Warrell Creek to Urunga Upgrade of the Pacific Highway

Threatened Flora Management Plan

Prepared for:

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Photo front page - Slender Marsdenia (*Marsdenia longiloba*)

EXECUTIVE SUMMARY

[Revision note: Version 5 of the TFMP (1/7/2016) is the same as Version 4 (24/12/2014) except for an update to Section 4.8.3, the translocation monitoring schedule. The following summary information from Version 4 remains unchanged and applies to Version 5.

Version 4 was prepared to assist with development, construction and operation of the southern half of the Warrell Creek to Urunga (WC2U) project known as the Warrell Creek to Nambucca Heads (WC2NH) upgrade. Additional threatened flora information relevant to WC2NH has been incorporated into the plan, including the results of additional flora surveys and analysis of impacts in terms of Roads and Maritime concept design.

This Plan update does not include additional records of threatened flora for the northern half of the WC2U project (i.e. NH2U) from pre-clearing surveys for NH2U. For example, the results of the targeted survey for Spider Orchid (*Dendrobium melaleucaphilum*) on NH2U were not included. NH2U is currently being constructed and management measures for protection of threatened flora, including translocation have already been implemented. Additional records from the NH2U construction phase were not considered relevant to implementation of this Plan for the WC2NH upgrade. (Seven-part tests of significance were revised after the NH2U pre-clearing flora survey to include additional records, but there was no change in the test conclusions.)

This version of the TFMP provides two definitions of directly impacted threatened flora. The two defintions differ in their spatial extent relative to the design footprint as seen below:

Northern Section NH2U - Directly impacted:- Directly impacted individuals are those located under the design footprint plus **10 metres**, which is the limit of clearing.

Southern Section WC2NH - Directly impacted:- Directly impacted individuals are those located:

- Under the concept design footprint plus **15 metres**.
- Under the operational water quality basins plus 10 metres.
- Under new or reconstructed access roads within Nambucca State Forest plus 10 metres.
- For utility adjustments within clearing requirements of utility authorities.
- Within three metre clearing width for boundary fencing - excluding within Nambucca State Forest and swamp forest where a flying fox camp is located.

The number of direct/indirect/in situ Rusty Plum, Slender Marsdenia and Floyds Grass differ slightly from ver. 1 (6/3/2013) of this plan. The number of Rusty Plum decreased following re-survey of the Cockburns Lane area at Warrell Creek in May 2014, as follows (previous in brackets): directly impacted 11 (12), indirectly impacted 1 (4) and in situ 0 (2). The number of Slender Marsdenia increased due to inclusion of additional records from the Slender Marsdenia genetic study currently underway and a utilities survey, as follows: directly impacted 176 (161), indirectly impacted 20 (22)

and in situ 4 (20). Of the four Floyds Grass points, one is now directly impacted, two indirectly impacted and one in situ.]

ECOS Environmental Pty Ltd has been engaged by Roads and Maritime Services to prepare a Threatened Flora Management Plan for the Warrell Creek to Urunga upgrade of the Pacific Highway.

The Threatened Flora Management Plan includes:

- a targeted survey of threatened plant species within the approved Warrell Creek to Urunga project boundary;
- assessment of the feasibility of undertaking translocation of affected threatened plant species;
- specification of management measures to ensure the protection of in-situ threatened flora during highway construction and operation;
- design of a detailed translocation proposal for impacted threatened species where translocation is considered to be a feasible management option.
- assessment of the requirement for compensatory habitat as a mitigatory measure for impacted threatened flora

The targeted survey recorded six threatened species (four endangered and two vulnerable), two ROTAP species and one species recommended for threatened species listing within the project boundary.

Table 1A shows the number of species directly impacted, indirectly impacted and to remain in situ for the whole WC2U corridor.

Table 1A: Threatened and rare flora impacted by the whole WC2U project

WC2U (whole road corridor)	**Directly Impacted**		**Indirectly Impacted**		**Road Reserve - in-situ**	
Threatened Species	points	no.	points	no.	Points	no.
Slender Marsdenia (E) (*Marsdenia longiloba*)	68	176	7	20	2	4
Rusty Plum (V) (*Niemeyera whitei*)	12	12 +sdg	0	0	0	0
Maundia (V) (*Maundia triglochinoides*)	~500+ m^2		~50 m^2		~50 m^2	
Floyds Grass (E) (*Alexfloydia repens*)	1	~2m^2	2	~2m^2	1	~2m^2
Wooll's Tylophora (E) (*Tylophora woollsii*)	5	9	-	-	3	6
Spider Orchid (E) (*Dendrobium melaleucaphilum*)	13	~40	16	35	70	200
ROTAP*						
Ford's Goodenia (*Goodenia fordiana*)	9	9m^2	1	1m^2	-	-
Potential Threatened Species Listing						
Koala Bells (*Artanema fimbriatum*)	7	65	2	55	-	-

*Eucalyptus ancophila not included as it was relatively common in the study area.

Table 1B shows the number of species directly impacted, indirectly impacted and to remain in situ for the southern half of the project – WC2NH.

Table 1B - Threatened and rare flora impacted by the WC2NH project

Southern WC2NH section	**Directly Impacted**		**Indirectly Impacted**		**Road Reserve - in-situ**	
Threatened Species	points	no.	points	no.	Points	no.
Slender Marsdenia (E) (*Marsdenia longiloba*)	43	75	2	4	1	1
Rusty Plum (V) (*Niemeyera whitei*)	10	10 +sdg	0	0	0	0
Maundia (V) (*Maundia triglochinoides*)	~500+ m^2		~50 m^2		~50 m^2	
Floyds Grass (E) (*Alexfloydia repens*)	1	~2m^2	2	~2m^2	1	~2m^2
Wooll's Tylophora (E) (*Tylophora woollsii*)	2	2	0	0	0	0
Spider Orchid (E) (*Dendrobium melaleucaphilum*)	3	10	0	0	0	0
ROTAP						
Ford's Goodenia (*Goodenia fordiana*)	2	2m^2	1	1m^2	0	0
Potential Threatened Species Listing						
Koala Bells (*Artanema fimbriatum*)	2	13	0	0	0	0

The translocation feasibility assessment concluded that translocation of the subject species would be technically feasible and have significant conservation benefits for the impacted species.

The management plan also outlines a process for incorporating compensatory habitat for impacted threatened plant species in the Biodiversity Offset Strategy.

A Translocation Plan set out in Section 4 includes procedures for the translocation of four threatened plant species and two rare species impacted by WC2U upgrade. The proposed translocation involves three complementary activities:- salvage translocation, population enhancement and experimentation. Salvage translocation aims to save and re-establish those individuals of significant flora directly impacted by construction. Enhancement aims to improve the prospective viability of translocated populations by propagating and introducing additional individuals. The experimental component aims to increase understanding of species ecology and how translocation outcomes are affected by ecological factors. The Translocation Plan includes a monitoring program to be conducted during highway construction and operation. Evaluation criteria are defined for assessing translocation results.

The final two sections of the Management Plan deal with measures for the management of roadside (in-situ) threatened flora and management of unforseen impacts, including additional impacts due to possible design changes once the contract is awarded and the detailed design is prepared. Included in the former is a

monitoring program for in-situ roadside threatened flora that would run for 5 years post-construction.

The following table lists the Minister for Planning's Conditions of Approval for the Warrell Creek to Urunga highway upgrade relating to threatened flora management and where these are addressed in the Threatened Flora Management Plan.

Conditions of Approval dealing with threatened flora management	Section in Management Plan where addressed
B7(a)	Sections 1 to 3.5
B7(b)	Section 4
B7(d)	Section 5
B10(a)	Section 4.6.7
B31(b)(vi)	Section 5
B31(b) (vii)	Section 6

1 INTRODUCTION

1.1 Purpose

ECOS Environmental has been engaged by Roads and Maritime Services (RMS) to prepare a Threatened Flora Management Plan for the Warrell Creek to Urunga Upgrade of the Pacific Highway.

The purpose of this Management Plan is to fulfill Condition of Approval No.B7 of the Minister of Planning and Infrastructure, for the Warrell Creek to Urunga project, which concerns the mitigation of impacts on threatened plant species. Specifically, the Minister's Condition of Approval (MCoA) requires an assessment of the potential for the translocation of plants impacted by the project, and the need for compensatory habitat.

MCoA B7 states:

"Mitigation Measures - Amorphospermum whitei and Marsdenia longiloba

B7. Prior to the commencement of any construction work that would result in the disturbance of Amorphospermum whitei and Marsdenia longiloba, the Proponent shall in consultation with the OEH develop a management plan for these species which:
(a) investigates the potential for the translocation of plants impacted by the project;
(b) if investigation under Condition B7(a) reveals translocation of impacted plants is feasible, includes details of a translocation plan for the plants consistent with the Australian Network for Plant Conservation 2nd Ed 2OO4: Guidelines for the Translocation of Threatened Species in Australia, including details of ongoing maintenance such as responsibilities, timing and duration;
(c) identifies a process for incorporating appropriate compensatory habitat for the impacted plants in the Biodiversity Offset Strategy referred to in Condition B8 should the information obtained during the investigation referred to in Condition B7(a) find that translocation is not feasible or where the monitoring undertaken as part of condition B10 finds that translocation measures have not been successful (as identified through performance criteria); and
(d) includes detail of mitigation measures to be implemented during construction to avoid and minimise impacts to areas identified to contain these species, including excluding construction plant, equipment, materials and unauthorised personnel.
Unless otherwise agreed to by the Director General, the Plan shall be submitted for the Director General's approval prior to the commencement of any construction work that would result in the disturbance of Amorphospermum whitei and Marsdenia longiloba." (MCoAs B7, B8 & B10 can be found in Appendix 5).

This management plan aims to satisfy the Minister's requirements and formulate a comprehensive set of measures to mitigate impacts on threatened flora. As well as *Amorphospermum whitei* and *Marsdenia longiloba* specified in MCoA B7 above, RMS would apply the intent of this Condition of Approval to any other threatened plant species detected within the project boundary of the Warrell Creek to Urunga

Upgrade upgrade during the targeted threatened plant species survey carried out in conjunction with this management plan.
(Note - *Amorphospermum whitei* will be referred to below by its current name *Niemeyera whitei*.)

The threatened flora management tasks that ECOS Environmental Pty Ltd has been engaged by RMS to complete include:-

- targeted survey and marking of threatened plant species within the approved project boundary of the Warrell Creek to Urunga Upgrade prior to the commencement of construction;
- assessment of the feasibility of undertaking translocation of affected threatened plant species;
- specification of management measures to ensure the protection of in-situ threatened flora during highway construction and operation;
- design of a detailed translocation proposal for impacted threatened species where translocation is considered to be feasible management option.
- assessment of the requirement for compensatory habitat as a mitigatory measure for impacted threatened flora.

The contents of this report are set out as follows:-

- Section 2 provides an overview of the contents of the Threatened Flora Management Plan.

- Section 3 describes the methods and results of a survey targeting threatened flora which was conducted for this plan and then assesses the translocation potential of the species recorded. Section 3 also discusses the issue of compensatory habitat in the context of the feasibility of translocating species and overall conservation objectives.

- Section 4 sets out a Translocation Plan designed to salvage directly impacted threatened species and establish new, viable populations of these species.

- Section 5 provides details of measures to protect in-situ threatened flora within the project boundary during highway construction and operation.

- Section 6 addresses management of unforseen impacts on threatened and rare flora.

The remainder of this introduction provides a summary of Warrell Creek to Urunga Upgrade (WC2U) project and the natural environment of the project area, details of consultations with the Environmental Protection Authority (EPA) and the Department of Planning and Infrastructure (DPI) conducted during preparation of the report, and a glossary of terms.

Version 3 (26/11/2014) of the Threatened Flora Management Plan has been prepared to assist with implementation of the Plan for the southern half of the Warrell Creek to Urunga (WC2U) project, the Warrell Creek to Nambucca Heads (WC2NH), upgrade, soon to begin construction. Additional information relevant to WC2NH has been incorporated into the plan, including the results of additional threatened flora surveys and analysis of impacts in terms of the RMS concept design.

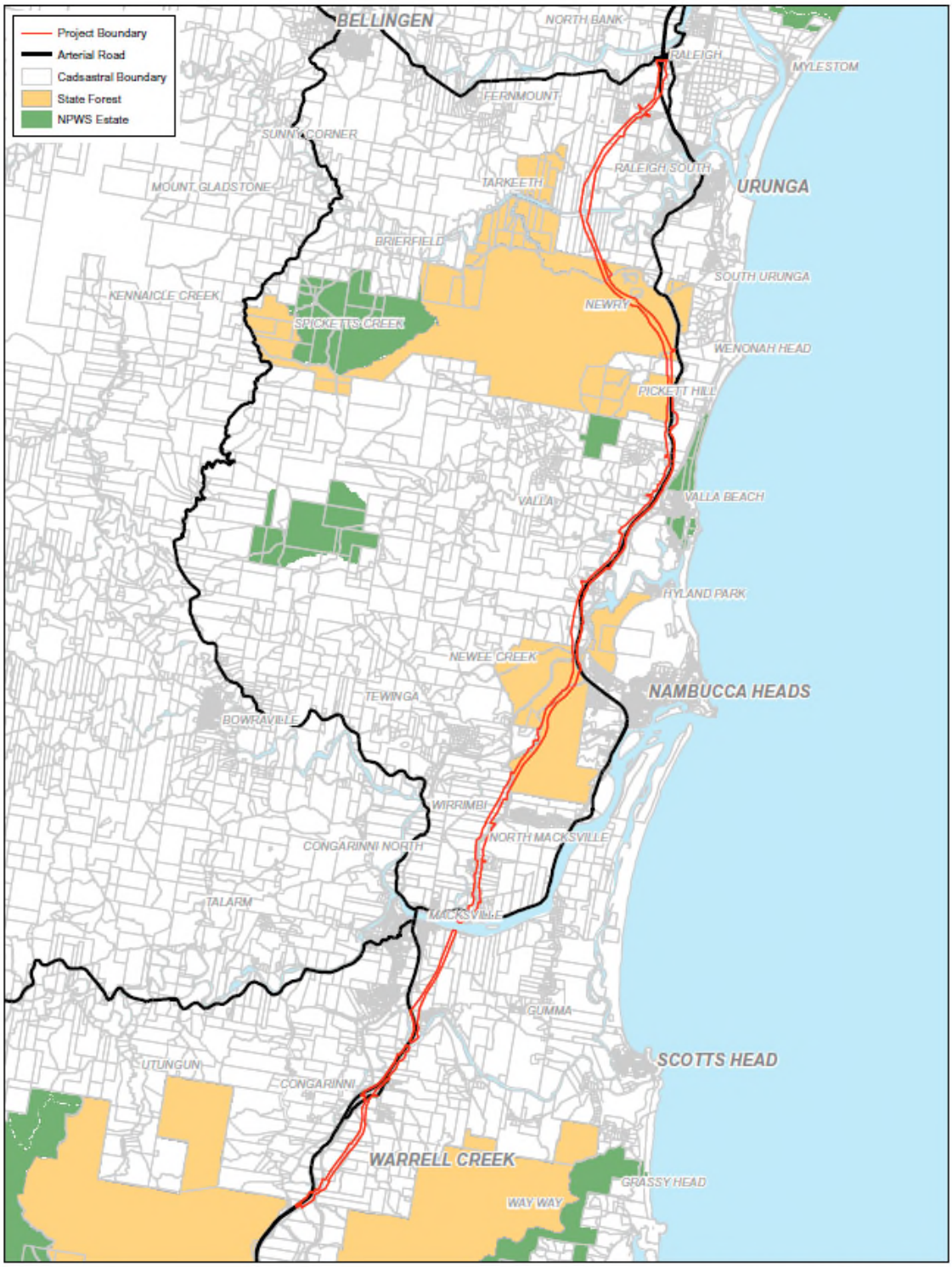

Figure 1: Location map of the Warrell Creek to Urunga Pacific Highway Upgrade corridor

1.2 Description of the Study Area

1.2.1 Location

The Warrell Creek to Urunga Upgrade of the Pacific Highway is located on the Mid North Coast of NSW and extends from Allgomera south of Warrell Creek, 42kms north to the Waterfall Way interchange at Raleigh, traversing the Nambucca and Bellingen local government areas (Figure 1). The study area for this report comprises land within the project boundary of WC2U upgrade, as approved by the Department of Planning.

1.2.2 Landscape Context

The study area lies within the coastal strip of the Manning-Macleay region and includes two landscape types: the Manning-Macleay Coastal Alluvial Plains and the Ingalba Coastal Hills (Mitchell 2003). The Manning-Macleay Coastal Alluvial Plains consists of wide valleys, channels, alluvial floodplains, swamps and terraces of rivers and creeks in the coastal part of the Manning and Macleay region. In the study area this landscape is present on the alluvial floodplains of the Nambucca and Kalang Rivers and smaller creeks including Deep Creek, Boggy Creek and Oyster Creek. Soils are formed on Quaternary alluvium and include dark organic loams and silty clays on the floodplain, gradational brown loams and yellow-brown texture-contrast soil on terraces, and organic silty mud in swamps. Forested areas are dominated by swamp sclerophyll forest, particularly Swamp Oak, and mixed floodplain forest.

The Ingalba Coastal Hills landscape comprises coastal hills and slopes underlain by metamorphic rocks of Permian age including slate, phyllite, schistose sandstone and schistose conglomerate, which collectively comprise the Nambucca Beds. Soil types formed on this geology include thin, stony gradational loam on upper slopes grading to yellow-brown texture-contrast soils on lower slopes and in valleys. The Ingalba Coastal Hills are represented by rolling hills with an elevation of a few hundred metres surrounding the coastal floodplain of Nambucca and Kalang Rivers and other small creeks. Natural vegetation consists of dry sclerophyll forest on upper slopes and ridges, and wet sclerophyll forest in gullies.

1.2.3 Native Vegetation

Approximately two-thirds of WC2U corridor intersects native vegetation. The most widespread vegetation types according to RTA (2010) are Dry and Moist Open Forest (i.e. dry and wet sclerophyll forest), which occur on hills and the coastal plain. Dry Open Forest dominated by Blackbutt (*E. pilularis*) is the commonest forest type (Table 1). This occurs on lower to upper hill slopes and has a grassy and/or shrubby understorey. Lower slopes and gullies support Moist Open Forest, which is characterised by a mesic understorey of small rainforest trees, shrubs and ferns. Two types of Moist Open Forest are present:- (i) Flooded Gum (*E. grandis*) and (ii) White Mahogany/Grey Gum/Ironbark (*E. acmendoides/E. propinqua/E. siderophloia*). Coastal floodplains support Moist Open Forest (Flooded Gum) and Swamp Sclerophyll Forest dominated by Swamp Oak (*Casuarina glauca*) and/or Paperbark (*Melaleuca stypheloides* and *Melaleuca quinquenervia*) and/or Swamp Mahogany (*Eucalyptus robusta*), together with small areas of Freshwater Wetland and Mangroves (Table 1).

The road corridor intersects native vegetation fragments of different sizes. On the cleared floodplains which are mostly used as agricultural land there is an abundance of small vegetation patches in the 1-10 ha range followed by larger patches in the 10-50 ha range (RTA 2010). The largest areas of continuous vegetation are located in Newry, Little Newry and Nambucca State Forests on hilly topography.

Table 1: Native vegetation types directly impacted by the WC2U road corridor, assuming a 10m construction buffer (source RTA 2010, Table 5-1)

Vegetation Association**	**Impact including 10m buffer (ha) (footprint)**
Dry Open Forest – Blackbutt	144.11
Moist Open Forest - White Mahogany/Grey Gum/Ironbark	28.76
Moist Open Forest - Flooded Gum	21.91
Mixed Floodplain Forest (EEC)	12.49
Swamp Forest - Swamp Mahogany/Paperbark (EEC)	12.47
Swamp Forest - Swamp Oak (EEC)	33.07
Freshwater Wetlands (EEC)	8.89*
Mangroves	0.19
Total	255.15

*updated in Dec. 2012 after follow-up vegetation mapping by Ecos Environmental for RMS
** Lowland Rainforest (EEC) was deleted in Ver. 3 after ground-truthing by ECOS Environmental (NH2U) and Geolink (WC2NH) found that vegetation mapped as Lowland Rainforest was either wet sclerophyll forest or camphor laurel.

1.3 Consultation

Consultation on the Threatened Flora Management Plan included the following steps:

The Draft Threatened Flora Management Plan was sent to the Environmental Protection Authority on 15/5/2012 for their review and comment. EPA provided comments on 20/7/2012.

A further draft of the Threatened Flora Management Plan was sent to the Environmental Protection Authority on 12/12/2012. EPA provided comments on 17/12/2012.

Full details of comments raised by EPA and RMS responses are attached in Appendix 9 of this report.

1.4 Glossary

Study area - for the purposes of this report, all land within the approved project boundary of WC2U Pacific Highway Upgrade.

Road corridor - all land within the approved project boundary of WC2U Pacific Highway Upgrade.

Road reserve - all land within the approved project boundary of WC2U Pacific Highway Upgrade, or land within the project boundary that is not part of the construction footprint (also referred to as residual land).

Footprint - the area within the project boundary that would will be cleared and disturbed during highway construction.

Wet sclerophyll forest - a broad vegetation type characterised by an upper stratum of *Eucalyptus* and sometimes *Lophostemon* and *Syncarpia*, with a mesophytic understorey of small trees, vines, shrubs or ferns.

Dry sclerophyll forest - a broad vegetation type characterised by an upper stratum of *Eucalyptus* and an understorey dominated by grasses and/or sclerophyllous shrubs.

Rainforest – can refer to a broad *vegetation type,* i.e. humid forest with a closed canopy; or it can refer to a class of *plant species,* i.e. broad-leaved/non-sclerophyllous species found in rainforest, but also in the understorey of open forest/wet sclerophyll forest. (Rusty Plum (*Niemeyera whitei*) is described as a 'rainforest' species below, as it has the leaf morphology of a rainforest plant, not because there is rainforest on WC2U; it occurs in wet sclerophyll forest.)

Genet - a plant individual originating by sexual reproduction (ie. chromosome recombination), which is genetically different from other plants of the same species. Genets grow from seed produced by the parent plant; ramets are produced vegetatively from the parent plant.

Ramet - a plant individual originating by vegetative reproduction and genetically the same as other individuals (ramets) from the same parent plant. There are various forms of vegetative reproduction. Ramets are usually produced from rhizomes and adventitious root suckers.

Sub-population - spatially discrete occurrences of a species more than 100 metres apart.

Threatened species point - GPS record or positional coordinates of a threatened species individual or closely spaced group of individuals.

Stem-individual - an individual plant in a group of ramets; used in this report to describe the structure and size of Slender Marsdenia occurrences.

Nationally rare or ROTAP species - a species listed in 'Rare or Threatened Australian Plants' (Briggs and Leigh 1995). Regionally significant - rare, disjunct or at the distributional limits of its range, after Sheringham and Westway (1995).

2 MANAGEMENT PLAN OVERVIEW

The following initiatives were incorporated in this management plan to mitigate impacts on threatened flora: -

- Targeted survey within the approved project boundary for threatened plant species, to provide comprehensive details of the distribution and number of threatened flora individuals;
- Consideration of road design adjustments to avoid or minimise where possible, impacts on any additional threatened flora individuals detected;
- Translocation of impacted threatened plant species where considered feasible and of conservation benefit;
- Protective measures for threatened flora retained in-situ within the project boundary/road reserve;
- Provision of threatened plant species compensatory habitat where considered essential to maintain or replace populations impacted by the project; and
- Management of unforseen additional impacts.

These measures are summarised briefly below and described in detail in the relevant sections of the management plan.

Targeted threatened flora survey

Botanical surveys of the preferred route for the WC2U upgrade were conducted in 2007 during the project Environmental Assessment (RTA 2010). A more intensive survey targeting threatened species within the approved boundary of the WC2U Upgrade was conducted by ECOS Environmental in Nov-Dec 2011, in conjunction with preparation of this management plan. Further flora survey work targeting threatened species was carried out in the Technical Review area in Oct 2012. The aim of surveys was to collect comprehensive and up-to-date data on the location and number of individuals of the threatened species within the approved project boundary, prior to the start of construction. Nationally rare (ROTAP) and regionally significant species were also recorded during the survey. The targeted surveys are described in detail in Section 3.

Avoiding impacts during highway design

The concept design for the WC2U project was developed during the route selection study and preliminary design stages, and includes refinements to avoid or minimise impacts on threatened flora within the study area. This included avoidance of potential habitat of the Eastern Underground Orchid (*Rhizanthella slateri*) in Newry State Forest (refer to page 104 of the Warrell Creek to Urunga- Submissions and preferred project report) and minimisation of impact on a population of the endangered Spider Orchid (*Dendrobium melaleucaphilum*) in Newry State Forest. The highway alignment in the concept design was assessed in the project Environmental Assessment, and approved by the Minister for Planning.

Since project approval was received, other initiatives have been implemented to avoid impacts to threatened species that occur within the project boundary. These include measures such as marking each threatened species within the project corridor with

flagging tape and labels to identify each species in the field, and to provide reference points on sensitive area plans used during the project.

Power utility infrastructure has also been relocated away from areas that contain threatened species individuals where possible. Design of the service utilities upgrade was conducted after the targeted threatened flora survey was completed, allowing impacts to be minimised taking into consideration the results of the targeted survey.

Most of service utilities will be relocated to the outer part of the road reserve, which had been less intensively surveyed than the centre of the road corridor. To address possible gaps in flora survey coverage, a further survey was conducted of the routes proposed for service utilities upgrade to identify any additional impacted threatened species. Additional impacts were recorded at two locations involving ten additional individuals of three already recorded species. These are included on the species location maps in Appendix 1, indicated by the suffix - 'u'. The service utilites flora survey is described in the report: 'Targeted Flora Survey of Proposed Service Utility Alignments, Nambucca Exit to Urunga' (ECOS Environmental 2012)

Following the results of the targeted flora survey conducted for this report, the following threatened flora locations were identified as sites where particular attention would be given to minimising adverse impacts during construction:-

- Maundia population at Williamson's Creek
- Floyds Grass population at Warrell Creek
- Slender Marsdenia sites in the Little Newry and Nambucca State Forest areas
- Spider Orchid populations in Newry State Forest
- Rusty Plum population at Cockburn's Lane, Warrell Creek.

Notwithstanding the activities already undertaken to reduce the impacts of the upgrade on threatened species, RMS is committed to ensuring that the potential impact to threatened species within the road corridor is reduced where reasonable and feasible. This will occur during both the ongoing development of the detailed design, and the construction phase of the upgrade. Results of all survey efforts undertaken to date will be incorporated into all the relevant design drawings and plans throughout the design and construction stages. Additional details of mitigation measures to be implemented are discussed in Sections 5 of this report.

Translocation

The purpose of translocating impacted threatened species in a developmental context is to avoid a decline in population number and genetic diversity of threatened species as a result of development impacts. The objective of translocation is to establish new, compensatory populations that are self-sustaining over the long term, which is usually implemented by a combination salvage transplanting, propagation and introduction, and habitat restoration. As well as assisting the maintenance of population number and genetic diversity, translocation can improve understanding of threatened species life history and ecology, through attempts to manipulate and maintain natural

populations. Following assessment of the technical feasibility and conservation benefits of species translocation, a Translocation Plan including pre-translocation assessment, translocation proposals for each species and post-translocation measures such as maintenance and monitoring is set out below in Section 4.

Compensatory Habitat

This section presents an assessment of whether compensatory habitat is required for threatened species impacted by the project, in the context of likely translocation outcomes for each impacted species and the overall objective of threatened flora mitigation for this project. The outcomes of threatened flora mitigation delivered by means of translocation and provision of compensatory habitat on previous North Coast highway projects is also discussed in Section 3.6.4.

Protection of in-situ roadside threatened flora

A substantial number of threatened species individuals will remain within the road reserve, outside the construction footprint. A series of measures designed to protect these plants from damage during construction and operation of the WC2U upgrade are set out in Section 5 of this report.

Management of unforseen additional impacts

Throughout the construction period there is a possibility of design changes that may impact on additional areas of native vegetation. This contingency would be managed with respect to the subject species as described in Section 6 below.

3 TARGETED FLORA SURVEYS

3.1 Environmental Assessment Vegetation Survey

A vegetation survey was conducted during the Environmental Assessment (EA) for the WC2U project in 2007, as described in the 'Working Paper 2, Flora and Fauna' (RTA 2010). The EA vegetation survey examined flora and plant communities on and adjoining the preferred route using quadrats, transects and traverses (see Figures 2-2 to 2-5, RTA 2010). The survey design employed a sampling approach rather than a continuous survey of the whole road corridor. *"Survey effort was determined through the stratification of the study area and the level of variability observed in each stratification unit."..."Stratification was based on a 150 m wide corridor (the study area) to account for the footprint and adjacent edge effects...The number of transects sampled was proportional to the size of the stratification units identified with up to two 100 m transects sampled per 2-50 ha of each stratification unit and three 100 m transects sampled per 51-250 ha of stratification unit (Department of Environment and Conservation 2004)"* (RTA 2010 p. 11-12).

The EA vegetation survey also involved targeted threatened species searches. *"Targeted threatened flora searches were focused on but not limited to slender marsdenia, rusty plum, Newry golden wattle, scented acronychia and milky silkpod, as specified in the Director-General's requirements. Also included in the targeted surveys were red bopple nut (Hicksbeachia pinnatifolia), Maundia triglochinoides and brown fairy-chain orchid (Peristeranthus hillii) "* (p. 12).

Two threatened species were recorded within the study area/road footprint during the EA survey: Marsdenia longiloba and Amorphospermum whitei (syn. Niemeyera whitei). Six additional threatened plant species were identified as potentially present within the road footprint - Acronychia littoralis, Acacia chrysotricha, Maundia triglochinoides, Parsonsia dorrigoensis, Hickesbeachia pinnatifolia and Peristeranthus hillii (RTA 2010, p. 155).

3.2 Targeted Orchid Surveys (EcoPro 2010 & Geolink 2012)

A flora survey targeting the endangered Eastern Underground Orchid and Spider Orchid was conducted by EcoPro in January and May 2010. The survey report concluded as follows:

"A detailed threatened orchid survey was undertaken within the proposed project road corridor located within Newry State Forest (on 18-22 January 2010). The main purpose of this survey was to identify individuals and habitat of the threatened Eastern Underground Orchid (*Rhizanthella slateri)*. Searches were also conducted for the threatened Spider Orchid (*Dendrobium melaleucaphilum*). A subsequent orchid survey was conducted in potential habitat for the Spider Orchid throughout the remainder of the proposed project road corridor and adjacent areas (on 17-19 May 2010). No Eastern Underground Orchids were found, although it was not the optimum time for this species detection.

Seven colonies of the threatened Spider Orchid were recorded. The two largest

populations were found in Newry State Forest in two branches of the same drainage line. These sites were estimated to contain about 2,000 individuals.

The original route alignment in Newry State Forest would have significantly impacted on potential Eastern Underground Orchid habitat, the two largest populations of Spider Orchid and on the Slender Marsdenia colony in this area. To minimise the impact on all three threatened species the alignment was shifted to the west. It is also recommended that the construction boundary (consisting of the extent of earthworks plus an additional five metres) be locked into place in this area to prevent an additional encroachment into threatened species habitat during detailed design and construction.

Using this construction boundary to assess the significance of the Proposal, it was determined that the refined route alignment would not significantly impact on the three threatened species discussed in this report. The refined alignment removes only a very small portion of Eastern Underground Orchid potential habitat. It also entirely avoids any direct impact on the Slender Marsdenia colony, while only a small portion of the Spider Orchid populations (about 60) would be directly impacted. Spider Orchids are fairly easy to translocate, and it is recommended that any directly impacted individuals be translocated into adjacent habitat.

A number of other mitigation measures have been recommended to reduce indirect impacts associated with the Proposal. These include careful control of locational information and maps with regards to the threatened Spider Orchid; installation of protective fencing near threatened species populations, assessment of the need for additional drainage measures near Eastern Underground Orchid habitat and an assessment of the need for visual screening of the Spider Orchid populations near the alignment.

Two additional orchids considered to be of significance were recorded along the route alignment; the Great Climbing Orchid (*Psuedovanilla foliata*) and *Arthrochilus prolixus*." (EcoPro 2010, p. 36)

Spatial impact analysis of the EcoPro (2010) survey data using the latest highway design showed that ten of the Spider Orchid points recorded by EcoPro were directly impacted and15 indirectly impacted by the project (i.e. located within <10 m of the construction footprint. A further 69 points would remain in-situ within the road reserve and 363 points were outside the project boundary (see Appendix 2, Table 2). The figure of 60 directly impacted Spider Orchid plants reported by EcoPro (2010) does not apply to the current highway design and appears to be based on an earlier design version, which was modified to avoid impacting this species.

A further survey targeting the Eastern Underground Orchid, as well as two endangered species of *Diuris* was conducted by Geolink in September 2012. The purpose of this survey was to search for the Eastern Underground Orchid during its reported flowering period, as the previous targeted survey conducted by Ecos Environmental was in November 2011 at the end, or outside its known flowering period. The Geolink survey also targeted the Willawarrin Doubletail (*Diuris disposita*) and Byron Bay Diuris (*Diuris byronensis*), two endangered species of terrestrial 'donkey' orchid, which have both been recorded on the Mid North Coast in habitat similar to that found in the study area. The survey concluded that "No

individuals of the subject orchid species were recorded at any of the targeted survey locations during the survey. No additional surveys for the target species along the NH2U section of the WC2U alignment are considered to be necessary. Safeguards and mitigation measures to protect potential occurrences of these species are considered to be adequate and any potential impacts of the Proposal on unidentified occurrences of these species are likely to be minor."

3.3 Targeted Survey for the Threatened Flora Management Plan

3.3.1 Survey Design

Due to the potential for additional threatened species and more individuals of already recorded species to be present in the road corridor, further targeted threatened flora survey work was commissioned by RMS to ensure that spatial threatened flora data forming the basis of the threatened flora management plan was as comprehensive as possible.

Desktop review indicated that threatened plant species could potentially occur in all habitats present in the road corridor, therefore all habitats would need to be surveyed during the follow-up survey. To ensure survey results were as comprehensive as possible it was considered necessary to conduct a continuous survey of the whole road corridor rather than adopt a sampling approach as used in the EA flora surveys.

The targeted survey was conducted by a team of three botanists with local flora survey experience. One botanist followed a traverse along the approximate centre line of the road corridor, using a Nautiz X7 handheld GPS/PDA for navigation. The other two botanists walked 20-50 metres to either side of the centre line, along roughly parallel meander traverses. The Nautiz was loaded with several GIS layers to assist in the survey including terrain contours, vegetation type, threatened flora locations (from the EA), the project boundary and the detailed road design. Field data were recorded with the PDA and entered using a touch screen keyboard.

The study area was stratified geographically into four sections approximately 10.5km long (equivalent to Figures 3-7 to 3-10 in Working Paper 2, Flora and Fauna):-
Section 1 - Nambucca River/Macksville to Allogomera
Section 2 - Nambucca Heads turn-off to the Nambucca River/Macksville
Section 3 - Little Newry State Forest to Nambucca Heads turnoff
Section 4 - Raleigh/Urunga to the southern boundary of Newry State Forest
Each section received approximately the same number of days. On average 4-5 km of road corridor were surveyed per day.

3.3.2 Indicative Species List

A list of threatened plant species potentially present in the study area was compiled prior to the start of the survey from OEH Wildlife Atlas records, the EPBC Act Protected Matters Search Tool and other flora survey reports (Table 2). Nationally rare species (ROTAP - Briggs and Leigh 1996) and regionally significant species (Sheringham and Westaway 1995; NPWS 1998) were included in the list of conservation significant species. State and Federal threatened species websites were checked for recent preliminary listings and final determinations of threatened plant species potentially in the study area.

Databases, reports and sources: -

- Wildlife Atlas - NSW Environmental Protection Authority (see Appendix 6);
- Protected Matters Search Tool - Federal Department of Sustainability, Environment, Water, Population and Communities (see Appendix 6);
- Australia's Virtual Herbarium;
- Tweedie, T.D., Bruskin, S., Chapman, W.S. and Heyward, R.W. (1995). Flora Survey, Urunga and Coffs Harbour Management Areas, Northern Region, New South Wales. Research Division, State Forests of New South Wales, Sydney;
- ROTAP (Briggs and Leigh 1995) for nationally rare species;
- Sheringham and Westaway (1995) and NPWS (1998) for regionally significant plants;
- ECOS Environmental (2006). Bonville Bypass Pre-clearing Threatened Flora Survey. Report to Abigroup Contractors P/L; and
- ECOS Environmental (2010). PART A: Targeted Survey of Threatened Flora on the Sapphire to Woolgoolga Upgrade of the Pacific Highway and Assessment of Translocation Feasibility. Report to Leighton Fulton Hogan Joint Venture.

Wildlife Atlas indicated that 15 threatened flora species were present within 10km of the road corridor (see Appendix 6). The dates of records showed that some were added to Wildlife Atlas after the EA surveys conducted in 2007. Other reports and information suggested that a further seven threatened plant species could occur in the study area, or a total of 22 potentially occurring threatened plant species (Table 2).

Table 2: Indicative list of threatened plant species known or potentially present in the study area based on the EA survey results, OEH Wildlife Atlas records and other sources. TSC Act and EPBC Act Conservation Status is shown as E – Endangered, CE - Critically Endangered, V- Vulnerable, nl - not listed.

Species	**TSC-EPBC Status**	**Habitat and Likelihood of Occurrence**
		Previously Recorded within Project Boundary
Marsdenia longiloba Slender Marsdenia	E - V	Wet sclerophyll forest in hilly terrain.
Niemeyera whitei Rusty Plum	V - nl	Wet sclerophyll forest.
		Possible Occurrence within Project Boundary
Acronychia littoralis Scented Acronychia	E - E	Coastal dune and back-barrier littoral rainforest and edges; Wildlife Atlas records in close vicinity to the project boundary.
Acacia chrysotricha - Newry Golden Wattle	E - nl	Wet sclerophyll forest edges; Wildlife Atlas records of this species are west of project boundary.
Maundia triglochinoides - Maundia	V - nl	Freshwater swamp; Wildlife Atlas records in close vicinity to the project boundary.

Tinospora tinosporoides - Arrow-head Vine	V - V	Subtropical and littoral rainforest; Wildlife Atlas records from Bundagen adjacent to the northern end of survey area.
Dendrobium melaleucaphilum	E - nl	Mainly in swamp sclerophyll forest on paperbarks, particularly Melaleuca stypelioides; Wildlife Atlas records in close vicinity to the project boundary.
Thesium australe Austral Toadflax	E - E	Grassy headlands, grassy open forest and woodland; generally in coastal areas only on headlands.
Alexfloydia repens - Floyds Grass	E - nl	Edges of coastal streams often within the tidal zone and in Swamp Oak forest; Wildlife Atlas records in close vicinity to the project boundary
Syzygium paniculatum - Magenta Lily Pilly	V - V	Rainforest, generally south of the survey area.
Phaius australis Swamp Orchid	E - E	Swamp sclerophyll forest margins with rainforest species, particularly palms and Alocasia; possible, but extremely rare between Coffs Harbour & Port Macquarie.
Senna acclinus	E - nl	Margin of open forest and rainforest; possible, recorded from the Coffs Habour and Port Macquarie areas.
Eleocharis tetraquetra Square-stemmed Spike Rush	E - nl	Coastal swamp and streamside seepage; possible but very rare, nearest records in the Coffs Harbour area.
Arthraxon hispidus A Grass	V - V	Swampy areas at the base of hillslopes; possible, recorded at Boambee and Kempsey.
Parsonsia dorrigoensis A vine	V - E	Wet sclerophyll forest and rainforest; recorded in State Forest immediately west of the survey area.
Hicksbeachia pinnatifolia - Red Bopple Nut	V - V	Wet sclerophyll forest and rainforest; recorded in State Forest not far west of survey area.
Diuris sp. aff chrysantha (Byron Bay Diuris)	E -	Grassy and heathy open forest; possible occurrence, recorded in the Coffs Harbour area (Conacher Consulting 2008).
Diuris disposita	E -	Grassy open forest in the Kempsey area, possible.
Diuris flavescens	CE -	Grassy open forest, known from one population near Wingham, outside chance.
Melaleuca biconvexa	V - V	Swamp sclerophyll forest, recorded Port Macquarie, outside chance.
		Unlikely
Chamaesyce psammogeton	E -	Recorded on the coast on sand, habitat not present in survey area.
Melaleuca groveana	V -	Recorded from rocky, heathy open forest, habitat not present in survey area.

3.3.3 Timing and Personnel

Approximately 80% of the road alignment was surveyed in November-December 2011 and the remaining 20% was surveyed in October 2012. The latter section was postponed until October 2012 due to a technical review of the Nambucca River crossing section, which extended from the southern boundary of Nambucca State Forest to the southern outskirts of Macksville. Targeted flora survey work was carried out by Dr Andrew Benwell, Justin O'Dowell and Shaan Watson.

3.3.4 Data Recording and Plant Marking

The location of all threatened plants found during survey was recorded with a Nautiz GPS/PDA. Each record was allocated a unique alphanumberic identifier comprising the first letters of the plant genus and species and a number (e.g. ML5 = Marsdenia longiloba, flora point number five). The GPS points referred to either a single plant, or group of closely spaced individuals (ie. <2 m apart). This was often the case with *Marsdenia longiloba*, which commonly occurred in clusters of two or more stems. Plants more than 10m apart were generally recorded as separate GPS points with different id codes. In the case of mat-forming such as *Maundia triglochinoides* and *Alexfloydia repens*, GPS points were recorded to show the extent of each patch. A proforma was set up in the Nautiz for recording species, identification number, plant height and other relevant details of each field point. The accuracy reported by the PDA was generally less than one meter.

3.3.5 Quadrats

Detailed vegetation quadrats were recorded to describe the habitat associated with each threatened species. Standard vegetation survey guidelines were used to record quadrat data (DEC 2004; NPWS 1995). The basic quadrat size was 400 m² (20x20m or 40x10m in linear habitats). Data were collected on species composition, vegetation structure, physical site variables and disturbance history. Species abundance was estimated visually according to the Braun Blanquet cover-abundance scale of 1 to 6, as follows:- 1 - sparse <5% crown-cover; 2 - any number <5%; 3 - 5-25%; 4 - 25-50%; 5 - 50-75% and 6 - 75-100% (Mueller-Dombois and Ellenberg 1974; NPWS 1995). The soil profile was examined to depth of approximately 80cm with a soil auger. Road cutting exposures indicated the soil profile at greater depth. The colour and soil texture of soil horizons was recorded. Soil pH was recorded with a MANUTEC soil pH test kit.

3.3.6 Targeted Survey for *Rhizanthella slateri*

An historical record of the Eastern Underground Orchid (*Rhizanthella slateri*) exists for Newry State Forest near the road alignmnent (EcoPro 2010). An area of potential habitat surrounding the historical record was identified by EcoPro (2010) with input from Mark Clements (CSIRO) and Bill Dowling who has studied the species on the Buladelah Bypass project. The Eastern Underground Orchid is a leafless, saprophytic orchid, which spends lives entirely underground apart from when it flowers, when flower heads push just above ground, usually amongst leaf litter. The flower heads have a diameter of about 20mm and are cream and purple in colour. Harden (1993) gives the flowering time as October and November. At Buladelah the species was reported to flower in September.

The area of potential habitat for the Eastern Underground Orchid mapped by EcoPro (2010) was surveyed for this report in November 2011. To identify other areas where the orchid may occur, habitat information was acquired from specimens of *Rhizanthella slateri* held at the Royal Botanic Gardens Herbarium in Sydney (10 collections) and the National Herbarium in Canberra (5 collections). This information indicated that *Rhizanthella slateri* occurs in wet and dry sclerophyll forest on siliceous soils formed on high quartz geology (e.g. sandstone and rhyolite). Chert, a siliceous metamorphic rock, appears to occur in the study area.

It was difficult to predict from geology and vegetation maps where areas of more siliceous soil might occur on the alignment, as the geology in the WC2U study area consists almost entirely of Permian metamorphics (Nambucca Beds) on hilly terrain, or floodplain alluvium in valleys. It was decided to search for *R. slateri* where vegetation indicators of more siliceous soil were observed, such as forest with a sclerophyllous or heathy understorey. At sites judged to be potential habitat for *R. slateri*, 10 m x 10 m plots were established and leaf litter and mulch partially removed so the ground surface could be examined for *R. slateri* flowers or seeding heads.

3.3.7 Additional Threatened Flora Records for WC2NH

For the southern WC2NH section, additional records of Slender Marsdenia within or adjoining the project boundry were incorporated into the TFMP from the following sources:

- ECOS Environmental (2014a). Targeted surveys (and sample collection) for a genetic study of *Marsdenia longiloba* currently being conducted by ECOS Environmental in collaboration with University of Sunshine Coast, titled "Analysis of genetic variability in the endangered species Slender Marsdenia (*Marsdenia longiloba*) at fine, medium and broad geographic scales"
- ECOS Environmental (2014b). Targeted re-survey of threatened species in the Cockburns Lane (Warrell Creek) area.
- ECOS Environmental (2014c).Targeted survey for a connector track with Old Coast Road, Nambucca Heads.
- GeoLink (2014). Targeted surveys along a utilities alignment.

3.3.8 Spatial Impact Analysis

The recorded flora points were overlaid on the highway design using a GIS to determine what points were directly impacted, indirectly impacted, remaining in-situ within the project boundary, or outside the project boundary, as follows:-
(Definitions of Directly impacted have been modified since version 1 dated 6/3/2013 submitted to the Dept of Planning)

Northern Section NH2U - Directly impacted:- Directly impacted individuals are those located under the design footprint plus 10 metres, which is the limit of clearing.

Southern Section WC2NH - Directly impacted:- Directly impacted individuals are those located:

- Under the concept design footprint plus **15 metres**.
- Under the operational water quality basins plus 10 metres.

- Under new or reconstructed access roads within Nambucca State Forest plus 10 metres.
- For utility adjustments within clearing requirements of utility authorities.
- Within three metre clearing width for boundary fencing - excluding within Nambucca State Forest and swamp forest where a flying fox camp is located.

Indirectly impacted:- Indirectly impacted individuals are those located within 10 m of the direct impact zone. The indirect impact zone is not subject to clearing, but threatened flora may be impacted by changes in microclimate, soil nutrient levels, weed invasion or other alteration of habitat conditions.

