-shaped fruits also have four angles.

LEGISLATIVE STATUS

TSC Act: VULNERABLE; EPBC Act: VULNERABLE.

DISTRIBUTION

Restricted to the coastal lowlands and foothills of northern NSW around Casino and Grafton.

HABITAT

Dry or moist eucalypt forest on moderately fertile soil, often in low areas with poor drainage.

THREATS

- Loss of habitat through clearing for agriculture.
- Timber harvesting activities.
- Road construction and maintenance.
- Grazing of young plants by domestic stock.
- Too-frequent fires, which inhibit regeneration.

Square-stemmed Spike-rush

(*Eleocharis tetraquetra*)

Source: http://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10265

DESCRIPTION

A tufted perennial plant distinguished by its slender four-angled stem and broad spikelet on top of the stem. Stems grow 30 to 100 cm tall and are 1 – 1.5 mm in diameter. The leaves are at the base of the stem and are not very conspicuous, being reduced to tubular sheaths. The spikelet is 10 – 20 mm long and 3.5 – 5mm in diameter. The seeds are contained within the spikelet and are a shining yellow or brown colour, approximately 1.5 mm long and 1 mm wide.

LEGISLATIVE STATUS

TSC Act: VULNERABLE; EPBC Act: VULNERABLE.

DISTRIBUTION

Thought to be extinct in NSW until it was rediscovered in 1997 at Boambee near Coffs Harbour. It has since been found in other north coast localities near Grafton and Murwillumbah. The species also occurs in south-east Queensland.

HABITAT

Found in damp locations on stream edges and in and on the margins of freshwater swamps.

THREATS

- Clearing of habitat for development and agriculture.
- Invasion of habitat by weeds and pasture grasses.
- Changes to the natural disturbance patterns such as grazing, fire and flooding.
- Degradation of habitat by intensive grazing by stock.

Four-tailed Grevillea

(*Grevillea quadricauda*)

Source: http://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&photo=28&file=67/012/Grevillea%20quadricauda.jpg

DESCRIPTION

This is a bushy shrub with yellow-green foliage, growing to 2 m in height and spread. New growth is pink or purple, especially on the tips of the leaves, and the branchlets are matted with hairs. The leaves are up to 1.8 cm long, tapered at both ends and often rolled under along the sides. Silky white hairs are sparse on the upper side and denser on the lower side. The hairy flowers are in groups of two to four, and are pink or red with a green base. Each 'petal' bears a distinct pointed 'tail' at its tip. The dry fruit has a long projection bent sharply backwards.

LEGISLATIVE STATUS

TSC Act: VULNERABLE; EPBC Act: VULNERABLE.

DISTRIBUTION

In NSW it is found to the north-west of Whiporie in Mount Belmore State Forest and Mount Neville Nature Reserve, and at Tucabia east of Grafton. It also occurs near Toowoomba in south-east Queenslandin damp locations on stream edges and in and on the margins of freshwater swamps.

HABITAT

Grows in gravely loam, in the understorey of dry eucalypt forest, usually along or near creeks

THREATS

- Timber harvesting activities.
- Too-frequent fire.
- Road widening and maintenance.
- Clearing for development and agriculture.
- Risk of local extinction because populations are small

Slender Screw Fern

(*Lindsaea incisa*)

Source: http://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10482

DESCRIPTION

Slender Screw Fern is a delicate-looking ground fern with a creeping underground root. The light-green fronds are slender, up to 30 cm long, and stand erect or tangled through other vegetation. Divided fan-shaped leaflets are spaced along the stems, often in pairs. The leafless part of the stem is straw-coloured, darker at the base, and is much shorter than the frond length. The spores are produced under membranous flaps on the lobes of some of the leaflets.

LEGISLATIVE STATUS

TSC Act: VULNERABLE; EPBC Act: VULNERABLE.

DISTRIBUTION

In NSW it is found to the north-west of Whiporie in Mount Belmore State Forest and Mount Neville Nature Reserve, and at Tucabia east of Grafton. It also occurs near Toowoomba in south-east Queenslandin damp locations on stream edges and in and on the margins of freshwater swamps.

HABITAT

Grows in gravely loam, in the understorey of dry eucalypt forest, usually along or near creeks

THREATS

- Land development and clearing.
- Frequent fire.
- Alterations to drainage of creeks.
- Recreation, including camping, near creeks.
- Grazing and trampling by domestic stock.
- Risk of local extinction because numbers are low.
- Broad leaved Paspalum, Crofton weed and soil nutrification (from agriculture and urban run-off).