In-Situ within road reserve:- These individuals are located outside the direct and indirect impact zones between the indirect impact zone and the project boundary, also referred to as the road reserve boundary.

Outside project corridor:- These individuals are located outside the approved project corridor and are in most cases are considered to be directly or indirectly impact by the proposed construction works. Exceptions may include wetland species that could be affected outside the project.

3.4 SURVEY RESULTS

3.4.1 Summary

Six threatened species (four endangered and two vulnerable), three ROTAP species and one species recommended for threatened species listing were recorded during the targeted survey:-

Threatened
Slender Marsdenia (*Marsdenia longiloba*), a small vine.
Rusty Plum (*Niemeyera whitei*), a medium sized rainforest tree.
Maundia (*Maundia triglochinoides*), an aquatic, emergent herb.
Floyds Grass (*Alexfloydia repens*), a mat forming grass.
Wooll's Tylophora (*Tylophora woollsii*), a small vine.
Spider Orchid (*Dendrobium melaleucaphilum*), an epiphytic orchid.

ROTAP
Ford's Goodenia (*Goodenia fordiana*), a mat forming herb.
Bellingen Ironbark (*Eucalyptus ancophila*), a tall tree of wet sclerophyll forest.
Hammer Orchid (*Arthrochilis prolixus*), terrestrial orchid (recorded by EcoPro 2010).

Potential Threatened Species Listing
Koala Bells (*Artanema fimbriatum*), a perennial herb of coastal forests.

Results of spatial impact analysis are summarised in Table 3A & 3B. These show the number of species directly impacted, indirectly impacted and remaining in situ for the whole WC2U corridor and southern half (WC2NH), respectively. Threatened and rare flora records were classed as either: (i) directly impacted (i.e. Northern section NH2U design footprint plus 10m; Southen section WC2NH design footprint plus 15 meters and other parameters given in Section 3.3.8), (ii) indirectly impacted (within 10m of the direct impact zone), or (iii) in-situ within the road reserve (outside the indirect impact zone but within the project boundary). Data from the EcoPro (2010) targeted orchid survey were included in the spatial impact analysis.

Detailed maps of threatened and rare species location, showing the type of impact (direct, indirect and in-situ) can be found in Appendix 1. Maps showing the overall distribution of threatened species on the WC2U road corridor are presented in Appendix 2.

(An additional threatened species, the rainforest tree *Acronychia littoralis,* was tentatively identified at Deep Creek (Valla) from leaf material, but flowers and fruits collected several months later keyed out to the common species *Acronychia oblongifolia*. The small trees were atypical for *A. oblongifolia* as they occured as a thicket of stems, which is a feature of one of the two forms of *A. littoralis*. Also, leaf oil dots were less transparent than typical *A.oblongifolia*, another feature of *A. littoralis* (Benwell 1996). However, the flowers and fruits were too small for *A. littoralis* and closer to *A. oblongifolia*. The fruits collected at Deep Creek contained no seed and microscopic examination revealed shrivelled, infertile ovules, which indicated the stem thicket of *A. obl*ongifolia at this site was a sterile hybrid and the copse of stems had formed by vegetative reproduction from root suckers, visible at the site).

Table 3A: Threatened and rare flora impacted by the whole WC2U project

WC2U (whole road corridor)	**Directly Impacted**		**Indirectly Impacted**		**Road Reserve - in-situ**	
Threatened Species	points	no.	points	no.	Points	no.
Slender Marsdenia (E) (*Marsdenia longiloba*)	68	176	7	20	2	4
Rusty Plum (V) (*Niemeyera whitei*)	12	12 +sdg	0	0	0	0
Maundia (V) (*Maundia triglochinoides*)	~500+ m^2		~50 m^2		~50 m^2	
Floyds Grass (E) (*Alexfloydia repens*)	1	~2m^2	2	~2m^2	1	~2m^2
Wooll's Tylophora (E) (*Tylophora woollsii*)	5	9	-	-	3	6
Spider Orchid (E) (*Dendrobium melaleucaphilum*)	13	~40	16	35	70	200
ROTAP*						
Ford's Goodenia (*Goodenia fordiana*)	9	9m^2	1	1m^2	-	-
Potential Threatened Species Listing						
Koala Bells (*Artanema fimbriatum*)	7	65	2	55	-	-

*Eucalyptus ancophila not included as it was relatively common in the study area.

Table 3B - Threatened and rare flora impacted by the WC2NH project

Southern WC2NH section	**Directly Impacted**		**Indirectly Impacted**		**Road Reserve - in-situ**	
Threatened Species	points	no.	points	no.	Points	no.
Slender Marsdenia (E) (*Marsdenia longiloba*)	43	75	2	4	1	1
Rusty Plum (V) (*Niemeyera whitei*)	10	10 +sdg	0	0	0	0
Maundia (V) (*Maundia triglochinoides*)	~500+ m^2		~50 m^2		~50 m^2	
Floyds Grass (E) (*Alexfloydia repens*)	1	~2m^2	2	~2m^2	1	~2m^2
Wooll's Tylophora (E) (*Tylophora woollsii*)	2	2	0	0	0	0
Spider Orchid (E) (*Dendrobium melaleucaphilum*)	3	10	0	0	0	0
ROTAP						
Ford's Goodenia (*Goodenia fordiana*)	2	2m^2	1	1m^2	0	0
Potential Threatened Species Listing						
Koala Bells (*Artanema fimbriatum*)	2	13	0	0	0	0

3.4.2 Slender Marsdenia (*Marsdenia longiloba*)

Locations
Slender Marsdenia was recorded in small sub-populations scattered along the length of the WC2U road corridor. Approximately 200 individuals ('stem-individuals) were recorded in 23 different sub-populations in the Raleigh south area, Newry State Forest, Little Newry State Forest, Valla south, Nambucca State Forest and Warrell Creek sections of the WC2U corridor. (Sub-populations' were defined as geographically separate records at least 100m apart). The great majority of recorded points were within the zone of direct and indirect impact, as survey work was concentrated on the construction footprint and indirect impact zone.

Directly impacted

- A total of 68 gps points representing 176 individuals ('stem-individuals) are directly impacted. These represent at least 23 different sub-populations. 43 gps points and 75 individuals were directly impacted on the southern WC2NH section. Occurrences are mapped in Appendix 1.

Indirectly impacted

- A total of 7 gps points representing 20 individuals are indirectly impacted.

In-situ within road reserve

- Two points representing 4 individuals would remain in-situ within the road reserve. Additional individuals may be present in the outer part of the road reserve, as survey work was focused on the footprint.

Slender Marsdenia is a small vine growing to a maximum height of about 5m. Most plants recorded during the survey were much smaller than this, generally less than 0.5m tall and with few leaves (Table 4). Only one point had a flowering plant and no plants with seed pods were recorded. Seed pods of this species are extremely rare (Harden 1992), so reproduction appears to occur vegetatively by root spread and suckering and only very rarely by seedling recruitment.

Plate 1: Small Slender Marsdenia plant with smooth, hairless leaves.

Plate 2: Typical Slender Marsdenia habitat in wet sclerophyll forest with understorey of small rainforest trees, shrubs and ground ferns, and open litter or fern covered ground layer, the roughed barked tree is Turpentine.

Plate 3: Only one plant of Slender Marsdenia was found with flowers. ML-42

Table 4: Size class distribution of Slender Marsdenia points

Size Class - Height (largest stem-individual if more than one present)	**Number of points (not including the Nambucca review area)**
<0.5 m	40
0.5 - 1 m	8
1 - 1.5 m	7
1.5 - 2 m	2 (1 flowering)
Total	57

Habitat

Found in moist open forest and gradational subtropical and warm temperate rainforest, mostly below 200m altitude (Quinn *et al.* 1995). Characteristics of Slender Marsdenia habitat recorded on the WC2U road corridor included: -

- soil type a yellow to red clay podzol formed on Permian metasediments;
- soil A-horizon 15-30cm deep, dark brown, humus enriched topsoil;
- wet sclerophyll forest with an open to mid dense rainforest understorey usually on a lower slope;
- sloping (gentle to moderate) and well drained, often with a southern aspect;
- understorey moderately well lit and open, not dense or heavily shaded;
- topsoil only slightly acidic (pH >6).

The total area of modelled potential habitat of Slender Marsdenia on the southern half of the WC2U project (WC2NH) has been estimated as 17.8 Ha (Jacobs SKM 2014) and a similar area is expected on the northern half (NH2U).

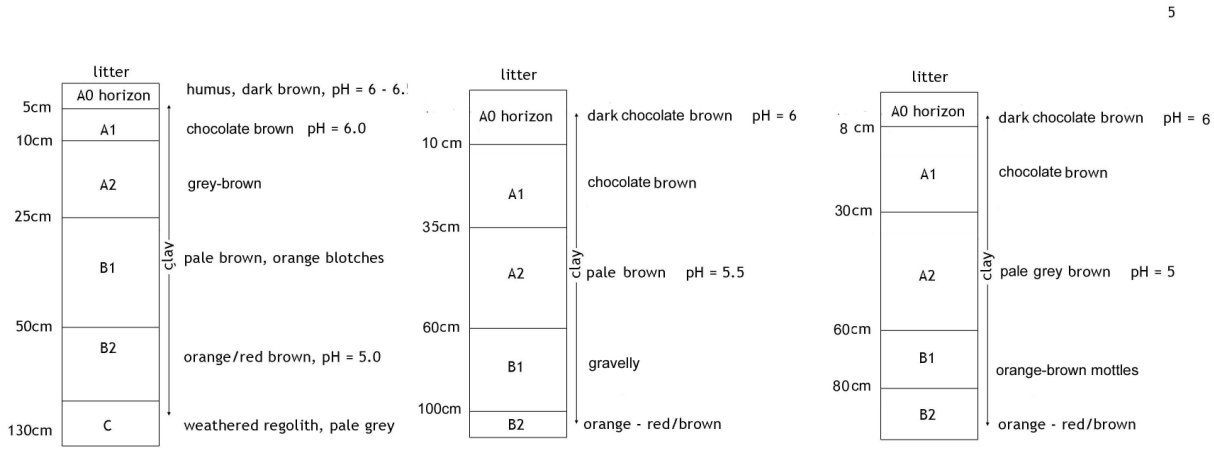

Figure a: Soil Profile at Mardenia longiloba site in Nambucca State Forest

Figure b: Soil Profile at *Niemeyera whitei* site at Cockburns Lane, Warrell Creek

Fiigure c: Soil Profile at *Acronychia littoralis* site at Deep Creek near Valla Beach

Figure 2: Representative soil profiles at threatened species sites on the WC2U corridor.

3.4.3 Rusty Plum (*Niemeyera whitei*)

Locations
Rusty Plum was recorded at three locations on the WC2U corridor:- Boggy Creek near Valla, north of the railway line at the Nambucca Heads turn-off, and Cockburn's Lane, Warrell Creek. Single small trees were recorded at Boggy Creek and the railway line. Eleven trees and saplings (plus seedlings) were recorded at Cockburn's Lane, Warrell Creek on the southern WC2NH section. Trees were up to 10 metres in height and 30 cm in diameter.

Directly impacted

- Ten trees at Cockburn's Lane (Warrell Creek) and the two trees north of the railway line Nambucca Heads and at Boggy Creek are directly impacted.

Note: nw-130 (green - outside project boundary) was included on Fig. 9 in Appx. 1. The position of this tree was estimated from a vantage point as it could not be accessed on the ground and may actually be within the road reserve; the precise location of the tree would be recorded during the pre-clearing survey.

Habitat
At Boggy Creek, a single Rusty Plum occurs on a creek bank in Flooded Gum wet sclerophyll forest with a well developed rainforest understorey. The tree north of the railway line is in wet sclerophyll forest on a south-facing hillslope. The population at Cockburn's Lane, Warrell Creek is in similar wet sclerophyll habitat on a south-facing hillslope and gully drainage line. The soil at the latter site is a red clay podzol formed on hornfels, a dark crystalline rock derived from the Nambucca Beds chert by secondary metamorphism during the Mt Yarrahappini intrusion (RTA 2010).

Plate 4: Rusty Plum sapling at Cockburn's Lane, Warrell Creek.

3.4.4 Woolls' Tylophora (*Tylophora woollsii*)

Locations
Woolls' Tylophora was recorded at Raleigh south, Newry State Forest and Nambucca State Forest at a total of four locations.

Directly impacted
- Nine individuals directly impacted at five locations in Newry and Nambucca State Forests and north of the Kalang River.

Indirectly impacted
- None recorded..

In-situ within road reserve
- Six individuals between the Kalang River and Raleigh south.

Note - Woolls' Tylophora is difficult distinguish from Slender Marsdenia on the basis of leaf morphology. The flowers of the two species are very different, but are rarely seen. Woolls' Tylophora was tentatively identified based on leaves that were more ovate, less elongated and darker green than Slender Marsdenia, sometimes with a purplish tinge to the petioles and underside of the leaves. *Tylophora woollsii* was postively identified on the Bonville upgrade project from a flowering plant (see Plate 6). Distinguishing the two species may not be crucial for management purposes, as both are listed as endangered.)

Habitat
Tylophora woollsii was recorded in wet sclerophyll habitat, as described for Slender Marsdenia, with which it co-occurs (see Slender Marsdenia habitat above).

Plate 5: *Tylophora woollsii* has very similar leaves to Slender Marsdenia, although the flowers are quite different (see Plate 3)

3.4.5 Maundia (*Maundia triglochinoides*)

Locations
Maundia was recorded only on the southern WC2NH half of the WC2U road corridor, at Williamson's Creek near Warrell Creek, and south of Macksville in freshwater wetland. The Williamson's Creek population occurs for ~150 metres along the creek either side of the existing Pacific Highway bridge, extending across the footprint of new bridge. There is a break in the population of about 40 meters under the existing highway bridge, which appears to be associated with a riffle section in the creek rather than shading by the bridge. RMS reported that a substantial quantity of Maundia was still present at the Williamson's Creek site in July 2014 (S. Walker pers.com.).

The second population occurs in a large freshwater wetland–swamp sclerophyll forest mosaic approx. 2 km southeast of Macksville. Not all of this habitat was surveyed due to access issues and it is likely other patches of Maundia occur between the Maundia records at the southern and northern limits of the swamp (see Appendix 1, Figure 11). On the southern edge of the swamp (mt-82), a large expanse of Maundia dominated freshwater wetland extended more than 100 meters outside the project boundary to the east, and only small section (~10-20m) extended inside the project boundary at representative point mt-82 (in November 2011).

Directly impacted
- Approximately 500 square meters of Maundia is directly impacted at Williamson's Creek and in freshwater wetland on the Nambucca floodplain. (Note – additional plants are likely to be directly impacted in the second area in the unsurveyed section between records Mt-82 and Mt-96 (Appendix 1, Figure 11) .

Indirectly impacted
- The Williamson's Creek population is indirectly impacted either side of the construction footprint/direct impact zone.
- An additional area of Maundia occurs in the indirect impact zone on the floodplain south of the Nambucca River.

In-situ within road reserve
- Part of the Williamson's Creek population is outside the indirect impact zone and within the in-situ zone on either side of the existing and new bridges.
- Some of the second population is also within the in-situ zone (to be confirmed during the pre-clearing survey).

Habitat
Maundia is an aquatic herb with emergent, sword-shaped leaves standing 0.5 m to 1 m high above water. The Maundia site on Williamson's Creek is located at the edge of the coastal floodplain, where the creek consists of a series of long pool and short riffle sections. Maundia grows in the pool sections in water 0.2 to 1 meter deep. Flood debris on the creek banks and fine sediment on Maundia leaves indicated that Maundia had been submerged during floods under fast flowing water. When inspected in October 2012, Maundia was just starting to produce new green shoots after dying back over winter. The Nambucca floodplain population occurs mostly in treeless freshwater wetland. Maundia will grow in full sun in treeless freshwater wetland or under medium shade in swamp forest.

Plate 6: Leaves and flower spike of *Maundia triglochinoides* at Williamson's Creek, November 2011.

Plate 7: Stand of Maundia in Williamson's Creek, a tributary of Warrell Creek, the water is 0.3-0.5 metres deep.

Plate 8: Williamson's Creek with band of Maundia in the creek at the base of slope and edge of tree line. Existing Pacific Highway bridge, looking south-west.

Plate 9: Williamson's Creek looking east under the existing Pacific Highway bridge; there was no Maundia in the section of the creek beneath the bridge and to either side for 20-30 metres.

3.4.6 Floyd's Grass (*Alexfloydia repens*)

Locations
Floyds Grass was recorded on the northern bank of Warrell Creek, on the eastern and western sides of the highway corridor, close to and within the project boundary. The population is confired to a narrow zone a few metres wide on the edge of Warrell Creek. On the western side of the corridor the population extends upstream of the project boundary for at least 20 metres. No plants were found downstream of the small patch on the eastern side of the corridor.

Directly impacted
- One gps point directly impacted, comprising approximately 2 m².

Indirectly impacted
- Two gps points indirectly impacted, comprising approximately 4 m².

In-situ within road reserve
- Nil (present outside the road reserve – one gps point).

Habitat
Floyds Grass occurs in a narrow zone 1-2 metres wide on the edge of Warrel Creek in Swamp Oak forest. The soil type is a humus-enriched, alluvial clay loam. The common native grass *Ottochloa gracillima* and Floyds Grass occur in different patches in essentially the same habitat indicating they are competitors.

Plate 10: Floyds Grass is a mat forming grass that looks somewhat like common Couch Grass.

3.4.7 Spider Orchid (*Dendrobium melaleucaphilum*)

Location

Dendrobium melaleucaphilum was recorded at three locations:-(i) ~4km north of the Kalang River, where only one mature plant was found, (ii) in Newry State Forest, where a substantial population was found in swamp forest next to the *Rhizanthella slateri* potential habitat area, and (iii) in Nambucca State Forest south of Nambucca Heads (EcoPro 2010). Population (ii) occurs on the eastern side of the road corridor and mostly outside the project boundary (see Appendix 1, Figure 4). The alignment was redesigned to minimise impact on the Spider Orchid population and potential *Rhizanthella slateri* habitat at this location. Impact analysis of the flora points recorded by EcoPro (2010) showed that the current design impacts directly on 13 Spider Orchid points, each point representing 1-5 Spider Orchids plants on one tree.

Directly impacted

- Thirteen Spider Orchid points are directly impacted. Each point represents from 1-5 individual plants (EcoPro 2010).

Indirectly impacted

- Sixteen Spider Orchid points are indirectly impacted. Each point represents from 1-5 individual plants (EcoPro 2010).

In-situ within road reserve

- Seventy (70) are located in situ within the road reserve.

Habitat

Dendrobium melaleucaphilum is an epiphytic orchid which grows in swamp sclerophyll forest and rainforest in coastal areas, often on *Melaleuca stypheliodes*.

Plate 11: *Dendrobium melaleucaphilum* (dm – 16a), a young plant growing on the bark of *Melaleuca stypheliodes* outside the project boundary.

3.4.8 Ford's Goodenia (*Goodenia fordiana*) (2RC-)

Locations
Ford's Goodenia was recorded at Raleigh south, Newry State Forest and Nambucca State Forest, and was most common in the Raleigh south area. Ten point localities were recorded, representing 8 locations. This prostrate ground-cover herb forms patches up to about a meter wide.

Directly impacted
- Nine of the ten gps points were directly impacted.

Indirectly impacted
- One gps point was indirectly impacted.

In-situ within road reserve
- Nil, however some plants are probably present in the road reserve outside the construction footprint, as the outer parts of the road corridor were not as closely searched.

Note - . Fords Goodenia is endemic to the NSW Lower North Coast between Coffs Harbour and Buladelah and is listed as nationally rare (Briggs and Leigh 1995).

Habitat
Found in wet sclerophyll forest under moderate to dense shade. The soil type is clay podzol formed on Permian metasediment.

Plate 12: Ford's Goodenia (*Goodenia fordiana*) a small herbaceous ground cover found in shaded wet sclerophyll forest on the WC2U road corridor.

3.4.9 Bellingen Ironbark (*Eucalyptus ancophila*) (2RC-)

Locations
Only a selection of locations of this nationally rare species was recorded, as the species was relatively common in the study area. This species occurs in wet sclerophyll forest in moist gullies and the hinterland margins of the coastal floodplain.

One very large old-growth specimen of *E. ancophila* was recorded north of the Kalang River on the clearing footprint. This tree on NH2U has since been protected by changes to the detailed design.

Note - *E. ancophila* is a medium-sized to tall forest tree known only from between Kempsey and Bellingen on the NSW Mid North Coast and is listed as nationally rare (ROTAP - Briggs and Leigh 1995). This species is one of a group of ironbarks distinguished by the combination of discolorous leaves, terminal inflorescences and flowers with staminodes. It has glossy green leaves which distinguish it from *E. fusiformis* , non-ribbed or non-angled fruit, which distinguishes it from *E. tetrapleura* and *E. fusiformis,* and longer leaves than *E. placita (www.anbg.gov.au/cpbr/cd-keys/Euclid/sample/html/ANCOPH.htm*).

Habitat
E. ancophila occurs in moist gully and valley bottom situations in wet sclerophyll forest on heavy clay podzols formed on Permian metasediments. Co-occuring tree species included Swamp Mahogany, Flooded Gum, Turpentine and White Mahogany.

3.4.10 Koala Bells (*Artanema fimbriatum*)

Locations
Artanema fimbriatum was recorded in the Raleigh, Raleigh south, Valla, Valla south and Nambucca State Forest areas. A total of ten gps points representing ten locations for recorded.

Directly impacted
- Seven locations are directly impacted.

Indirectly impacted
- Two locations are indirectly impacted; these are two and three metres from the edge of the construction footprint.

In-situ within road reserve
- None.

Note 1 - *Artanema fimbriatum* has been recommended for threatened species listing (NPWS 1998).

Habitat

Koala Bells was found mainly in damp sites on floodplains and occasionally in gullies in hilly terrain where crossed by tracks. Vegetation varied from open floodplain forest, swamp sclerophyll forest, clearings in dense wet sclerophyll forest and cleared or regenerating vegetation. At least half the occurrences were associated with track or clearing disturbance where patches of seedlings had established on bare soil.

Plate 13: Koala Bells (*Artanema fimbriatum*)

Plate 14: Wet sclerophyll forest habitat in Nambucca State Forest on the WC2U upgrade corridor

3.4.11 Other Rare of Regionally Significant Species

Several species were recorded near the southern limit of their range and were therefore of regional significance (Sheringham and Westaway 1995). Some appear to have spread from garden plantings to the adjoining road reserve, for example *Glochidion summatranum, Melicope elleryana* and *Macaranga tanarius*, and can be considered introduced native species. *Melicope elleryana* was seen at many locations in disturbed forest. Species occurring near the southern limit of their range without apparent human assistance included *Sannantha collina, Lepidozamia peroffskyana, Lophostemon suaveolens, Crinum pedunculatum, Cyperus filipes, Cymbidium maddidum* and *Lygodium scandens*. None of these species was considered rare enough to warrant specific conservation measures, but the records are of scientific interest as they more accurately define the present distributional range of each species. *Sannantha collina, Lepidozamia peroffskyana, Lophostemon suaveolens* and *Crinum pedunculatum* are suitable for use in highway landscaping, which could assist in preserving local populations of these species. Propagation should be from locally collected seed to preserve the local genotype best adapted to the local environment.

The Great Climbing Orchid (*Psuedovanilla foliata*) and the Hammer Orchid (*Arthrochilus prolixus*) were recorded by EcoPro (2010). Although not listed as threatened, they were considered to have conservation significance and it was recommended that " the two populations of *Arthrochilus prolixus* be translocated into nearby habitat by an orchid specialist. Translocation of the Great Climbing Orchid is not possible, however, it is recommended that seed be collected from the plants and replanted in newly created habitat on the edge of the alignment." (EcoPro (2010, p. 36)

The Hammer Orchid (*Arthrochilus prolixus*) is listed in ROTAP (Rare or Threatened Australian Plants - Briggs and Leigh 1995) under the category 'K', which indicates the species is poorly known, referring to its distribution and general abundance. In my own experience both the Hammer Orchid (*Arthrochilus prolixus*) and the Great Climbing Orchid (*Psuedovanilla foliata*) are widespread but uncommon. In Wildlife Atlas there are 22 records of the Great Climbing Orchid on the North Coast north of Pt Macquarie and 50 records of the Hammer Orchid on the North Coast.

The Great Climbing Orchid is a saprophytic orchid which flowers in summer and spends the rest of the year underground. Collection of seed, as recommended by EcoPro (2010) may not be practical, as seed may not be present when vegetation is cleared, or the plant may have died back to its underground saprophytic state. The Hammer Orchid is a small terrestrial ground orchid that flowers in late summer and autumn. The apparent rarity of these two species is at least partly due to their cryptic life cycle and limited capacity to be detected unless in flower. Most ground orchids are likely to be difficult to translocate successfully, due to their mycorrhizal requirements and sensitivity to small differences in soil microhabitat.

Translocation measures for the Hammer Orchid and Great Climbing Orchid as recommended by EcoPro (2010) are not considered warranted for the following reasons:

- Both species appear to be widely distributed, not particularly rare and may in fact be reasonably common, as they are often cryptic and hard to detect.

- Neither species is listed as threatened or recommended for threatened species listing and therefore not necessarily relevant to the Minister's CoA.

- Resources to conduct translocation and research on threatened and rare species are limited and need to be prioritised; it is probably not possible to include all species of conservation significance in the management plan.

3.4.12 *Rhizanthella slateri*

The area of potential habitat mapped by EcoPro (2010) was surveyed for the Eastern Underground Orchid in November 2011. In addition, habitat information provided by the Royal Botanic Gardens Herbarium in Sydney (10 collections) and the National Herbarium in Canberra (five collections) indicated that *Rhizanthella slateri* ocurrs in wet and dry sclerophyll forest on siliceous soils formed on high quartz geology (e.g. sandstone, rhyolite, chert).

Twelve locations supporting understorey vegetation with a higher cover-abundance of sclerophyllous species indicating more siliceous soil, such as *Allocasuarina littoralis* and *Leptospermum polygalifolium* were searched for *R. slateri*, but no plants (flowers or fruiting flower heads) were found. Survey work was conducted in late November at the end of the reported flowering period of *R. slateri*.

A further survey targeting the Eastern Underground Orchid was conducted by Geolink in September 2012. The purpose of this survey was to search for the Eastern Underground Orchid during its reported flowering period. The previous targeted survey conducted by Ecos Environmental was in November 2011, at the end, or outside its known flowering period. No plants were recorded by Geolink during the September (2012) survey and they concluded that the species were unlikely to occur in the survey area. Weather conditions were dry during the survey, but Geolink did not indicate this could have affected the survey results. *R. slateri* was recorded under varying weather conditions at Buladelah (RMS pers.comm.).

3.4.13 Limitations of the Survey

The timing of the survey was appropriate for identification of most potentially occurring threatened or rare species (see Table 3), the great majority of which are perennial, woody plants that can be identified from foliage throughout the year if flowers are not present.

Arthraxon hispidus (Hairy Joint Grass), an annual species, can be overlooked in spring and early summer when plants are still small. However, the plant can still be identified from small seedlings when the observer is familiar with them and it is unlikely the species was overlooked during survey work.

The targeted survey focused on the construction footprint. Vegetation in the outer part of the road reserve was not surveyed as rigorously, as any significant flora in this zone was unlikely to be impacted by construction. Nevertheless, much of the outer road reserve zone was also surveyed during the service utilities flora survey where the latter are mostly located (ECOS Environmental 2012). For any threatened flora individuals in the outer part of the road reserve that may have been missed during

surveys, general prescriptions to minimise clearing and disturbance outside the construction footprint would provide adquate protection (see Section 5).

Most ground orchids tend to be missed by summer flora surveys as most species are autumn to early spring flowering herbs, and flowers are essential for species identificiation. Threatened ground orchid species potentially present in the WC2U road corridor that may have been overlooked by surveys conducted between late Spring and early Autumn include *Diuris sp. aff chrysantha* (Byron Bay Diuris), also known to occur in the Coffs Harbour area, and *Diuris disposita* from the Kempsey area. Diuris species generally flower in August and September, later than most other ground orchid genera. They occur in grassy open forest. The two *Diuris* species were included in the targeted survey conducted by Geolink (2012) in September, but no plants were found.

Plate 15: Flooded Gum wet sclerophyll forest with a well developed rainforest understorey in a gully at Cockburn's Lane, within the highway alignment.

3.5 DISCUSSION - Translocation Feasibility

3.5.1 Introduction

This section discusses the feasibility of undertaking salvage translocation of each of the threatened species directly impacted by the WC2U project, as required by Condition of Approval B7. (Translocation of some additional individuals, indirectly impacted under the current road design, may become necessary if the detailed road design changes after awarding the contract.) The feasibility of undertaking salvage translocation is assessed in terms of several factors including: -

- technical feasibility;
- potential for generation of new and useful scientific information; and
- availability of receival sites with suitable habitat and security of tenure.

These factors were drawn from the translocation principles set out in DECC (2007) "Translocation Policy and Guidelines" (Draft), specifically Policy Principles 1 to 4 ('General') and 22 ('Translocation in context of development consent and approval'). The overall thrust of these principles is that the potential conservation, scientific and educational benefits of translocation should outweigh the potential risks and costs.

3.5.2 Slender Marsdenia (*Marsdenia longiloba*)

Technical feasibility

Slender Marsdenia has been translocated on two previous highway upgrade projects: Bonville Deviation (Benwell and Watson 2011) and Sapphire to Woolgoolga (Benwell 2011). Results for the latter two projects demonstrated that this species has the potential to be translocated successfully.

Bonville Upgrade
Approximately 100 Slender Marsdenia were translocated from the road corridor of the Bonville Upgrade south of Coffs Harbour to two receival sites in 2006-7. Excavation of plants revealed that stems grew from a horizontal rhizome network at a depth of 5-10cm. Stems connected to a piece of rhizome ('stem-individuals') and stemless rhizome pieces were transplanted to pots in October 2006 and grown-on before planting out in the field. Ninety percent of plants and rhizomes survived transplanting to pots and grew rapidly in response to watering and fertiliser.

The potted plants were introduced to two translocation receival sites. The first site (TA1) was planted with 27 vines in February 2007 and the second site with 64 vines in February 2008.

In TA1, the vines grew well for the first six months, but had declined noticeably in vigour after 12 months. After 2 years the survival rate of stem individuals in TA1 was 33%.

In TA2, the 64 vines were planted ou to compare the species' performance on two soil types present at this site – grey clay loam with quartz gravel in the northern half of the site and brown clay loam in the southern half. A similar pattern of stem dieback and decline as recorded in TA1 was recorded in TA2, on both soil types. Plants showing stem dieback were excavated in winter 2009 and the rhizome system was found to be

alive and healthy, but apparently in a dormant or suppressed state, at nearly all planting points. As the rhizome was still alive, the actual survival rate of transplants appeared was substantially higher (~ 80%) than that based on live stems (~25%). Live rhizomes were also found in a sample of plants that had died back in TA2. The decline was even more rapid, the survival rate falling to 22% after one year. After 4 years (2011) the survival rate of stem individuals was 26%, (minor re-shooting in TA2) about the same as TA1.

Monitoring of naturally growing local Slender Marsdenia populations in the road reserve showed no evidence of a seasonal growth pattern, rather new shoot growth could be found at any time of year, even in spring when the soil was relatively dry. There was no obvious relationship between shoot dieback and planting depth, or site variables such as aspect or soil type. However, stem dieback did appear to be induced by the planting treatment. Slow release fertilizer and hay mulch were used at both TA1 and TA2 to stimulate the growth of Slender Marsdenia. After the poor performance of Slender Marsdenia at TAI (planted a year earlier), larger planting holes were dug at TA2 and filled with humus enriched topsoil gathered from the adjacent forest. Slow release fertiliser was again added to the soil, as at TA1. This additional site preparation appeared to result in faster rate of decline after planting out.

The following hypothesis was proposed to explain the decline of Slender Marsdenia recorded in the Bonville translocation project. Slender Marsdenia is a small vine able to compete and co-exist with shrubs and trees by utilizing nutrients released in the topsoil by decomposition of organic matter. It can apparently do this efficiently when nutrients are produced steadily at very low concentration, as in humus enriched topsoil. When artificial fertiliser is added to the soil, it stimulates the roots of shrubs and trees to grown into the root zone of Slender Marsdenia causing increased interspecific root competition with Slender Marsdenia. This suppresses Slender Marsdenia growth and prevents stem growth and replenishment of rhizome food storage, causing the plant to eventually die. In summary, it is hypothesized that Slender Marsdenia is unable to absorb sufficient nutrient under conditions of high interspecific root density or competition.

To test this hypothesis, Slender Marsdenia translocated on WC2U will be directly transplanted to receival sites and planted with and without slow release fertiliser; no other soil improvement will be carried out. If the hypothesis is correct, then Slender Marsdenia plants translocated without addition of slow release fertiliser should show a higher survival rate.

Sapphire to Woolgooga Upgrade

A small number of Slender Marsdenia was transplanted on the Sapphire to Woolgoolga Upgrade. As on the Bonville project, the plants were transplanted first to pots and grown-on before planting out. Eight stem-individuals were introduced to the receipient site in March 2011. Five of these were transplanted stem-individuals and three were grown from rhizome pieces. The plants were introduced without fertiliser or any other nutrient enrichment except for a small amount of cane mulch. All were surviving in October 2011, but by October 2012 most had died back. Although the number of replicates was small, the results show a similar translocation response to the Bonville project (Ecos Environmental 2012). This could be related to the use of

cane mulch, which if fairly rich in nutrient, or the cultivation in pots prior to planting out may be the operative factor leading to dieback.

Translocation Benefits

The following conservation, scientific and educational benefits would flow from the salvage translocation of this species on the WC2U project: -

- Preservation of a high conservation value species (Endangered). Relatively few populations are known to exist.

- Translocation of this species is technically feasible as successful transplanting, propagation and introduction have been carried out before (Benwell and Watson 2011), although further research and trials are required to improve translocation results.

- Translocation could build on insights into the species' ecology gained from the Bonville Translocation Project (Benwell and Watson 2006)

- Suitable translocation receival sites are available in the road reserve and/or adjacent State Forest at no additional cost to the taxpayer.

- Maintenance of (putative) genetic diversity in an endangered species by salvage and reestablishment of individuals that would otherwise be destroyed.

- Maintenance of population numbers of an endangered species by salvage and reestablishment of individuals that would otherwise be destroyed.

Translocation Risks

- The translocated individuals may fail to establish over the long-term.

Various choices are available for recipient sites to establish new or expanded populations of Slender Marsdenia, as detailed in Section 4.3.2 below. Details of performance criteria to assess the success or failure of translocation are presented in Section 4.6.8.

3.5.3 Woolls' Tylophora (*Tylophora woollsii*)

Technical feasibility

Woolls' Tylophora was translocated for the Bonville Deviation in 2006-7 (Benwell and Watson 2011). *Tylophora woollsii* is a small vine similar in appearance to Slender Marsdenia. On the Bonville project a few large *Tylophora woollsii* plants were recorded growing in moist open forest with Slender Marsdenia. Both vines have a rhizome, but in *T. woollsii* it does not appear to ramify and produce adventitious shoots as seen in Slender Marsdenia. *T. woollsii* was successfully transplanted to pots and when planted out grew well for 6-12 months then underwent stem decline, as in Slender Marsdenia. Excavation found that rhizomes were still alive so it appears to have the same problems of competition affecting Slender Marsdenia.

Translocation Benefits

The following conservation, scientific and educational benefits would flow from salvage translocation of this species on the WC2U project: -

- Preservation of a high conservation value species (Endangered). Relatively few populations are known to exist.

- Translocation of this species is technically feasible as successful transplanting, propagation and introduction have been carried out before (Benwell and Watson 2006), although further research and trials are required to improve techniques.

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- Suitable translocation receival sites are available in the road reserve and/or adjacent State Forest at no additional cost to the taxpayer.

- Maintenance of (putative) genetic diversity in an endangered species by salvage and reestablishment of individuals that would otherwise be destroyed.

- Maintenance of population numbers of an endangered species by salvage and reestablishment of individuals that would otherwise be destroyed.

Translocation Risks

- The translocated individuals may fail to establish over the long-term.

3.5.4 Rusty Plum (*Niemeyera whitei*)

Technical feasibility

Rusty Plum has been translocated on two previous highway upgrade projects: Bonville Deviation (Benwell and Watson 2011) and Sapphire to Woolgoolga (Benwell 2011). Results for these two projects demonstrated that Rusty Plum can be translocated successfully.

Bonville Upgrade
A total of 17 Rusty Plums were transplanted for the Bonville Deviation project in 2007 The survival rate after 4 years was 42% (Benwell and Watson 2011). This relatively low survival rate was due to a number of factors, which are avoidable or could be approached differently to improve survival rate. This includes the experimental pruning experiment applied to eight individuals. Factors contributing to the relatively low survival rate at Bonville were:-

- Eight individuals were subject to an experimental pruning/planting treatment to test if it was possible to successfully transplant trees with less pruning. The stem-

branch system was reduced by about one half instead of two thirds or more, as usually carried out. The reduction in pruning resulted in greater transplant death, which appeared to be due to greater physiological stress of a larger shoot system making excessive demands on the impaired root system damaged during transplanting.

- Sub-optimal habitat; most of the receival site was on a grey clay podzol with impeded drainage, which is a sub-optimal habitat for Rusty Plum.
- Clearing mulch applied to the transplants caused yellowing of foliage and loss of vigour by increasing the soil C:N ratio (despite repeated addition of soluble and slow release fertiliser).
- Poor planting technique, the transplants should have been mounded up on the poorly drained clay soil.

Sapphire to Woolgoolga Upgrade
Survival was greatly improved on the S2W project where a site with more optimal habitat was selected. A total of 14 trees and saplings, and five seedlings were transplanted between October 2010 and September 2011. In addition, 68 seeds were planted in the translocation area in November 2010. The survival rate of transplants was 100% after one year and 75% of the introduced seed had germinated and survived after one year.

DECC (2007 p.23) states that "translocation of adult plants usually fails, whereas propagation followed by planting out may be more effective." Our experience with rainforest species translocation shows the opposite is true – the smaller the transplanted individual, the less its chance of survival and propagated seedlings can be difficult to establish in the field. Mature, long-lived resprouters (stress tolerators) transplant much better than obligate seeders. This has been tested on several translocation projects including Yelgun to Chinderah, Bonville and Brunswick Heads to Yelgun.

Translocation Benefits

The following conservation, scientific and educational benefits would accrue from the salvage translocation of this species on the WC2U project:-

- Translocation of this species is technically feasible as successful transplanting and propagation have been carried out before (Benwell and Watson 2011), although there is potential to improve the survival rate (see Sec. 4.4.3). It is noted that DECC (2007) cites Rusty Plum as an example of a species that has failed to translocate successfully (p.7). However, the results of the Sapphire to Woodlgoolga translocation project in particular show that this species can be translocated with a high survival rate.

- Suitable translocation receival sites are available in the road reserve and/or adjacent State Forest at no additional cost to the taxpayer.

- Maintenance of genetic diversity and population numbers by salvage and reestablishment of individuals that would otherwise be destroyed.

- Disturbed habitat will selected as a receival site which will then benefit from habitat restoration

Translocation Risks

- The translocated individuals may fail to establish over the long-term.

DECC (2007 p.23) states that "translocation of adult plants usually fails, whereas propagation followed by planting out may be more effective." Our experience with rainforest species translocation shows the opposite is true – the smaller the transplanted individual, the less its chances of survival and propagated seedlings are difficult to establish in the field. Mature long-lived resprouters (stress tolerators) transplant much better than obligate seeders. This has been tested on several translocation projects including Bonville, Sapphire to Woolgoolga

3.5.5 Maundia (*Maundia triglochinoides*)

Maundia occurs along Williamson's Creek for distance of ~150 m where it crosses the highway corridor. The creek will be re-routed during construction of a new bridge and most of the Maundia along the creek will have to be cleared, within the direct and indirect impact zones. A second population is located in freshwater swamp and adjoining swamp sclerophyll forest southeast of Macksville. Approximately 500 m² is currently estimated to be directly impacted. The total area may be greater, as ~1km section of swamp between mt-82 and mt-92 was not surveyed due to access issues.

Maundia also occurs extensively outside the project boundary. During the 2011 survey, a large area of Maundia dominated freshwater swamp was observed at mt-82 east of the road alignment (see Appendix 1, Figure 11) covering at least 1 hectare outside the project boundary. Other stands of Maundia were recorded in swamp sclerophyll forest west of the project boundary at mt-98 and mt-99 (see Appendix 1, Figure 11).

Recent surveys, particularly in the Lower Macleay district south of the Nambucca have found Maundia to be more common than previously thought. A flora survey targeting Maundia, conducted in 2012 for the Fredrickton to Eungai project (Benwell 2012), found that Maundia was relatively common on the Collombatti Creek floodplain and along creeks leading back into State Forest. During surveys of the same area for the Kempsey bypass EIS several years earlier, Maundia was very rare and present at only one or two locations. These were dry years when freshwater wetland contracted to drainage canals. So it appears that Maundia undergoes large fluctuations in population size and extent depending on rainfall in the current and preceding year. At present Maundia appears to be relatively secure on the NSW Mid North Coast which is at the centre of its distributional range.

The prospects for successfully translocating Maundia are uncertain. It is possible to introduce and establish many aquatic plant species and even whole wetland ecosystems in new areas, as evidenced by the number of plant nurseries dealing exclusively in native aquatic plants. An unsuccessful attempt was made to translocate Maundia by the Royal Botanical Gardens on the Central Coast by the introduction of propagated seedlings. One of the people involved indicated that Maundia seed were difficult to germinate and the seedlings failed to establish when planted out at the translocation site (Benwell 2012). Translocation of this species by transplanting established rhizomes may have a better chance of success, as the root system would already be grown and established. Pacifico has suggested transplanting Maundia from

Williamson's Creek to the re-routed creek, using a machine to move plants and substate together to the new drainage line. The new stream course would be engineered to recreate the still-water pools of the present stream. Transplanting could also be carried out manually for comparison, so that the shoot/leafy part of some plants was not overly damaged during transplanting, but mostly this would be done by machine and aim to regenerate Maundia from rhizome material transplanted with the muddy substrate.

Given the relatively secure status of *Maundia triglochinoides* on the NSW Mid North Coast it is proposed that management of the population on the Nambucca floodplain southeast of Macksville focus on amelioration of impacts to in-situ Maundia growing in wetland outside the direct and indirect impact zones, a significant task in itself. No translocation is proposed for Maundia on the Nambucca flooplain, unless opportunities arise to translocate the species to receival sites within the project boundary such as sed basins. Management will instead focus on protection/minimisation of impacts and monitoring of adjacent in-situ stands outside the direct and indirect impact zones.

During detailed design, emphasis would be placed on minimising impacts to Maundia remaining in-situ within and adjoining the project boundary. Management measures are detailed in Section 4.5.4 below. A well designed monitoring program to study the effect of the new highway on adjoining/in-situ Maundia stands would be of positive benefit both in understanding the effect of infrastructure construction on this wetland species and in clarifying its population dynamics, which appears to follow a boom and bust cycle in some areas (Benwell 2012).

3.5.6 Floyds Grass (*Alexfloydia repens*)

Technical feasibility

The revised concept design indicates that a small area of Floyds Grass is directly and indirectly impacted and would probably require translocation (~6 m²). Floyds Grass was successfully translocated for the Bonville Deviation project in 2006-8. The translocated population was still in good condition in 2013.

Translocation Benefits

The following conservation, scientific and educational benefits would flow from the salvage translocation of this species on the WC2U project: -

- Translocation would help to preserve populations of this high conservation value species (the only population known outside the Bonville-Coffs Harbour area).

- Suitable translocation receival sites are available in the road reserve and/or adjacent lands purchased by RMS.

- Maintenance of genetic diversity and population number by salvage and reestablishment of individuals that would otherwise be destroyed.

Translocation Risks

- The translocated individuals may fail to establish over the long-term due to unforeseen factors

3.5.7 Spider Orchid (*Dendrobium melaleucaphilum*)

Technical feasibility

There appear to be no previous attempts to translocate this species, although epiphytic orchids are commonly taken from the wild and established in cultivation (often illegally). Tranplanting of epiphytic orchid plants would be subject to similar pre-conditions as the other species, such as a suitable receival site with matching habitat, care and appropriate technique during transplanting and follow-up plant care, including watering. Propagation of orchid plants vegetatively or from seed, and introduction to appropriate habitat is considered to have a reasonable chance of success given the plants hardy, drought resistant growth-form, known habitat requirements and propagation capability.

Translocation Benefits

The following conservation, scientific and educational benefits would flow from the salvage translocation of this species on the WC2U project: -

- Translocation would help to preserve populations of this high conservation value species.

- Suitable translocation receival sites are available in the road reserve and/or adjacent lands purchased by RMS.

- Maintenance of genetic diversity and population number by salvage and reestablishment of individuals that would otherwise be destroyed.

Translocation Risks

- The translocated individuals may fail to establish over the long-term due to unforeseen factors

3.5.8 Other species

Of the other three conservation significant plant species recorded during the targeted survey - *Goodenia fordiana, Eucalyptus ancophila* and *Artanema fimbriatum* - translocation would be technically quite feasible for all three species. The ROTAP species *Goodenia fordiana* which is probably easy to transplant and propagate because of its mat forming growth form. Tranlocation of *Artanema fimbriatum* by transplanting or by propagation and introduction is also considered feasible as this was translocated successfully during the Oxley Highway upgrade near Port Macquaried. The ROTAP species *Eucalyptus ancophila* is relatively common in State Forest surrounding the WC2U corridor and for this reason is considered not to warrant translocation. It could be used in landscaping and revegetation, using seed collected during clearing.

Translocation of the rare species *Goodenia fordiana* and *Artanema fimbriatum* would aim to preserve impacted individuals and establish new stands or populations to compensate for those cleared.

3.5.9 Conclusion - Translocation Feasibility

This assessment concludes that salvage translocation of Slender Marsdenia, Woolls' Tylophora, Rusty Plum, Maundia, Floyds Grass and Spider Orchid (threatened species), and Goodenia fordiana and Koala Bells (rare or ROTAP species) is feasible and justified in terms of technical practicality, conservation benefit and advancements in conservation science and translocation techniques. Translocation of Maundia would be limited to the Williamson's Creek population and management of this species elsewhere would focus on minimisation of impacts and monitoring of in-situ stands outside the direct and indirect impact zones.

Four of these threatened species are listed under the TSC/EPBC Acts as Endangered, the highest category of conservation risk, so prevention of any loss to existing populations of these species is necessarily a high priority.

The risk of the translocated individuals failing to establish is lessened by RMS' commitment to follow-up maintenance and monitoring during highway construction and a minimum 5 year period after the completion of construction. Genetic risks to the subject species are not considered significant as all translocations will be limited to relocating individuals within their local population/source area.

Better understanding of threatened species habitat, plant morphology, disturbance response behaviour and population dynamics can be generated by systematic and well monitored salvage translocation, as proposed for the WC2U project.

3.6 DISCUSSION - Compensatory Habitat

3.6.1 Introduction

In relation to MCoA B7 & B8 (see Appendix 5), RMS has requested " A discussion of the process identified for incorporating compensatory habitat for the impacted plants in the Biodiversity Offset Strategy should translocation be identified as not feasible or where monitoring of translocated plants establishes that translocation has been unsuccessful."

3.6.2 Assessing Translocation Outcomes

In the Ministers Condition of Approval B7(c) the preparation of a Biodiversity Offset Strategy for threatened plants appears to be conditional upon the actual or likely outcome of undertaking translocation of the subject species. MCoA B7 (c) states: "*identifies a process for incorporating appropriate compensatory habitat for the impacted plants in the Biodiversity Offset Strategy referred to in Condition B8 should the information obtained during the investigation referred to in Condition B7(a) find that translocation is not feasible or where the monitoring undertaken as part of condition B10 finds that translocation measures have not been successful (as identified through performance criteria);"* In other words, inclusion of threatened plant species in a Biodiversity Offset Strategy would be required if translocation was not considered feasible, or if it was unsuccessful, as demonstrated by monitoring.

Section 3.5 above concluded that it is feasible to undertake translocation of the subject species, in terms of techical feasibility and potential conservation benefit. However it may not be practically possible to demonstrate through monitoring whether a translocation is successful or not over the long-term, because of the slow rate of processes involved in establishing a functional and viable population. There will be element of uncertainty as to the outcome, particulary for perennial, long-lived species that would not complete their life cycle during the time allocated for monitoring.

Monitoring of threatened species translocation for highway development projects managed by RMS is normally undertaken for 5-10 years. Is this long enough to demonstrate whether a translocation has been successful or not? If it is, is the lag time involved in demonstrating success or not, too long to expect a consistent management response several years after the start of highway operation?

Different sets of criteria have been developed for assessing the success of threatened species translocations. For example, Pavlik (1996) sets out a rigorous scheme of proximal (short-term) and distal (long-term) translocation objectives organised under four goals: abundance, extent, resilience and persistence. Typical proximal abundance objectives included "life cycle can be completed in-situ without habitat management; size distribution matches natural populations; and seed output matches natural populations" (see Table 6-1, p. 133). The proximal objectives for the other goals (i.e. extent, resilience and persistence) and the distal objectives for these goals are more complex and unlikely to be demonstrable during the life of a typical monitoring program. Long-lived trees, shrubs and vines may take several years to establish from seedlings, decades to reach reproductive maturity and centuries to demonstrate resilience to environmental perturbations and persistence. In a development context, goals and objectives need to be practically tailored to the species life history and the

time period and resources available for monitoring. Even though Pavlick's criteria are perhaps too rigorous to be practically implemented, they are nevertheless comprehensive and valid for assessing whether a translocation has been successful or not in the long-term (i.e. 20-50+ years).

The outcome of threatened species translocation is therefore inevitably uncertain within the life of a typical monitoring program. The monitoring time-frame is too short to observe the complete life cycle of plants and ecosystem processes such as succession and habitat maturation that may determine if a population persists and reproduces or not. Given the complexity of factors affecting translocation outcomes and the long time period required to establish whether a translocation is successful or not, it would seem appropriate that mitigation measures for impacted threatened plant species include both translocation (where considered feasible) and provision of compensatory habitat containing populations of the same species that can be managed specifically for conservation purposes where feasible and reasonable.

This has been the general approach adopted on other Pacific Highway development projects on the NSW North Coast. For example, the Brunswick Heads to Yelgun, Yelgun to Chinderah, Bonville Deviation and Tugun Bypass projects, all provided compensatory habitat containing populations of impacted threatened species in addition to conducting translocation of the impacted species. On all of these projects, translocation was carried out at least in part to compensatory habitat containing populations of the impacted species, so the provision of compensatory habitat may provide a dual purpose in this regard. The primary benefit of translocation not provided by compensatory habitat is the maintenance of population number and genetic diversity. Without translocation, impacted threatened species would incur a net loss of population number and genetic diversity.

3.6.3 Compensatory Habitat for Threatened Plants

In relation to threatened plants, MCoA B8 provides the following guidelines for developing a Biodiversity Offset Strategy:
"Unless otherwise agreed to by OEH, offsets shall be provided on a like-for-like basis and at a minimum ratio of 4:1 'for areas of high conservation value (including EEC and threatened species or their habitat identified in the Environmental Assessment to be impacted by the project and poorly conserved vegetation communities identified as being more than 75% cleared in the catchment management area) and 2:1 for the remainder of native vegetation areas (including mangroves, seagrass, salt marsh and riparian vegetation). The Strategy shall include, but not necessarily be limited to:
(a) confirmation of the vegetation communities/ habitat (in hectares) to be offset and the size of offsets required (in hectares);
(b) details of the available offset measures that have been identified to compensate for the biodiversity impacts of the project, such as (but not necessarily limited to): suitable compensatory land options and/ or contributions towards biodiversity programs for high conservation value areas on nearby lands (including research programs). Where the use of State Forest land managed in accordance with an lntegrated Forestry Operations Approval is proposed to offset biodiversity impacts, the Proponent shall clearly demonstrate how this would provide the biodiversity outcomes required under this condition including any additional offset requirements to cover residual impacts;

(c) the decision-making framework that would be used to select the final suite of offset measures to achieve the aims and objectives of the Strategy, including the ranking of offset measures;
(d) a process for addressing and incorporating offset measures for changes to impact (where these changes are generally consistent with the biodiversity impacts identified for the project in the documents listed under condition A1, including:
i. changes to footprint due to design changes;
ii. changes to predicted impacts resulting from changes to mitigation measures;
iii. identification of additional species/habitat through pre-clearance surveys; and
iv. additional impacts associated with ancillaryfacilities; and
(e) options for the securing of biodiversity options in perpetuity." (MCoA B8)

3.6.4 Process for Incorporating Compensatory Habitat for Threatened Plants in the Biodiversity Offset Strategy

1) Identify the threatened species impacted.

2) Determine the type and extent of the habitat of the threatened species impacted

3) Determine the number of individuals (or other demographic measure as appropriate) of the threatened species impacted.

4) Determine the area of habitat of the threatened species impacted.

5) Determine the minimum quantity of mitigation at a ratio of 4:1 for number of individuals and habitat area of the threatened species impacted, according to MCoA B8.

6) Conduct desktop assessment of areas likely to contain suitable compensatory habitat for the subject species.

7) Conduct field survey to confirm that necessary attributes are present in nomimated areas - i.e. populations of the subject species, sufficient habitat area and suitable habitat condition.

8) Selection of appropriate compensatory habitat land for threatened plants, would be guided by the following criteria:

    - The compensatory habitat to be within 20km of the WC2U corridor.

    - The compensatory habitat to provide the same type of threatened species habitat to that removed (i.e. geology, soil type, topography, plant community).

    - The compensatory habitat to support populations or sub-populations of the subject threatened species similar in configuration to that removed.

    - The compensatory habitat to also contain suitable unoccupied recipient sites for conducting the translocation of impacted species, with the goal no net reduction in the local population of each species.

- Preferably the compensatory habitat would adjoin an existing Nature Reserve or National Park and be incorporated into NPWS estate.

- In accordance with MCoA B8, "Where the use of State Forest land managed in accordance with an lntegrated Forestry Operations Approval is proposed to offset biodiversity impacts, the Proponent shall clearly demonstrate how this would provide the biodiversity outcomes required under this condition including any additional offset requirements to cover residual impacts."

3.6.5 Determining the Type and Area of Threatened Plant Species Habitat

Several types of habitat would be required for compensatory habitat according to the different habitat preferences of the subject species:

- Wet sclerophyll forest in hilly terrain on Nambucca Beds geology.
- Well shaded rainforest understorey in wet sclerophyll forest, or swamp forest dominated by Melaleuca stypheloides.
- Riparian Swamp Oak forest.
- Freshwater wetland.

Table 5: Habitat types required to provide compensatory habitat for impacted threatened species on the WC2U upgrade.

Threatened Species	Habitat Type Required
Slender Marsdenia (*Marsdenia longiloba*)	Wet sclerophyll gully in hilly terrain on Nambucca Beds geology
Rusty Plum (*Niemeyera whitei*)	Wet sclerophyll gully on Nambucca Beds or hornfels geology
Wooll's Tylophora (*Tylophora woollsii*)	Wet sclerophyll gully on Nambucca Beds geology
Spider Orchid (*Dendrobium melaleucaphilum*)	Rainforest understorey in WSF; Swamp sclerophyll forest dominated by *Melaleuca styphelioides*
Floyds Grass (*Alexfloydia repens*)	Floodplain riparian Swamp Oak forest
Maundia (*Maundia triglochinoides*)	Freshwater wetland or swampy stream margin.

Determining the area of impacted threatened plant species habitat is not straight forward. For example, where does the habitat of a threatened species start and end? Are we referring to actual or potential threatened species habitat? Is the actual and potential habitat also dependent on adjoining habitats or plant communities to provide topographic shelter and protection?

The simplest approach may be to calculate the area of plant communities that provide habitat for the threatened species, according to the vegetation mapping in the EA, and multiple by four. A potential complication here is that there may be inaccuracies in the vegetation mapping and description, so that the mapped and field vegetation types do not correspond well, which was noted in a few cases during targeted survey. This would have to be considered in detemining the appropriate type and area of compensatory habitat.

4 TRANSLOCATION PLAN

4.1 Introduction

This section of the Threatened Flora Management Plan sets out a plan to translocate threatened plant species directly impacted by construction of the Warrell Creek to Urunga Upgrade of the Pacific Highway (Table 6), in accordance with Ministers Condition of Approval B7.

In addition to the two species specified in MCoA B7 (*Marsdenia longiloba* and *Niemeyera whitei*), RMS would also undertake the translocation of other threatened and rare (ROTAP) species recorded during the targeted flora survey, which are directly impacted by project works, as described in Section 3.

Table 6: Threatened and rare species directly impacted by the WC2U upgrade and included in this translocation plan.

Species	**Conservation Status**
Threatened Species	
Slender Marsdenia (*Marsdenia longiloba*)	TSC Act (V); EPBC Act (E)
Wooll's Tylophora(*Tylophora woollsii*)	TSC Act (E); EPBC Act (E)
Floyds Grass(*Alexfloydia repens*)	TSC Act (E)
Spider Orchid (*Dendrobium melaleucaphilum*)	TSC Act (E)
Rusty Plum (*Niemeyera whitei*)	TSC Act (V)
Maundia (*Maundia triglochinoides*)	TSC Act (V)
Other Species	
Ford's Goodenia (*Goodenia fordiana*)	ROTAP
Koala Bells (*Artanema fimbriatum*)	Potential Threatened Species Listing

The translocation plan has been structured according to the format recommended by the Australian Network for Plant Conservation (2004), as summarised below:

- Section 4.1 - Introduction.
- Section 4.2 - General Considerations - discusses the type of translocation action to be carried out, the objectives of the translocation project, designing translocated populations, genetic management and the advantages of incorporating experimental design.
- Section 4.3 - Pre-translocation Assessment - describes the selection of receival sites and the ecology of the subject species.
- Section 4.4 - The Translocation Proposal - outlines the overall translocation approach.
- Section 4.5 – The Species Proposals – outlines the proposals for each species to be to be translocated
- Section 4.6 - The Translocation Action - details how the translocations will be carried out.

- Section 4.7 - Post-translocation Actions - describes follow-up measures including maintenance, habitat restoration, monitoring and project evaluation.

Table 7: below provides definitions of various technical terms used in the translocation plan

Technical term	Definition
Translocation	The deliberate transfer of plants or regenerative plant material from one place to another, including existing or new sites or sites where the taxon previously occurred. (This term is synonymous with re-introduction.)
Transplanting	A translocation technique where plants are dug or excavated from the ground and moved to another site. Individuals translocated in this way are referred to as 'transplants'.
Propagation	A translocation technique or approach where plants are propagated (e.g. seed, cuttings, tissue culture) under nursery conditions then introduced to a site.
Threatened species	Plant taxa in danger of extinction and protected by state or federal environmental legislation.
ROTAP Species	Rare Or Threatened Australian Plants listed in Briggs and Leigh (1995)
Population	In a general sense, a group of individuals sharing some common relationship (e.g. spatial, genetic, morphological). In one sense, a group of individuals in which there is free breeding and gene exchange.
Provenance	A genetically distinct area of a species distribution and usually thought to represent genetic adaptation to local environmental conditions.
In-situ	The original place; pertaining to the maintenance of plants in the wild.
Genetic variability	Variation in the genetic composition between individuals and populations.
Inbreeding	The mating of individuals related by descent, usually causing a reduction in gene heterozygosity and diversity.
Inbreeding depression	A reduction in vigour and fitness due to inbreeding.
Self-sustaining	A population of plants that maintains itself without external assistance.
Local population	An assemblage of individuals belonging to the same species occurring within 5 km of the project within similar habitat in terms of soil type and plant community.
Enhancement	An attempt to increase population size or genetic diversity by adding to individuals to an existing population. This may be part of the process of restoration or reconstruction of a site where the taxon occurs, but requires population manipulation to increase viability. Also referred to as re-enforcement, re-stocking, enrichment, supplementation or augmentation.
Reintroduction	An attempt to establish a population in a site where it formerly occurred, but where it is now extinct. This may be part of the process of restoration or reconstruction of a habitat where the taxon was previously known to occur. Also, referred to as re-

	establishment
Conservation	An attempt to establish a taxon, for the purposes of introduction conservation, at a site where it is not known to occur now or to have occurred in historical times, but which is considered to provide appropriate habitat for the taxon."
Salvage dig	The transplantation of mature plants or soil to an area not affected by the development. Also referred to as transplantation or rescue dig. Salvage digs are likely to be the least effective method of translocation and should only occur when combined with other translocation methodologies.
Ameliorative enhancement	An attempt to increase population size by adding individuals to an existing population to ameliorate the loss of part of that population due to development.
Compensatory	The establishment of a population to compensate for the introduction impact of a development. In the majority of cases such translocations will meet the definition of introduction as described above.

4.2 General Considerations

4.2.1 What Kind of 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). Translocation is carried out in two main contexts: (i) as a research or conservation measure to assist in the recovery of threatened or rare species, and (ii) as a mitigation measure to ameliorate the adverse impact of a development activity (Falk *et al.* 1996, ANPC 2004). Translocation in both of these cases has the same general conservation purpose, which is to avoid loosing populations of threatened species and increasing the risk of population extinction (Pavlik 1996).

Under translocation for conservation purposes, three types of translocation are described by ANPC (2004):-

Enhancement: An attempt to increase population size or genetic diversity by adding to individuals to an existing population. This may be part of the process of restoration or reconstruction of a site where the taxon occurs, but requires population manipulation to increase viability. Also referred to as re-enforcement, re-stocking, enrichment, supplementation or augmentation.

Reintroduction: An attempt to establish a population in a site where it formerly occurred, but where it is now extinct. This may be part of the process of restoration or reconstruction of a habitat where the taxon was previously known to occur. Also, referred to as re-establishment.

Conservation introduction: An attempt to establish a taxon, for the purposes of conservation, at a site where it is not known to occur now or to have occurred in historical times, but which is considered to provide appropriate habitat for the taxon.

Under the heading of ameliorative or developmental translocation, three types of translocation are described: -
Salvage dig: The transplantation of mature plants or soil to an area not affected by the development. Also referred to as transplantation or rescue dig. Salvage digs are likely to be the least effective method of translocation and should only occur when combined with other translocation methodologies.

Ameliorative enhancement: An attempt to increase population size by adding individuals to an existing population to ameliorate the loss of part of that population due to development.

Compensatory introduction: The establishment of a population to compensate for the impact of a development. In the majority of cases such translocations will meet the definition of introduction as described above.

The translocation proposed for the WC2U project involves three complementary activities:- salvage translocation, population enhancement and experimentation. Salvage translocation aims to save and re-establish those individuals of significant flora directly impacted by construction. Enhancement aims to improve the prospective viability of the translocated population by propagating and introducing additional individuals. This is consistent with ANPC (2004) that recommends salvage translocations be combined with population enhancement to improve translocation outcomes. The experimental component aims to increase understanding of species ecology and how ecological factors affect translocation outcomes. Translocation presents a unique opportunity to conduct systematic research by conducting field manipulation of plants and growing conditions during the translocation process. It should be noted that while the proposed translocation involves an experimental component, the focus will be on ensuring successful salvage translocation and population enhancement.

4.2.2 WC2U Translocation Objectives

The overall objective of threatened plant translocation is to establish populations that are self-sustaining over the long term. To demonstrate successful translocation in the short-term the species concerned should be able to carry out basic life-history processes (i.e. healthy growth, reproduction, dispersal and recruitment) such that the probability of local extinction by random factors is low. Pavlik (1996) distinguished between short term goals (abundance, extent) and long-term goals (resilience and persistence). "Whereas abundance and extent can develop over short periods of time (1-10 years) and be directly influenced by design aspects of the (translocation) project, resilience and persistence are only tested over long periods of time (one to several decades) by natural variation in the environment and in the new population itself." (Pavlik 1996, p. 130).

It is also necessary to distinguish between biological success and project success in defining objectives. Biological success includes the performance of individuals or populations of the target taxon. Project success is broader. With an experimental design and careful monitoring, a translocation project can be successful even if its new population fails, by contributing to our knowledge of threatened or rare plants or by developing new management techniques, although mitigation efforts are usually required to achieve some level of biological success (Pavlik 1996).

Pavlik (1996) erected a scheme of proximal (early) and distal (late) objectives organised under the four translocation goals of abundance, extent, resilience and persistence. However, the scheme is suited to annual and short-lived perennial plants rather than long-lived rainforest trees and shrubs on the WC2U project. These may take several years to establish from seedlings, decades to reach reproductive maturity and centuries to demonstrate resilience to environmental perturbations and persistence. Objectives need to be practically tailored to species life history and the time period and resources available for monitoring.

Objectives and performance criteria that can be assessed in the short term whilst at the same time being consistent with and promoting longer term goals would be more appropriate.

In this context, the general objectives of this translocation project are defined as follows:

- To transplant and successfully re-establish impacted individuals of the subject species (and other significant species) at a nearby site with soil type and topography closely matching the original site of each species;
- To promote the long-term sustainability of the founder (translocated) population by enhancing population size and genetic diversity through propagation and introduction of additional individuals;
- To promote long-term sustainability by restoring good quality habitat and establishing functional habitat conditions;
- To undertake translocation using a monitored, experimental approach that improves knowledge of species ecology and translocation technology; and
- To preserve individuals of the subject species (and other significant species) in-situ wherever possible and limit transplanting to individuals directly impacted construction.

4.2.3 Designing Translocated Populations

According to Bottin *et al.* (2007) successful translocation depends on three criteria:-

- Consistency between the environmental characteristics of the translocation receival site and the ecological needs of the species;
- Sufficient population size; and
- Sufficient genetic variability.

Selecting suitable habitat for rare plant introductions can be far from self-evident. Consideration must be given to physical, biological, logistical and historical criteria (Fiedler and Laven 1996). These criteria were applied to the site selection process for this project, as described below (Section 4.3.2). Maintaining sufficient levels of genetic variability is discussed in Sec. 4.2.4 and 4.4.1.2. The remainder of this section is concerned with determining a sufficient size for initial or founder populations of the subject species.

"Models that predict extinction probabilities can be used to set a long-term abundance objective by determining the minimal viable population (MVP) size of a new population for its specific environment. One definition of MVP is the smallest number of individuals required for a 95% probability of survival over one hundred years. But

applying such model predictions to a practical conservation effort is often specious and always difficult" (Pavlick 1996, p. 135).

There are no magic numbers for establishing populations with good long-term prospects for survival, but research has defined a range in which to begin. "Selection of an appropriate minimum viable population (MVP) size depends on the life history characteristics of the target species. Long-lived, woody, self-fertile plants with high fecundity would have an MVP in the range of 50 to 250 individuals" (Pavlick 1996, p. 137). The subject species to be translocated on the WC2U project fall within this general life history class, although fecundity appears not particularly high in some species. The minimum number of individuals in a self-sustaining population would therefore be 50. As a proportion of the individuals introduced as seedlings or propagated cuttings would be subject to selection and mortality or thinning of the initial population, the population introduced would need to be significantly larger than the MVP size. It is suggested that the translocation project aim at introducing two to three times the minimum MVP (100-150) to allow for mortality and thinning of the initial population.

4.2.4 Genetic Management

Genetic factors can play an important role in the short-term establishment and long term resilience and persistence of translocated populations. Ideally, a translocation project would include a genetic survey to determine the genetic structure of existing populations and appropriate level of genetic diversity in the translocated population. If information on genetic variation is not available, habitat type (e.g. geology, soil type, elevation, topographic position and associated plant community) and geographic distance can be used as surrogates for genetic variability and a basis for demarcating provenances. Studies have found that the genetic dissimilarity of populations usually increases as the distance between them increases so that geographic distance can be used as an indirect measure of the genetic difference between populations. This spatio-genetic relationship does not always apply though, as some species can be genetically homogeneous over large distances (Bussel et al. 2006) and marked genetic differentiation can occur over very short distances if there are abrupt changes in soil type or other aspects of habitat (Benwell 2011).

Conservation geneticists generally recommend that the best strategy for facilitating the persistence and evolutionary flexibility of species is by maintaining genetic diversity and heterozygosity in populations (Hopper and Coates 1990; Ellstrand and Ellam 1993; DECC 2007. Poorly selected genetic material can result in inbreeding or outbreeding depression, and loss of genetic flexibility to cope with changing environments. Consideration of genetic issues in a species translocation requires a balance between maximising genetic diversity, helping to purge deleterious alleles, avoiding breaking co-adapted gene complexes and avoiding importation of mal-adapted genes (Bottin et al. 2007).

The origin of introduced plants is the key issue here. Individuals are more likely to be adapted to site if they originate from the same site or locale, have been subject to a short ex situ period (e.g. during propagation or storage), or are from another population connected by gene flow (Bottin et al. 2007). In a salvage translocation context, the potential for introduction of inappropriate genetic material is probably low if individuals are relocated within the bounds of their local population, unless that

population has already become inbred or genetically homogenised due to the effects of clearing. There may also be genetic risks if population enhancement is undertaken. For this project, the following procedures would be implemented to promote genetic diversity and avoid introduction of inappropriate genetic material during species translocation and habitat restoration:-

- Propagate from local (<10km) provenances.
- Where possible the source populations used for propagation should contain more than 10 mature individuals.
- Select propagation material from a broad sample of parent plants within local area.
- Limit the number of seedlings introduced from any one source individual to a maximum of 15% of the total number introduced.
- Avoid planting seedlings/cuttings propagated from the same parent plant close to each other.
- Label and monitor all plants throughout the translocation process.
- No more than 5% of reproductive material or available cuttings to be removed from a parent plant (unless it is going to be destroyed).

4.2.5 Experimental Component

Translocation projects incorporating experimental design can generate useful information on translocation techniques and species ecology (Guerrant 1996). For example, Ecker (1990) salvaged a number of plants of the rare cactus *Mammillaria thornberi* from a construction right of way in Arizona before their habitat was developed. Some of this material was used experimentally to test a number of hypotheses about how best to transplant it; planting cactus under nurse plants, especially creosotebush (*Larrea tridentata*) proved to be most successful. Experimental translocations of three endangered plants undertaken in South Australia confirmed the impact of specific site factors (weed competition, grazing and physical microsite factors) thought to affect the survival and establishment of seedlings of each species (Jusaitis 2005). Guerrant and Kaye (2007) recommended that translocation projects are best done as well designed scientific experiments that test explicit hypotheses.

An experimental approach would be incorporated in the WC2U translocation project where practical and not overly jeopardizing species survival 'targets' (i.e. experimentation may involve subjecting species to sub-optimal growth conditions). Experimental comparisons can produce valuable insights into species ecology and improve translocation techniques, both of which can assist species recovery. Salvage translocation can also test techniques for assisted migration or geographical transfer of species in response to climate change (DECC 2007). For example, the successful translocation of the endangered species Floyds Grass (*Alexfloydia repens*) at Bonville (Ecos Environmental 2009) demonstrated how this species could be relocated if its estuarine habitat is threatened with inundation by rising sea level, as predicted to occur this century due to global warming.

For the WC2U project it recommended that further research be conducted on Slender Marsdenia in particular, to clarify its life history attributes, population dynamics and site requirements. This is considered appropriate given the level of impact of the project on this species.

4.3 Pre-translocation Assessment

4.3.1 Species Ecology

4.3.1.1 Slender Marsdenia (*Marsdenia longiloba*)

Regional Distribution: Slender Marsdenia occurs between the Hastings River district (Port Macquarie) and southeast Qld and from the coast inland to the Great Escarpment ranges, at widely scattered locations.

Local Distribution: Slender Marsdenia was recorded in the Raleigh south, Newry State Forest, Little Newry State Forest, Valla south, Nambucca State Forest and Warrell Creek sections of the WC2U corridor. A total of 189 stem-individuals were recorded in at least 22 different sub-populations.

Habitat: Found in moist open forest and gradational subtropical and warm temperate rainforest, mostly below 200m altitude (Quinn *et al.* 1995). Characteristics of Slender Marsdenia habitat recorded on the WC2U road corridor included: -

- soil type a yellow to red clay podzol formed on Permian metasediments;
- soil A-horizon 15-30cm deep, dark brown, humus enriched topsoil;
- wet sclerophyll forest with an open to mid dense rainforest understorey usually on a lower slope;
- sloping (gentle to moderate) and well drained, often with a southern aspect;
- understorey moderately well lit and open, not dense or heavily shaded;
- topsoil only slightly acidic (pH >6).

Life History and Population Dynamics: Benwell and Watson (2011) have recorded the life history attributes of Slender Marsdenia during translocation and monitoring of this species for the Bonville upgrade near Coffs Harbour, as follows:-

- Slender Marsdenia is a small, perennial, rhizomatous vine.
- Sub-populations are composed of single-stemmed ramets growing from underground rhizomes; several stems may be attached to the same branching rhizome.
- Above ground stems are comparatively short-lived (1-10 years), while the rhizomes are probably more long-lived.
- The rhizomes are relatively thin, 10-30cm long and grow horizontally within the soil A1 horizon (occasional vertical rhizomes are also present); the rhizomes ramify through the soil, budding off and separating from the parent rhizome to form separate plants.
- Plants may die back to the rhizome and remain stem-less and dormant for up to two years (probably longer), then produce new stem shoots.
- Most stem-individuals never grow more than 30cm tall before dying back.
- Only large stem-individuals (ie >1m tall) produce flowers; production of pods and seed is extremely rare; only 1 pod has ever been recorded during several years of monitoring at several locations.
- *Marsdenia longiloba* appears to rely on vegetative reproduction for population persistence; flowering and seed dispersal play a minor role in this process.

- Discrete sub-populations and patches of *Marsdenia longiloba* may originate vegetatively from the same parent plant and spread over a considerable area (e.g. 0.04 ha).
- *Marsdenia longiloba* stems are conspicuously absent from recently (<1-6 yrs) logged or burnt forest, although monitoring of translocation areas has shown that quiescent rhizomes may be present in the soil. This suggests that conditions during early post-disturbance succession are not favourable for growth of *Marsdenia longiloba,* and stem growth may occur mainly during mid to late stages of succession. The response of *Marsdenia longiloba* to fire has never been monitored.

Transplanting potential: Slender Marsdenia has been transplanted successfully (Benwell and Watson 2011).

Propagation potential: Slender Marsdenia has been propagated successfully from rhizome pieces (Benwell and Watson 2011).

Recovery Plan: A Draft Recovery Plan has been prepared for the Slender Marsdenia.

4.3.1.2 Wooll's Tylophora (*Tylophora woollsii*)

Regional Distribution: *Tylophora woollsii* occurs from the Hawkesbury River north to Byron Bay and the Qld border, and from the coast inland to the Great Escarpment Ranges. There is a concentration of records in an arc extending from Coffs Harbour-Bellinger Valley northwest to Dorrigo district and Gibraltar Range (Wildlife Atlas).

Local Distribution: *Tylophora woollsii* was recorded at three locations on the WC2U corridor:- between Raleigh and the Kalang River, Newry State Forest and Nambucca State Forest. Single plants were found at two locations and two plants at the third location. This species may have been under-recorded as its leaves are very similar to *Marsdenia longiloba*. Generally, the species appeared to be very rare; all individuals were small plants.

Habitat: The species is found in rainforest and wet sclerophyll forest. Quinn *et al.* (1995) describe the habitat of this species as "brown clay over metasediments in wet sclerophyll forest at altitudes between 10 and 750 m." In the Coffs Harbour area it occupies the same habitat as *Marsdenia longiloba*, which is moist open forest on mid to upper, SE/S-facing hillslopes with a weakly developed rainforest understorey.

Life History and Population Dynamics: Little is known about the life history and population dynamics of *Tylophora woollsii*.

Transplanting potential: *Tylophora woollsii* has been transplanted successfully.

Propagation potential: *Tylophora woollsii* has been propagated successfully from rhizome pieces.

Recovery Plan: A Draft Recovery Plan has been prepared for the Woolls' Tylophora (Draft).

4.3.1.3 Rusty Plum (*Niemeyera whitei*)

Regional Distribution: Found from the Macleay River north to upper Tallebudgera Creek inland from the Gold Coast (Floyd 1989). The distribution of *Niemeyera whitei* is characterised by separate northern and southern meta-populations (NPWS 1998). The northern meta-population is restricted to the Mt Warning Shield on the NSW-Qld border. The southern meta-population occurs from the Coffs Harbour district south to Ingalba State Forest, and inland to the Dorrigo and Upper Bellinger districts (Wildlife Atlas). It is also reported from the Port Macquarie district (Harden 2000), which appears to represent a small, disjunct, southern population.

Habitat: Typical habitat consists of gully rainforest or wet sclerophyll forest with a well-developed rainforest understorey on medium fertility soil formed on metasediment or rhyolite. The altitudinal range of this species is from near sea level to 600 m (Floyd 1989).

Local Occurrence: *Niemeyera whitei* was recorded at two locations: Boggy Creek near Valla and Cockburn's Lane south of Warrell Creek. A single small tree was recorded at Boggy Creek and 17 trees and saplings plus seedlings were recorded in a 150 meter long section of the road corridor at Cockburn's Lane. The trees were up to 10 metres in height with a maximum diameter of about 30 cm.

Life History and Population Dynamics: Rusty Plum appears to be a long-lived tree. Field observations indicate that trees and saplings of this species recover from natural or man-made disturbance by epicormic and to lesser extent basal resprouting.

Transplantation potential: This species can be transplanted with a moderate to high success rate depending on choice of site (Benwell and Watson 2011).

Propagation potential: This species propagates readily from seed, which ripen in November in the Coffs Harbour area (Benwell and Watson 2011).

Recovery Plan: No Recovery Plan has been prepared for this species.

4.3.1.4 Floyd's Grass (*Alexfloydia repens*)

Regional Distribution: The species is only found between Coffs Harbour and Warrell Creek within 10km of the coast.

Local Distribution: Floyds Grass was recorded at one location on the northern bank of Warrell Creek on the eastern and western sides of the project boundary.

Habitat: The habitat of Floyd's Grass has been described as "coastal stands of Swamp Oak and Paperbark in peat-like soil edging the upper tidal areas of mangroves. It is known to grow on the banks of estuarine creeks." (DEC species profile). On Bonville Creek south of Coffs Harbour, Floyd's Grass occurs on estuarine levees and the edge of back-levees, in floodplain open forest and swamp sclerophyll forest, respectively. In Swamp Oak forest it occurs just above the king tide zone. Swamp Oak extends well into the king tide zone which appears to be unsuitable for Floyds Grass.

At Warrell Creek, Floyds Grass occurs in a narrow zone 1-2 metres wide on the edge of the creek in Swamp Oak forest. The soil type is a humus-enriched, clay loam formed on alluvium.

Life History and Population Dynamics: Translocation and monitoring of Floyds Grass for the Bonville Upgrade (Benwell and Watson 2011), yielded the following information on the species' life history and population dynamics:-

- *Alexfloydia repens* is a perennial, stoloniferous, matt-forming grass.
- The species spreads by stolons or runners. When introduced to Swamp Oak Forest after clearing the understorey and ground layer of exotics, stolons grew up to 2.4 metres long in 12 months.
- On bare ground formed either artificially, or as a result of flood erosion and dieback of ground layer vegetation, Floyds Grass can regenerate rapidly from runners to form a dense cover.
- Flowers are produced very sparsely in forested situations (ie. habitat with a tree canopy) and abundantly in more open habitat, where the vegetation structure has been simplified by disturbance (ie. tree clearing).
- To persist at a location *Alexfloydia repens* relies on vegetative regeneration after disturbance rather than seedling recruitment; new bare sites may be colonised by seed dispersal and seedling establishment, although there is little evidence to indicate this occurs frequently.
- Established ground cover vegetation forms a barrier to the spread of runners.
- The common native grass *Ottochloa gracillima* appears to compete strongly with Floyds Grass as they two species occur together in mutually exclusive patches in essentially the same habitat.

Transplanting potential: The stoloniferous growth habitat of Floyds Grass makes it relatively easy to transplant (Benwell and Watson 2011).

Propagation potential: Floyds Grass can be propagated vegetatively (Benwell and Watson 2011).

4.3.1.5 Spider Orchid (Dendrobium melaleucaphilum)

Regional Distribution: *Dendrobium melaleucaphilum* is an epiphytic orchid found in coastal districts and nearby ranges from lower Blue Mountains north to Qld. In NSW, it is currently known from seven recent collections.

Local Distribution: *Dendrobium melaleucaphilum* was recorded at two loocations within the project boundary - north of the Kalang River, where only one mature plant was found, and in Newry State Forest. Other occurrences have been recorded in Newry State Forest outside the road alignment

*Habita*t: *Dendrobium melaleucaphilum* is an epiphytic orchid, which grows in swamp sclerophyll forest, wet sclerophyll forest and rainforest in coastal areas, often on Prickly Paperbark (*Melaleuca stypheliodes*).

Life History and Population Dynamics: There is little information on the life history of this species. Orchids in general produce large quantities of very fine, wind dispersed seed. The seed germinates on a suitable substrate, in this case the rough

papery bark of *Melaleuca stypheliodes,* where it must then be infected with a specific fungal symbiont in order for the plant to grow.

Transplanting potential: Dendrobium species transplant in cultivation with a high success rate as they have tough desiccation resistant leaves and a perennial pseudobulb from which new shoots will grow if the plant dies back. A high survival rate is also likely to be dependent on selection of an appropriate receival site and maintenance while plants become established.

Propagation potential: Dendrobium species can be propagated vegetatively or from seed.

Recovery Plan: A Recovery Plan has not been prepared for *Dendrobium melaleucaphilum.*

4.3.1.6 Ford's Goodenia (*Goodenia fordiana*)

Regional Distribution: Fords Goodenia is endemic to the NSW Lower North Coast between Coffs Harbour and Buladelah and is listed as nationally rare (Briggs and Leigh 1995).

Local Distribution: Ford's Goodenia was recorded at eight locations in the Raleigh south, Newry State Forest and Nambucca State Forest areas. It was most common in the Raleigh south area. This prostrate ground-cover herb forms patches up to about 0.5m wide.

Habitat: Found in gully wet sclerophyll forest under moderate to dense shade. The soil type is clay podzol formed on Permian metasediment.

Life History and Population Dynamics: Ford's Goodenia appears to regenerate vegetatively from stolons and by seed dispersal.

Transplanting potential: The stoloniferous growth form of Ford's Goodenia indicates that it can be transplanted with a high success rate, given appropriate receival site selection and maintenance during establishment.

Propagation potential: Probably vegetatively or from seed.

Recovery Plan: A Recovery Plan has not been prepared for *Goodenia fordiana*.

4.3.1.7 Koala Bells (*Artanema fimbriatum*)

Regional Distribution: The North Coast of NSW from Forster north to the Qld border (Wildlife Atlas) and also eastern Queensland.

Local Distribution: *Artanema fimbriatum* was recorded at a total of ten locations in the Raleigh, Raleigh south, Valla, Valla south and Nambucca State Forest areas.

Habitat: Koala Bells was found mainly in damp (not swampy) floodplain sites and occasionally in wet sclerophyll forest crossed by tracks. Vegetation varied from open

floodplain forest, swamp sclerophyll forest, clearings in dense wet sclerophyll forest and cleared or regenerating vegetation. At least half the occurrences were associated with track or clearing disturbance where patches of seedlings had established on bare soil.

Life History and Population Dynamics: Regenerates from seed on tracks where the soil has been disturbed.

Transplanting potential: Best to transplant in spring.

Propagation potential: Can be propagated from seed or cuttings.

Recovery Plan: A Recovery Plan has not been prepared for *Artanema fimbriatum*.

4.3.1.8 Maundia (*Maundia triglochinoides*)

Regional Distribution: From Botany Bay north into south eastern Queensland.

Local Distribution: Only know locally from the wetland southeast of Macksville and Williamson's Creek

Habitat: Freshwater swamps, swamp sclerophyll forest, flowing creeks with pool and riffle sections, farm dams and channels.

Life History and Population Dynamics: Apparently grows as a long-lived perennial in permanent swamps, or if the swamp drys out it can persist as dormant seed in the soil. Capable of rapid population increase during periods of high rainfall and flooding conditions. The plant is rhizomatous and appears to spread by vegetative spread and seedling establishment (Benwell 2012).

Transplanting potential: Best to transplant in late spring.

Propagation potential: Can probably be propagated from rhizome cuttings.

Recovery Plan: A Recovery Plan has not been prepared for *Maundia glochinoides.*.

4.3.2 Description of the Original/Donor Site

The Warrell Creek to Urunga Upgrade of the Pacific Highway is located on the Mid North Coast of NSW between Allgomera south of Warrell Creek and the Waterfall Way interchange at Raleigh, a distance of 42kms. The road corridor includes two landscape types: Alluvial Plains and Coastal Hills (see Section 1.2.2). Alluvial floodplains are present on the Nambucca and Kalang Rivers and smaller creeks such as Deep Creek, Boggy Creek and Oyster Creek. Soils are formed on Quaternary alluvium. Forested areas are dominated by swamp sclerophyll forest, particularly Swamp Oak, and mixed floodplain forest.

Coastal Hills surrounding the coastal floodplain are underlain by Permian metasediments. Characteristic soil types include thin, stony gradational loam on the slopes grading to yellow-brown texture-contrast soils on lower slopes and in valleys.

Forested areas are dominated by dry sclerophyll forests with moist sclerophyll forests in gullies.

The seven threatened and rare species proposed for translocation are associated with two habitat types: gully wet sclerophyll forest and alluvial floodplain forest (Table 8). Receival sites would be required that match the donor sites habitat characteristics.

Table 8: Habitat characteristics of donor sites where threatened species would be translocated from.

Broad habitat type	Threatened Species	Specific habitat type
Wet Sclerophyll Forest (wsf)	Slender Marsdenia (*Marsdenia longiloba*)	gully wsf on Permian metasediments, mostly lower slope and south aspect
	Rusty Plum (*Niemeyera whitei*)	gully wsf or perennial stream bank in hilly terrain on Permian metasediment
	Wooll's Tylophora (*Tylophora woollsii*)	gully wsf on Permian metasediments, lower slope, south aspect
	Ford's Goodenia (*Goodenia fordiana*)	gully wsf on Permian metasediments, lower slope, south aspect
	Koala Bells (*Artanema fimbriatum*)	wsf and open forest Permian metasediments, or alluvial floodplain
Alluvial Floodplain	Floyds Grass (*Alexfloydia repens*)	alluvial floodplain with Swamp Oak forest adjoining a creek
	Spider Orchid (*Dendrobium melaleucaphilum*)	alluvial floodplain supporting swamp sclerophyll forest or wsf

4.3.3 Selection of the Receival Site

Prospective recipient sites were required to meet the following criteria:-

- abiotic environment - soil type and topography closely matching the donor site;
- plant community – vegetation (extant or original) closely matching the donor site;
- site disturbed or partially cleared with regrowth, rather than undisturbed;
- close to a water source;
- the site of suitable size and area;
- accessible to vehicles and machinery, preferably with an existing access track;
- tenure suited to long-term conservation;
- close proximity to the original location of impacted individuals;
- no likelihood of impact during highway construction and operation;
- not affected by installation of new service utilities; and
- control of exotic plants in and around the translocation site is feasible.

Four types of land tenure were considered as possible receival sites for threatened species translocated from the WC2U project:

- State Forest adjoining the WC2U road corridor.
- Road reserve within the WC2U project boundary, but outside the construction footprint.

- Properties adjoining the WC2U corridor purchased by RMS, the residual land to be sold on by RMS after completion of highway construction.
- Land purchased by RMS to provide compensatory habitat for the WC2U project.

These tenures were assessed as follows: -

State Forest
State Forest was considered suitable for the location of translocation receival sites (particularly for threatened species were impacted where the road corridor crossed State Forest), as long the receival sites did not interfere with future logging operations. The visual amenity strip in State Forest which adjoins highways was seen as potentially suitable for translocation receival site. Logging exlusion areas such as drainage lines may also be suitable.

Road Reserve
Most areas of the WC2U road reserve were considered unsuitable as a translocation receival site due to:-

- limited lateral extent and area available to establishing a self-sustaining population;
- presence of in-situ threatened flora - disturbance by translocation activity;
- potential to be impacted by future highway widening;
- potential to be impacted by installation of service utilities for the current project; and
- potential for accidental damage during maintenance of roadside vegetation.

RMS purchased properties
Sites on RMS owned land outside the project boundary were considered better for establishing translocated populations because they were larger and unlikely to be affected by vegetation clearing for service installation and future highway upgrades. Several RMS owned properties with suitable habitat for receival sites are currently being considered. Legal covenants would be attached to these properties protecting translocation areas before they are sold on by RMS after completion of construction.

Compensatory habitat
No details of compensatory habitat for the WC2U are currently available.

Table 9: Attributes considered in selecting receival sites.

Site Attribute
Physical
slope aspect
slope angle
topographic position
Landform
Geology
soil
proximity to donor site
area of potential habitat available
Vegetation
original plant community
extant plant community

threatened species already present
invasive/difficult to control weeds present
Logistical
Accessibility
available water source
distance to water source
likelihood of disturbance during construction
Tenure/conservation
land ownership/ protection mechanism
potential disturbance by future road widening
other project conservation uses
Conservation benefits of the land
biogeographic context
configuration of the land
improves vegetation cover / habitat in a fragmented landscape, provides connectivity
close to extant population
better option than rehabilitating other degraded habitat.
land care involvement

4.3.4 Receival Sites

The following translocation receival sites were considered (see Appendix 7 for location maps): -

State Forest (visual amenity strip) adjoining the highway corridor

A significant number of individuals of threatened and rare flora are presently located in State Forest traversed by the highway corridor. To preserve these individuals in suitable habitat within the local area, relocation sites within State Forest adjacent to the highway corridor seem most appropriate. For threatened and rare species individuals currently located in State Forest, it is proposed to utilise adjoining State Forest within 50m of the road as the translocation receival site. This will become the new the visual amenity strip in State Forest adjoining the new highway so will not interfere with forestry logging operations. The species requiring translocation in State Forest are *Marsdenia longiloba* and *Tylophora woollsii*.

Area 1 (ch. 39160 - 38840)

Area 1 is located on a block of RMS owned land near the northern end of the WC2U corridor in the Urunga area, south of Bellingen Shortcut Road (see Appendix 7). The block includes a section of the road corridor and the residue includes a sizeable area of low lying and hill slope forest suitable as a receival site for Slender Marsdenia, Woolls' Tylophora, Spider Orchid, Goodenia fordiana and Koala Bells.

Area 2 (ch 37140 - 36700)

Area 2 is located on a block of RMS owned land north of the Kalang River (see Appendix 7). The block includes a section of the road corridor and the residue

includes a sizeable area of hill slope and gully forest suitable as a receival site for Slender Marsdenia, Woolls' Tylophora, Goodenia fordiana and Koala Bells.

Area 3 (ch 28300 - 27640)

Area 3 comprises two blocks located on the southern boundary of Little Newry State Forest, adjoining the road corridor on the western side. This area is covered by forest and cleared land which would be suitable for translocation of Slender Marsdenia, Woolls' Tylophora, Rusty Plum, Goodenia fordiana and Koala Bells.

Note - Area 3 is not available as a receival site. Area 3 would not be considered further.

Area 4 (ch 1340 - 980)

Area 4 located at the southern end of the WC2U corridor south of Warrell Creek was selected as the receival site for populations of Rusty Plum and Slender Marsdenia impacted on this section of the road corridor. There are two potential receival sites: (i) within the project boundary either side of the construction footprint, or (ii) a triangle of residue land just to the north of (i). Land within the project boundary at (i), to be acquired by RMS, is quite wide and probably well in excess of what is required for construction works. The actual area disturbed by works may depend on the final detailed design. Land at (ii) is outside the project boundary and would not be disturbed during constrution. Final decision on the use of Area 4 (i) or (ii) could be made closer to the start of construction when translocations would be carried out.

4.3.5 Logistical Assessment

The translocations will be supervised by a plant ecologist, bush regenerator or horticulturist who has previous experience with the translocation of threatened species in northeast NSW. Table 10 below provides details of resources required for proposed translocation works.