Maundia

(*Maundia triglochinoides*)

Source: http://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&photo=26&file=66/708/Maundia%20triglochinoides%20in%20Windmill%20Dam,%20Clybucca.JPG

DESCRIPTION

Perennial with rhizomes about 5mm thick and emergent tufts of leaves arising along their length. Leaves are spongy, inflated and triangular in cross section, to 80 cm long, sometimes longer, 5 - 10mm wide. Inflorescence to 10cm long and 2.5 cm wide. Carpels (female parts of flower) 6 - 8mm long, sessile, each with a spreading beak. The fruit is 1cm long to 8mm wide.

LEGISLATIVE STATUS

TSC Act: VULNERABLE

DISTRIBUTION

Restricted to coastal NSW and extending into southern Queensland. The current southern limit is Wyong; former sites around Sydney are now extinct.

HABITAT

- Grows in swamps, lagoons, dams, channels, creeks or shallow freshwater 30 - 60 cm deep on heavy clay, low nutrients.
- Flowering occurs during warmer months.
- Associated with wetland species e.g. Triglochin procerum.
- Probably wind pollinated.
- Diaspore is the seed and root tubers, which are probably dispersed by water.
- Spreads vegetatively, with tufts of leaves arising along rhizome. Populations expand following flood events and contract to more permanent wetlands in times of low rainfall.
- Flowers November-JanuaryGrows in gravely loam, in the understorey of dry eucalypt forest, usually along or near creeks.

THREATS

- Further loss and fragmentation of habitat.
- changes in hydrology and water quality.
- Weed invasion.

Weeping Paperbark

(*Melaleuca irbyana*)

Source: http://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10518

DESCRIPTION

Weeping Paperbark (formerly Melaleuca tamariscina subsp. irbyana) has thick, spongy, papery bark and grows to about 8 m tall. It has a dense, rounded canopy of very fine, weeping foliage. The tiny, stalkless, pointed leaves are less than 4 mm long, smaller than any other NSW Melaleuca species, and are pressed close to the branchlets, wrapping around them slightly. In summer profuse white brushes, made up of groups of flowers in threes, appear and are followed by tight clusters of woody fruits.

LEGISLATIVE STATUS

TSC Act: ENDANGERED

DISTRIBUTION

Found in only a few places in north-east NSW, including near Coraki, Casino and Coutts Crossing south of Grafton. Also occurs in near Ipswich in south-east Queensland

HABITAT

Open eucalypt forest in poorly drained, usually clay, soils

THREATS

- Fire, particularly when too frequent to allow regeneration.
- Clearing of habitat for agriculture and development.
- Grazing by domestic stock.
- Invasion of habitat by weeds particularly introduced grasses.
- Road-works, including grading and slashing.
- Timber harvesting activities.
- Risk of local extinction because populations are small and may also lack genetic diversity.

King of the Fairies Orchid

(*Oberonia titania*)

Source: http://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10571

DESCRIPTION

King of the Fairies is a small orchid which grows on trees and rocks. Each plant possesses one to several shoots in a tight, iris-like clump. There are 4-10 leaves per shoot. The leaves are narrowly oval- to spear-shaped, 1-8 cm long, 2-8 mm wide, and green to greenish pink in colour. About 50-350 tiny red flowers are borne on erect to drooping stems 5-17 cm long in autumn and spring.

LEGISLATIVE STATUS

TSC Act: VALNERABLE

DISTRIBUTION

King of the Fairies occurs on the NSW north coast north from Kendall, and also in in Queensland and Norfolk Island. It is known from 10 locations in NSW, two of which occur within Dorrigo National Park and Washpool National Park.

HABITAT

King of the Fairies occurs in littoral and subtropical rainforest and paperbark swamps, but it can also occur in eucalypt-forested gorges and in mangroves.

THREATS

- Loss of habitat through clearing, degradation and fragmentation of native vegetation.
- Collection by orchid enthusiasts.

Square-stemmed Olax

(*Olax angulata*)

Source: http://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10574

DESCRIPTION

Square-stemmed Olax is an upright shrub, which may be parasitic on the roots of other plants. Its stiff branches are often yellowish in colour, with prominent U-shaped ridges. The branchlets are square in cross-section and are yellow-green or blue-green like the leaves. The leaves are stalkless, arranged alternately, and are smooth, brittle and oval-shaped with a tiny point at the end. Small white flowers are often present with the fleshy, egg-shaped, one-seeded fruits.

LEGISLATIVE STATUS

TSC Act: VULNERABLE; EPBC Act: VULNERABLE.