Table 10: Personnel, equipment and materials required for translocation procedures

Procedures	Personnel	Plant and Equipment	Materials
Select and mark out translocation area, planting layout, access etc.	Plant ecologist, RMS.		pegs, flagging tape
Install stock fencing as required.	Plant ecologist, Fencing contractor.	tractor,	1.2m hinge-joint fencing, star pickets, fencing wire, strainers etc
Seed/cutting collection	Plant ecologist		secateurs, disinfectant, damp newspapers, zip lock bags, labelling
Propagation	Plant ecologist, plant nursery	nursery facilities.	soil mix, pots, labels etc.
Transplanting	Plant ecologist, assistants, machine operator	excavator, backhoe, truck, ute/trailer, spades, pruning saws,	tags, indelible pen
Install watering system	Plant ecologist, assistant	irrigation pump – e.g. 5hp firefighter petrol pump	polypipe, fittings, hoses
Habitat restoration	Plant ecologist, 2 assistants	bush regenerators kit	
Maintenance – watering, mulching, weed control	Plant ecologist, 2 assistants		herbicide, coarse straw mulch, slow release fertiliser, chemical record sheet
Monitoring	Plant ecologist	camera	data sheets, tags, indelible marker pen
Access control, fencing, signage	Plant ecologist/ Principal contractor		wire and paraweb fencing, signage

4.4 The Translocation Proposal

4.4.1 General Approach

The WC2U translocation project would involve salvage transplanting of five (six including Maundia at Williamson's Creek) threatened species and two rare species (Table 6) with the aim of establishing populations at new locations, which are self-sustaining over the long-term. As well as transplanting, this will require propagation and introduction of additional individuals to establish minimum viable population (MVP) sizes and adequate levels of genetic diversity. Further integral aspects of the translocation process include restoration of good quality habitat to the receival sites where required, adequate maintenance to ensure transplants and population enhancement individuals become established and monitoring and reporting of the translocation results.

4.4.2 Translocation Procedures

4.4.2.1 Salvage transplanting

Of the species to be translocated, one is a tree, two are small vines, one an epiphytic orchid, one a grass and two (three including Maundia) are herbaceous perennials. Salvage transplanting will be conducted for directly impacted individuals and any indirectly impacted individuals that the Project Ecologist considers are likely to go into decline due to their proximity to the edge of clearing (ie. changed microclimate etc). Tree species (Rusty Plum) will be transplanted with an excavator using the direct transplanting method. Manual transplanting would be used for the other species. Manual transplanting will involve digging up plants with a spade and mattock, or in the case of the epiphytic orchid removal from tree bark.

Salvage translocation of a wide range of rainforest tree and shrub species on the NSW North Coast has shown that most species have the capacity to recover from stem and root damage incurred during transplanting. The benefits of transplanting established individuals of threatened species were pointed out by Primack (1996):- "There are nonetheless ecological advantages to using transplanted plants rather than seeds in reintroduction (translocation) efforts. Plants, particularly adult plants have a higher likelihood of successful establishment than seeds (or seedlings) if they are planted into a suitable site and well tended. These plants have overcome the most vulnerable stages in their life cycle (seed germination and seedling establishment) so that their chances of surviving in the new habitat are greatly increased. These individuals also have proven genotypes that are free of lethal mutations and adapted to the general environmental conditions. When reintroduction efforts involve reproductively mature adult plants, the new population has the potential to flower, produce and disperse seeds and create a second generation of plants within a year (or so) of transplantation".

4.4.2.2 Population Enhancement

Additional individuals will be propagated and introduced to the translocation receival sites to (i) provide back-up individuals to replace mortalities incurred during transplanting, and (ii) to increase the probability of long-term population persistence

by establishing a larger initital population. Population enhancement individuals will be propagated from seed or cuttings collected from local populations of each species.

The following procedures will be used to maintain the genetic integrity of local populations, whilest aiming to introduce a modest degree of genetic diversity:-

- Seed or cuttings to be collected from several parent plants in local area.
- The source populations should contain several mature individuals.
- Limit the number of seedlings introduced from any one source individual to a maximum of 20% of the total number introduced.
- Avoid planting seedlings / cuttings propagated from the same parent plant close together.
- Selection of propagation material should not be biased towards the tallest plant, the most attractive plant, the plant with the greatest amount of seed or flowers etc.
- Planted individuals to be clustered or arranged to increase the likelihood of cross-pollination.

The overall structure of the species translocations, including the number of transplant individuals and population enhancement individuals is provided in Table 11.

Table 11: The structure of the translocations in terms of number of transplant and MVP number to be established on the translocation site, how these would be propagated and seed collection time.
(Note – these numbers will be adjusted in proportion according to the final numbers salvaged, following detailed design and the contractor's pre-clearing targeted survey; no population enhancement is proposed for Maundia)

Species	Transplanted# Individuals	MVP Number	Type of propagation	Seeding time
Threatened Species				
Slender Marsdenia (Marsdenia longiloba)	176	300	rhizome cuttings	Winter
Rusty Plum (Niemeyera whitei)	13	150	seed	November
Floyds Grass (Alexfloydia repens)	~6m²	50m²		
Wooll's Tylophora (Tylophora woollsii)	5	50	rhizome cuttings	
Spider Orchid (Dendrobium melaleucaphilum)	~30	300	pseudobulbs & seed	spring
Other Species				
Ford's Goodenia (Goodenia fordiana)	~8	50	stolons	
Koala Bells (Artanema fimbriatum)	~20	100	seed	summer

Indirectly impacted individuals may also be translocated after completion of the detailed design, as determined by the Project Ecologist in consultation with the Principal Contractor.

4.4.2.3 Maintenance

Measures to be implemented to ensure adequate maintenance is carried out would include:-

- clear specification and scheduling of maintenance activities;
- supervision of maintenance activities;
- works to be carried out by bush regeneration specialists (not road construction staff); and
- commitment to monitoring and remedial action, where necessary.

A program of maintenance entailing weed control and bush regeneration would be undertaken for five years or until translocated populations are well established and surrounding habitat develops mature vegetation structure and exotics are reduced to low levels. The need for further maintenance will then be reviewed at the end of each year and a work program prepared for the following year.

4.4.2.4 Habitat restoration

Translocation receival sites with disturbed or degraded vegetation would be restored to good quality habitat using bush regeneration techniques and local species planting. The restoration work would be intensive for the 1-2 years, then gradually decrease.

4.4.2.5 Research and Experimentation

Slender Marsdenia (*Marsdenia longiloba*)

In the context of detailed data recorded on the distribution of Slender Marsdenia within the WC2U road corridor and the considerable number of individuals impacted by construction, a research project looking at the population genetics of Slender Marsdenia is being conducted by the Ecos Environmental Pty Ltd and the Genecology Research Centre of the University of the Sunshine Coast, as part of the offset package and in conjunction with the translocation plan for this species. The aim of genetic research is to identify patterns of genetic variation within and between populations of Slender Marsdenia at local and regional scales and to use this information to better understand the population genetic structure, life history, breeding system and population dynamics of this cryptic and poorly understood species. Such information can be used to improve management and science-based conservation of the species

The Bonville translocation project produced significant new information on the life history of Slender Marsdenia (see below), but the population processes by which Slender Marsdenia persists at a site remain poorly understoood. As well as providing information on spatial variation in genetic diversity, genetic analysis techniques can provide indirect evidence of rates and direction of pollen flow, levels of out-crossing and therefore method of reproduction – ie. vegetative or sexual/by seed. This type of research has been conducted by RMS previously for Scented Acronychia (*Acronychia littoralis*) on the Chinderah Bypass and the DoP consider research a valid 'offset' initiative.

Slender Marsdenia is an interesting plant as it appears to rarely if ever form seed. The Flora of NSW states the fruit has never been recorded, although the writer has observed the fruit on one occasion in a decade of surveying and monitoring vegetation

where the species occurs. Patterns of genetic variation within and between sub-populations can be used to indicate levels of sexual and vegetative reproduction, which can provide insight into a species demographics and how it is able to persist in an area. The surveys conducted for whole WC2U project represent a 42km longitudinal sample of the species' distribution. Detailed mapping of sub-populations, the essential first stage of recording spatial data, has in effect been completed. Analysis of patterns of genetic variation within and between sub-populations along this geographic transect would greatly improve understanding of this species genetics and therefore the breeding system and processes by which populations are maintained. Research on these aspects of species ecology is consistent with Priority Recovery Actions recommended for Slender Marsdenia by the Commonwealth Department of Environment and Heritage (DEH) and the Environmental Protection Authority.

The genetic research project currently underway is titled Analysis of genetic variability in the endangered species Slender Marsdenia (*Marsdenia longiloba*) at fine, medium and broad geographic scales, and research is being directed at answering the following questions: -

- Given that Slender Marsdenia appears to rarely produce seed, how much genetic variation exists in this species within and between sub-populations within the Nambucca area and across the species distribution?

- What do patterns of genetic variation within and between sub-populations of Slender Marsdenia tell us about levels of sexual and vegetative reproduction, and levels out-crossing and inbreeding in Slender Marsdenia?

- Are sub-populations of Slender Marsdenia in adjacent gullies genetically different from each other? If they are genetically different, how did they become different when seed production (sexual reproduction/chromosomal recombination) is so rare? If they are genetically the same, how did they disperse to two adjacent gullies when seed production is so rare?

- What do patterns of genetic variation across the species distribution tell us about the frequency of pollination and direction of pollen flow in Slender Marsdenia across the landscape at different scales?

- What does the spatial distribution of genetic variability within and between populations indicate about present and past population dynamics of this species?

- Do patterns of genetic variation in Slender Marsdenia indicate any significant risk of causing inbreeding or outcrossing depression by undertaking translocation of the species?

- What other practical implications do the research findings have for conservation and management of Slender Marsdenia? Such as where are the areas of higher genetic diversity found within the species and how significant are the populations to be translocated for the genetic diversity of the species as a whole.

Approximately 360 samples have been collected across the species range from the Nambucca valley to northwest of Brisbane and patterns of genetic variation are being analysed using microsatellite and chloroplast DNA techniques. The latter is being

used to elucidate the identification of Tylophora woollsii and Slender Marsdenia (Marsdenia longiloba), these species being very similar vegetatively and difficult to identify from vegetative features alone.

The translocation project for WC2U (NH2U/WC2NH has been planned to carrying on from the research conducted for the Bonville translocation project and has been designed to examine the survival response of Slender Marsdenia to different methods of translocation and micro-habitat type.

4.4.2.6 Monitoring

Monitoring is essential to document the establishment and survivorship of reintroduced plants and the basic life-history processes of growth and reproduction. "Monitoring is the foundation of success in a good reintroduction project; it is not a luxury. Monitoring is the stage that will eventually require the greatest amount of time in any reintroduction project." (Sutter 1996).

Monitoring techniques and processes must meet four criteria:-

- Monitoring data must have a known and acceptable level of precision.
- Data collection techniques are repeatable over years and across personnel.
- Data must be collected over a long enough period of time to capture important natural processes such as recruitment and responses to management.
- Monitoring must be efficient and practical within budget constraints (Sutter 1996).

A monitoring program designed to measure, assess and report the results of the translocation project will be conducted during construction and for a period of 5 years after the completion of translocation works, or for a total of approximately 8 years (see Section 4.6.7).

4.4.3 Implementation Schedule

The schedule for implementation of the translocation program is shown in Table 12 below.

Table 12: Implementation schedule for the WC2U Threatened Flora Translocation

No.	Tasks	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
1	Site Selection and Preparation						
1.1	Selection of translocation sites	+					
1.2	Plan Scope of Works for translocation, prepare list of material/equipment required	+					
1.3	Repair access tracks where required, mark out planting layout	+					
1.4	Erect necessary fencing and install watering system where required	+					
2	Transplant threatened and rare species						
2.1	Transplant directly impacted	+					

	individuals to the receival sites; tag and mark clearly						
2.2	Initial maintenance of transplants: water daily for two weeks then reduce; mulch; spray Maxicrop	+					
3	Population enhancement						
3.1	Seed and cutting collection	+	+				
3.2	Propagation	+					
3.3	Introduce propagated plants		+				
4	Habitat restoration						
4.2	Propagation of non-threatened species from locally collected seed, or source from local rainforest nurseries	+					
4.1	Plant out tubestock (disturbed or cleared sites only)	+	+				
5	Receival Site Maintenance						
5.1	Weed spraying	+	+	+	+	+	+
5.2	Slashing	+	+	+	+	+	+
6	Monitoring						
6.1	Monitor transplants:- Completion of transplanting; 3-monthly intervals for 1 yr; 6-monthly intervals for two years; and once a year thereafter	+	+	+	+	+	+
6.2	Monitor in-situ plants during road clearing and construction.	+	+	+	+		
6.3	Monitoring of in-situ roadside threatened plants during highway operation					+	+
7	Reporting						
7.1	Prepare annual report documenting the results of the translocation project	+	+	+	+	+	+
8	Project Review						
8.1	Five-year review of translocation project – Determine future project actions, including potential future maintenance and monitoring requirements.						+

4.5 Species Proposals

4.5.1 Slender Marsdenia (*Marsdenia longiloba*)

Slender Marsdenia occurs in small, sparse sub-populations scattered along the length of the WC2U road corridor. Approximately 200 individuals ('stem-individuals) were recorded in 23 different sub-populations from the Raleigh area, Newry State Forest, Little Newry State Forest, Valla south, Nambucca State Forest and Warrell Creek sections of the WC2U corridor. A total of 43 gps points and 75 individuals were recorded on the southern WC2NH section. Plans showing the location of recorded occurrences are provided Appendices 1 and 3.

Translocation of Slender Marsdenia for the northern (NH2U) project was undertaken in December 2013. In version one of the WC2U TFMP in was proposed that any further translocation of Slender Marsdenia on the southern half/WC2NH would be dependent on the results of Slender Marsdenia translocation on NH2U and that this would be assessed over a monitoring period of two years. This fitted in with initial information that the likely start of construction on the two sections would be two years apart. The project scheduling has since changed and construction of the southern section is likely to commence late 2014 or early 2015, only about 12 months since the NH2U translocation of Slender Marsdenia. This has necessitated an earlier decision whether or not to translocate Slender Marsdenia on the southern section based on monitoring results up to September 2014 – see Table 12b.

The previous attempt to translocate Slender Marsdenia (and Woolls Tylophora) on the Bonville project was unsuccessful after five years. Without going into detail, it was hypothesised that the poor result was due to the adverse of effect of slow release fertiliser and soil amelioration on Slender Marsdenia establishment at the receival site. A different approach has been applied on the NH2U project involving direct transplanting and no use of fertiliser. The results to September 2014 in Table 12b show no evidence of a marked decline in the health and vigour of Slender Marsdenia transplants during the first 9 months, despite a dry autumn and cold and dry winter in 2014. However, based on the survival pattern recorded on the Bonville translocation project, it is too early to say if results are definitely improved. Given the monitoring results recorded to Sept 2014 on NH2U and since construction of WC2NH is likely to start late 2014, translocation of Slender Marsdenia will also proceed on the WC2NH project so as not to delay the start of construction.

Table 12b: Results of the NH2U translocation of Slender Marsdenia after 3, 6 and 9 months after translocation.

NH2U – no fertiliser addition	**3 months March 2014**	**6 months July 2014**	**9 months Sept 2014**
condition - poor	16	14	20
condition – fair	35	45	40
condition – healthy	95	87	86
	146	146	146

Table 13: Directly impacted Slender Marsdenia recorded on the WC2U corridor. Each recorded point may encompass more than one plant, as indicated in column 'No.'

Southern Half (WC2NH) as of 10/6/2014

ID	Species	Easting	Northing	No.	Size
ml-125	Marsdenia longiloba	497488.408000	6610582.878000	1	0.1m
ml-126	Marsdenia longiloba	497493.501000	6610586.158000	1	0.1m
ml-127	Marsdenia longiloba	497496.352000	6610583.216000	3	1m
ml-128	Marsdenia longiloba	489653.000000	6594556.000000	1	0.1m
ml-22	Marsdenia longiloba	496188.410408	6608256.097960	2	0.1m
ml-23	Marsdenia longiloba	496180.251673	6608299.314590	1	1m
ml-24	Marsdenia longiloba	496177.372208	6608314.274170	1	0.5m
ml-25	Marsdenia longiloba	496182.954756	6608331.453140	2	0.8m
ml-26	Marsdenia longiloba	496256.890152	6608315.410310	6	0.5m
ml-27	Marsdenia longiloba	496471.828945	6608754.696510	1	0.4m
ml-35	Marsdenia longiloba	495663.835870	6607571.959330	1	4m
ml-36	Marsdenia longiloba	495660.804035	6607567.525330	1	0.2m
ml-37	Marsdenia longiloba	495671.485200	6607608.163410	3	0.8m
ml-38	Marsdenia longiloba	495684.423981	6607593.392690	1	0.1m
ml-39	Marsdenia longiloba	495702.778781	6607610.022940	1	0.1m
ml-40	Marsdenia longiloba	495744.282604	6607632.942110	1	small
ml-41	Marsdenia longiloba	495722.548309	6607682.802220	10	small
ml-42	Marsdenia longiloba	495722.699901	6607703.119170	1	1.5m
ml-43	Marsdenia longiloba	495716.783427	6607725.280690	1	0.1
ml-44	Marsdenia longiloba	495748.069111	6607748.011070	2	0.3m
ml-5	Marsdenia longiloba	496683.949976	6609585.722830	1	small
ml-63	Marsdenia longiloba	489635.678810	6594537.005010	1	0.1m
ml-68	Marsdenia longiloba	489663.695772	6594588.748820	1	1.5m
ml-7	Marsdenia longiloba	496637.195041	6609472.118760	6	0.6m
ml-71a	Marsdenia longiloba	489553.726825	6594591.727680	3	2m
ml-72	Marsdenia longiloba	489683.316469	6594582.857250	1	1m
ml-8	Marsdenia longiloba	496576.593202	6609216.292200	2	0.6m
ml-9	Marsdenia longiloba	496589.206798	6609222.021860	1	4m
ml-93	Marsdenia longiloba	494336.000000	6604191.000000	1	0.0
ml-136	Marsdenia longiloba	489584.000000	6594404.000000	1	0.0
ml-137	Marsdenia longiloba	495058.000000	6606623.000000	1	0.0
ml-133	Marsdenia longiloba	489559.000000	6594392.000000	2	0.0
ml-134	Marsdenia longiloba	489560.000000	6594392.000000	3	0.0
ml-135	Marsdenia longiloba	489567.000000	6594394.000000	1	0.0
ml-138	Marsdenia longiloba	489653.000000	6594556.000000	1	1.6
ml-147	Marsdenia longiloba	496207.000000	6608368.000000	1	3.0
ml-139	Marsdenia longiloba	489660.000000	6594591.000000	1	0.6
ml-141	Marsdenia longiloba	495672.000000	6607601.000000	1	0.2
ml-142	Marsdenia longiloba	496172.000000	6608264.000000	1	0.2
ml-143	Marsdenia longiloba	496185.000000	6608287.000000	1	2.2
ml-144	Marsdenia longiloba	496192.000000	6608323.000000	1	0.3
ml-145	Marsdenia longiloba	496184.000000	6608313.000000	1	0.3

ml-146	Marsdenia longiloba	496212.000000	6608369.000000	1	1.5

Northern Half (NH2U), as of 6/3/2013

ml-1	Marsdenia longiloba	497485.537248	6610602.704080	1	small
ml-2	Marsdenia longiloba	497468.445578	6610614.520770	1	small
ml-3	Marsdenia longiloba	497477.228559	6610618.955580	15	small
ml-49	Marsdenia longiloba	497496.039690	6612142.718430	1	0.15m
ml-46	Marsdenia longiloba	497598.702108	6613063.459720	40	to 5m
ml-48	Marsdenia longiloba	497602.055454	6613069.370790	10	to 1.5m
ml-16	Marsdenia longiloba	500442.890991	6618806.680550	1	0.4m
ml-15	Marsdenia longiloba	500426.432922	6618920.638680	1	3.5m
ml-14a	Marsdenia longiloba	500409.842004	6620668.210490	2	small
ml-14	Marsdenia longiloba	500386.537955	6620686.516890	2	small
ml-14b	Marsdenia longiloba	500435.641790	6620740.522920	1	small
ml-11	Marsdenia longiloba	499195.302516	6622426.508930	6	small
ml-12	Marsdenia longiloba	499214.008854	6622428.172560	1	small
ml-13	Marsdenia longiloba	499200.737108	6622446.456410	1	small
uml-6	Marsdenia longiloba	497772.427480	6625850.919071	1	1m
ml-17	Marsdenia longiloba	497791.779559	6625851.107730	1	small
uml-5	Marsdenia longiloba	497779.939952	6625872.714539	1	1.5m
ml-18	Marsdenia longiloba	497816.564585	6625875.307700	1	0.1m
ml-19	Marsdenia longiloba	497826.637279	6625891.378130	4	0.2m
ml-20	Marsdenia longiloba	497827.754605	6625902.460010	1	0.2m
ml-21	Marsdenia longiloba	497835.590897	6625905.231990	5	0.2m
ml-28	Marsdenia longiloba	498002.652999	6626288.504580	1	small
ml-33	Marsdenia longiloba	498121.454487	6626489.842450	1	0.3m
ml-34	Marsdenia longiloba	498198.977611	6626789.798790	1	4m

It is proposed to conduct the translocation of Slender Marsdenia as follows: -

- Directly impacted plants to be transplanted to adjoining State Forest, road reserve and RMS owned property, which ever is closest, provides suitable habitat and is in a location/tenure suitable for long-term conservation.

- Rhizome pieces dislodged during transplanting (soil breaks up easily) to be used to for propagation of population enhancement plants.

- All transplants to be tagged with its donor ID number throughout the translocation process; all propagated plants to be labelled with the parent donor ID number throughout the propagation and introduction process.

- Experimental work to be incorporated in the Slender Marsdenia translocation including:-

  - study of genetic variation within and between sub-populations using shoot material taken during transplanting (stems to be pruned).

  - study of flowering and seed production in transplants under pot cultivation

- study of plant response to translocation introduction treatments - i.e. direct transplanting vs. planting after initial pot stabilisation; fertiliser/mulch vs. no fertiliser treatment; disturbed vegetation vs undisturbed vegetation.

Monitoring of the translocation including the experiments would be conducted during construction and after construction for a minimum of 5 years, a total of approximately 8 years.

4.5.2 Wooll's Tylophora(*Tylophora woollsii*)

Five records of Woolls' Tylophora are directly impacted in Newry State Forest and Nambucca State Forest and would require translocation, as indicated in Table 14 below. Records are mapped in Appendices 1 and 3.

Table 14: Directly impacted *Tylophora woollsii* proposed for translocation. Each record is a gps point, which may encompass more than one plant.

tw-4	Tylophora woollsii	496704.871330	6609581.111790	1	small
tw-6	Tylophora woollsii	496614.669628	6609500.001180	1	0.4m
tw-9a	Tylophora woollsii	498593.927600	6622812.829640	1	0.5m
utw-1	Tylophora woollsii	497840.222513	6625937.923801	1	1.4
utw-2	Tylophora woollsii	497841.820182	6625946.420056	5	0.5

Translocation of Tylophora woollsii would be conducted as follows:

- As discussed in Section 3.3.4, identification of Tylophora woollsii is problematic, especially in the case of small plants. Most of the time we do not know for certain whether suspected *Tylophora woollsii* plants are in fact that species or Slender Marsdenia, unless flowering occurs, which is rare. A sample of *Tylophora woollsii* would be transplanted to pots and grown-on to encourage flowering and confirm the identification. Previous pot cultivation of *Tylophora woollsii* and Slender Marsdenia for the Bonville project showed that flowering can be induced in 12 months by providing additional fertiliser and water.

- Once positively identified from flowers, detailed examination of leaf morphology will be carried to determine features that can be used to identify the species and distinguish it from Slender Marsdenia using leaves.

- After identification, the potted plants would be introduced to field sites in State Forest.

- Population enhancement will be carried out if possible using salvaged rhizome pieces to propagate additional individuals from.

- All transplants to be tagged with its donor ID number throughout the translocation process; all propagated plants to be labelled with the parent donor ID number throughout the propagation and introduction process.

Monitoring of the translocation would be conducted during construction and after construction for a minimum of 5 years, a total of approximately 8 years.

4.5.3 Rusty Plum (*Niemeyera whitei*)

Rusty Plum was recorded at three locations on the WC2U corridor - Boggy Creek near Valla, north of the railway line at Nambucca Heads and Cockburn's Lane south of Warrell Creek. Single small trees at Boggy Creek and the railway line, and 11 trees and saplings at Cockburn's Lane (as well as seedlings) are directly impacted and would require translocation. The largest trees are 8-10 metres in height with a maximum diameter of about 30 cm. Occurrences of Rusty Plum are mapped in Appendix 1 and tabulated in Appendix 2.

Table 15: Directly impacted Rust Plum proposed for translocation. Each record is a gps point, which may encompass more than one plant (seedlings not listed).

ID	Species	Easting	Northing	No.	Size
nw-50	Niemeyera whitei	497460.267315	6612110.387950	1	2.5m
nw-50b	Niemeyera whitei	489598.600127	6594456.623420	1	8m
nw-54	Niemeyera whitei	489610.242842	6594455.157100	1	8m
nw-55	Niemeyera whitei	489599.063113	6594472.508300	1	sdlg
nw-56	Niemeyera whitei	489581.206261	6594468.612190	1	1.2m
nw-57	Niemeyera whitei	489570.696540	6594452.902240	1	7m
nw-58	Niemeyera whitei	489569.106161	6594448.467830	1	6m
nw-59	Niemeyera whitei	489571.204261	6594422.796200	1	10m
nw-64	Niemeyera whitei	489636.959937	6594531.465170	1	8m
nw-66	Niemeyera whitei	489647.610383	6594566.753670	1	4m
nw-73	Niemeyera whitei	489672.663574	6594549.969920	1	5m
unw-9	Niemeyera whitei	497406.818180	6611193.165320	1	7m
nw-129	Niemeyera whitei	489592.530000	6594469.550000	1	4m

Translocation of Rusty Plum would be conducted as follows: -

- Directly impacted individuals will be transplanted into adjoining habitat on RMS land.
- Population enhancement will be carried out by collecting seed from locally occurring trees and direct seeding into suitable habitat on RMS land.
- All transplants to be tagged with its donor ID number throughout the translocation process; all propagated plants to be labelled with the parent donor ID number throughout the propagation and introduction process.

Monitoring of the translocation would be conducted during construction and after construction for a minimum of 5 years, a total of approximately 8 years.

4.5.4 Maundia (*Maundia triglochinoides*)

Maundia occurs on the southern WC2NH section at two locations:- Williamson's Creek near Warrell Creek and the Nambucca River floodplain southeast of

Macksville. In Version 2 of the TFMP, no translocation of Maundia was proposed, rather management focused on amelioration of impacts and monitoring. However, Pacifico has indicated they would like to "give it a go" translocating Maundia during re-routing of Williamson's Creek. The only known previous attempt at translocating Maundia on the Central Coast by the Royal Botanic Gardens Sydney using propagated seedlings apparently failed. Translocation using established rhizomes may have better chance of success. Pacifico has suggested using a machine to move plants and substate together to the new drainage line. The new stream would be engineered to recreate the still-water pools of the present stream. Some plants could be transplanted by hand so that the shoot or leafy part of the plant was not overly damaged, but most of the transplanting would be by excavator and aim to regenerate Maundia plants from rhizome material moved with the muddy substrate.

The Nambucca floodplain population would be managed with the aim of minimising impacts to Maundia remaining within the project boundary after clearing and in wetland adjoining the road corridor, by applying the measures listed below.

Table 16a: Representative GPS points marking the extent of the Maundia stand at Williamson's Creek.

ID	Species	Easting	Northing	No.
mt-74	Maundia triglochinoides	491716	6598059	Mat
mt-75	Maundia triglochinoides	491659	6598066	Mat
mt-76	Maundia triglochinoides	491604	6598050	Mat
mt-77	Maundia triglochinoides	491524	6598033	Mat

Table 16b: Representative GPS points marking the approximate extent of the Maundia population on the Nambucca floodplain.

ID	Species	Easting	Northing	No.
mt-82	Maundia triglochinoides	492733	6600457	Mat
mt-94	Maundia triglochinoides	493295	6601470	Mat
mt-95	Maundia triglochinoides	493286	6601461	Mat
mt-96	Maundia triglochinoides	493285	6601445	Mat
mt-97	Maundia triglochinoides	493304	6601479	Mat

During detailed design and construction, emphasis would be placed on minimising impacts to in-situ individuals. Management measures include (but are not limited to) the following:-

(a) investigate engineering solutions, undertake design optimisation and adopt design and construction solutions which:

(i) minimise the footprint of the Project Works and Temporary Works adjacent to areas of Maundia triglochinoides;

(ii) precisely locate proposed construction and operational water quality treatment facilities to avoid direct and indirect impacts on Maundia triglochinoides; and

(iii) ensure that, during construction and operation of the Project Works, the drainage paths and the quantity and quality of water, both surface and subsurface, are maintained to Maundia triglochinoides populations;

(b) identify all Maundia triglochinoides populations on environmentally sensitive area mapping and in the Design Documentation as exclusion zones;

(c) locate ancillary facilities for the Contractor's Work to avoid direct and indirect impacts on Maundia triglochinoides;
(d) address any of the Contractor's Work that is undertaken within 100 m of Maundia triglochinoides in a site specific environmental work method statement;
(e) erect and maintain sediment fencing around all areas of Maundia triglochinoides that are affected by the Contractor's Work; and
(f) include in the urban and landscape design specific landscaping / revegetation measures to buffer the areas adjacent to Maundia triglochinoides populations with appropriate vegetation.

Maundia would be included in the Ecological Monitoring Program to assess the effectiveness of management measures (a) to (f) listed above. This would entail a series of 'control' and 'impact' (ie within and adjoining the project boundary) reference plots to be monitored during construction and for a minimum of five years during highway operation.

4.5.5 Floyds Grass (*Alexfloydia repens*)

Floyds Grass was recorded only on the southern WC2NH section at one location on the northern bank of Warrell Creek, within and outside project boundary (see Appendix 1). Impact analysis of the RMS concept design found that one gps point is directly impacted and two are indirectly impacted, comprising a total of approximately 6 m² of Floyds Grass. All points would probably require translocation as Floyds Grass is unlikely to survive long-term in the indirect impact zone, where it would be threatened by weed invasion and increased cover of native species such as ground ferns. Indirect impacts such as run-off from the construction zone and soil eutrophication could also be a problem, although sed and erosion control measures would minimise such impacts.

Table 17: GPS points marking directly and indirectly impacted Floyds Grass.

ID	Species	Easting	Northing	No.
ar-78	Alexfloydia repens	492334.706995	6599021.622260	mat
ar-79	Alexfloydia repens	492344.763916	6599013.133180	mat
ar-81	Alexfloydia repens	492261.429754	6599090.278560	mat

Translocation of Floyds Grass would be conducted as follows: -

- Directly impacted plants would be transplanted to suitable adjoining habitat on RMS land.

- Translocation methods would follow those used successfully on the Bonville Translocation Project.

4.5.6 Spider Orchid (*Dendrobium melaleucaphilum*)

Dendrobium melaleucaphilum was recorded at two locations on the northern half of the project - approximately 4km north of the Kalang River, where only one mature plant is in the indirect impact zone; and in Newry State Forest where 10 flora points containing approximately 10 to 20 plants are directly impacted. Additional indirectly impacted points with approximately 20 to 30 plants may require translocation. The individual north of the Kalang River is less than 4 metres from the edge of the construction zone and given its likely sensitivity to microclimatic change, translocation to appropriate habitat would be carried out. The mapped occurrences are shown in Appendix 1.

A third population occurs on the southern half of the project in Nambucca State Forest. Three flora points were recorded by EcoPro (2010) (see Appendix 1, Fig 9). These have not been confirmed and should be checked during at the pre-clearing stage of the project.

A large area of potential habitat for this species is present on the WC2U corridor, but a sizeable population occurs only at one location in Newry State Forest indicating how depleted this species has become. Population enhancement would be included as part of the translocation process to increase population size and compensate for loss of potential habitat due to highway construction.

Table 18: *Dendrobium melaleucaphilum* proposed for translocation, including points from EcoPro (2010).

ID	Species	Easting	Northing	No.
dm-34a	*Dendrobium melaleucaphilum*	498827.816416	6627524.966920	1
	Dendrobium melaleucaphilum	498943.121891	6622574.465214	1-5
	Dendrobium melaleucaphilum	496635.580000	6609457.970000	1-5
	Dendrobium melaleucaphilum	496639.630000	6609426.260000	1-5
	Dendrobium melaleucaphilum	498903.212004	6622587.312599	1-5
	Dendrobium melaleucaphilum	498898.412923	6622585.542959	1-5
	Dendrobium melaleucaphilum	498899.946650	6622585.542959	1-5
	Dendrobium melaleucaphilum	498896.780246	6622574.465214	1-5
	Dendrobium melaleucaphilum	498938.322809	6622561.497853	1-5
	Dendrobium melaleucaphilum	498944.746322	6622570.695981	1-5
	Dendrobium melaleucaphilum	498584.963644	6622899.449064	1-5
dm-1	*Dendrobium melaleucaphilum*	496635.580000	6609457.970000	1-5
dm-2	*Dendrobium melaleucaphilum*	496639.630000	6609426.260000	1-5
dm-3	*Dendrobium melaleucaphilum*	496064.044126	6608287.453294	1-5

It is proposed to conduct the translocation of *Dendrobium melaleucaphilum* as follows: -

- Follow-up pre-clearing survey to clarify the occurrence of Spider Orchid at sites recorded by EcoPro (2010).

- Translocate directly impacted individuals and indirectly impacted individuals if advised by the project plant ecologist.

- Translocated individuals will be re-located to swamp forest dominated by *Melaleuca styphelioides* (the favoured host) or well-developed rainforest understorey in wet scerlophyll forest. A section of bark supporting the Spider Orchid plant will be cut away from the tree and taken to the receival site for re-attachment to a suitable host tree (e.g. small *M. stypheloides* or rainforest tree with rough persistent bark). The transplants should be kept moist and out of the sun during transplanting. Cotton ribbon is used to fix the bark with orchid to the host tree, or wire if a whole branch or section of wood has been removed.

- Follow-up watering of plants is important to assist re-establishment; a dilute solution of seaweed fertiliser will be applied twice and then discontinued.

- Seed will be collected if present during transplanting, or collected from other plants in the local area, and propagated to produce individuals for population enhancement.

- Propagated plants will be grown-on to a mature size, hardened-off and then introduced to a receival site(s) selected to contain suitable habitat for this species.

- Six months before introduction, the propagated Spider Orchid plants will be inoculated with fungal mycorrhize using bark and soil organic matter collected from a local *Dendrobium melaleucaphilum* site.

Monitoring of the translocation would be conducted during construction and after construction for a minimum of 5 years, a total of approximately 8 years.

4.5.7 Ford's Goodenia (*Goodenia fordiana*)

Ford's Goodenia is directly impacted at nine locations at Raleigh south, Newry State Forest and Nambucca State Forest. Most are in the Raleigh south area. Locations are shown in Appendix 1.

Table 20: Directly impacted Ford's Goodenia proposed for translocation. Each record is a gps point, which may encompass more than one plant.

ID	Species	Easting	Northing	No.
gf	Goodenia fordiana	498645.057057	6623095.050150	mat
gf	Goodenia fordiana	498008.413738	6626272.991330	mat
gf	Goodenia fordiana	497989.696142	6626297.182810	mat
gf	Goodenia fordiana	498019.123273	6626308.639270	mat
gf	Goodenia fordiana	498017.824042	6626416.315720	mat
gf	Goodenia fordiana	498119.372903	6626503.140060	mat
gf	Goodenia fordiana	498740.165666	6627464.008120	mat
gf	Goodenia fordiana	495678.042363	6607581.015290	mat
gf	Goodenia fordiana	495708.849288	6607601.898610	mat
gf	Goodenia fordiana	498672.994767	6627368.143990	mat

It is proposed to conduct the translocation of Fords Goodenia as follows: -

- Directly impacted plants will be transplanted to a site adjoining the WC2U corridor containing suitable habitat, on RMS land.
- Since Fords Goodenia is a ROTAP species not listed as threatened; it is proposed to translocate a sample of directly impacted individuals comprising a minimum 30% of recorded flora points, as determined by the Project Ecologist.

Monitoring of the translocation would be conducted during construction and after construction for a minimum of 5 years, a total of approximately 8 years.

4.5.8 Koala Bells (*Artanema fimbriatum*)

Artanema fimbriatum is directly impacted at seven locations in the Raleigh, Raleigh south, Valla, Valla south and Nambucca State Forest areas.

Table 21: Directly impacted Koala Bells proposed for translocation. Each record is a gps point, which may encompass more than one plant.

ID	Species	Easting	Northing	No.
af	Artanema fimbriatum	497462.035272	6610707.607140	30
af	Artanema fimbriatum	497461.092414	6610642.223760	1
af	Artanema fimbriatum	495851.457703	6607944.201690	1
af	Artanema fimbriatum	496151.378340	6608221.361400	12
af	Artanema fimbriatum	498290.907731	6613899.162890	10
af	Artanema fimbriatum	498996.450225	6615072.078720	6
af	Artanema fimbriatum	500301.385190	6616814.366140	5

It is proposed to conduct the translocation of Koala Bells as follows: -

- Directly impacted plants will be transplanted to a site adjoining the WC2U corridor containing suitable habitat, on RMS land.
- Since Koala Bells is a ROTAP species not listed as threatened; it is proposed to translocate a sample of directly impacted individuals comprising a minimum 30% of recorded flora points, as determined by the Project Ecologist.

Monitoring of the translocation would be conducted during construction and after construction for a minimum of 5 years, a total of approximately 8 years.

4.6 The Translocation Action

4.6.1 Preparation for Transplanting

Prior to the start of transplanting the following actions would be carried out: -

- Mark out receival site;
- Repair access tracks;
- Install fencing to exclude stock and clearly demarcate the receival site; and
- Set up watering system.

4.6.2 Timing

Autumn on the NSW North Coast is the ideal time to conduct transplanting of trees, shrubs and vines, because of high soil moisture and cooler temperatures, which both reduce evapo-transpiration stress and promote transplant survival. At the same time, experience has shown provide a water source is readily available, transplanting of trees, shrubs and vines can be conducted at any time of year. In the case of Maundia, it would be best if transplanting was carried out in spring at the start of its growth season.

4.6.3 Transplanting

Transplanting would be carried out using an excavator or back-hoe to trench and lift the tree or shrub from the ground with a soil-root ball. Tree species would be pruned back and then transported to the receival site, planted and then watered. Pruning of the trunk and branch system is necessary to reduce transpiration demand on the damaged root syste, damaged during transplanting.

4.6.4 Pruning and Hygiene

Pruning of trees is essential to achieve satisfactory survival rates. Pruning is carried out after plants are excavated from the ground and before transportation to the receival site. Most of plant foliage is removed (~90%) and the length of the trunk and branch system reduced by about half. New tools (e.g. secateurs, pruning saw, bow-saw) would be used and disinfected by scrubbing with methylated spirits before use on each plant to guard against possible transfer of disease agents.

4.6.5 Watering

Prevention of tissue desiccation is the key to transplant survival in most species. Adequate water of transplants immediately after planting in the receival site is a crucial aspect of salvage transplanting. Watering needs to be every day for the first two weeks. The receival site should have access to a creek or dam from which water can be pumped rather than relying on a water carrier, which is also more expensive.

The soil around the transplant should be saturated as soon as it is planted. Watering would be carried out daily for the first two weeks then gradually reduced in frequency. Watering would be carried out using a small pump and applied by hand with a hose.

4.6.6 Anti-transpirant and Plant Stimulant

Maxicrop, a weak fertiliser and plant tonic made from seaweed, would be sprayed onto remaining foliage as well as the stem and bark of the transplants immediately after planting at the receival site. Maxicrop also functions as an anti-transpirant, temporarily blocking the leaf stomata. Trace elements and low concentrations of organic N, P and K help to optimise plant health and capacity for recovery.

4.6.7 Mulching

Mulching would be carried out directly after planting. Local slashed grass from the relocation site can be used, or if not available, then good quality straw hay can be purchased.

4.6.8 Shade-cloth Shelters

Shade cloth supported by stakes would be erected around transplanted trees to provide protection from wind and sun if initial conditions are exposed in the translocation area. The shelters would be required until fast growing species are established, probably for the first year.

4.6.9 Seed/cutting Collection and Propagation

Propagation of threatened and rare species would be required to establish minimum viable population sizes. Seed and cutting collection would be carried out from local populations of the subject species, i.e. within 10km of the project boundary.

The location of each parent plant from which seed / cuttings are collected would be recorded and the seed/cuttings kept in separate bags labeled with the parent plant number. Propagation trays containing the seed/cuttings would be labeled with this number throughout the propagation process.

Propagation would be carried out at a reputable local nursery using standard propagation procedures. Plants would be grown-on in super tubes or 140mm pots until at least 35cm tall and thoroughly hardened off before planting out.

Collection and propagation of seed and cuttings would be undertaken during and after transplanting until the required number of plants have been propagated.

4.7 Post-translocation Actions

4.7.1 Maintenance

On-going maintenance would be required for a minimum of five years or until the translocated populations are well established and habitat has been restored to good condition. Maintenance would involve the actions described below.

4.7.2 Watering

It is essential that the soil remains damp during the first months after transplanting. Watering would carried out daily for the first two weeks then gradually decreased. Care would be taken not to over-water and produce boggy soil conditions. Watering would be carried out by pumping from the local creek.

Later introductions of tubestock will be watered when first planted out. Further watering may be required during extended periods of dry weather.

4.7.3 Mulching

The transplants would be mulched twice a year for two years to suppress weed growth, increase soil organic matter, provide nutrient and improve plant condition. Mulch would be applied thickly so that it persists for six months. Tubestock plantings would also be mulched when first planted out.

4.7.4 Weed Control

Regular weed control would be carried out to ensure the transplants and later introductions are kept free of competition from introduced grasses and broad-leaved weeds. The herbicide Round-up Biactive (glyphosate 360 without surfactant) or similar would be used to minimise potential impacts on adjacent aquatic ecosystems.

All weed control work would be carried out by locally experienced and suitably licensed bush regenerators and supervised by a plant ecologist. This work would be carried out for a minimum of five years to fully rehabilitate the site.

4.7.5 Fire hazard Reduction

Where required a perimeter fire break would be maintained around the translocation receival site and slashed to control tall grass and weeds if they present a fire hazard.

4.7.6 Habitat Restoration

Bush regeneration and tubestock planting would be carried out to restore good quality habitat to the receival site, including a 20 meter buffer to the site.

4.8 Monitoring Program

4.8.1 Objectives

- To record data that will enable an assessment to be made of the success of the threatened flora translocations.

- To record data that assists advancement in translocation knowledge and practice from both positive and possible negative outcomes, to utilise in future translocation projects.

4.8.2 Monitoring Methods

All transplanted and population enhancement individuals are to be allocated a unique monitoring number. Flagging tape with the individual's monitoring number and source identification code (transplants only), are to be attached to each plant. Different individuals from the same donor point site are to be indicated by an additional suffix on the source identification code – e.g. Ml-46-7

In the case of Maundia translocated at Williamson's/Couche' Creek, clumps of translocated Maundia plants are to be marked with a numbered hardwood stake and details of each clump recorded as for the other species.

The main data fields to be recorded area are as follows:-

> Slender Marsdenia, Woolls' Tylophora, Rusty Plum, Maundia and Koala Bells: Monitoring Number, Date, Line, Source Label, Species - Translocation Plan Label, Species - Current ID, Condition, Height (cm), New Shoots (Y/N), Comment, sig. growth (+) or sig. dieback (-), Waypoint, Coordinates
>
> Spider Orchid: Monitoring Number, Date, Source Label, Species, Number of pseudobulbs with leaves, Length of the longest pseudobulb, New growth, Condition, Waypoint, Coordinates

Other observations such as possible disease, insect grazing and decline in habitat condition including weed invasion are to be recorded in the comments column.

The key attribute for evaluating species health and survival is Condition Class. This is to be scored on a scale of 0 to 6, as indicated in Tables 2-3 below.

Table 2: Condition Class scores applied to Slender Marsdenia and Woolls' Tylophora

Score	Condition Class
0	dead
1	stem died back, no leaves or green stem, may be a live stem stub
2	stem with leaves, no active growth; green leafless stem
3	stem with leaves, active growth – ie new shoot growth stem with leaves and plant >75cm tall
4	plant with lots of leaves, mature or nearing maturity
5	plant flowering or seeding

Table 3: Condition scores applied to Rusty Plum, Red Bopple Nut, Koala Bells and Maundia

Score	Condition Class
0	dead
1	leafless and no sign of re-shooting
2	pruned foliage retained, or small amount of re-shooting after defoliating, or foliage sparse/discoloured (<40 cm Koala Bells)
3	vigorous re-shooting (>40 cm Koala Bells)
4	crown recovering, foliage healthy
5	growing actively, flowering or seeding recorded

Table 4: Condition scores applied to Spider Orchid

Score	Condition Class
0	dead
1	pseudobulbs discoloured/being eaten/withering, no new growth
2	pseudobulbs healthy in colour, not withering, no new growth
3	plant small, not many healthy pseudobulbs, new growth occurring
4	several healthy pseudobulbs present, new growth occurring
5	several good sized, healthy pseudobulbs, flowering or seeding recorded

4.8.3 Timing/Frequency

NH2U Section
Monitoring frequency for the translocations is as follows: once every 3 months in the first year; every 6 months in the second year, then once a year to the end of the monitoring program. Monitoring is to be conducted during construction (~3 yrs) and after construction for 5 years, a total of 8 years.

WC2NH Section
Monitoring frequency for the translocations is as follows: three monitoring periods in the first year (6^{th}, 8^{th} and 12^{th} month), three monitoring periods in the second year (June 2016, November 2016 and January 2017), then once a year in November to the end of the monitoring program. Monitoring to be conducted during construction (~3 yrs) and after construction for 5 years, a total of 8 years.

November monitoring is designed to coincide with the flowering time of Marsdenia longiloba and Niemeyera whitei.

(Note – monitoring to be conducted before the 9^{th} of February 2017 which technically is the start of Year-3 of construction).

4.8.4 Data entry and analysis

Monitoring data are to be entersed into Excel spreadsheets.

Species Percent Survival (per Sector) to be calculated as:
((number of individuals in condition classes 2+3+4+5/total)*100)).

The species survival rates for WC2NH are to be compared with the results of the Bonville, Sapphire to Woolgoolga and Nambucca Heads to Urunga projects where the same species were translocated, using appropriate statistical methods – e.g. t-tests, analysis of variance or general linear modelling.

4.8.5 Annual monitoring report

An annual translocation monitoring report is to be prepared at the end of each year and include the following information: -

- Background and description of the translocation project;
- Implementation of the translocation project;
- A description of monitoring methods;
- An analysis of monitoring data on a species by species basis;
- An assessment of causes of plant mortality;
- A record of the plants transplanted and propagated;
- A description of the population enhancement program;
- An assessment of the success or failure of the translocation based on criteria set out in the WC2U TFMP (Section 4.7.8);
- An evaluation of the methods and cost-effectiveness of the translocation project; and
- Work plan for the next twelve months.

4.8.6 Performance Indicators

The following performance indicators are to be used to evaluate the success of the threatened species translocations (salvage translocation and population enhancement):

a) All directly impacted individuals of threatened species were salvaged and relocated to the receival site(s).
b) At least 60% of transplant and enhancement individuals are surviving after the first year, 50% after five years and 40% after eight years.
c) At the end of the monitoring program (8 years), at least 50% of surviving individuals have a Condition Class of 3 or higher.

4.8.7 Corrective Actions

Specific corrective actions will be triggered if monitoring identifies lower results than specified by the above performance indicators. If lower results are detected by the plant ecologist conducting the monitoring, the Environmental Manager will be informed within 5 working days, and corrective actions undertaken within 1 month. Examples of corrective actions to be considered include-

- Weed control in situations where exotic species increase and pose a potential threat to the vigour and persistence of the translocated species.
- Installation of surveillance cameras and signage to deter further theft of translocated species.
- Installation of hessian screening as a temporary measure to protect plants from over-exposure to sun and wind, until indivuduals become more established.

[See Table 4 Appendix 11 for summary of monitoring program]

5 MANAGEMENT OF ROADSIDE THREATENED FLORA

In-situ threatened flora located on the edge of the construction footprint would be protected during the construction and operation of the WC2U upgrade by a range measures directed at maintaining individuals and their habitat in good condition, as described below.

5.1 Safeguards During Clearing and Construction

Damage can potentially occur to significant flora close to the edge of the construction zone during vegetation clearing and construction activity. Any damage to legislatively protected threatened species (protected by law) that occurs during vegetation clearing and highway construction is likely to result in prosecution by the EPA. The following measures would be implemented to ensure that this does not occur:-

5.1.1 Pre-clearing Survey

To ensure that threatened plants on the edge of the construction zone are provided with protected during clearing, a pre-clearing survey would be undertaken once the clearing line is marked by surveyors prior to the start of clearing operations. Pre-clearing surveys are standard practice on most highway construction projects. Threatened species on the edge of clearing zone (Table 22) may have been under-recorded during the targeted survey.

Individuals of threatened and rare flora occurring within 10 metres of the clearing line will be recorded with a gps, tagged with a unique ID number and clearly marked with flagging tape.

Table 22: Threatened flora recorded within 10m of the direct impact zone that may require protective measures during clearing. 'Distance' is the distance of the plant to the edge of clearing. This table will require updating following completion of the detailed design and pre-clearing surveys.

ID	Species	Easting	Northing	No.	Ht	Distance
ar-81	Alexfloydia repens	492261.429754	6599090.278560	mat		2.82166
ar-79	Alexfloydia repens	492344.763916	6599013.133180	mat		9.18854
af	Artanema fimbriatum	498993.037493	6627709.492660	50		2.18388
af	Artanema fimbriatum	500347.886710	6616794.232820	5		3.60148
ml-30	Marsdenia longiloba	498005.986444	6626426.102340	2	0.3m	9.37399
ml-31	Marsdenia longiloba	498004.547702	6626422.038800	1	1.3m	9.95268
ml-32	Marsdenia longiloba	498104.834883	6626406.357810	1	0.4m	6.37603
ml-43	Marsdenia longiloba	495716.783427	6607725.280690	1	0.1m	4.21898
ml-47	Marsdenia longiloba	497588.956090	6613070.291360	10	to 1m	3.09248
ml-63	Marsdenia longiloba	489635.678810	6594537.005010	1	0.1m	2.37169

5.1.2 No-go Zones

No Go Zones would be designated at all in-situ threatened species locations within 10 metres of the construction footprint.

5.1.3 Fencing and Signage

Temporary fencing would be installed around the perimeter of each in-situ threatened species location before the start of vegetation clearing. The fencing would be kept in good repair during the construction period. A sign identifying the site as an Environmental Protection Area would also be attached to the fence.

5.1.4 Toolbox Sessions

All personnel would be informed at tool box sessions about the importance of observing protective measures for threatened plant species and the consequences if any damage occurs.

5.1.5 Tagging and Marking

Flagging tape would be attached to threatened plants so they are visible to surveyors and personnel walking through the area.

5.1.6 Mapping

All No-go Zones and Environmental Protection Areas (that include threatened flora locations) would be clearly marked on Sensitive Area Plans and all relevant design drawings used in day-to-day management of construction work.

5.2 Measures to Counteract Edge Effects

After clearing of the road corridor, threatened plant species at the edge of clearing become exposed to edge effect processes than can cause decline in plant condition. The main edge effect processes of concern to the management of threatened plant species are exposure/altered microclimatic, exotic species invasion, competitive displacement, soil eutrophication, sedimentation and changes in hydrology. In order to minimise any potential edge effect processes, the following measures would also be implemented where the construction corridor adjoins remnant and regenerating forest vegetation (as defined in the EA).

5.2.1 Sedimentation Control

Sedimentation controls are a highly effective means of minimising adverse effects on natural vegetation at the edge of clearing zones. Sedimentation controls prevent soil material and run-off, eutrophied and colonised by weed seed, from spilling into adjoining native vegetation and impacting on ground layer flora and initiating weed invasion. It also provides a visible physical barrier which deters movement of people and machines through a sensitive area.

Sedimentation controls would be installed along the upstream side of vegetation edges at: (i) in-situ threatened flora sites, set back from the stem/trunk at the edge of its

crown (ii) the edge of EECs and rainforest revegetation locations. Sedimentation controls would be monitored regularly and repaired if damaged or filled with trapped sediment.

5.2.2 Landscaping and Revegetation

Results of landscaping adjoining roadside threatened species locations often have mixed results. Tall rank grass may end up being the dominant vegetation and landscape plantings may become suppressed or die. Threatened species sites are usually set back from the edge of the highway near the edge of the road reserve and are not readily visible from the roadside where landscaping and revegetation results may be much better.

Targeted landscaping and revegetation management is to be applied to roadside threatened species locations. Where threatened plant species are present on the edge of construction, the Landscaping/ Revegetation Plan is to revegetate batters and bare areas with ecologically compatible, native species to prevent weed growth, restore natural vegetation and provide edge protection for threatened species.

Weeds often invade roadside vegetation in salvaged topsoil used to top-dress batters and bare areas. The WC2NH footprint has extensive areas of weed free forest with topsoil free of weed seed and rhizomes that should be used for this purpose. Topsoil salvaged from weed free forest is to be used to top-dress batters and bare areas. (This topsoil can also be used to revegetate around sedimentation basins, which are usually finished early, ahead of other earthworks, as in the NH2U project.)

The Landscaping Plan and CEMP for the WC2NH project are to identify that specific revegetation measures are required as per points a) to d) below for roadside threatened flora to ensure these sites are adequately buffered with fast growing native species and weeds do not become dominant. The Landscaping Plan and CEMP are to contain an implementation schedule with actions for areas adjacent to in-situ threatened species.

Specific revegetation measures for areas adjacent to in-situ threatened species:-

a) Topsoil salvaged from weed free forest during clearing to be stored and used to top-dress batters and bare areas.

b) Alternatively, plant around threatened flora sites with tubestock of hardy, locally occurring native ground-covers, shrubs and small tree trees.

c) Carry out revegetation of bare/disturbed ground surrounding in-situ threatened species locations as soon as earthworks are completed. Use of forest topsoil with native species seedbank is recommended to ensure hardy, locally occurring species (gound-covers, shrubs and small trees) are established.

d) A plant ecologist/horticulturalist to identify/advise on areas of forest within the clearing footprint suitable for salvage of weed free topsoil for use in revegetation/landscaping and appropriate methods of storage and use.

5.3 Monitoring of In-situ Roadside Specimens

5.3.1 Monitoring Methods

Slender Marsdenia, Woolls' Tylophora, Rusty Plum and Koala Bells remaining in-situ within 10 meters of the edge of construction are to be monitored. The specific individuals to be monitored are to be determined after pre-clearing surveys have been completed and other details such as sedimentation basins have been added to the road construction design.

In the case of Maundia, indirect impacts may extend more than 10 meters from the edge of clearing/construction, because of the nature of its aquatic habitat. In the case of this species it is recommended that monitoring include all remaining in-situ plants within 30 metres of the construction footprint, particularly where Maundia grows up to the edge of the footprint.

In the case of Spider Orchid, impacts may also extend more than 10 meters from the edge of clearing/construction, because this species grows in a protected microclimate. It is therefore recommended that monitoring include all remaining in-situ plants within 20 metres of the construction footprint

In-situ roadside individuals will be tagged with the existing number in the TFMP, or if new individuals are identified these will be given a new unique number for monitoring. Since Maundia occurs as a mat of leafy shoots, the cover-abundance of this plant is to be recorded using a photographic record approach. Photographs are to be taken from an elevated position and a grid superimposed over the photograph to calculated crown cover/cover-abundance.

The same data will be recorded for in-situ threatened plants as the translocated plants.

5.3.2 Timing/Frequency

Monitoring frequency for in-situ roadside threatened plant is as follows: initially after installing protective barriers (prior to start of clearing), 6-monthly intervals for two years and once a year thereafter.

In addition to the above, monthly inspections of all in-situ flora are to be carried out during clearing and the construction phase (without recording monitoring data). Monitoring is to be conducted during construction (~3 yrs) and after construction for a minimum of 5 years, a total of 8 years.

5.3.3 Annual monitoring report

An annual report is to be prepared at the end of each year describing the results of monitoring in-situ roadside threatened plants. This report will be combined with the translocation monitoring in a single report (if only six months monitoring of in-situ plants has been completed that will be included in the annual monitoring report). The condition of each species is to be summarised and include an assessment of the effectiveness of mitigation measures and any corrective actions carried out.

5.3.4 Performance Indicators

The following performance indicators are to be used to evaluate the success of protective measures for in-situ threatened flora:

a) The survival rate of in-situ threatened flora at the finish of clearing is 100%. No accidental damage occurs during clearing.

b) The survival rate of in-situ threatened flora at the end of years 1-3 of the monitoring program is at least 80% and at least 70% at the end of years 4-8;

c) Of plants surviving at the end of each year, at least 75% are in good condition – i.e. they have healthy foliage, no sign of die-back or disease and exhibit new shoot growth (Condition Class 3 or >)

5.3.5 Corrective Actions

Specific corrective actions will be triggered if monitoring identifies lower results than specified by the above performance indicators. If lower results are detected by the plant ecologist conducting the monitoring, the Environmental Manager will be informed within 5 working days, and corrective actions undertaken within 1 month. Examples of corrective actions to be considered include-

- Weed control in situations where exotic species increase and pose a potential threat to the vigour and persistence of the translocated species.
- Installation of surveillance cameras and signage to deter further theft of in-situ species.
- Installation of hessian screening as a temporary measure to protect in situ threatened plants from over-exposure to sun and wind after vegetation clearing, until protective revegetation becomes established.

5.4 Slender Marsdenia and Woolls' Tylophora Habitat Condition

5.4.1 Monitoring Methods

Monitoring of potential changes in the habitat of Slender Marsdenia and Woolls'Tylophora is to be conducted within the indirect impact zone – ie within 10 metres of the edge of clearing/construction. A total of 17.8 Ha of Slender Marsdenia and Woolls' Tylophora habitat has been identified within the project boundary (Jacobs SKM 2014). Monitoring is to be conducted in areas of this habitat adjacent to the construction footprint and to be plot-based.

Plot based assessment

Permanent plots will be established in the indirect impact zone at 10 representative points in Slender Marsdenia and Woolls'Tylophora habitat. The plots are to be 10 metres wide and 20 metres long, with the long axis parallel to the edge of clearing. Monitoring will focus on recording vegetation structure, the level of weed incursion and microclimate descriptors. Structure consists of the height, crown cover and dominant species in each vegetation layer and will be recorded according to the current OEH vegetation standard (Native Vegetation Interim Type Standard –

http://www.environment.nsw.gov.au/research/VISplot.htm). This will provide a measure of the intactness of the habitat and potential changes in structure over time that could affect the growth of Slender Marsdenia and Woolls'Tylophora. All exotic species will be recorded and the species crown cover (cover-abundance) estimated visually according to the vegetation standard (ie. <1%, 1%, 5%, 10%, 15% etc). The abundances of all exotic species will be summed to provide an index of weed incursion. Total (overlapping) exotic species crown cover will also be recorded and used as an index.

To record microclimate the following categories (1-6) are to be applied:

Microclimate Class (less exposed to more exposed)	**Microclimate Type**
1	Sheltered aspect (e.g. south) and vegetation understorey slightly more open and exposed than before clearing.
2	Sheltered aspect (e.g. south) and vegetation understorey moderately more open and exposed than before clearing.
3	Sheltered aspect (e.g. south) and vegetation understorey much more open and exposed than before clearing.
4	Explosed aspect (e.g. east, north and west) and vegetation understorey slightly more open and exposed than before clearing.
5	Explosed aspect (e.g. east, north and west) and vegetation understorey moderately more open and exposed than before clearing.
6	Explosed aspect (e.g. east, north and west) and vegetation understorey much more open and exposed than before clearing.

Note – an increase in microclimate exposure class (e.g. 1 to 2) may be recorded between monitoring events if there is a noticeable decline in understorey or overstorey structure allowing greater sun and wind penetration, and consequent drying of Slender Marsdenia and Woolls' Tylophora habitat.

5.4.2 Timing/Frequency

The plots are to be established within one month of the finish of vegetation clearing (baseline monitoring) and then monitored at 12-monthly intervals during construction and the operation phase for a total of 8 years.

5.4.3 Annual monitoring report

The results of Slender Marsdenia and Woolls Tylophora habitat condition monitoring shall be included in the annual monitoring report. This is to be prepared at the end of each year. The quantitative habitat descriptors (i.e. vegetation structure, weed abundance and microclimate) are to be summarised and compared with the previous year(s) to assess any changes in habitat condition.

5.4.4 Performance Indicators

The following performance indicators are to be used to evaluate changes in habitat condition

a) Plot crown-cover of exotic species is no more than 15% (overlapping and/or summed) at the end of Year-1 and no more than 25% at the end of Years-2 to 8.

b) Baseline vegetation structure (height and crown cover) remains the same or increases in height and crown cover at the end of year compared to the previous year.

c) There is no increase in the microclimate exposure class (e.g. 1 to 2, or 4 to 5) compared to the previous year.

5.4.5 Corrective Actions

Specific corrective actions will be triggered if monitoring identifies changes as specified by the above performance indicators. If such changes are detected by the plant ecologist conducting the monitoring, the Environmental Manager will be informed within 5 working days, and corrective actions undertaken within 1 month. Examples of corrective actions to be considered include-

a) Weed control in and around Slender Marsdenia and Woolls' Tylophora habitat representative of such plots where exotic species exceed thresholds and pose a potential threat to habitat condition and the vigour and persistence of Slender Marsdenia and Woolls' Tylophora. Weed control to be applied by an experienced bush regenerator familiar with identification of Slender Marsdenia and Woolls' Tylophora.

b) Prioritise revegetation of batters and bare areas adjacent to Slender Marsdenia and Woolls' Tylophora habitat to minimise potential for deterioration in habitat microclimate and structure, and weed incursion. Use salvaged topsoil seed bank (Sec. 5.2.2) for this purpose to minimise weed spread from revegetated areas into adjacent habitat.

6 MANAGEMENT OF UNFORSEEN IMPACTS

Throughout the early works, detailed design and construction period there is a possibility of design refinements that may impact on additional areas of threatened species. This may include but not be limited to, clearing for: fencing, Property Works and Service Works.

A consistency assessment would be undertaken against the Minister for Planning's Conditions of Approval for the project. If the additional impacts are deemed inconsistent with the Minister for Planning's Conditions of Approval then a modification under Section 75 W of the *Environmental Planning and Assessment Act 1979* would be lodged for determination by the Minster for Planning. This process would also enable a detailed record of any additional impacts outside of what was anticipated in the Threatened Flora Management Plan.

If additional assessment identifies an increased impact to threatened species within the project corridor additional translocation measures would be considered. Any additional translocation measures would be determined using the same methodology as detailed in Section 4.4, 4.5 & 4.6 of this report. Any additional translocation efforts would be in accordance with the translocation objectives for the project which are defined as follows:-

- To transplant and re-establish impacted individuals of threatened species at a nearby site with soil type and topography closely matching the original site of each species;
- To promote the long-term sustainability of the founder (translocated) population by enhancing population size and genetic diversity through propagation and introduction of additional individuals;
- To promote long-term sustainability by restoring good quality habitat and establishing functional habitat conditions;
- To undertake translocation using a monitored, experimental approach that improves knowledge of species ecology and translocation technology; and
- To preserve individuals of threatened and rare species in-situ wherever possible and limit transplanting to individuals directly impacted by construction, or as otherwise directed by the Project Ecologist.

An addendum to the translocation plan would be prepared for any additional species or individuals to be translocated due to design changes associated with the detailed design period.

If any significant additional impacts, as identified by the Project Ecologist are identified, RMS would consult with Environmental Protection Authority and Department of Planning and Infrastructure to determine the appropriate approval and /or management measures necessary.

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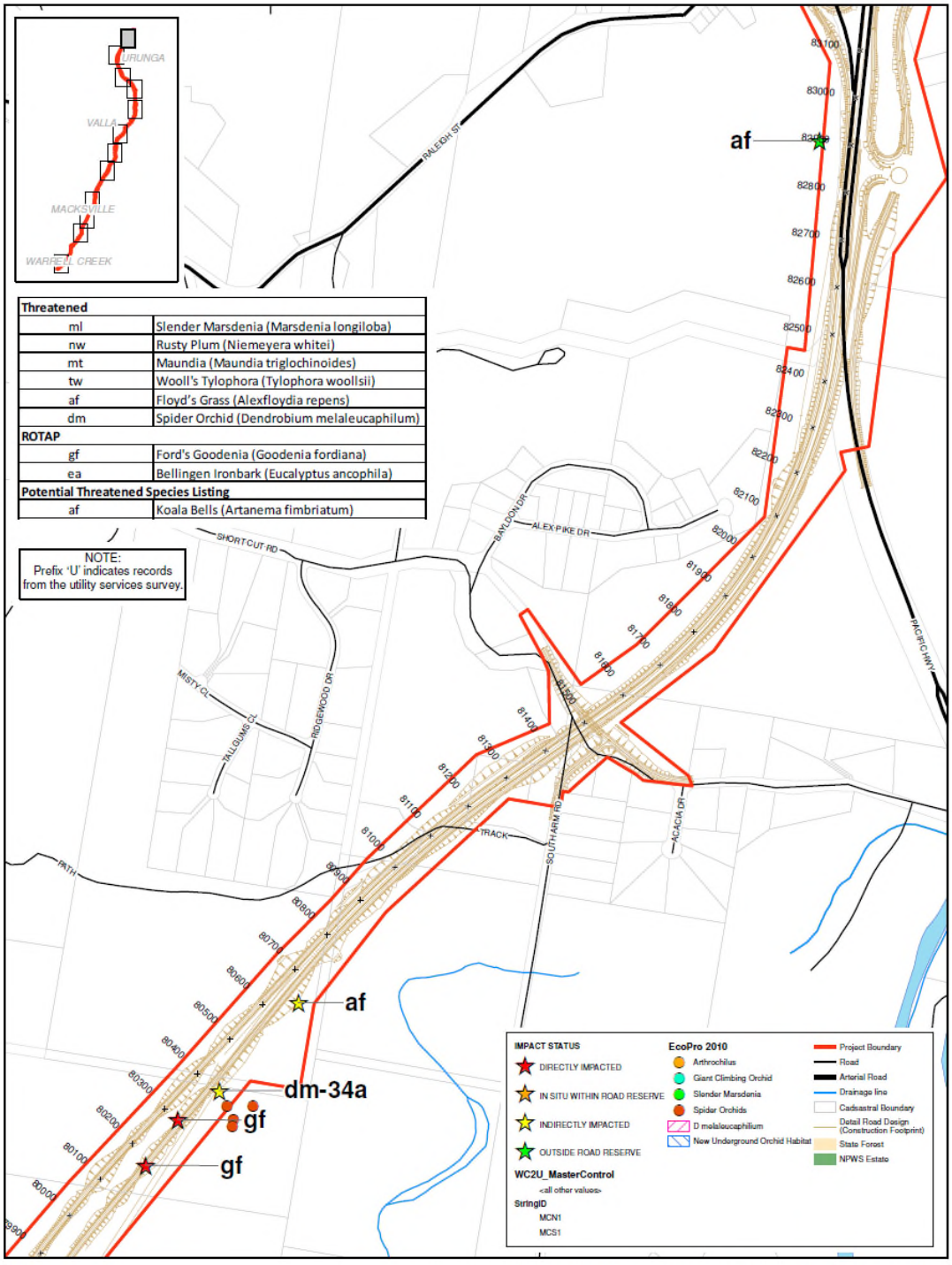
APPENDIX 1: PLANS 2-13 SHOWING THE LOCATION OF THREATENED AND RARE SPECIES

AND RARE SPECIES within the project boundary of the WC2U upgrade, as recorded during targeted flora surveys conducted for this report in November 2011 and October 2012, and EcoPro (2010). Additional threatened flora data for the southern half of WC2U (WC2NH) were included in Version 2 of the WC2U TFMP from the following sources:

- ECOS Environmental (2014a). Targeted surveys (and sample collection) for a genetic study of *Marsdenia longiloba* currently being conducted by ECOS Environmental in collaboration with University of Sunshine Coast, titled "Analysis of genetic variability in the endangered species Slender Marsdenia (*Marsdenia longiloba*) at fine, medium and broad geographic scales"
- ECOS Environmental (2014b). Targeted re-survey of threatened species in the Cockburns Lane (Warrell Creek) area.
- ECOS Environmental (2014c).Targeted survey for a connector track with Old Coast Road, Nambucca Heads.
- by GeoLink (2014). Targeted surveys along the utilities alignment.

Note - the road design shown on plans below for the northern half of WC2U (i.e. NH2U, presently under construction) is based on the (modified) Concept Design, as presented in the WC2U TFMP Ver. 1 (6/3/2013). The road design shown on the plans below for the southern half of WC2U (i.e. WC2NH) is the latest RMS Concept Design as of July 2014. Construction of WC2NH is expected to start later in 2014. Further small changes to the design of WC2NH may be required during the detailed design phase.



Threatened	
ml	Slender Marsdenia (Marsdenia longiloba)
nw	Rusty Plum (Niemeyera whitei)
mt	Maundia (Maundia triglochinoides)
tw	Wooll's Tylophora (Tylophora woollsii)
af	Floyd's Grass (Alexfloydia repens)
dm	Spider Orchid (Dendrobium melaleucaphilum)
ROTAP	
gf	Ford's Goodenia (Goodenia fordiana)
ea	Bellingen Ironbark (Eucalyptus ancophila)
Potential Threatened Species Listing	
af	Koala Bells (Artanema fimbriatum)

Figure 2 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

Cadastre: Roads and Traffic Authority 2007 Highway Design (footprint): RTA 2011
Flora Survey: ECOS December 2011/ February 2012 / Oct-Nov 2012 Project Boundary: RTA 2011
Roads: Geoscience Australia 2009 Drainage: Geoscience Australia 2009
State Forests: NSW Department of Primary Industries 2008

This plan was prepared for the purpose and exclusive use of ECOS and is not to be used for any other purpose. This plan is conceptual, and is not a detail design.

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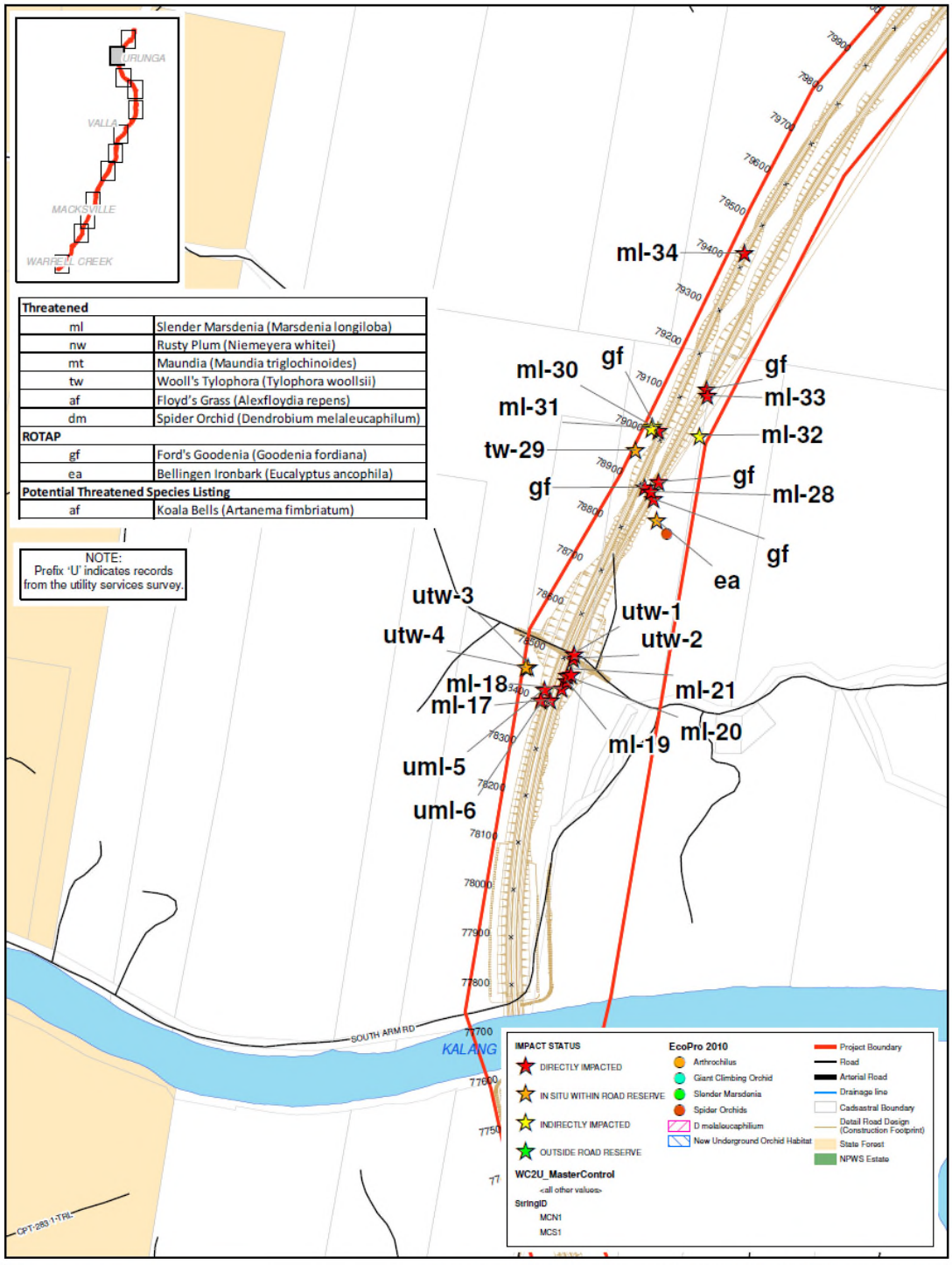


Figure 3 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

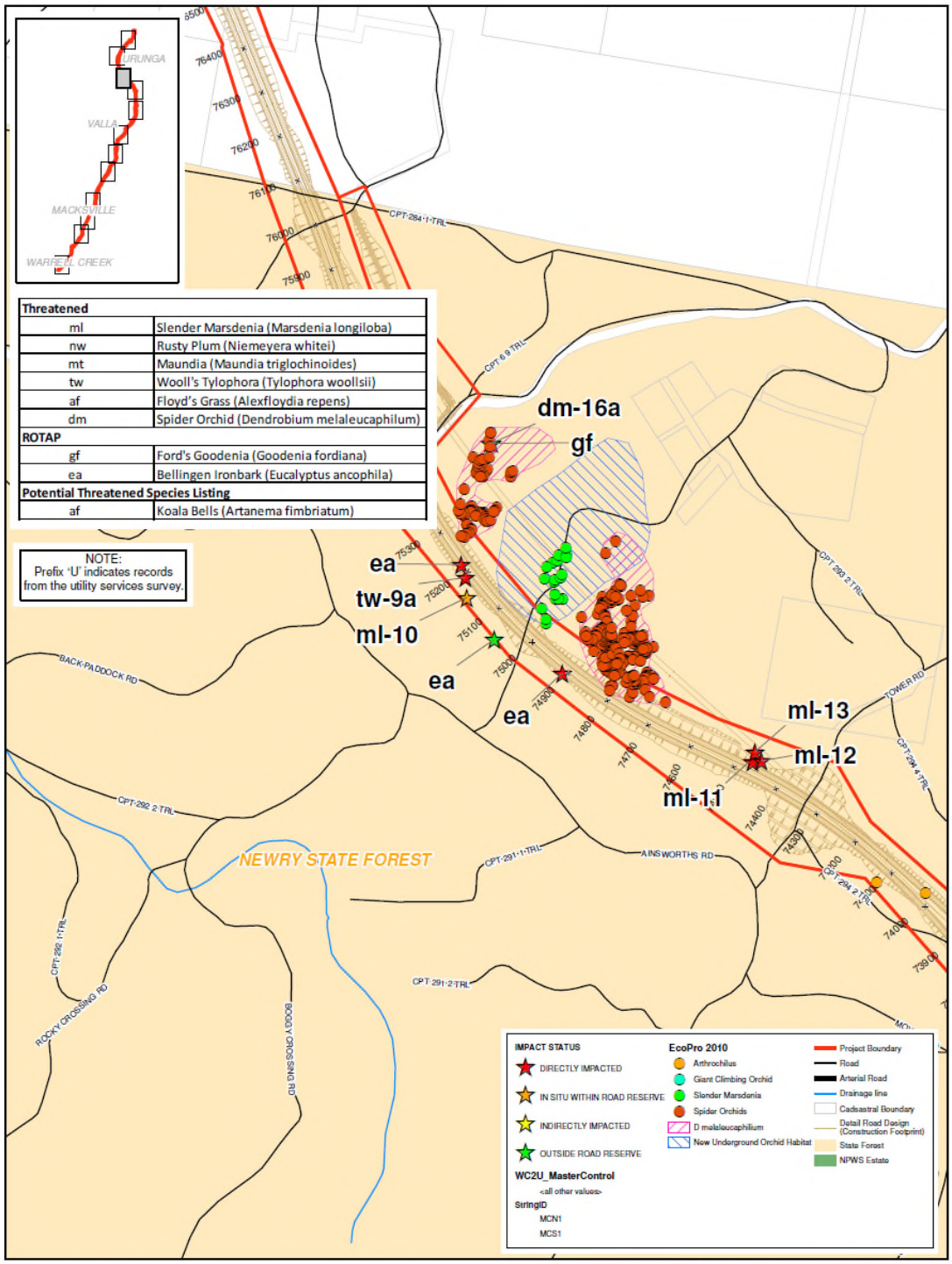
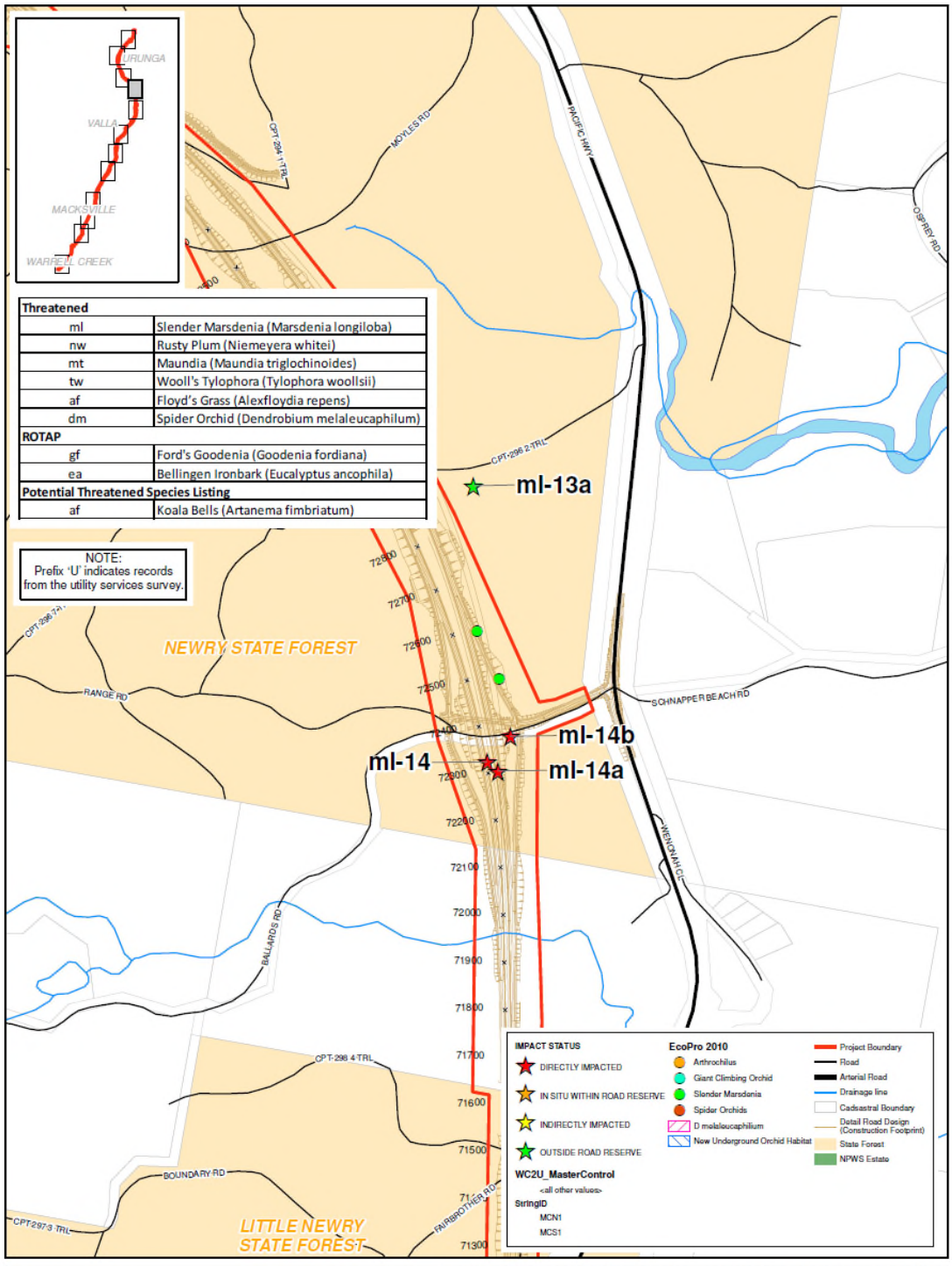


Figure 4 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual



Threatened	
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mt	Maundia (Maundia triglochinoides)
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af	Floyd's Grass (Alexfloydia repens)
dm	Spider Orchid (Dendrobium melaleucaphilum)
ROTAP	
gf	Ford's Goodenia (Goodenia fordiana)
ea	Bellingen Ironbark (Eucalyptus ancophila)
Potential Threatened Species Listing	
af	Koala Bells (Artanema fimbriatum)

Figure 5 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

A4 Scale 1:10,000

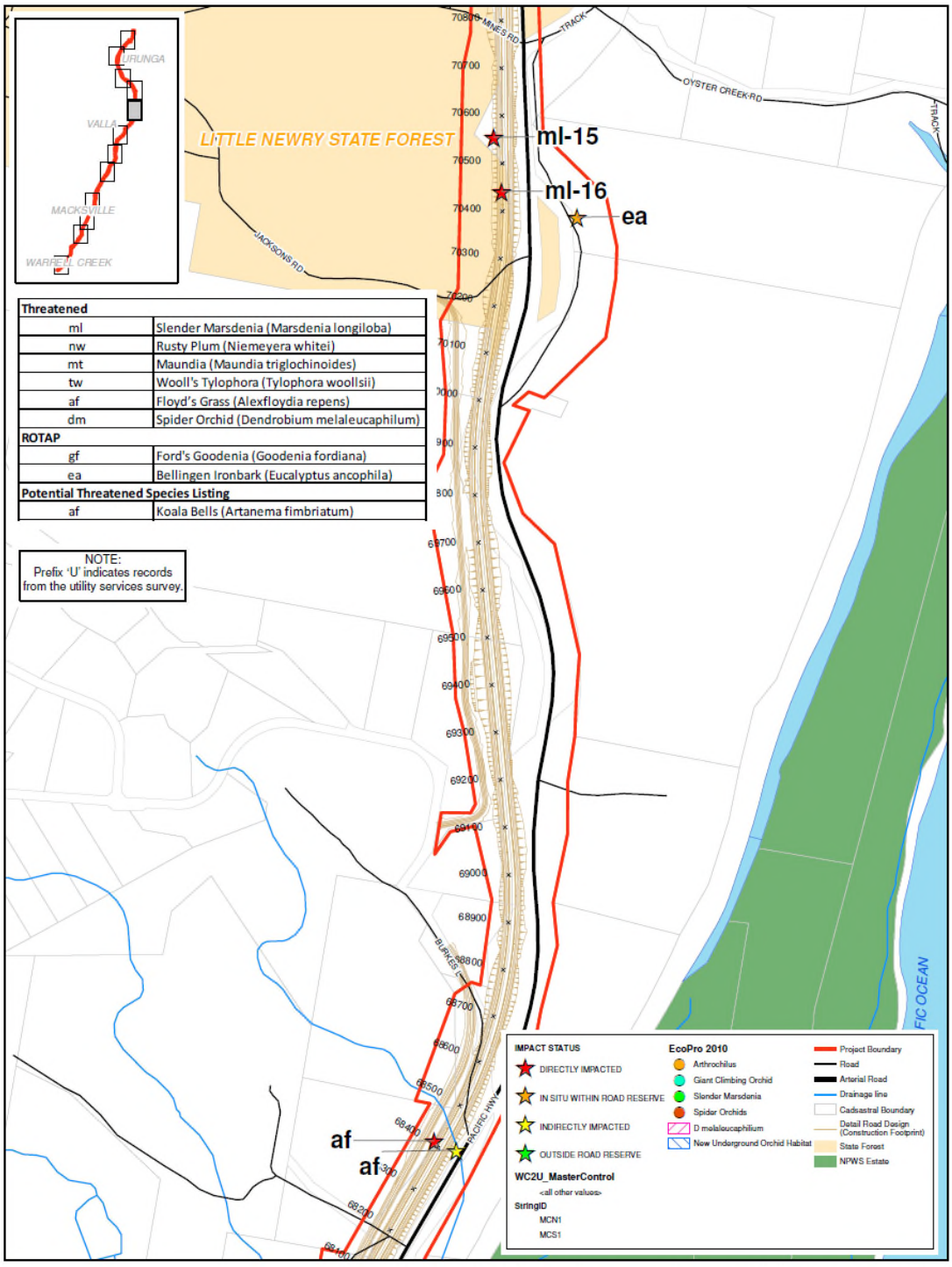

Figure 6 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

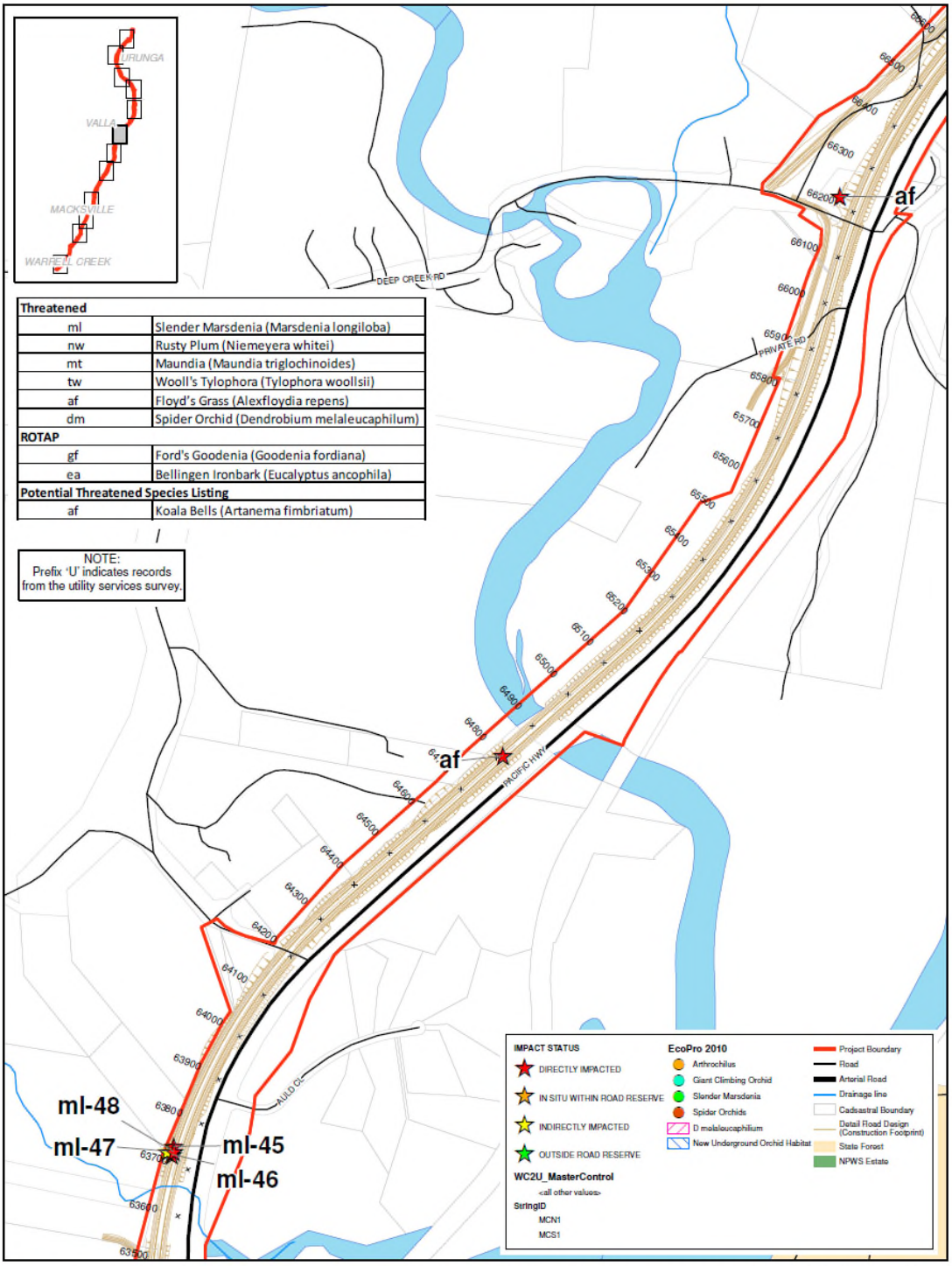

Figure 7 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

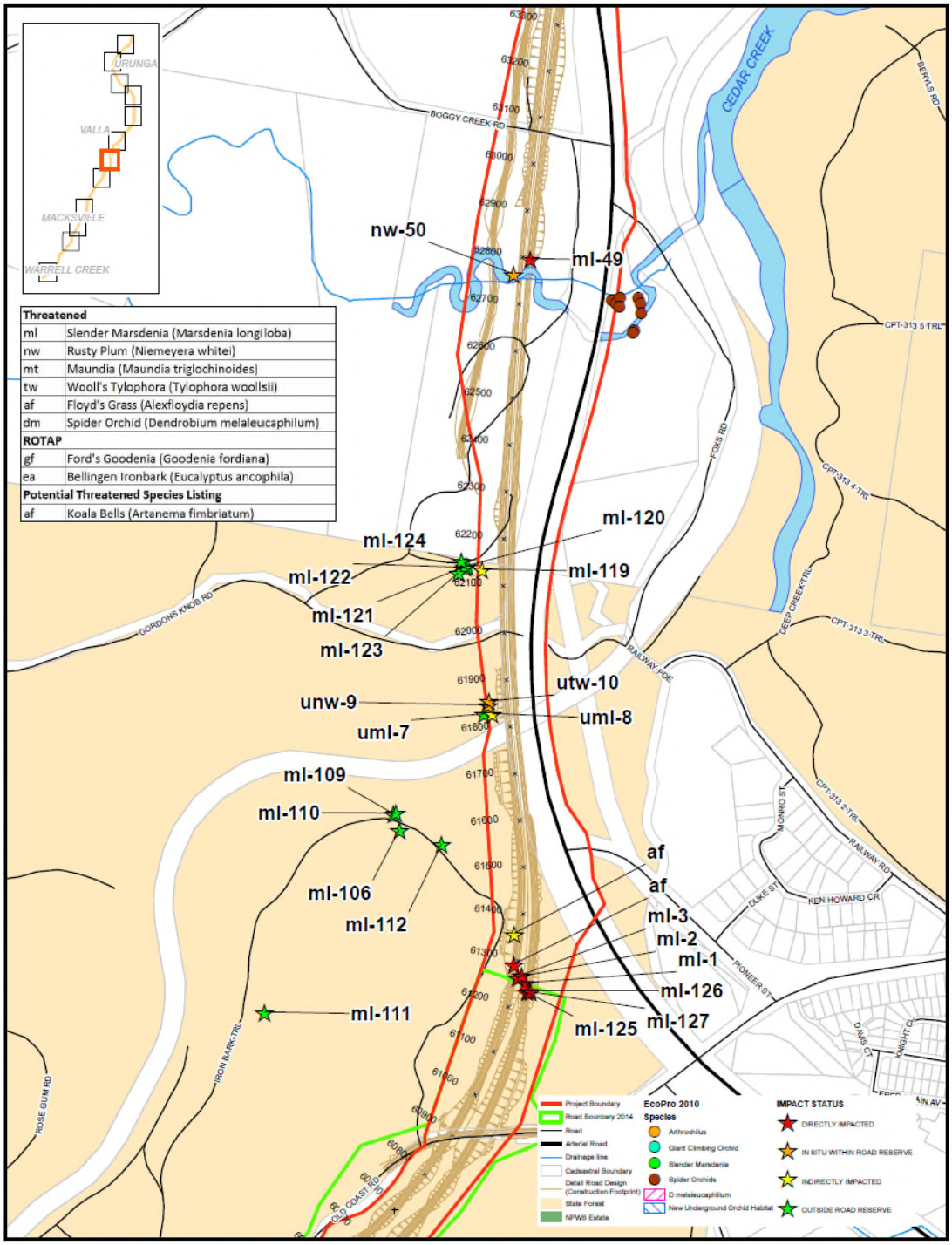

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Figure 8

Threatened and rare species recorded during the 2011-2014 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