DISTRIBUTION

Known from a small area east of Grafton, near Minnie Water and Wooli, mainly in Yuraygir National Park and on nearby leasehold land. Locally common. Also known from an area north of Grafton in Banyabba Nature Reserve, Fortis Creek National Park and adjoining freehold land.

HABITAT

Low-lying coastal heaths and heathy woodlands on sandy soils near swamps, often in association with Wallum Banksia (*Banksia aemula*).

THREATS

- Clearing of habitat for urban development.
- Frequent fire.
- Trampling by visitors.
- Track widening and maintenance, and road maintenance.
- Weed invasion of habitat, particularly Bitou Bush.
- Risk of local extinction because populations are small.
- Eutrophication from urban run-off increasing weed threat - localised impacts
- Do not know extent of the population throughout the reserve.

Singleton Mint Bush

(*Prostanthera cineolifera*)

Source: http://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10574

DESCRIPTION

Erect shrub, 1 - 4 m high, strongly aromatic; branches moderately to densely covered with short, curled hairs and more or less sessile glands. Leaves more or less narrow-ovate, 12 - 50 mm long, 4 - 12 mm wide; apex obtuse; base cuneate to obtuse; margins entire; surfaces light green, mostly hairless, sparsely to densely hairy on midrib on lower surface, densely glandular with more or less sessile glands. Flowers clustered at the ends of branches; bracteoles not persistent, 1 - 2 mm long. Sepals 3 - 4 mm long; tube 2 - 2.5 mm long; upper lobe 1 - 2 mm long, not enlarged in fruit. Petals 8 - 11 mm long, pale mauve to dark purple-mauve, darker in throat. The taxonomic status of this species is uncertain.

LEGISLATIVE STATUS

TSC Act: VULNERABLE; EPBC Act: VULNERABLE.

DISTRIBUTION

Restricted to only a few localities near Walcha, Scone, Cessnock and St Albans.

HABITAT

- Grows in open woodlands on exposed sandstone ridges.
- Usually found in association with shallow or skeletal sands.
- Fire response is unknown, but other Prostanthera species are fire sensitive, with recruitment occurring from the soil seed bank following a fire.
- Life span is unknown but is expected to be in the vicinity of 10-20 years while the estimated minimum time to produce seed is approximately 3-4 years

THREATS

- Frequent fire may threaten some populations given it is fire sensitive.
- The known populations are small and therefore highly susceptible to demographic and environmental stochasticity

Southern Swap Orchid

(*Phaius australis*)

Source: http://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10610

DESCRIPTION

This orchid has flower stems up to 2 m tall and large broad leaves with a pleated appearance, both arising from a fleshy bulb near ground level. The large, showy flowers, with up to 20 per stem, have four petals which are white on the outside and brown with white or yellow veins on the inside. The central tongue of the flower is pink and yellow with lobes slightly curved inwards

LEGISLATIVE STATUS

TSC Act: ENDANGERED; EPBC Act: ENDANGERED.

DISTRIBUTION

Occurs in Queensland and north-east NSW as far south as Coffs Harbour. Historically, it extended farther south, to Port Macquarie.

HABITAT

Swampy grassland or swampy forest including rainforest, eucalypt or paperbark forest, mostly in coastal areas.

THREATS

- Illegal collection for horticulture or cut flowers. This showy species is highly sought after.
- Small population size.
- Drainage of swamps, or pollution from nutrient run-off.
- Frequent fire
- Grazing and trampling by domestic stock and feral pigs.
- Invasion of habitat by introduced weeds.
- Trail bike riders disturbing substrate and destroying plants.
- Rubbish dumping and other disturbance due vehicles and/or people
- Clearing and fragmentation of habitat for development, agriculture and roadworks.

Swap Mint-Bush

(*Prostanthera palustris*)

Source: http://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10679

DESCRIPTION

Swamp Mint-bush is a low, straggling, herb-like shrub with a few slender branches up to 90 cm long. It winds inconspicuously through other vegetation. Unlike many other mintbushes, it has little or no aromatic smell. The leaves are less than 1 cm in length, spoon-shaped, mid-green above and paler below. The small, lobed flowers are pale mauve with a yellow-dotted white throat.

LEGISLATIVE STATUS

TSC Act: VULNERABLE; EPBC Act: VULNERABLE.

DISTRIBUTION

Only known from the Jerusalem Creek area in the north of Bundjalung National Park, near Evans Head.

HABITAT

Grows in poorly drained sandy soils, subject to extended waterlogging, in wet shrubland to heathland.

THREATS

- Frequent fire.
- Damage to plants during track maintenance.
- Trampling by visitors to the National Park.
- Risk of local extinction because populations are small
- l.
- Species is susceptible to Phytopthora I