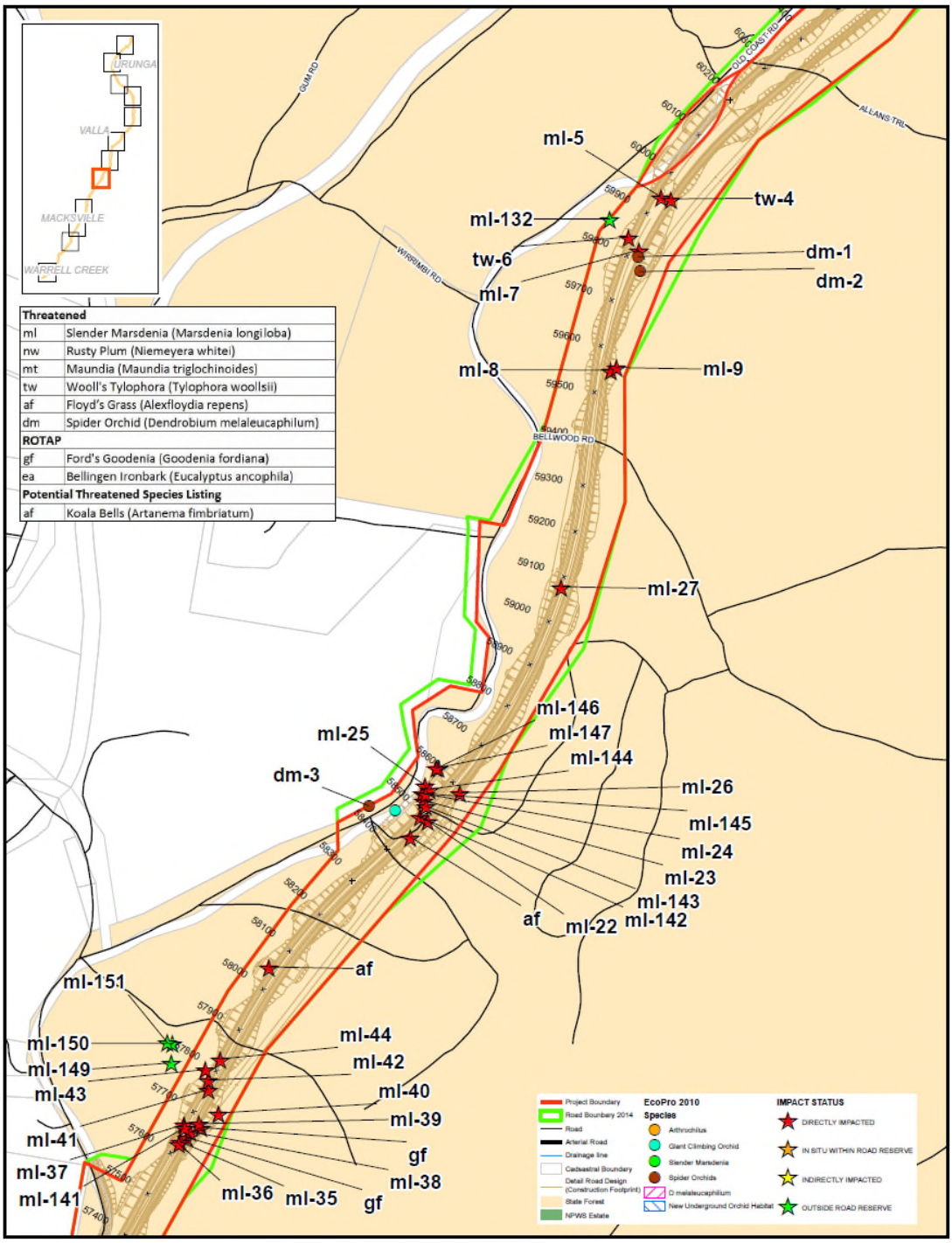

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Figure 9

Threatened and rare species recorded during the 2011-2014 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

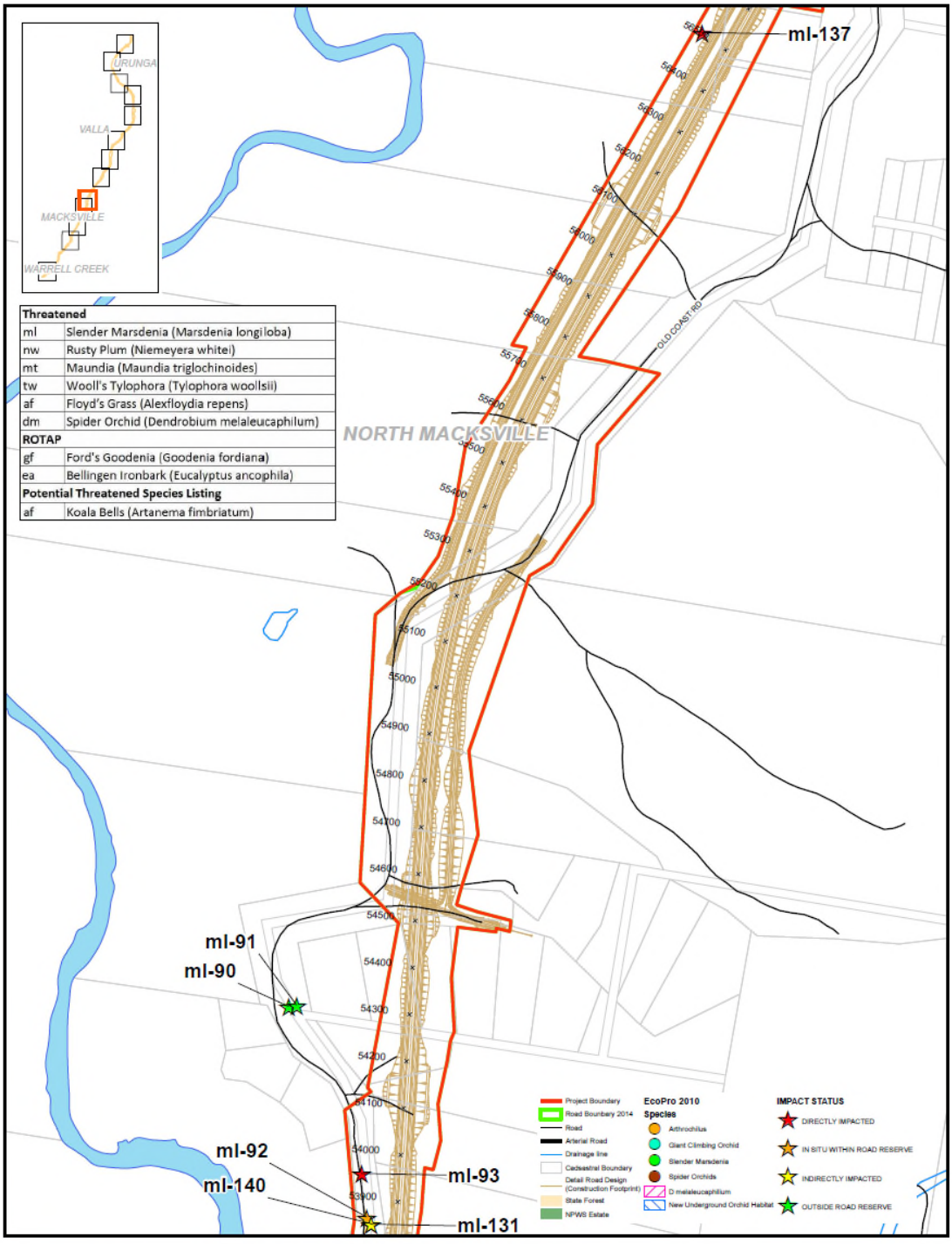

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Figure 10

Threatened and rare species recorded during the 2011-2014 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

Note: ml-92 is shown as directly impacted (red) as it was indicated there would be an upgrade/works along Old Coast Road. The impact status of this point would be updated as the detailed design progresses and during the pre-clearing survey.

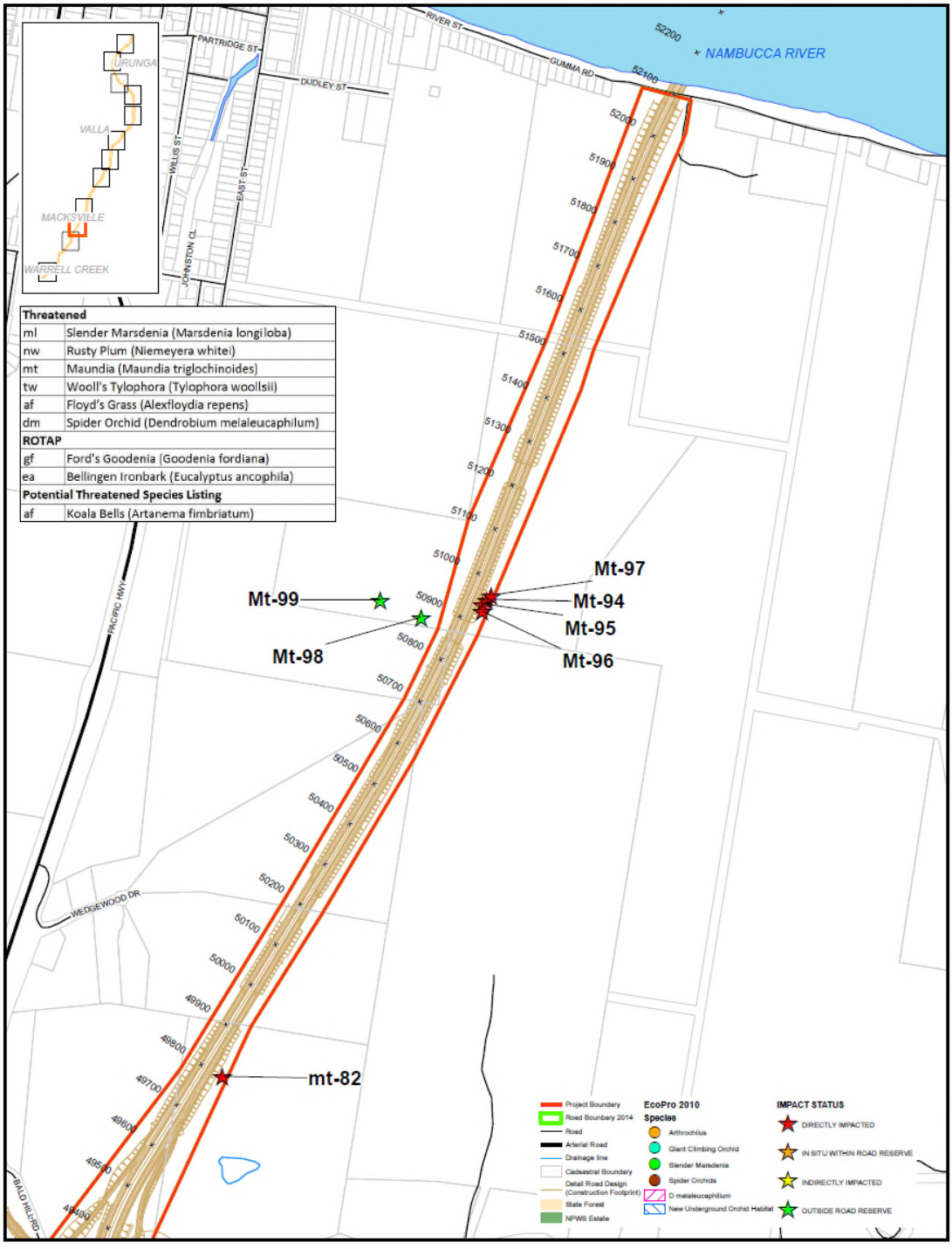

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Figure 11

Threatened and rare species recorded during the 2011-2014 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

Note: mt-82 marks the western tip of a large population of Maundia that in 2011 extended for more than 100m east of the project boundary; between mt-82 and the project boundary was a short distance (few metres) of indirectly impacted. The section from mt-82 to mt-96 was not surveyed due to access limitations; Maundia distribution in this section will be clarified during the pre-clearing survey.

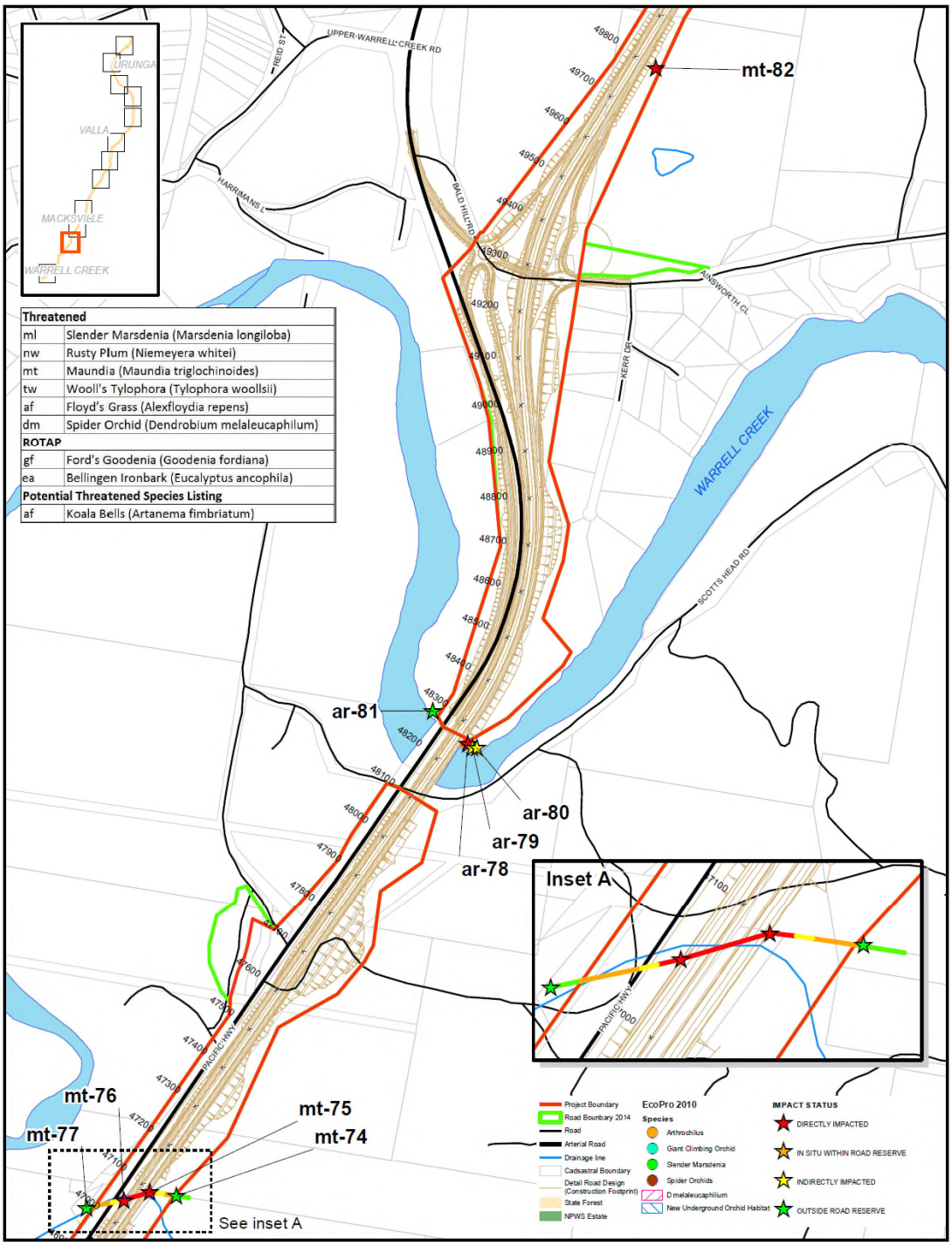

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Figure 12

Threatened and rare species recorded during the 2011-2014 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

Note: the colour coding in the inset is to be interpreted as per impact status in the existing legend – ie. red = directly impacted; yellow = indirectly impacted; orange = in situ; green = outside road reserve/project boundary. See note on Fig 11 for point mt–82.

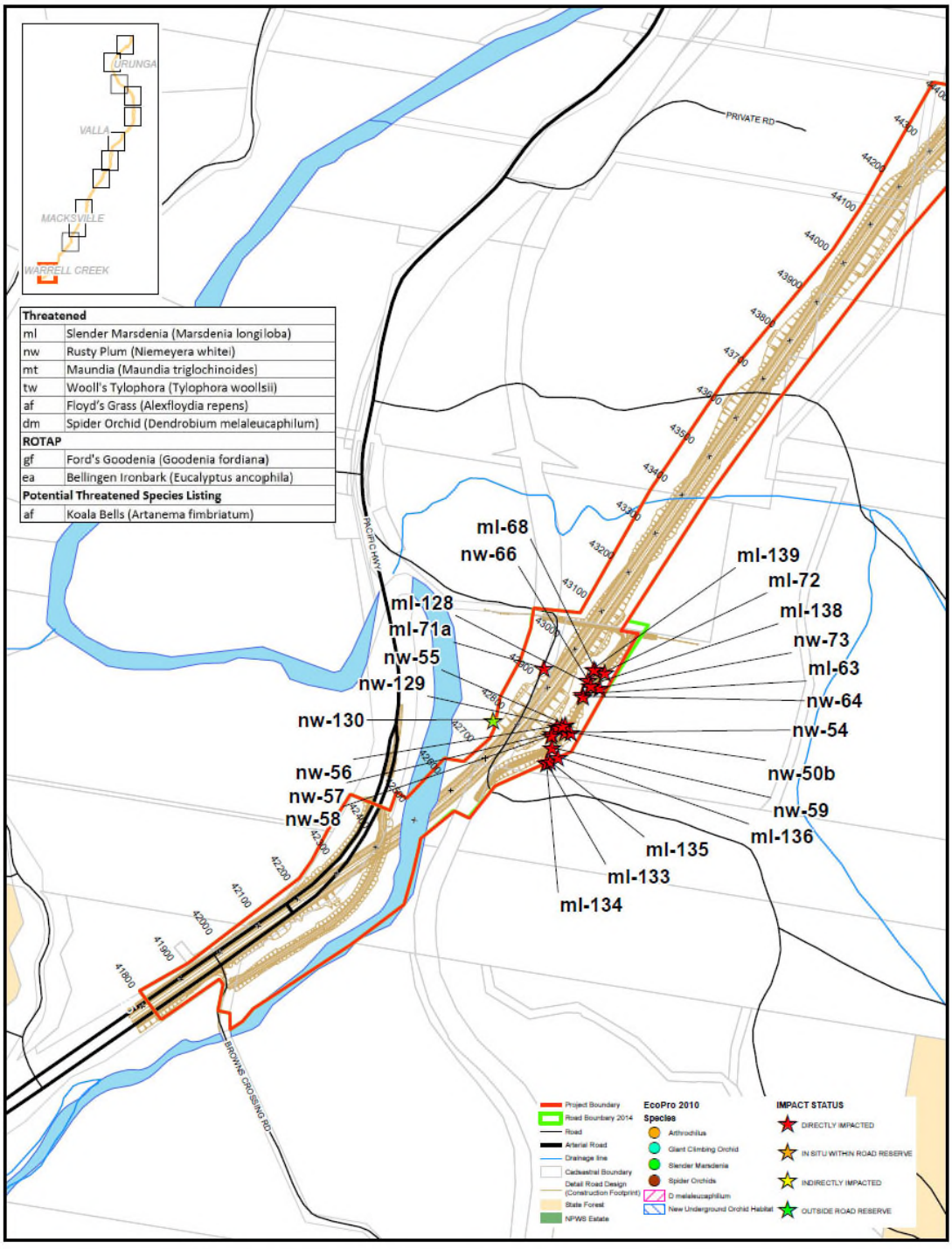

Figure 13
Threatened and rare species recorded during the 2011-2014 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

Note: the position of point nw-130 (green – outside project boundary) was estimated from a vantage point as it could not be accessed on the ground and it could actually be within the road reserve; the precise location of the tree would be recorded during the pre-clearing survey.

APPENDIX 2: LOCATION COORDINATES OF THREATENED FLORA AND RESULTS OF IMPACT ANALYSIS for (i) the southern half of WC2U – Warrell Creek to Nambucca Heads (WC2NH) and (ii) northern half of WC2U – Nambucca Heads to Urunga (NH2U), indicating if individuals are directly impacted, indirectly impacted, outside the indirect zone within the project boundary (in situ within the road reserve) or outside the project boundary/road reserve. The results for the EcoPro (2010) targeted orchid survey are given below

(i) Warrell Creek to Nambucca Heads (WC2NH)

ID	SPECIES	EASTING	NORTHING	NUMBERS	HEIGHT	IMPACT_RMS
ar-78	Alexfloydia repens	492334.706995	6599021.622260	mat		DIRECTLY IMPACTED
ar-79	Alexfloydia repens	492344.763916	6599013.133180	mat		INDIRECTLY IMPACTED
ar-80	Alexfloydia repens	492353.539390	6599011.846530	mat		INDIRECTLY IMPACTED
ar-81	Alexfloydia repens	492261.429754	6599090.278560	mat		OUTSIDE ROAD RESERVE
af	Artanema fimbriatum	495851.457703	6607944.201690	1		DIRECTLY IMPACTED
af	Artanema fimbriatum	496151.378340	6608221.361400	12		DIRECTLY IMPACTED
gf	Goodenia fordiana	495678.042363	6607581.015290	mat		DIRECTLY IMPACTED
gf	Goodenia fordiana	495708.849288	6607601.898610	mat		DIRECTLY IMPACTED
ml-22	Marsdenia longiloba	496188.410408	6608256.097960	2	0.1m	DIRECTLY IMPACTED
ml-23	Marsdenia longiloba	496180.251673	6608299.314590	1	1m	DIRECTLY IMPACTED
ml-24	Marsdenia longiloba	496177.372208	6608314.274170	1	0.5m	DIRECTLY IMPACTED
ml-25	Marsdenia longiloba	496182.954756	6608331.453140	2	0.8m	DIRECTLY IMPACTED
ml-26	Marsdenia longiloba	496256.890152	6608315.410310	6	0.5m	DIRECTLY IMPACTED
ml-27	Marsdenia longiloba	496471.828945	6608754.696510	1	0.4m	DIRECTLY IMPACTED
ml-35	Marsdenia longiloba	495663.835870	6607571.959330	1	4m	DIRECTLY IMPACTED
ml-36	Marsdenia longiloba	495660.804035	6607567.525330	1	0.2m	DIRECTLY IMPACTED
ml-37	Marsdenia longiloba	495671.485200	6607608.163410	3	0.8m	DIRECTLY IMPACTED
ml-38	Marsdenia longiloba	495684.423981	6607593.392690	1	0.1m	DIRECTLY IMPACTED
ml-39	Marsdenia longiloba	495702.778781	6607610.022940	1	0.1m	DIRECTLY IMPACTED

ml-40	Marsdenia longiloba	495744.282604	6607632.942110	1	small	DIRECTLY IMPACTED
ml-41	Marsdenia longiloba	495722.548309	6607682.802220	10	small	DIRECTLY IMPACTED
ml-42	Marsdenia longiloba	495722.699901	6607703.119170	1	1.5m	DIRECTLY IMPACTED
ml-43	Marsdenia longiloba	495716.783427	6607725.280690	1	0.1	DIRECTLY IMPACTED
ml-44	Marsdenia longiloba	495748.069111	6607748.011070	2	0.3m	DIRECTLY IMPACTED
ml-5	Marsdenia longiloba	496683.949976	6609585.722830	1	small	DIRECTLY IMPACTED
ml-63	Marsdenia longiloba	489635.678810	6594537.005010	1	0.1m	DIRECTLY IMPACTED
ml-68	Marsdenia longiloba	489663.695772	6594588.748820	1	1.5m	DIRECTLY IMPACTED
ml-7	Marsdenia longiloba	496637.195041	6609472.118760	6	0.6m	DIRECTLY IMPACTED
ml-71a	Marsdenia longiloba	489553.726825	6594591.727680	3	2m	DIRECTLY IMPACTED
ml-72	Marsdenia longiloba	489683.316469	6594582.857250	1	1m	DIRECTLY IMPACTED
ml-8	Marsdenia longiloba	496576.593202	6609216.292200	2	0.6m	DIRECTLY IMPACTED
ml-9	Marsdenia longiloba	496589.206798	6609222.021860	1	4m	DIRECTLY IMPACTED
mt-74	Maundia triglochinoides	491716.604039	6598059.237540	mat		INDIRECTLY IMPACTED
mt-75	Maundia triglochinoides	491659.329340	6598066.765920	mat		DIRECTLY IMPACTED
mt-76	Maundia triglochinoides	491604.147159	6598050.284420	mat		DIRECTLY IMPACTED
mt-77	Maundia triglochinoides	491524.399223	6598033.044450	mat		OUTSIDE ROAD RESERVE
mt-82	Maundia triglochinoides	492733.536182	6600457.027550	mat		DIRECTLY IMPACTED
nw-50b	Niemeyera whitei	489598.600127	6594456.623420	1	8m	DIRECTLY IMPACTED
nw-54	Niemeyera whitei	489610.242842	6594455.157100	1	8m	DIRECTLY IMPACTED
nw-55	Niemeyera whitei	489599.063113	6594472.508300	1	sdlg	DIRECTLY IMPACTED
nw-56	Niemeyera whitei	489581.206261	6594468.612190	1	1.2m	DIRECTLY IMPACTED
nw-57	Niemeyera whitei	489570.696540	6594452.902240	1	7m	DIRECTLY IMPACTED
nw-58	Niemeyera whitei	489569.106161	6594448.467830	1	6m	DIRECTLY IMPACTED
nw-59	Niemeyera whitei	489571.204261	6594422.796200	1	10m	DIRECTLY IMPACTED
nw-64	Niemeyera whitei	489636.959937	6594531.465170	1	8m	DIRECTLY IMPACTED
nw-66	Niemeyera whitei	489647.610383	6594566.753670	1	4m	DIRECTLY IMPACTED
nw-73	Niemeyera whitei	489672.663574	6594549.969920	1	5m	DIRECTLY IMPACTED

tw-4	Tylophora woollsii	496704.871330	6609581.111790	1		DIRECTLY IMPACTED
tw-6	Tylophora woollsii	496614.669628	6609500.001180	1		DIRECTLY IMPACTED
ml-90	Marsdenia longiloba	494181.000000	6604547.000000	2		OUTSIDE ROAD RESERVE
ml-91	Marsdenia longiloba	494198.000000	6604550.000000	1		OUTSIDE ROAD RESERVE
ml-92	Marsdenia longiloba	494347.000000	6604098.000000	1		IN SITU WITHIN ROAD RESERVE
ml-93	Marsdenia longiloba	494336.000000	6604191.000000	1		DIRECTLY IMPACTED
mt-94	Maundia triglochinoides	493295.000000	6601470.000000	mat		DIRECTLY IMPACTED
mt-95	Maundia triglochinoides	493286.000000	6601461.000000	mat		DIRECTLY IMPACTED
mt-96	Maundia triglochinoides	493285.000000	6601445.000000	mat		DIRECTLY IMPACTED
mt-97	Maundia triglochinoides	493304.000000	6601479.000000	mat		DIRECTLY IMPACTED
mt-98	Maundia triglochinoides	493156.000000	6601432.000000	mat		OUTSIDE ROAD RESERVE
mt-99	Maundia triglochinoides	493069.000000	6601470.000000	mat		OUTSIDE ROAD RESERVE
ml-111	Marsdenia longiloba	496931.363625	6610540.871290	1		OUTSIDE ROAD RESERVE
ml-125	Marsdenia longiloba	497488.408000	6610582.878000	1	0.1m	DIRECTLY IMPACTED
ml-126	Marsdenia longiloba	497493.501000	6610586.158000	1	0.1m	DIRECTLY IMPACTED
ml-127	Marsdenia longiloba	497496.352000	6610583.216000	2	1m	DIRECTLY IMPACTED
ml-128	Marsdenia longiloba	489653.000000	6594556.000000	1	0.1m	DIRECTLY IMPACTED
nw-129	Rusty Plum	489592.530000	6594469.550000	1	4m	DIRECTLY IMPACTED
nw-130	Rusty Plum	489445.710000	6594482.210000	1		OUTSIDE ROAD RESERVE
ml-131	Marsdenia longiloba	494356.000000	6604083.000000	3		INDIRECTLY IMPACTED
ml-132	Marsdenia longiloba	496575.000000	6609539.000000	1		OUTSIDE ROAD RESERVE
ml-133	Marsdenia longiloba	489559.000000	6594392.000000	2		DIRECTLY IMPACTED
ml-134	Marsdenia longiloba	489560.000000	6594392.000000	3		DIRECTLY IMPACTED
ml-135	Marsdenia longiloba	489567.000000	6594394.000000	1		DIRECTLY IMPACTED
ml-136	Marsdenia longiloba	489584.000000	6594404.000000	1		DIRECTLY IMPACTED
ml-137	Marsdenia longiloba	495058.000000	6606623.000000	1		DIRECTLY IMPACTED
ml-138	Marsdenia longiloba	489653.000000	6594556.000000	1	1.6m	DIRECTLY IMPACTED
ml-139	Marsdenia longiloba	489660.000000	6594591.000000	1	0.6m	DIRECTLY IMPACTED
ml-140	Marsdenia longiloba	494356.000000	6604084.000000	1		INDIRECTLY IMPACTED

ml-141	Marsdenia longiloba	495672.000000	6607601.000000	1	0.2m	DIRECTLY IMPACTED
ml-142	Marsdenia longiloba	496172.000000	6608264.000000	1	0.2m	DIRECTLY IMPACTED
ml-143	Marsdenia longiloba	496185.000000	6608287.000000	1	2.2m	DIRECTLY IMPACTED
ml-144	Marsdenia longiloba	496192.000000	6608323.000000	1	0.3m	DIRECTLY IMPACTED
ml-145	Marsdenia longiloba	496184.000000	6608313.000000	1	0.3m	DIRECTLY IMPACTED
ml-146	Marsdenia longiloba	496212.000000	6608369.000000	1	1.5m	DIRECTLY IMPACTED
ml-147	Marsdenia longiloba	496207.000000	6608368.000000	1	3m	DIRECTLY IMPACTED
ml-149	Marsdenia longiloba	495645.000000	6607740.000000	1		OUTSIDE ROAD RESERVE
ml-150	Marsdenia longiloba	495647.000000	6607781.000000	1		OUTSIDE ROAD RESERVE
ml-151	Marsdenia longiloba	495636.000000	6607784.000000	1		OUTSIDE ROAD RESERVE

(ii) Nambucca Heads to Urunga (NH2U)

ID	SPECIES	EASTING	NORTHING	NUMBERS	HEIGHT	IMPACT_RMS
af	Artanema fimbriatum	497461.092414	6610642.223760	1		DIRECTLY IMPACTED
af	Artanema fimbriatum	497462.035272	6610707.607140	30		DIRECTLY IMPACTED
af	Artanema fimbriatum	498290.907731	6613899.162890	10		DIRECTLY IMPACTED
af	Artanema fimbriatum	498996.450225	6615072.078720	6		DIRECTLY IMPACTED
af	Artanema fimbriatum	500347.886710	6616794.232820	5		INDIRECTLY IMPACTED
af	Artanema fimbriatum	500301.385190	6616814.366140	5		DIRECTLY IMPACTED
af	Artanema fimbriatum	498993.037493	6627709.492660	50		INDIRECTLY IMPACTED
af	Artanema fimbriatum	500084.954156	6629520.828840	5		OUTSIDE ROAD RESERVE
dm-16a	Dendrobium melaleucaphilum	498649.693941	6623095.420120	1		OUTSIDE ROAD RESERVE
dm-34a	Dendrobium melaleucaphilum	498827.816416	6627524.966920	1		INDIRECTLY IMPACTED
ea	Eucalyptus ancophila	500600.800758	6618752.556970	3	30m	IN SITU WITHIN ROAD RESERVE
ea	Eucalyptus ancophila	498796.690430	6622611.905850	10	30m	DIRECTLY IMPACTED

ea	Eucalyptus ancophila	498654.541974	6622683.550800	6	25m	OUTSIDE ROAD RESERVE
ea	Eucalyptus ancophila	498584.490443	6622840.717360	5	25m	DIRECTLY IMPACTED
ea	Eucalyptus ancophila	498014.979409	6626228.850630	1	45m	IN SITU WITHIN ROAD RESERVE
gf	Goodenia fordiana	498645.057057	6623095.050150	mat		OUTSIDE ROAD RESERVE
gf	Goodenia fordiana	498008.413738	6626272.991330	mat		DIRECTLY IMPACTED
gf	Goodenia fordiana	497989.696142	6626297.182810	mat		DIRECTLY IMPACTED
gf	Goodenia fordiana	498019.123273	6626308.639270	mat		DIRECTLY IMPACTED
gf	Goodenia fordiana	498017.824042	6626416.315720	mat		DIRECTLY IMPACTED
gf	Goodenia fordiana	498119.372903	6626503.140060	mat		DIRECTLY IMPACTED
gf	Goodenia fordiana	498672.994767	6627368.143990	mat		DIRECTLY IMPACTED
gf	Goodenia fordiana	498740.165666	6627464.008120	mat		DIRECTLY IMPACTED
ml-1	Marsdenia longiloba	497485.537248	6610602.704080	1	small	DIRECTLY IMPACTED
ml-2	Marsdenia longiloba	497468.445578	6610614.520770	1	small	DIRECTLY IMPACTED
ml-3	Marsdenia longiloba	497477.228559	6610618.955580	15	small	DIRECTLY IMPACTED
ml-112	Marsdenia longiloba	497307.547452	6610897.439340	1		OUTSIDE ROAD RESERVE
ml-106	Marsdenia longiloba	497217.461181	6610927.522240	1		OUTSIDE ROAD RESERVE
ml-109	Marsdenia longiloba	497205.154142	6610962.427000	1		OUTSIDE ROAD RESERVE
ml-110	Marsdenia longiloba	497210.424389	6610963.721250	1		OUTSIDE ROAD RESERVE
uml-7	Marsdenia longiloba	497397.718757	6611174.508620	2	0.5	OUTSIDE ROAD RESERVE
uml-8	Marsdenia longiloba	497415.287488	6611175.436340	2	5	INDIRECTLY IMPACTED
ml-123	Marsdenia longiloba	497343.340779	6611474.444920	1		OUTSIDE ROAD RESERVE
ml-119	Marsdenia longiloba	497393.491629	6611482.399180	3		INDIRECTLY IMPACTED
ml-122	Marsdenia longiloba	497357.393480	6611486.084350	3		OUTSIDE ROAD RESERVE
ml-121	Marsdenia longiloba	497357.233304	6611487.931290	4		OUTSIDE ROAD RESERVE
ml-120	Marsdenia longiloba	497362.503737	6611489.594860	2		OUTSIDE ROAD RESERVE
ml-124	Marsdenia longiloba	497349.723490	6611499.565420	3		OUTSIDE ROAD RESERVE
ml-49	Marsdenia longiloba	497496.039690	6612142.718430	1	0.15m	DIRECTLY IMPACTED

ml-46	Marsdenia longiloba	497598.702108	6613063.459720	40	to 5m	DIRECTLY IMPACTED
ml-48	Marsdenia longiloba	497602.055454	6613069.370790	10	to 1.5m	DIRECTLY IMPACTED
ml-47	Marsdenia longiloba	497588.956090	6613070.291360	10	to 1m	INDIRECTLY IMPACTED
ml-45	Marsdenia longiloba	497602.692015	6613080.268090	1	small	DIRECTLY IMPACTED
ml-16	Marsdenia longiloba	500442.890991	6618806.680550	1	0.4m	DIRECTLY IMPACTED
ml-15	Marsdenia longiloba	500426.432922	6618920.638680	1	3.5m	DIRECTLY IMPACTED
ml-14a	Marsdenia longiloba	500409.842004	6620668.210490	2	small	DIRECTLY IMPACTED
ml-14	Marsdenia longiloba	500386.537955	6620686.516890	2	small	DIRECTLY IMPACTED
ml-14b	Marsdenia longiloba	500435.641790	6620740.522920	1	small	DIRECTLY IMPACTED
ml-13a	Marsdenia longiloba	500357.942502	6621267.385270	1	small	OUTSIDE ROAD RESERVE
ml-11	Marsdenia longiloba	499195.302516	6622426.508930	6	small	DIRECTLY IMPACTED
ml-12	Marsdenia longiloba	499214.008854	6622428.172560	1	small	DIRECTLY IMPACTED
ml-13	Marsdenia longiloba	499200.737108	6622446.456410	1	small	DIRECTLY IMPACTED
ml-10	Marsdenia longiloba	498596.651119	6622771.273610	3	0.2m	IN SITU WITHIN ROAD RESERVE
uml-6	Marsdenia longiloba	497772.427480	6625850.919070	1	1	DIRECTLY IMPACTED
ml-17	Marsdenia longiloba	497791.779559	6625851.107730	1	small	DIRECTLY IMPACTED
uml-5	Marsdenia longiloba	497779.939952	6625872.714540	1	1.5	DIRECTLY IMPACTED
ml-18	Marsdenia longiloba	497816.564585	6625875.307700	1	0.1m	DIRECTLY IMPACTED
ml-19	Marsdenia longiloba	497826.637279	6625891.378130	4	0.2m	DIRECTLY IMPACTED
ml-20	Marsdenia longiloba	497827.754605	6625902.460010	1	0.2m	DIRECTLY IMPACTED
ml-21	Marsdenia longiloba	497835.590897	6625905.231990	5	0.2m	DIRECTLY IMPACTED
ml-28	Marsdenia longiloba	498002.652999	6626288.504580	1	small	DIRECTLY IMPACTED
ml-32	Marsdenia longiloba	498104.834883	6626406.357810	1	0.4m	INDIRECTLY IMPACTED
ml-31	Marsdenia longiloba	498004.547702	6626422.038800	1	1.3m	INDIRECTLY IMPACTED
ml-30	Marsdenia longiloba	498005.986444	6626426.102340	2	0.3m	INDIRECTLY IMPACTED
ml-33	Marsdenia longiloba	498121.454487	6626489.842450	1	0.3m	DIRECTLY IMPACTED
ml-34	Marsdenia longiloba	498198.977611	6626789.798790	1	4m	DIRECTLY IMPACTED

unw-9	Niemeyera whitei	497406.818180	6611193.165320	1	7	IN SITU WITHIN ROAD RESERVE
nw-50	Niemeyera whitei	497460.267315	6612110.387950	1	2.5m	IN SITU WITHIN ROAD RESERVE
utw-10	Tylophora woollsii	497407.934163	6611201.661690	4	1	IN SITU WITHIN ROAD RESERVE
tw-9a	Tylophora woollsii	498593.927600	6622812.829640	1	0.5m	DIRECTLY IMPACTED
utw-3	Tylophora woollsii	497745.864037	6625919.435150	2	1.3	IN SITU WITHIN ROAD RESERVE
utw-4	Tylophora woollsii	497740.905756	6625920.726980	3	0.4	IN SITU WITHIN ROAD RESERVE
utw-1	Tylophora woollsii	497840.222513	6625937.923800	1	1.4	DIRECTLY IMPACTED
utw-2	Tylophora woollsii	497841.820182	6625946.420060	5	0.5	DIRECTLY IMPACTED
tw-29	Tylophora woollsii	497970.168547	6626375.858880	1	0.3m	IN SITU WITHIN ROAD RESERVE

Table 2: Impact Analysis of threatened flora data recorded by EcoPro (2010) overlaid on the highway concept design

SPECIES	EASTING	NORTHING	IMPACTED
Slender Marsdenia	500412.655032	6620861.763829	DIRECTLY IMPACTED
Slender Marsdenia	500365.488803	6620960.403751	DIRECTLY IMPACTED
Spider Orchids	498943.121891	6622574.465214	DIRECTLY IMPACTED
Spider Orchids	496635.580000	6609457.970000	DIRECTLY IMPACTED
Spider Orchids	496639.630000	6609426.260000	DIRECTLY IMPACTED
Spider Orchids	498903.212004	6622587.312599	DIRECTLY IMPACTED
Spider Orchids	498898.412923	6622585.542959	DIRECTLY IMPACTED
Spider Orchids	498899.946650	6622585.542959	DIRECTLY IMPACTED
Spider Orchids	498896.780246	6622574.465214	DIRECTLY IMPACTED

Spider Orchids	498938.322809	6622561.497853	DIRECTLY IMPACTED
Spider Orchids	498944.746322	6622570.695981	DIRECTLY IMPACTED
Spider Orchids	498584.963644	6622899.449064	DIRECTLY IMPACTED
Arthrochilus	499558.731888	6622149.631687	DIRECTLY IMPACTED
Spider Orchids	498962.301725	6622589.202214	IN SITU WITHIN ROAD RESERVE
Slender Marsdenia	498762.875980	6622715.976409	IN SITU WITHIN ROAD RESERVE
Slender Marsdenia	498763.420206	6622724.784617	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498036.000000	6626200.000000	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498843.790000	6627493.210000	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498863.194922	6622659.337938	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498880.758570	6622646.490553	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498885.549406	6622642.721320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498888.814760	6622640.951680	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498882.391247	6622635.412808	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498880.758570	6622633.523193	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498884.015679	6622629.863937	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498884.015679	6622627.984320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498885.557652	6622624.325065	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498891.981164	6622624.325065	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498891.981164	6622627.984320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498890.348487	6622629.863937	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498891.981164	6622618.786192	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498908.002840	6622613.247320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498914.335648	6622611.367702	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498915.968325	6622616.906575	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498917.592757	6622618.786192	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498917.592757	6622618.786192	IN SITU WITHIN ROAD RESERVE

Spider Orchids	498919.134730	6622616.906575	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498951.178081	6622589.202214	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498951.178081	6622591.091829	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498955.968916	6622592.861469	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498955.968916	6622592.861469	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498954.344485	6622592.861469	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498952.711808	6622592.861469	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498951.178081	6622591.091829	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498947.912726	6622592.861469	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498946.378999	6622592.861469	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498946.378999	6622592.861469	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498952.711808	6622591.091829	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498952.711808	6622591.091829	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498954.344485	6622594.741087	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498967.100806	6622594.751084	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498952.711808	6622598.400342	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498949.545403	6622596.630702	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498947.912726	6622596.630702	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498946.378999	6622596.630702	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498946.378999	6622594.741087	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498944.746322	6622605.828830	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498939.947241	6622603.939214	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498938.322809	6622600.289957	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498936.780836	6622602.169574	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498933.523728	6622602.169574	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498944.746322	6622603.939214	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498911.169244	6622616.906575	IN SITU WITHIN ROAD RESERVE

Spider Orchids	498914.335648	6622613.247320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498909.536567	6622616.906575	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498906.370163	6622618.786192	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498904.737486	6622618.786192	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498903.203758	6622622.445447	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498891.981164	6622626.104703	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498890.348487	6622626.104703	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498888.814760	6622626.104703	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498888.814760	6622627.984320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498888.814760	6622627.984320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498887.182083	6622629.863937	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498887.182083	6622629.863937	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498887.182083	6622627.984320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498887.182083	6622629.863937	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498885.557652	6622627.984320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498882.391247	6622627.984320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498600.985319	6622906.877552	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498578.523639	6622954.857786	IN SITU WITHIN ROAD RESERVE
Spider Orchids	497671.126195	6612053.876649	IN SITU WITHIN ROAD RESERVE
Spider Orchids	497669.493518	6612053.876649	IN SITU WITHIN ROAD RESERVE
Spider Orchids	497677.549708	6612046.568137	IN SITU WITHIN ROAD RESERVE
Spider Orchids	496064.044126	6608287.453294	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498888.814760	6622618.786192	INDIRECTLY IMPACTED
Spider Orchids	498896.780246	6622613.247320	INDIRECTLY IMPACTED
Spider Orchids	498898.412923	6622613.247320	INDIRECTLY IMPACTED
Spider Orchids	498901.579327	6622611.367702	INDIRECTLY IMPACTED
Spider Orchids	498946.378999	6622589.202214	INDIRECTLY IMPACTED

Spider Orchids	498947.912726	6622589.202214	INDIRECTLY IMPACTED
Spider Orchids	498944.746322	6622589.202214	INDIRECTLY IMPACTED
Spider Orchids	498930.357324	6622592.861469	INDIRECTLY IMPACTED
Spider Orchids	498904.745731	6622607.708447	INDIRECTLY IMPACTED
Spider Orchids	498906.370163	6622605.818832	INDIRECTLY IMPACTED
Spider Orchids	498970.366160	6622578.124469	INDIRECTLY IMPACTED
Spider Orchids	499013.533155	6622552.309723	INDIRECTLY IMPACTED
Spider Orchids	498979.956077	6622563.387468	INDIRECTLY IMPACTED
Spider Orchids	498596.186238	6622904.987937	INDIRECTLY IMPACTED
Spider Orchids	498591.387156	6622897.569447	INDIRECTLY IMPACTED
Arthrochilus	499456.376223	6622173.676793	INDIRECTLY IMPACTED
Giant Climbing Orchid	496119.901475	6608278.275162	INDIRECTLY IMPACTED
Spider Orchids	498899.930158	6622762.846869	OUTSIDE ROAD RESERVE
Spider Orchids	498888.790023	6622864.356207	OUTSIDE ROAD RESERVE
Spider Orchids	498941.571672	6622720.295530	OUTSIDE ROAD RESERVE
Spider Orchids	498909.511829	6622890.290928	OUTSIDE ROAD RESERVE
Spider Orchids	498928.716401	6622696.360402	OUTSIDE ROAD RESERVE
Spider Orchids	498928.716401	6622696.360402	OUTSIDE ROAD RESERVE
Spider Orchids	498941.563426	6622773.934612	OUTSIDE ROAD RESERVE
Spider Orchids	498978.306908	6622775.714250	OUTSIDE ROAD RESERVE
Spider Orchids	498965.550587	6622772.054995	OUTSIDE ROAD RESERVE
Spider Orchids	498949.528912	6622753.548762	OUTSIDE ROAD RESERVE
Spider Orchids	498944.738076	6622733.262891	OUTSIDE ROAD RESERVE
Spider Orchids	498960.767998	6622637.192446	OUTSIDE ROAD RESERVE
Spider Orchids	498975.156996	6622615.026957	OUTSIDE ROAD RESERVE
Spider Orchids	498989.545994	6622602.169574	OUTSIDE ROAD RESERVE

Spider Orchids	498931.973509	6622744.350634	OUTSIDE ROAD RESERVE
Spider Orchids	498960.751506	6622786.791995	OUTSIDE ROAD RESERVE
Spider Orchids	498927.182674	6622696.360402	OUTSIDE ROAD RESERVE
Spider Orchids	498907.986348	6622772.044997	OUTSIDE ROAD RESERVE
Spider Orchids	498949.537158	6622675.974552	OUTSIDE ROAD RESERVE
Spider Orchids	498688.844790	6623028.782739	OUTSIDE ROAD RESERVE
Spider Orchids	498688.844790	6623025.023504	OUTSIDE ROAD RESERVE
Spider Orchids	498688.844790	6623034.331609	OUTSIDE ROAD RESERVE
Spider Orchids	498693.643872	6623036.101249	OUTSIDE ROAD RESERVE
Spider Orchids	498637.712310	6623037.980866	OUTSIDE ROAD RESERVE
Spider Orchids	498640.870468	6623041.640122	OUTSIDE ROAD RESERVE
Spider Orchids	498631.280551	6623025.013506	OUTSIDE ROAD RESERVE
Spider Orchids	498631.280551	6623026.893123	OUTSIDE ROAD RESERVE
Spider Orchids	498909.520075	6622770.165379	OUTSIDE ROAD RESERVE
Spider Orchids	498901.562835	6622775.704252	OUTSIDE ROAD RESERVE
Spider Orchids	498621.690634	6623041.630124	OUTSIDE ROAD RESERVE
Spider Orchids	498911.152752	6622768.395740	OUTSIDE ROAD RESERVE
Spider Orchids	498912.785430	6622766.506124	OUTSIDE ROAD RESERVE
Spider Orchids	498915.951834	6622768.395740	OUTSIDE ROAD RESERVE
Spider Orchids	498909.520075	6622777.593867	OUTSIDE ROAD RESERVE
Spider Orchids	498907.986348	6622785.012357	OUTSIDE ROAD RESERVE
Spider Orchids	498620.148661	6623045.399356	OUTSIDE ROAD RESERVE
Spider Orchids	498907.986348	6622783.132740	OUTSIDE ROAD RESERVE
Spider Orchids	498917.576265	6622799.749358	OUTSIDE ROAD RESERVE
Spider Orchids	498920.742669	6622796.100100	OUTSIDE ROAD RESERVE
Spider Orchids	498919.109992	6622797.869740	OUTSIDE ROAD RESERVE
Spider Orchids	498987.913317	6622666.776424	OUTSIDE ROAD RESERVE

Spider Orchids	498975.148750	6622661.237551	OUTSIDE ROAD RESERVE
Spider Orchids	498973.524319	6622657.578296	OUTSIDE ROAD RESERVE
Spider Orchids	498970.357914	6622653.809063	OUTSIDE ROAD RESERVE
Spider Orchids	498971.891641	6622653.809063	OUTSIDE ROAD RESERVE
Spider Orchids	498970.357914	6622653.809063	OUTSIDE ROAD RESERVE
Spider Orchids	498621.682388	6623049.058611	OUTSIDE ROAD RESERVE
Spider Orchids	498967.092560	6622653.809063	OUTSIDE ROAD RESERVE
Spider Orchids	498967.092560	6622657.578296	OUTSIDE ROAD RESERVE
Spider Orchids	498967.092560	6622663.117169	OUTSIDE ROAD RESERVE
Spider Orchids	498968.725237	6622663.117169	OUTSIDE ROAD RESERVE
Spider Orchids	498973.524319	6622664.896807	OUTSIDE ROAD RESERVE
Spider Orchids	498970.357914	6622659.357934	OUTSIDE ROAD RESERVE
Spider Orchids	498970.357914	6622659.357934	OUTSIDE ROAD RESERVE
Spider Orchids	498970.357914	6622659.357934	OUTSIDE ROAD RESERVE
Spider Orchids	498970.357914	6622659.357934	OUTSIDE ROAD RESERVE
Spider Orchids	498626.481470	6623050.938229	OUTSIDE ROAD RESERVE
Spider Orchids	498970.357914	6622659.357934	OUTSIDE ROAD RESERVE
Spider Orchids	498963.926156	6622668.666039	OUTSIDE ROAD RESERVE
Spider Orchids	498962.293479	6622666.776424	OUTSIDE ROAD RESERVE
Spider Orchids	498963.926156	6622670.435679	OUTSIDE ROAD RESERVE
Spider Orchids	498963.926156	6622668.666039	OUTSIDE ROAD RESERVE
Spider Orchids	498962.293479	6622670.435679	OUTSIDE ROAD RESERVE
Spider Orchids	498962.293479	6622670.435679	OUTSIDE ROAD RESERVE
Spider Orchids	498963.926156	6622670.435679	OUTSIDE ROAD RESERVE
Spider Orchids	498963.926156	6622668.666039	OUTSIDE ROAD RESERVE
Spider Orchids	498962.293479	6622668.666039	OUTSIDE ROAD RESERVE
Spider Orchids	498616.891553	6623036.091251	OUTSIDE ROAD RESERVE

Spider Orchids	498962.293479	6622670.435679	OUTSIDE ROAD RESERVE
Spider Orchids	498962.293479	6622670.435679	OUTSIDE ROAD RESERVE
Spider Orchids	498965.558833	6622675.974552	OUTSIDE ROAD RESERVE
Spider Orchids	498965.558833	6622677.864167	OUTSIDE ROAD RESERVE
Spider Orchids	498967.092560	6622677.864167	OUTSIDE ROAD RESERVE
Spider Orchids	498965.558833	6622677.864167	OUTSIDE ROAD RESERVE
Spider Orchids	498963.926156	6622675.974552	OUTSIDE ROAD RESERVE
Spider Orchids	498962.293479	6622675.974552	OUTSIDE ROAD RESERVE
Spider Orchids	498960.759752	6622674.204912	OUTSIDE ROAD RESERVE
Spider Orchids	498960.759752	6622675.974552	OUTSIDE ROAD RESERVE
Spider Orchids	498644.127577	6623100.808078	OUTSIDE ROAD RESERVE
Spider Orchids	498960.759752	6622674.204912	OUTSIDE ROAD RESERVE
Spider Orchids	498955.960670	6622674.204912	OUTSIDE ROAD RESERVE
Spider Orchids	498955.960670	6622674.204912	OUTSIDE ROAD RESERVE
Spider Orchids	498955.960670	6622670.435679	OUTSIDE ROAD RESERVE
Spider Orchids	498951.169835	6622677.854169	OUTSIDE ROAD RESERVE
Spider Orchids	498952.703562	6622674.204912	OUTSIDE ROAD RESERVE
Spider Orchids	498955.960670	6622679.743784	OUTSIDE ROAD RESERVE
Spider Orchids	498963.926156	6622681.513424	OUTSIDE ROAD RESERVE
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Spider Orchids	498645.669549	6623087.850715	OUTSIDE ROAD RESERVE
Spider Orchids	498959.127075	6622685.282657	OUTSIDE ROAD RESERVE
Spider Orchids	498959.127075	6622687.052297	OUTSIDE ROAD RESERVE
Spider Orchids	498952.703562	6622685.282657	OUTSIDE ROAD RESERVE
Spider Orchids	498954.327993	6622687.052297	OUTSIDE ROAD RESERVE
Spider Orchids	498954.327993	6622683.403040	OUTSIDE ROAD RESERVE

Spider Orchids	498952.703562	6622685.282657	OUTSIDE ROAD RESERVE
Spider Orchids	498952.703562	6622679.743784	OUTSIDE ROAD RESERVE
Spider Orchids	498952.703562	6622679.743784	OUTSIDE ROAD RESERVE
Spider Orchids	498955.960670	6622675.974552	OUTSIDE ROAD RESERVE
Spider Orchids	498952.703562	6622675.974552	OUTSIDE ROAD RESERVE
Spider Orchids	498947.904480	6622675.974552	OUTSIDE ROAD RESERVE
Spider Orchids	498947.904480	6622675.974552	OUTSIDE ROAD RESERVE
Spider Orchids	498647.293981	6623117.434694	OUTSIDE ROAD RESERVE
Spider Orchids	498946.370753	6622674.204912	OUTSIDE ROAD RESERVE
Spider Orchids	498951.169835	6622679.743784	OUTSIDE ROAD RESERVE
Spider Orchids	498951.169835	6622681.513424	OUTSIDE ROAD RESERVE
Spider Orchids	498951.169835	6622683.403040	OUTSIDE ROAD RESERVE
Spider Orchids	498951.169835	6622685.282657	OUTSIDE ROAD RESERVE
Spider Orchids	498949.537158	6622685.282657	OUTSIDE ROAD RESERVE
Spider Orchids	498949.537158	6622688.941912	OUTSIDE ROAD RESERVE
Spider Orchids	498951.169835	6622687.052297	OUTSIDE ROAD RESERVE
Spider Orchids	498952.703562	6622688.941912	OUTSIDE ROAD RESERVE
Spider Orchids	498957.494397	6622688.941912	OUTSIDE ROAD RESERVE
Spider Orchids	498647.293981	6623117.434694	OUTSIDE ROAD RESERVE
Spider Orchids	498960.759752	6622690.821530	OUTSIDE ROAD RESERVE
Spider Orchids	498967.092560	6622692.601167	OUTSIDE ROAD RESERVE
Spider Orchids	498954.327993	6622687.052297	OUTSIDE ROAD RESERVE
Spider Orchids	498947.904480	6622683.403040	OUTSIDE ROAD RESERVE
Spider Orchids	498944.738076	6622683.403040	OUTSIDE ROAD RESERVE
Spider Orchids	498943.105399	6622687.052297	OUTSIDE ROAD RESERVE
Spider Orchids	498941.571672	6622685.282657	OUTSIDE ROAD RESERVE
Spider Orchids	498610.558744	6623065.675229	OUTSIDE ROAD RESERVE

Spider Orchids	498939.938995	6622683.393042	OUTSIDE ROAD RESERVE
Spider Orchids	498938.314564	6622687.052297	OUTSIDE ROAD RESERVE
Spider Orchids	498938.314564	6622685.282657	OUTSIDE ROAD RESERVE
Spider Orchids	498936.772591	6622685.282657	OUTSIDE ROAD RESERVE
Spider Orchids	498941.571672	6622709.217785	OUTSIDE ROAD RESERVE
Spider Orchids	498931.981755	6622677.854169	OUTSIDE ROAD RESERVE
Spider Orchids	498973.524319	6622664.896807	OUTSIDE ROAD RESERVE
Spider Orchids	498871.152162	6622736.912148	OUTSIDE ROAD RESERVE
Spider Orchids	498880.742079	6622772.044997	OUTSIDE ROAD RESERVE
Spider Orchids	498880.742079	6622759.077636	OUTSIDE ROAD RESERVE
Spider Orchids	498880.742079	6622759.077636	OUTSIDE ROAD RESERVE
Spider Orchids	498885.541160	6622757.307996	OUTSIDE ROAD RESERVE
Spider Orchids	498887.173837	6622759.077636	OUTSIDE ROAD RESERVE
Spider Orchids	498885.541160	6622757.307996	OUTSIDE ROAD RESERVE
Spider Orchids	498885.541160	6622759.077636	OUTSIDE ROAD RESERVE
Spider Orchids	498890.340241	6622759.077636	OUTSIDE ROAD RESERVE
Spider Orchids	498890.340241	6622760.967252	OUTSIDE ROAD RESERVE
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Spider Orchids	498893.597350	6622762.846869	OUTSIDE ROAD RESERVE
Spider Orchids	498879.208352	6622755.418381	OUTSIDE ROAD RESERVE
Spider Orchids	498879.208352	6622755.418381	OUTSIDE ROAD RESERVE
Spider Orchids	498879.208352	6622751.769124	OUTSIDE ROAD RESERVE
Spider Orchids	498875.951243	6622747.999891	OUTSIDE ROAD RESERVE
Spider Orchids	498885.541160	6622735.142508	OUTSIDE ROAD RESERVE
Spider Orchids	498887.173837	6622733.262891	OUTSIDE ROAD RESERVE
Spider Orchids	498887.173837	6622729.603636	OUTSIDE ROAD RESERVE

Spider Orchids	498891.972919	6622718.525890	OUTSIDE ROAD RESERVE
Spider Orchids	498890.340241	6622720.295530	OUTSIDE ROAD RESERVE
Spider Orchids	498879.216597	6622707.438147	OUTSIDE ROAD RESERVE
Spider Orchids	498879.216597	6622705.558530	OUTSIDE ROAD RESERVE
Spider Orchids	498874.417516	6622703.668915	OUTSIDE ROAD RESERVE
Spider Orchids	498869.618435	6622700.009659	OUTSIDE ROAD RESERVE
Spider Orchids	498860.028518	6622690.811532	OUTSIDE ROAD RESERVE
Spider Orchids	498864.827599	6622688.931914	OUTSIDE ROAD RESERVE
Spider Orchids	498866.361326	6622675.964554	OUTSIDE ROAD RESERVE
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Spider Orchids	498877.583920	6622679.733786	OUTSIDE ROAD RESERVE
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Spider Orchids	498888.806514	6622679.733786	OUTSIDE ROAD RESERVE
Spider Orchids	498888.806514	6622677.854169	OUTSIDE ROAD RESERVE
Spider Orchids	498890.348487	6622675.964554	OUTSIDE ROAD RESERVE
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Spider Orchids	498895.139323	6622675.964554	OUTSIDE ROAD RESERVE
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Spider Orchids	498893.605596	6622681.513424	OUTSIDE ROAD RESERVE

Spider Orchids	498891.972919	6622685.272659	OUTSIDE ROAD RESERVE
Spider Orchids	498893.605596	6622687.052297	OUTSIDE ROAD RESERVE
Spider Orchids	498899.938404	6622685.282657	OUTSIDE ROAD RESERVE
Spider Orchids	498901.571081	6622683.393042	OUTSIDE ROAD RESERVE
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Spider Orchids	498896.772000	6622690.821530	OUTSIDE ROAD RESERVE
Spider Orchids	498895.139323	6622690.821530	OUTSIDE ROAD RESERVE
Spider Orchids	498895.139323	6622692.591169	OUTSIDE ROAD RESERVE
Spider Orchids	498891.972919	6622696.360402	OUTSIDE ROAD RESERVE
Spider Orchids	498891.972919	6622696.360402	OUTSIDE ROAD RESERVE
Spider Orchids	498899.938404	6622694.470787	OUTSIDE ROAD RESERVE
Spider Orchids	498896.772000	6622696.360402	OUTSIDE ROAD RESERVE
Spider Orchids	498898.404677	6622698.130042	OUTSIDE ROAD RESERVE
Spider Orchids	498898.404677	6622698.130042	OUTSIDE ROAD RESERVE
Spider Orchids	498898.404677	6622700.019657	OUTSIDE ROAD RESERVE
Spider Orchids	498898.404677	6622692.591169	OUTSIDE ROAD RESERVE
Spider Orchids	498899.938404	6622692.591169	OUTSIDE ROAD RESERVE
Spider Orchids	498899.938404	6622694.470787	OUTSIDE ROAD RESERVE
Spider Orchids	498899.938404	6622692.591169	OUTSIDE ROAD RESERVE
Spider Orchids	498899.938404	6622707.438147	OUTSIDE ROAD RESERVE
Spider Orchids	498899.930158	6622760.967252	OUTSIDE ROAD RESERVE
Spider Orchids	498899.930158	6622766.506124	OUTSIDE ROAD RESERVE
Spider Orchids	498899.930158	6622768.385742	OUTSIDE ROAD RESERVE
Spider Orchids	498899.930158	6622770.165379	OUTSIDE ROAD RESERVE
Spider Orchids	498899.930158	6622768.385742	OUTSIDE ROAD RESERVE
Spider Orchids	498899.930158	6622773.934612	OUTSIDE ROAD RESERVE

Spider Orchids	498899.930158	6622775.704252	OUTSIDE ROAD RESERVE
Spider Orchids	498901.562835	6622777.583869	OUTSIDE ROAD RESERVE
Spider Orchids	498907.986348	6622772.044997	OUTSIDE ROAD RESERVE
Spider Orchids	498967.092560	6622663.117169	OUTSIDE ROAD RESERVE
Spider Orchids	498962.293479	6622690.821530	OUTSIDE ROAD RESERVE
Slender Marsdenia	498777.166028	6622844.000351	OUTSIDE ROAD RESERVE
Slender Marsdenia	498787.118762	6622848.689396	OUTSIDE ROAD RESERVE
Slender Marsdenia	498789.345140	6622859.447206	OUTSIDE ROAD RESERVE
Slender Marsdenia	498806.001746	6622861.736740	OUTSIDE ROAD RESERVE
Slender Marsdenia	498805.597700	6622854.698173	OUTSIDE ROAD RESERVE
Slender Marsdenia	498804.657673	6622874.684105	OUTSIDE ROAD RESERVE
Slender Marsdenia	498764.698312	6622834.712241	OUTSIDE ROAD RESERVE
Slender Marsdenia	498760.130114	6622809.907290	OUTSIDE ROAD RESERVE
Slender Marsdenia	498780.126287	6622803.498595	OUTSIDE ROAD RESERVE
Slender Marsdenia	498781.264213	6622809.107453	OUTSIDE ROAD RESERVE
Slender Marsdenia	498793.525784	6622812.496763	OUTSIDE ROAD RESERVE
Slender Marsdenia	498796.692188	6622818.865467	OUTSIDE ROAD RESERVE
Slender Marsdenia	498797.887835	6622767.865847	OUTSIDE ROAD RESERVE
Slender Marsdenia	498783.333920	6622767.685884	OUTSIDE ROAD RESERVE
Slender Marsdenia	498754.085910	6622747.969897	OUTSIDE ROAD RESERVE
Slender Marsdenia	498789.163732	6622769.155585	OUTSIDE ROAD RESERVE
Slender Marsdenia	498781.552818	6622778.273729	OUTSIDE ROAD RESERVE
Spider Orchids	498898.100000	6627492.280000	OUTSIDE ROAD RESERVE
Spider Orchids	498857.090000	6627464.450000	OUTSIDE ROAD RESERVE
Spider Orchids	498855.240000	6627450.610000	OUTSIDE ROAD RESERVE
Spider Orchids	498983.122481	6622605.828830	OUTSIDE ROAD RESERVE
Spider Orchids	498844.006842	6622694.470787	OUTSIDE ROAD RESERVE

Spider Orchids	498847.173247	6622694.470787	OUTSIDE ROAD RESERVE
Spider Orchids	498845.639519	6622698.130042	OUTSIDE ROAD RESERVE
Spider Orchids	498866.361326	6622692.591169	OUTSIDE ROAD RESERVE
Spider Orchids	498867.994003	6622688.931914	OUTSIDE ROAD RESERVE
Spider Orchids	498860.028518	6622683.393042	OUTSIDE ROAD RESERVE
Spider Orchids	498850.438601	6622683.393042	OUTSIDE ROAD RESERVE
Spider Orchids	498847.173247	6622688.931914	OUTSIDE ROAD RESERVE
Spider Orchids	498891.981164	6622642.721320	OUTSIDE ROAD RESERVE
Spider Orchids	498891.981164	6622642.721320	OUTSIDE ROAD RESERVE
Spider Orchids	498973.524319	6622603.949212	OUTSIDE ROAD RESERVE
Spider Orchids	498973.524319	6622607.708447	OUTSIDE ROAD RESERVE
Spider Orchids	498971.891641	6622603.949212	OUTSIDE ROAD RESERVE
Spider Orchids	498970.357914	6622602.169574	OUTSIDE ROAD RESERVE
Spider Orchids	498947.912726	6622605.828830	OUTSIDE ROAD RESERVE
Spider Orchids	498947.904480	6622646.500551	OUTSIDE ROAD RESERVE
Spider Orchids	498947.904480	6622646.500551	OUTSIDE ROAD RESERVE
Spider Orchids	498947.904480	6622648.270191	OUTSIDE ROAD RESERVE
Spider Orchids	498946.370753	6622648.270191	OUTSIDE ROAD RESERVE
Spider Orchids	498946.370753	6622648.270191	OUTSIDE ROAD RESERVE
Spider Orchids	498936.780836	6622648.270191	OUTSIDE ROAD RESERVE
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Spider Orchids	498922.391838	6622637.182448	OUTSIDE ROAD RESERVE
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Spider Orchids	498923.925565	6622637.182448	OUTSIDE ROAD RESERVE
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APPENDIX 3: PLANS SHOWING THE DISTRIBUTION OF THREATENED AND RARE SPECIES on the whole WC2U road corridor

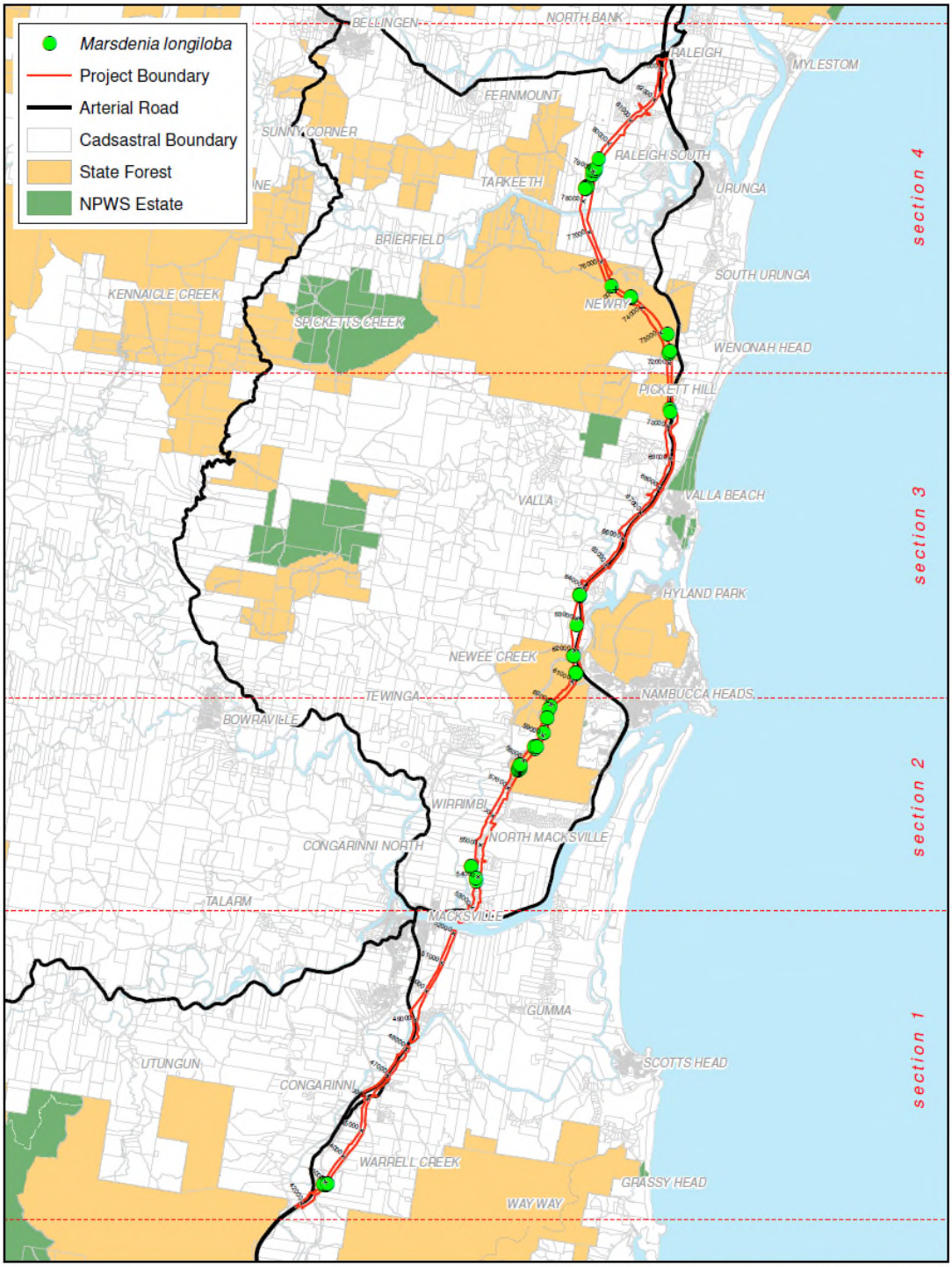

Figure 12: Distribution of Slender Marsdenia (Marsdenia longiloba) on the WC2U road corridor recorded during the 2011 targeted flora survey.

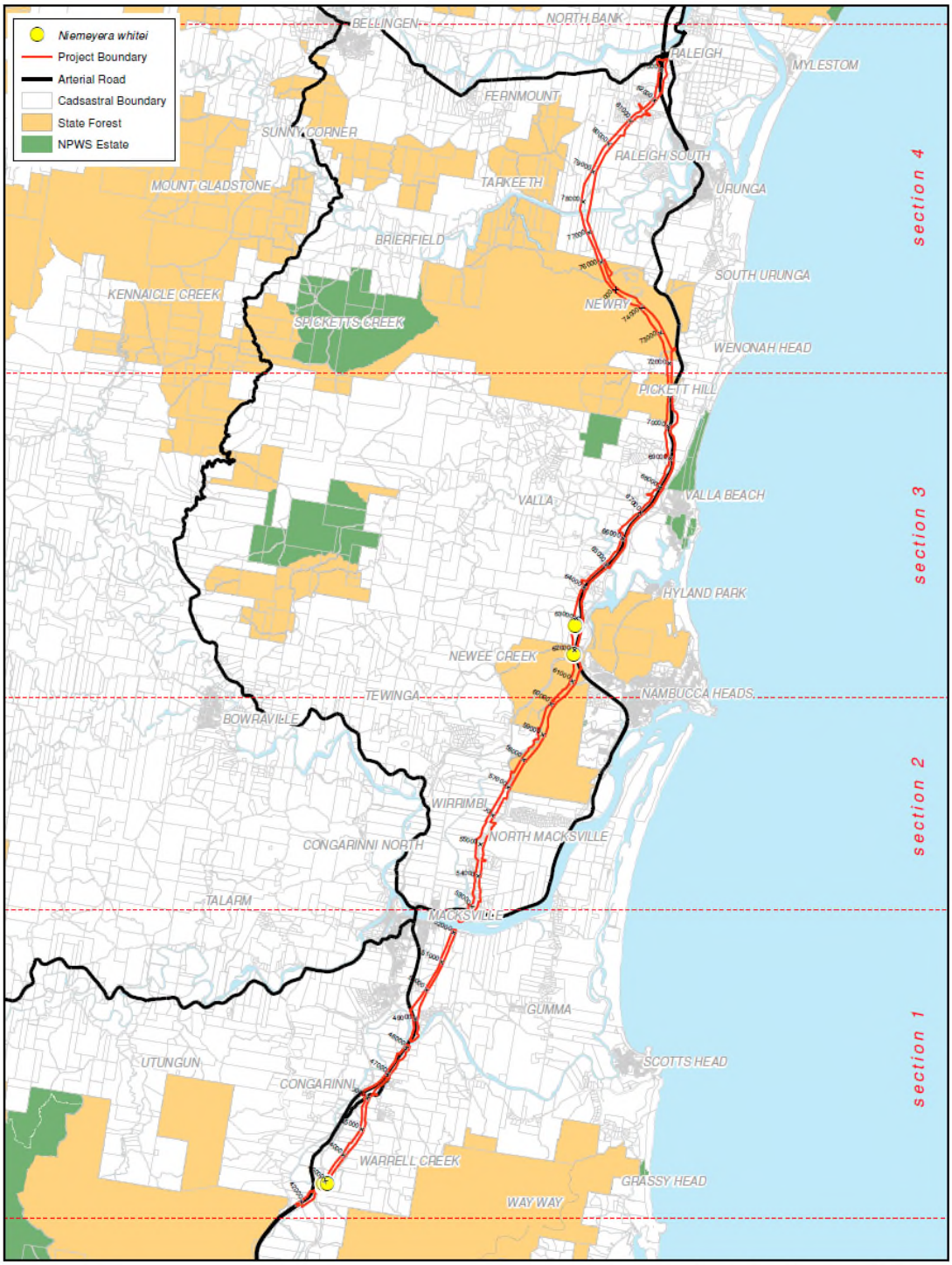

Figure 13: Distribution of Rusty Plum (Niemeyera whitei) on the WC2U road corridor recorded during the 2011 targeted flora survey.

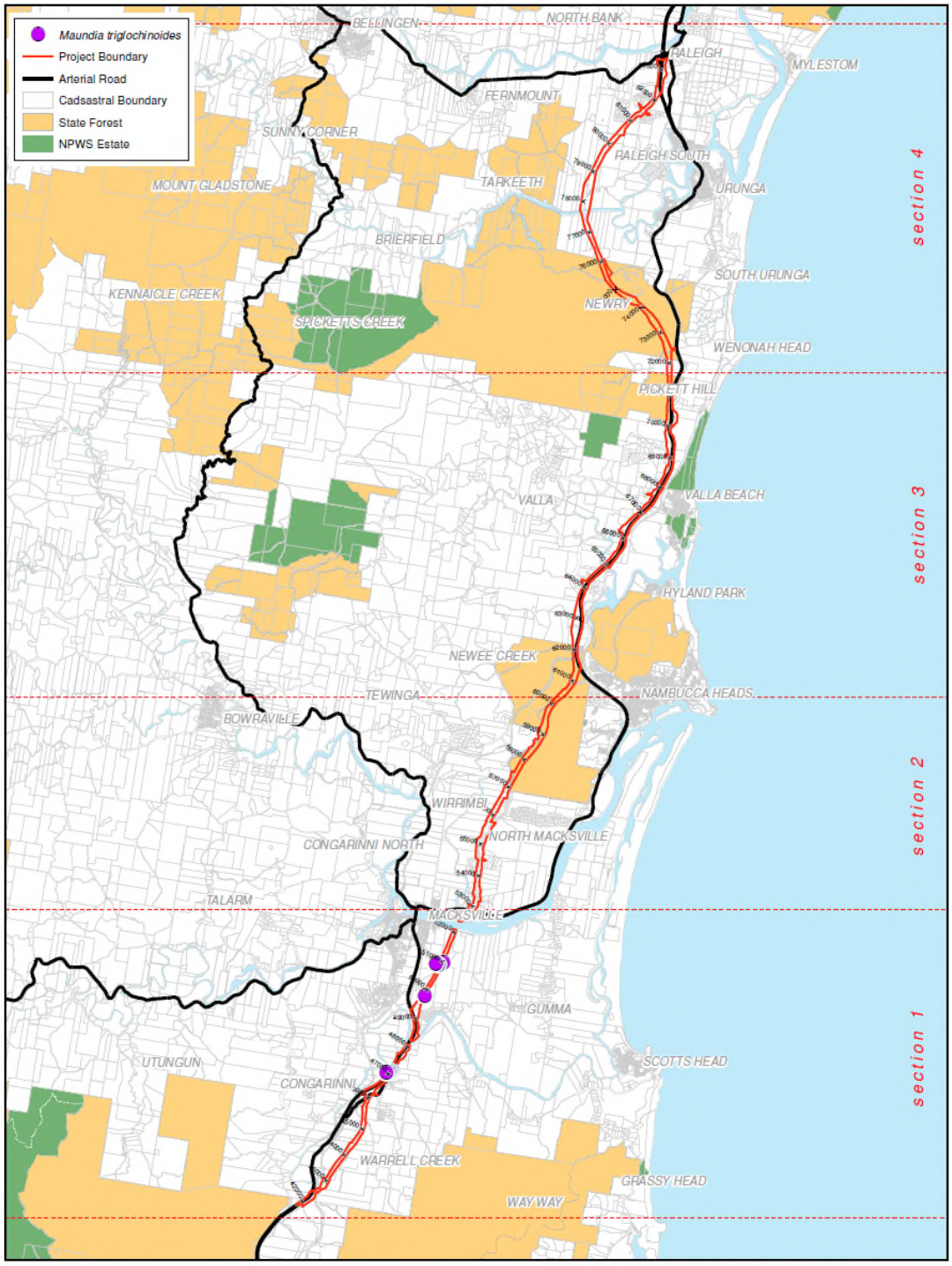

Figure 15: Distribution of Maundia (Maundia triglochinoides) on the WC2U road corridor recorded during the 2011 targeted flora survey.

Source: Cadastre: Roads and Traffic Authority 2007; Flora Survey: ECOS December 2011; Roads: Geoscience Australia 2009; Highway Design (footprint): RTA 2011; Project Boundary: RTA 2011; Drainage: Geoscience Australia 2009; State Forests: NSW Department of Primary Industries 2009

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0 2 4 6 8 Kilometers

A4 Scale 1:150,000

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File: Figure_15_RTA_Grafton_Flora_Survey_Species_Distribution Date: 25-01-2012

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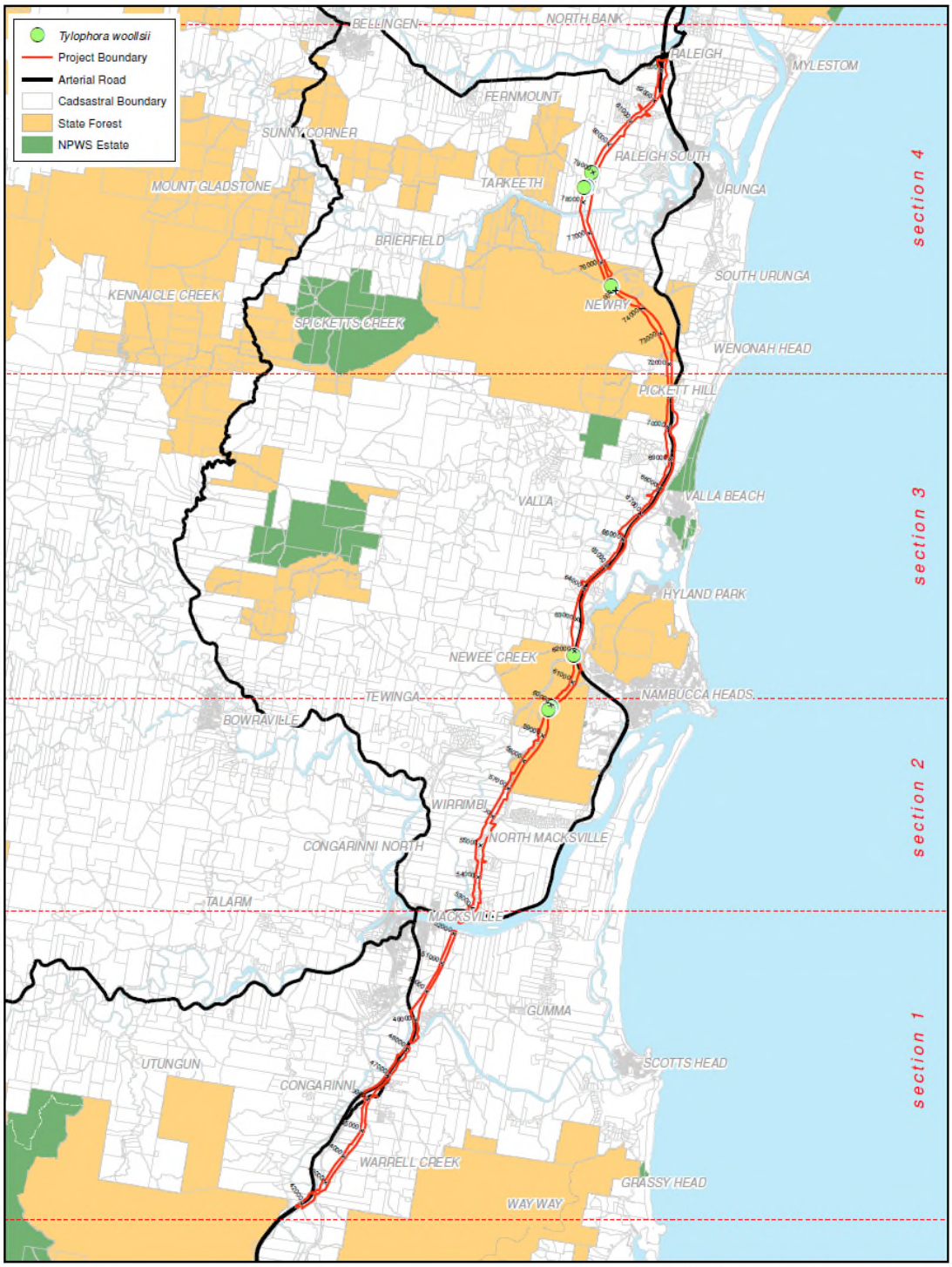

Figure 16: Distribution of Woolls Tylophora (Tylophora woollsii) on the WC2U road corridor recorded during the 2011 targeted flora survey.

Cadastre: Roads and Traffic Authority 2007 Highway Design (footprint): RTA 2011
Flora Survey: ECOS December 2011/ Project Boundary: RTA 2011
February 2012 Drainage: Geoscience Australia 2009
Roads: Geoscience Australia 2009 State Forests: NSW Department of Primary Industries 2009

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File: Figure_16_RTA_Grafton_Flora_Survey_Species_Distribution Date: 10-03-2012

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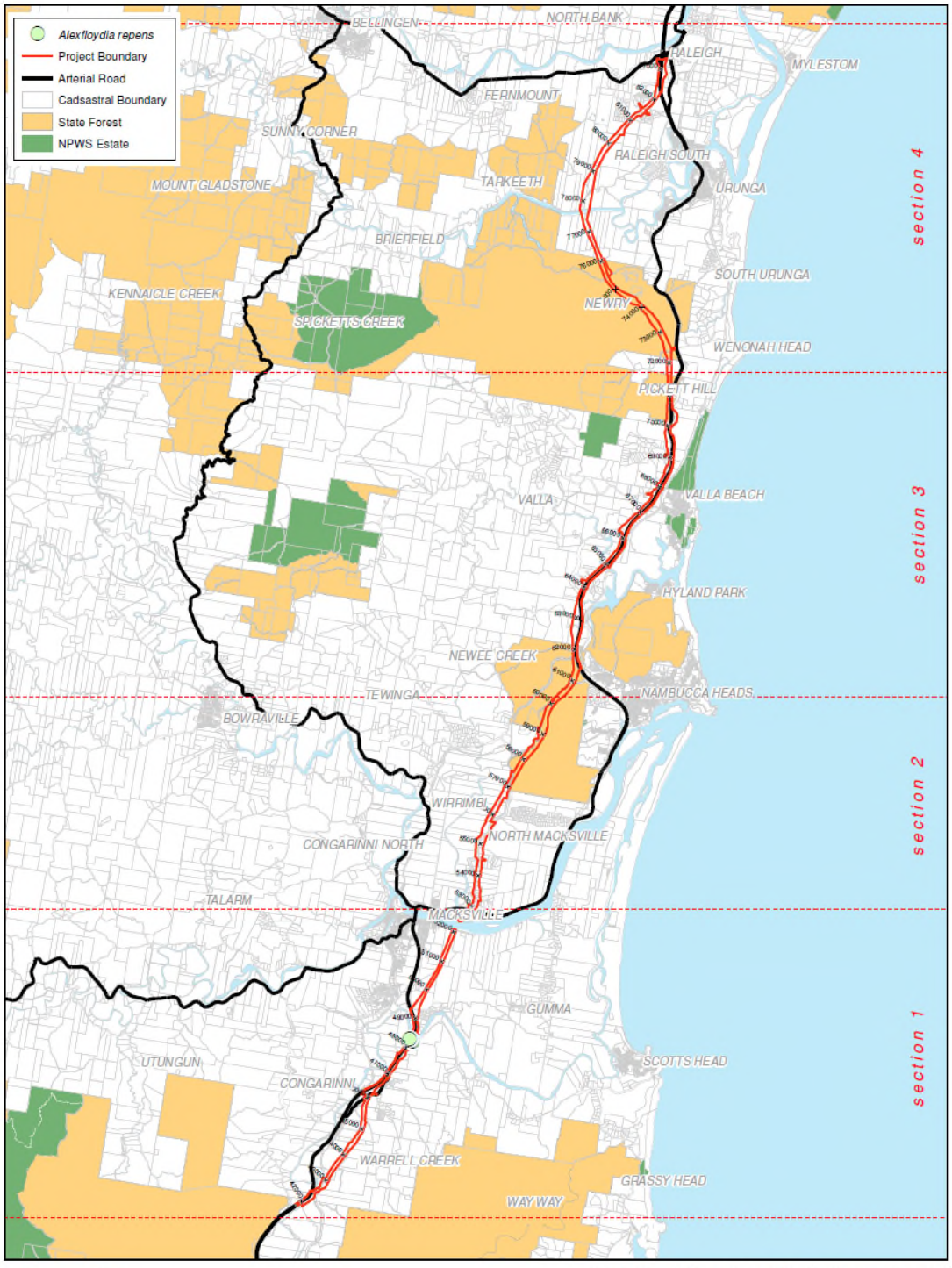

Figure 17: Distribution of Floyds Grass (Alexfloydia repens) on the WC2U road corridor recorded during the 2011 targeted flora survey.

Source:
Cadastre: Roads and Traffic Authority 2007
Flora Survey: ECOS December 2011
Roads: Geoscience Australia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW Department of Primary Industries 2009

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0 2 4 6 8 Kilometers

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File: Figure_17_RTA_Grafton_Flora_Survey_Species _Distribution Date: 25-01-2012

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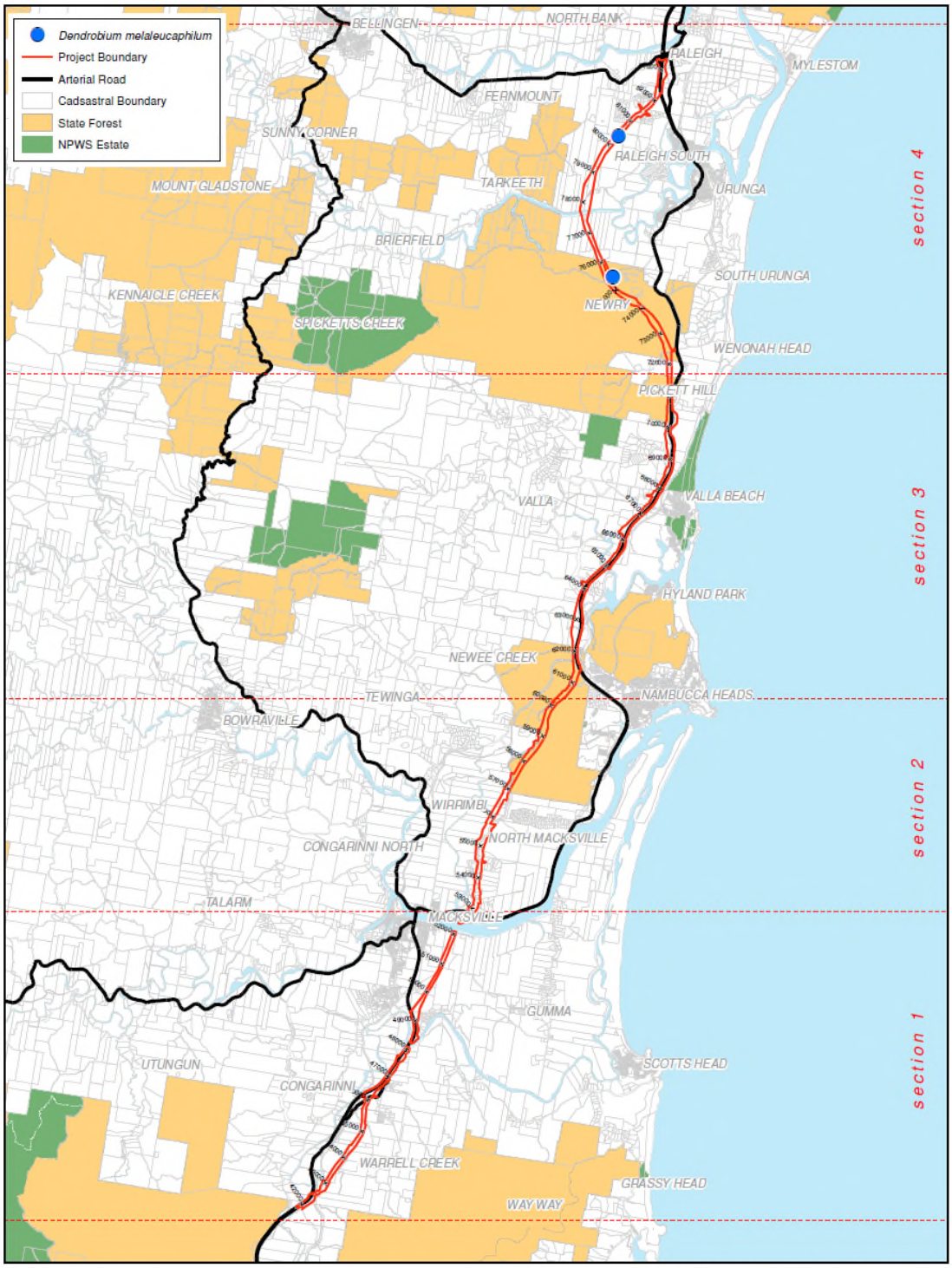

Figure 18: Distribution of Spider Orchid (Dendrobium melaleucaphilum) on the WC2U road corridor recorded during the 2011 targeted flora survey.

Source:
Cadastre: Roads and Traffic Authority 2007
Flora Survey: ECOS December 2011
Roads: Geoscience Australia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW Department of Primary Industries 2008

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0 2 4 6 8
Kilometers

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File: Figure_18_RTA_Grafton_Flora_Survey_Species_Distribution Date: 25-01-2012

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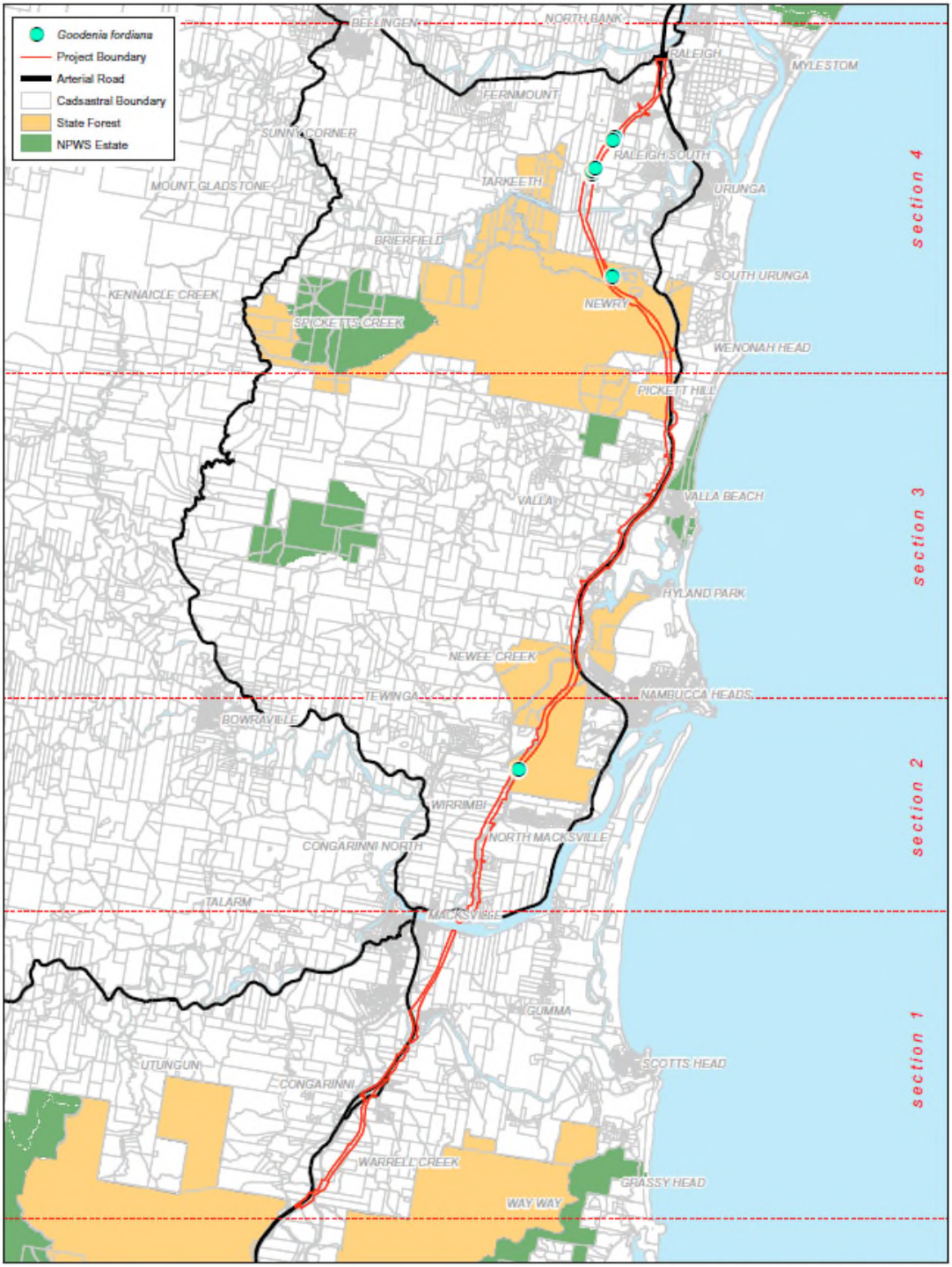

Figure 19: Distribution of Ford's Goodenia (Goodenia fordiana) on the WC2U road corridor recorded during the 2011 targeted flora survey.

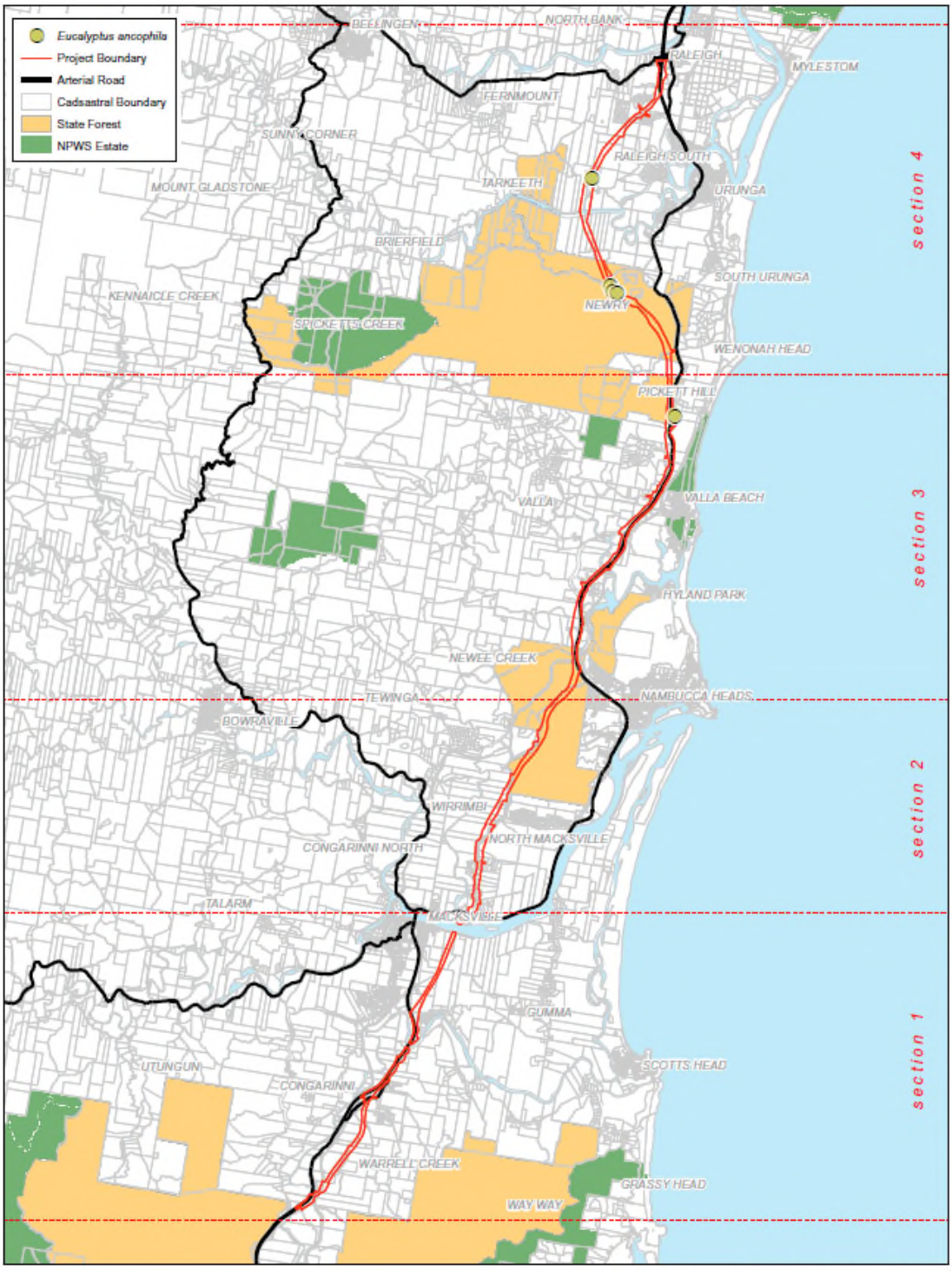

Figure 20: Distribution of Bellingen Ironbark (Eucalyptus ancophila) on the WC2U road corridor recorded during the 2011 targeted flora survey.

A4 Scale 1:150,000

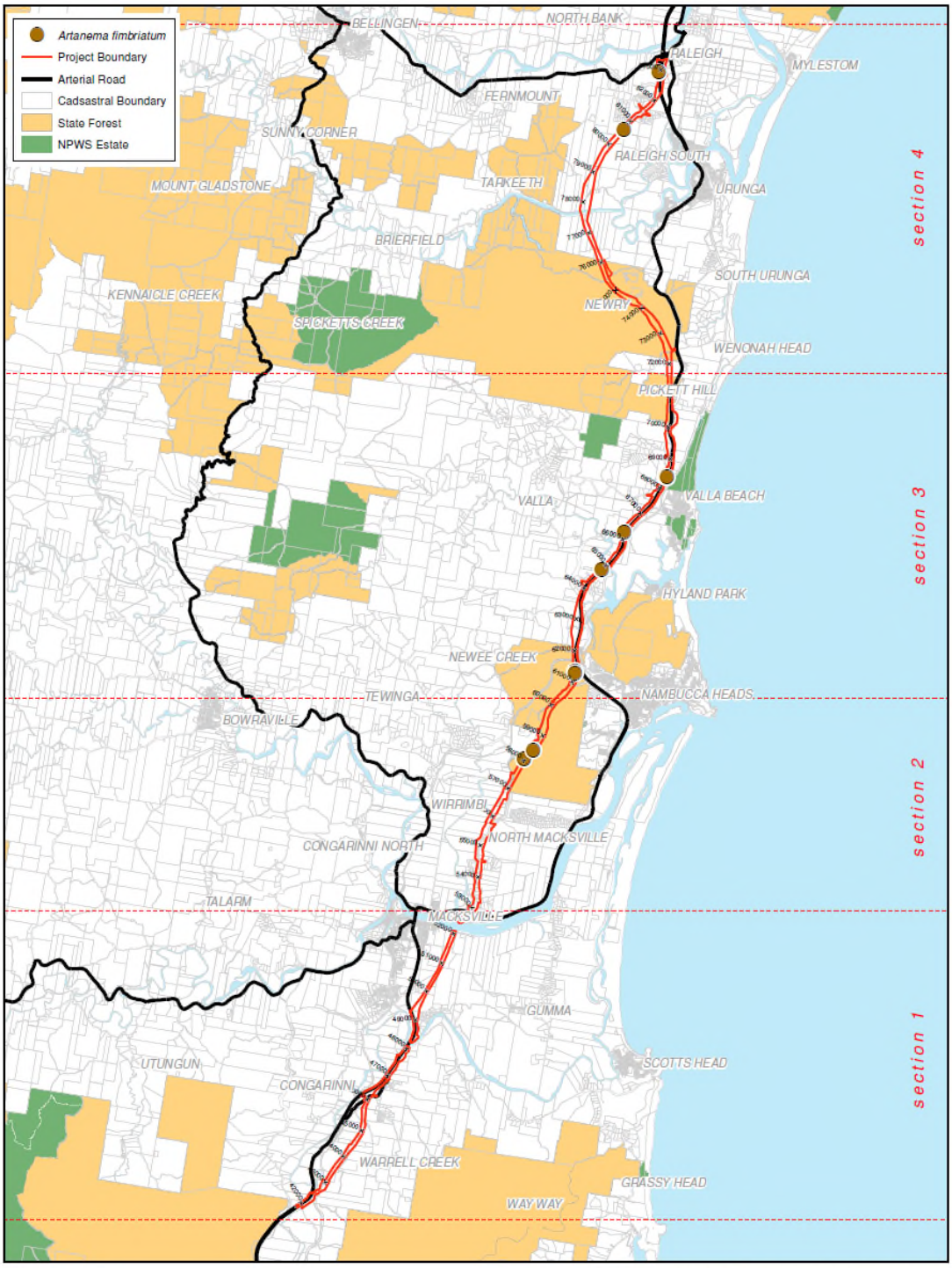

Figure 21: Distribution of Koala Bells (Artanema fimbriatum) on the WC2U road corridor recorded during the 2011 targeted flora survey.

Source:
Cadastre: Roads and Traffic Authority 2007
Flora Survey: ECOS December 2011
Roads: Geoscience Australia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW Department of Primary Industries 2008

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0 2 4 6 8
Kilometers

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File: Figure_21_RTA_Grafton_Flora_Survey_Species_Distribution Date: 25-01-2012

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APPENDIX 4: THREATENED SPECIES QUADRATS

Quadrat 1
***Niemeyera whitei* (Rusty Plum) – TSC Act Vulnerable**

Location: Warrell Creek
NW-50
Vegetation Type: wet sclerophyll forest with well developed rainforest understorey.
Substrate: red clay loam on hornfels
Slope Aspect: south
Slope Angle: moderate
Disturbance history: logged 30-40 years ago; fire 50-100 years ago
Condition: good
Quadrat Size: 20m x 50m

Stratum	Height (m)	Crown Cover (%)	Species 1	Species 2	Species 3
Upper 2	20-40	50	*Eucalptus grandis*		
Upper 1	6-18	70	*Pouteria australis*	*Cissus hypoglauca*	*Alphitonia excelsa*
Mid	1-6	80	*Wilkea huegeliana*	*Lantana camara*	*Rubus moluccanus*
Lower	0-1	40	*Blechnum cartilagineum*	*Lomandra spicata*	*Lastreopsis decomposita*

Species (* exotic species)	Growth-form	Cover-abundance Class
Pouteria australis	T	3
Blechnum cartilagineum	F	3
Cryptocarya microneura	T	2
Wilkea huegeliana	S	2
Morinda jasminoides	V	3
Stenocarpus salignus	T	1
Cryptocarya rigida	T	2
Flagellaria indica	V	2
Pittosporum multiflorum	S	1
Endiandra muelleri ssp. muelleri	T	2
Lomandra spicata	H	3
Melicope micrococca	T	1
Notelaea longifolia	T	2
Niemerya whitei	T	2
Tabernaemontana pandaqui	S	2
Lastreopsis decomposita	F	2
Guioa semiglauca	T	2
Eucalyptus grandis	T	4
Cordyline stricta	S	2
Cyathea leichhardtiana	S	1
Alphitonia excelsa	T	3
Allocasuarina torulosa	T	2

Acacia floribunda	T	2
Acacia melanoxylon	T	1
**Lantana camara*	S	2
Embelia australasica	V	2
Ripogonum fawcettianum	V	2
Smilax glyciphylla	V	2
Litsea australis	T	1
Cissus hypoglauca	V	3
Rubus moluccanus	V	3
Synoum glandulosum	T	2
Neolitsea dealbata	T	1
Linospadix monostachys	S	2
Schizomeria ovata	T	1
Ficus coronata	T	2
Malasia scandens	V	2
Breynia oblongifolia	S	1
Ottochloa gracillima	G	2
Oplismenus imbecilis	G	2
Pseuderantherum variable	H	2
Hibbertia scandens	V	1
Archontophoenix cunninghamii	T	1
Pilidiostigma glabrum	S	1
Toona ciliata	T	1

Quadrat 3

Marsdenia longiloboa **(Slender Marsdenia) – TSC Act Endangered**

Location: Nambucca State Forest ~1 km southeast of gabbage tip.
Vegetation Type: wet sclerophyll forest with well developed rainforest understorey.
Substrate: clay loam on metasediment
Slope Aspect: south
Slope Angle: 3
Disturbance history: logged ~20 years ago
Condition: good
Quadrat Size: 20 m x 50 m

Stratum	**Height (m)**	**Crown Cover (%)**	**Species 1**	**Species 2**	**Species 3**
Upper	15-25	40	*Corymbia intermedia*	*Syncarpia glomulifera*	*Lophostemon confertus*
Mid 2	8-15	60	*Syncarpia glomulifera*	*Lophostemon confertus*	
Mid 1	1-8	80	*Endiandra muelleri*	*Endiandra discolor*	*Cissus hypoglauca*
Lower	0-1	70	*Blechnum cartilagineum*	*Lastreopsis decomposita*	*Ripogonum fawcettianum*

Species	Habit	Cover-abundance Class
Endiandra discolor	T	3
Blechnum cartilagineum	F	4
Calanthes spicata	H	1
Cryptocarya rigida	T	2
Ripogonum fawcettianum	V	3
Malasia scandens	V	2
Backhousia myrtifolia	S	1
Lastreopsis decomposita	F	2
Allocasuarina torulosa	T	2
Syzygium australe	T	1
Lophostemon confertus	T	3
Syncarpia glomulifera	T	5
Corymbia intermedia	T	4
Croton verrauxii	S	2
Dioscorea transversa	V	2
Pseuderantherum variable	H	2
Livistona australis	T	2
Litsea australis	T	2
Breynia oblongifolia	S	1
Cissus hypoglauca	V	3
Rubus moluccanus	V	2
Mischocarpus pyriformis	T	2
Wilkea huegeliana	S	2
Cordyline stricta	S	2
Melodinus australe	V	1
Notelaea longifolia	T	2
Alpinea small	H	2
Doodia aspera	F	2
Gymnostachys anceps	H	1
Flagellaria indica	V	1
Canthium coprosmoides	T	2
Citriobatus pauciflorus	S	1
Embelia australasica	V	1
Euphomatia bennettiana	S	1
Morinda jasminoides	V	2
Tabernaemontana pandaqui	S	2
Kreysigia multiflora	H	1
Cissus antarctica	V	1
Smilax australis	V	2

Quadrat 4

***Maundia triglochinoides* – TSC Act Vulnerable**

Location: Williamson's Creek ~1 km south of Warrell Creek, population extends up and downstream of existing Pacific Highway bridge
Vegetation Type: emergent aquatic vegetation
Substrate: running creek which floods
Slope Aspect: na
Slope Angle: na
Disturbance history: creek flows through cleared pastureland
Condition: good
Quadrat Size: 10 m x 50 m

Stratum	**Height (m)**	**Crown Cover (%)**	**Species 1**	**Species 2**	**Species 3**
Upper	1-2	80	*Persicaria strigosa*	*Maundia triglochinoides*	*Schoenoplectus mucronatus*

Species (* exotic species)	**Habit**	**Cover-abundance Class**
Philydrum lanuginosum	H	1
Schoenoplectus vallidus	R	1
Schoenoplectus mucronatus	R	3
*Paspalum urvillei	G	3
Perscaria strigosa	H	4
Alternanthera denticulatum	H	2
*Ligustrum sinense	T	3
Paspalum distichum	G	4
*Rumex sp.	H	2
Ranunculus plebeia	H	2
Cyclosorus interruptus	F	2
Juncus planifolius	R	2
*Cyperus eragrostis	H	2
Carex appressa	H	1
Enydra fluctuans	H	2
Typha orientalis	R	2
Ranunculus inundatus	H	2
Ludwigia peploides	H	2
Maundia triglochinoides	H	3

APPENDIX 5: MINISTER OF PLANNING'S CONDITIONS OF APPROVAL

Mitigation Measures - Amorphospermum whitei and Marsdenia longiloba

B7. Prior to the commencement of any construction work that would result in the disturbance of *Amorphospermum whitei* and *Marsdenia longiloba*, the Proponent shall in consultation with the OEH develop a management plan for these species which:
(a) investigates the potential for the translocation of plants impacted by the project;
(b) if investigation under Condition B7(a) reveals translocation of impacted plants is feasible, includes details of a translocation plan for the plants consistent with the Australian Network for Plant Conservation 2nd Ed 2OO4: Guidelines for the Translocation of Threatened Species in Australia, including details of ongoing maintenance such as responsibilities, timing and duration;
(c) identifies a process for incorporating appropriate compensatory habitat for the impacted plants in the Biodiversity Offset Strategy referred to in Condition B8 should the information obtained during the investigation referred to in Condition B7(a) find that translocation is not feasible or where the monitoring undertaken as part of condition B10 finds that translocation measures have not been successful (as identified through performance criteria); and
(d) includes detail of mitigation measures to be implemented during construction to avoid and minimise impacts to areas identified to contain these species, including excluding construction plant, equipment, materials and unauthorised personnel.
Unless otherwise agreed to by the Director General, the Plan shall be submitted for the Director General's approval prior to the commencement of any construction work that would result in the disturbance of Amorphospermum whitei and Marsdenia longiloba.

Biodiversity Offsets

B8. The Proponent shall, in consultation with the OEH and DPI (Fisheries), develop a Biodiversity Offset Strategy that identifies available options for offsetting the biodiversity impacts of the project in perpetuity, with consideration to OEH's Principles for the Use of Biodiversity Offsets. Unless otherwise agreed to by OEH, offsets shall be provided on a like-for-like basis and at a minimum ratio of 4:1 'for areas of high conservation value (including EEC and threatened species or their habitat identified in the Environmental Assessment to be impacted by the project and poorly conserved vegetation communities identified as being more than 75% cleared in the catchment management area) and 2:1 for the remainder of native vegetation areas (including mangroves, seagrass, salt marsh and riparian vegetation). The Strategy shall include, but not necessarily be limited to:
(a) confirmation of the vegetation communities/ habitat (in hectares) to be offset and the size of offsets required (in hectares);
(b) details of the available offset measures that have been identified to compensate for the biodiversity impacts of the project, such as (but not necessarily limited to): suitable compensatory land options and/ or contributions towards biodiversity programs for high conservation value areas on nearby lands (including research programs). Where the use of

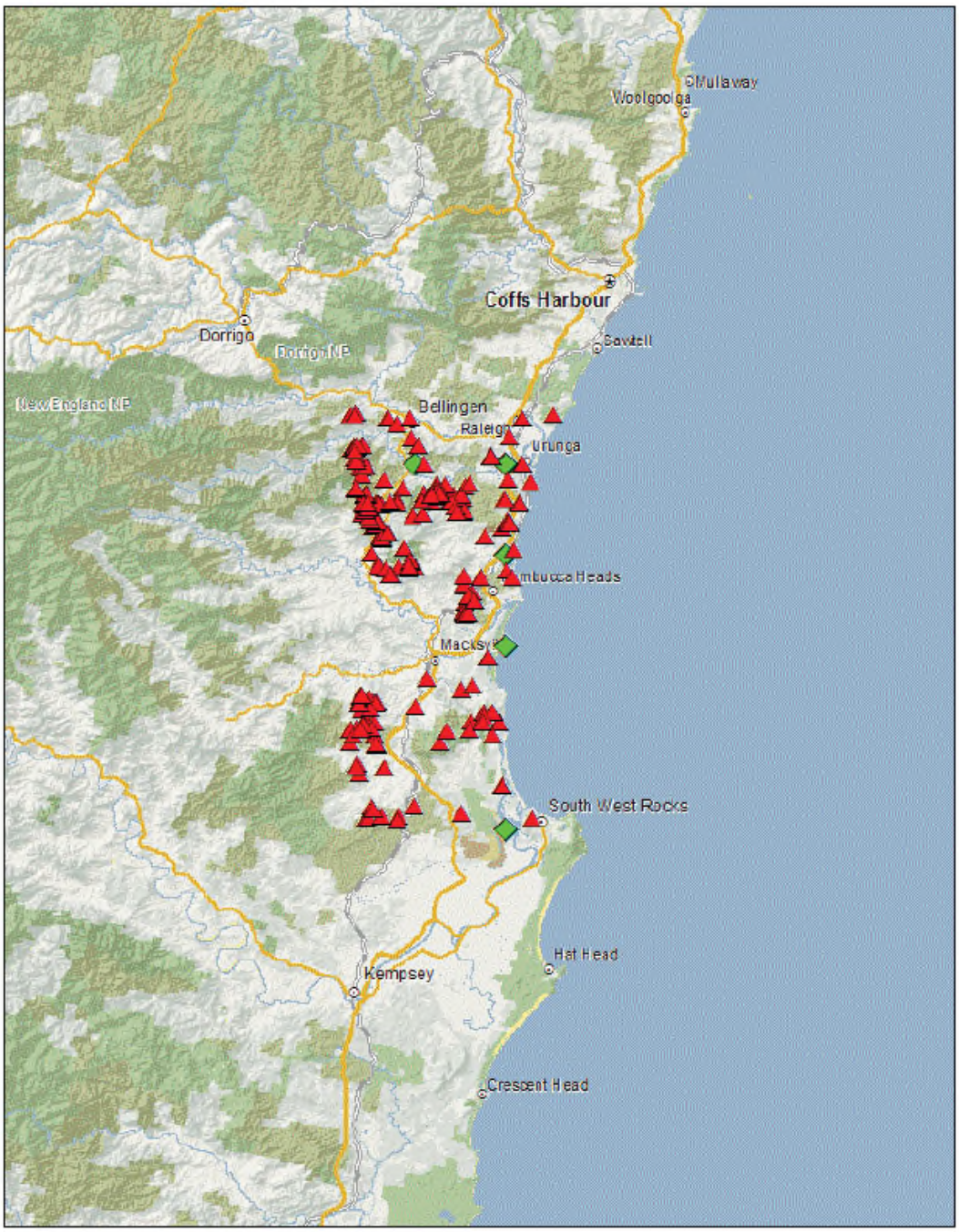
State Forest land managed in accordance with an lntegrated Forestry Operations Approval is proposed to offset biodiversity impacts, the Proponent shall clearly demonstrate how this would provide the biodiversity outcomes required under this condition including any additional offset requirements to cover residual impacts;
(c) the decision-making framework that would be used to select the final suite of offset measures to achieve the aims and objectives of the Strategy, including the ranking of offset measures;
(d) a process for addressing and incorporating offset measures for changes to impact (where these changes are generally consistent with the biodiversity impacts identified for the project in the documents listed under condition A1, including:
i. changes to footprint due to design changes;
ii. changes to predicted impacts resulting from changes to mitigation measures;
iii. identification of additional species/habitat through pre-clearance surveys; and
iv. additional impacts associated with ancillaryfacilities; and
(e) options for the securing of biodiversity options in perpetuity.
The Biodiversity Offset Strategy shall be submítted to, and approved by, the Director General prior to the commencement of any construction work that would result in the disturbance of any native vegetation, unless otherwise agreed by the Director General. Unless otherwise agreed, the Biodiversity Offset Strategy shall be submitted to the Director General for approval no later than 6 weeks prior to the commencement of any construction that would result in the disturbance of any native vegetation.
The Proponent may elect to satisfy the requirements of this condition by implementing a suitable offset package which addresses impacts from multiple Pacific Highway Upgrade projects (including the Warrell Creek to Urunga Project) within the North Coast Bio-region. Any NSW Government Department of Planning and lnfrastructure such agreement made with the OEH must be made in consultation with the Department and approved by the Director General within a timeframe agreed to by the Director General.

Within two years of the approval of the Biodiversity Offset Strategy, unless otherwise agreed by the Director General, the Proponent shall prepare and submit a Biodiversity Offset Package which identifies the final suite of offset measures to be implemented for the project for the approval of the Director General. The Package shall be developed in consultation with OEH, and shall provide details of:
(a) the final suite of the biodiversity offset measures selected for the project demonstrating how it achieves the requirements and aims of the Biodiversity Offset Strategy (including specified offset ratios);
(b) the final selected means of securing the biodiversity values of the offset package in perpetuity including ongoing management, monitoring and maintenance requirements; and
(c) timing and responsibilities for the implementation of the provisions of the package over time.
The requirements of the Package shall be implemented by the responsible parties according to the timeframes set out in the Package.

Ecological Monitoring

B10. Prior to the commencement of any construction work that would result in the disturbance of any native vegetation, the Proponent shall develop an Ecological Monitoring Program to monitor the effectiveness of the mitigation measures implemented as part of the project. The program shall be developed in consultation with OEH and prepared by a suitably qualified ecologist and shall include but not necessarily be limited to:
(a) an adaptive monitoring program to assess the effectiveness of the mitigation measures identified in condition 81 to 86, B7(b), B7(d), 821(c) and B3'1(b)and allow amendment to the measures if necessary. The monitoring program shall nominate appropriate and justified monitoring periods and performance targets against which effectiveness will be measured. The monitoring shall include operational road kill surveys to assess the effectiveness of fauna crossing and exclusion fencing implemented as part of the project;
(b) mechanism for developing additional monitoring protocols to assess the effectiveness of any additional mitigation measures implemented to address additional impacts in the case of design amendments or unexpected threatened species finds during construction (where these additional impacts are generally consistent with the biodiversity impacts identified for the project in the documents listed under condition A1;
(c) monitoring shall be undertaken during construction (for construction-related impacts) and from opening of the project to traffic (for operation/ongoing impacts) until such time as the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of five successive monitoring periods (i.e. 5 years) after opening of the project to traffic, unless otherwise agreed to by the Director General. The monitoring period may be reduced with the agreement of the Director General in consultation with OEH, depending on the outcomes of the monitoring;
(d) provision for the assessment of the data to identify changes to habitat usage and if this can be attributed to the project;
(e) details of contingency measures that would be implemented in the event of changes to habitat usage patterns directly attributable to the construction or operation of the project; and
(f) provision for annual reporting of monitoring results to the Director General and OEH, or as otherwise agreed by those agencies.
The Program shall be submitted for the Director General's approval prior to the commencement
of any construction work that would result in the disturbance of any native vegetation. Unless otherwise agreed, the Program shall be submitted to the Director General for approval no later than 6 weeks prior to the commencement of any construction that would result in the disturbance of any native vegetation.

APPENDIX 6: NSW WILDLIFE ATLAS AND EPBC PROTECTED MATTERS SEARCH TOOL RESULTS



Legend

Species records mapped as held

Category 3 sensitive spp. 0.01°(~1km) rounded

Category 2 sensitive spp.0.1°(~10km) rounded

Atlas of NSW Wildlife records

N

Data from the BioNet Atlas of NSW Wildlife website, which holds records from a number of custodians. Location accuracy varies. Maps from the website are interactive: map displays can be modified from the original extent and a maximum of 5 species can be selected to display. Map may contain errors and omissions. Neither the Office of Environment and Heritage nor any other data custodian will accept liability for any loss, damage, cost or expenses incurred as a result of the use of, or reliance upon, the information in the map. Map copyright the State of NSW through the Office of Environment and Heritage.

Your Selection: Public Report of all Valid Records of Threatened (listed on TSC Act 1995) Plants in selected area [North: -30.44 West: 152.83 East: 153.11 South: -30.89] returned a total of 452 records of 15 species.

Report generated on 12/12/2011 2:23 PM

Data from the BioNet Atlas of NSW Wildlife website, which holds records from a number of custodians. The data are only indicative and cannot be considered a comprehensive inventory, and may contain errors and omissions.
Species listed under the Sensitive Species Data Policy may have their locations denatured (^ rounded to 0.1°; ^^ rounded to 0.01°).

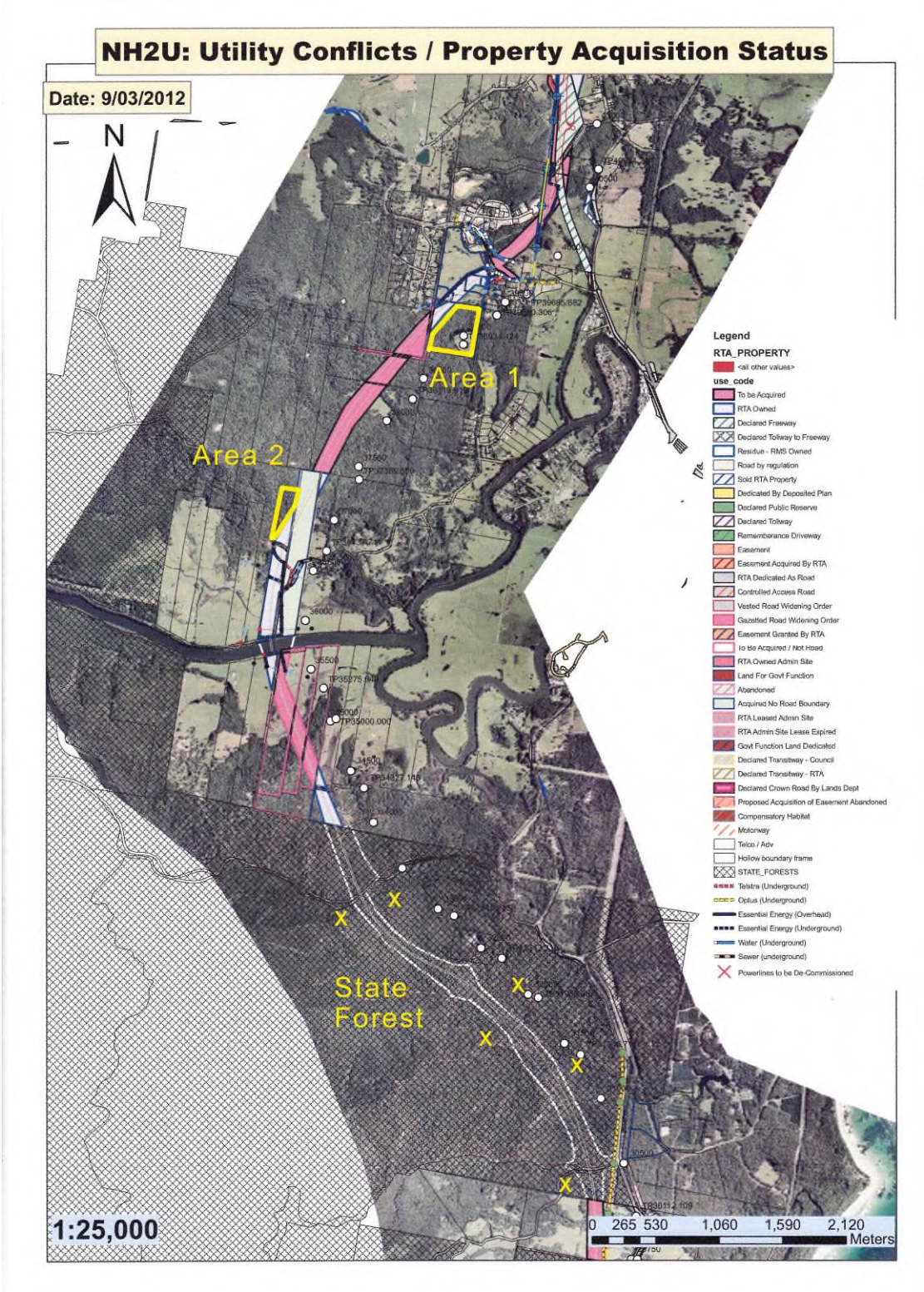
Search criteria : Public Report of all Valid Records of Threatened (listed on TSC Act 1995) Plants in selected area [North: -30.44 West: 152.83 East: 153.11 South: -30.89] returned a total of 452 records of 15 species.
Report generated on 12/12/2011 2:17 PM

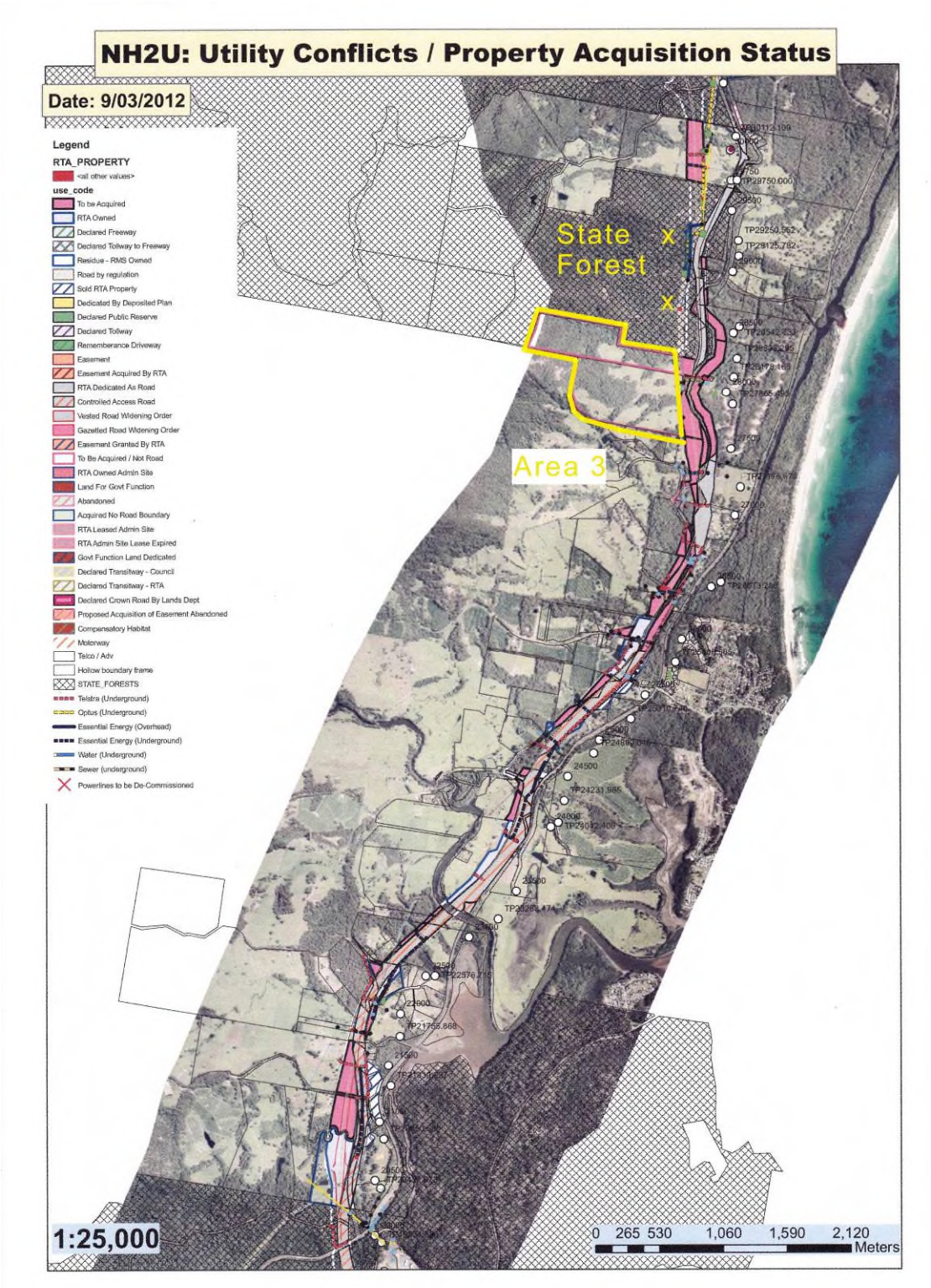
Kingdom	Class	Family	Species Code	Scientific Name	Exotic	Common Name	Legal Status	Records	Info
Flora	Flora	Apocynaceae	1233	*Marsdenia longiloba*		Slender Marsdenia	E1	58	
Flora	Flora	Apocynaceae	9505	*Parsonsia dorrigoensis*		Milky Silkpod	V	133	
Flora	Flora	Euphorbiaceae	9851	*Chamaesyce psammogeton*		Sand Spurge	E1	1	
Flora	Flora	Fabaceae (Mimosoideae)	3739	*Acacia chrysotricha*		Newry Golden Wattle	E1	102	
Flora	Flora	Juncaginaceae	3363	*Maundia triglochinoides*			V	1	
Flora	Flora	Menispermaceae	3691	*Tinospora tinosporoides*		Arrow-head Vine	V	2	
Flora	Flora	Myrtaceae	4252	*Melaleuca groveana*		Grove's Paperbark	V	5	
Flora	Flora	Myrtaceae	4293	*Syzygium paniculatum*		Magenta Lilly Pilly	E1	1	
Flora	Flora	Orchidaceae	6630	*^Dendrobium melaleucaphilum*		Spider orchid	E1	7	
Flora	Flora	Orchidaceae	4480	*^Phaius australis*		Southern Swamp Orchid	E1	1	
Flora	Flora	Poaceae	8979	*Alexfloydia repens*		Floyd's Grass	E1	1	
Flora	Flora	Proteaceae	5432	*Hicksbeachia pinnatifolia*		Red Boppel Nut	V	5	
Flora	Flora	Rutaceae	6457	*Acronychia littoralis*		Scented Acronychia	E1	13	
Flora	Flora	Santalaceae	5871	*Thesium australe*		Austral Toadflax	V	1	
Flora	Flora	Sapotaceae	11957	*Niemeyera whitei*		Rusty Plum, Plum Boxwood	V	121	

EPBC Act Protected Matters Report

PLANTS		
Acronychia littoralis Scented Acronychia [8582]	Endangered	Species or species habitat likely to occur within area
Allocasuarina defungens Dwarf Heath Casuarina [21924]	Endangered	Species or species habitat likely to occur within area
Arthraxon hispidus Hairy-joint Grass [9338]	Vulnerable	Species or species habitat may occur within area
Cryptostylis hunteriana Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat may occur within area
Cynanchum elegans White-flowered Wax Plant [12533]	Endangered	Species or species habitat likely to occur within area
Euphrasia arguta [4325]	Critically Endangered	Species or species habitat may occur within area
Hicksbeachia pinnatifolia Monkey Nut, Bopple Nut, Red Bopple, Red Bopple Nut, Red Nut, Beef Nut, Red Apple Nut, Red Boppel Nut, Ivory Silky Oak [21189]	Vulnerable	Species or species habitat likely to occur within area
Marsdenia longiloba Clear Milkvine [2794]	Vulnerable	Species or species habitat likely to occur within area
Parsonsia dorrigoensis Milky Silkpod [64684]	Endangered	Species or species habitat likely to occur within area
Quassia sp. Moonee Creek (J.King s.n. 1949) NSW Herbarium [82054]	Endangered	Species or species habitat likely to occur within area
Taeniophyllum muelleri Minute Orchid, Ribbon-root Orchid [10771]	Vulnerable	Species or species habitat likely to occur within area
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat likely to occur within area
Tinospora tinosporoides Arrow-head Vine [5128]	Vulnerable	Species or species habitat likely to occur within area
Tylophora woollsii [20503]	Endangered	Species or species habitat likely to occur within area

APPENDIX 7: TRANSLOCATION RECEIVAL SITES




NH2U: Utility Conflicts / Property Acquisition Status
Date: 9/03/2012
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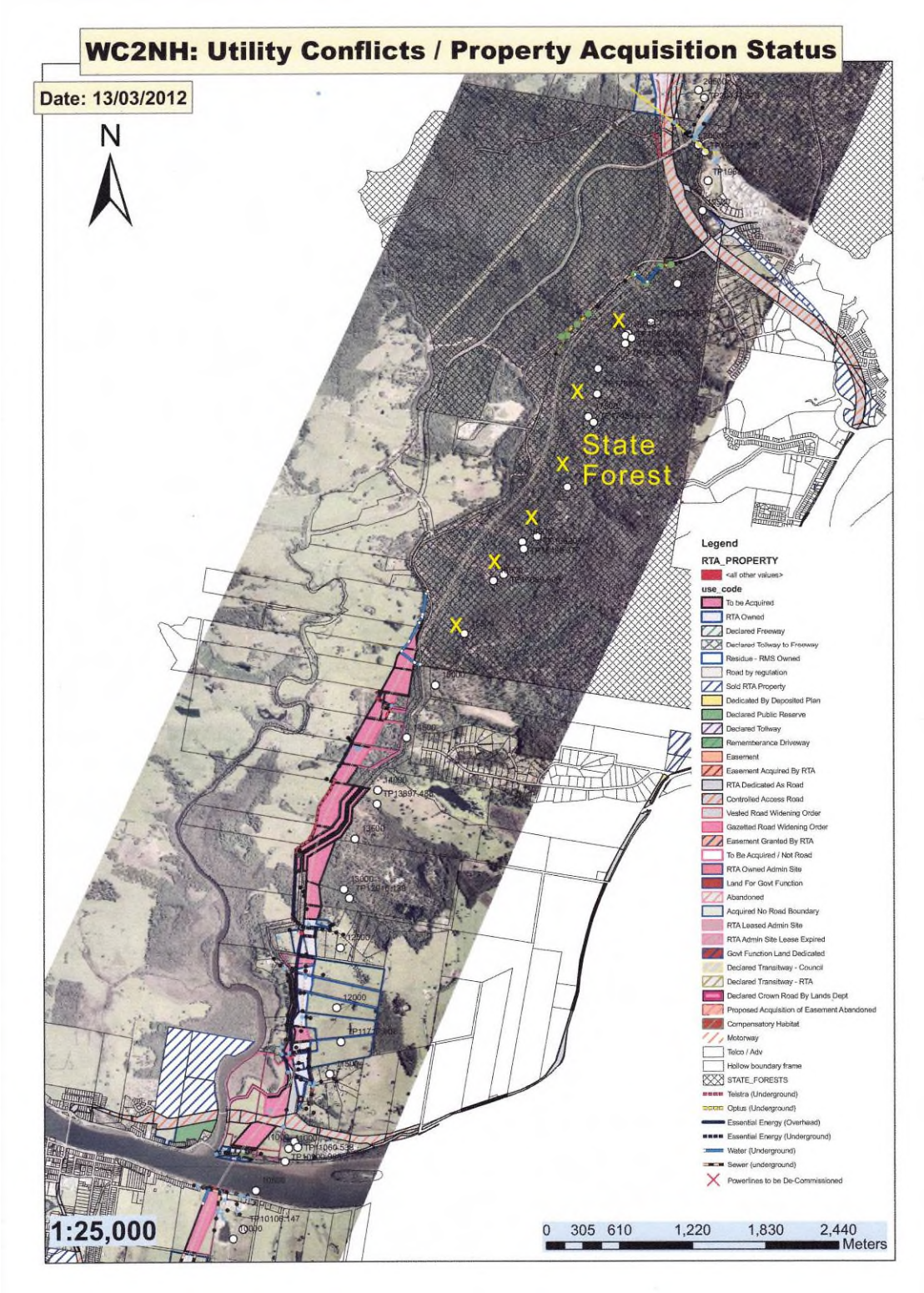
To be Acquired
RTA Owned
Declared Freeway
Declared Tollway to Freeway
Residue - RMS Owned
Road by regulation
Sold RTA Property
Dedicated By Deposited Plan
Declared Public Reserve
Declared Tollway
Remembrance Driveway
Easement
Easement Acquired By RTA
RTA Dedicated As Road
Controlled Access Road
Vested Road Widening Order
Gazetted Road Widening Order
Easement Granted By RTA
To Be Acquired / Not Road
RTA Owned Admin Site
Land For Govt Function
Abandoned
Acquired No Road Boundary
RTA Leased Admin Site
RTA Admin Site Lease Expired
Govt Function Land Dedicated
Declared Transitway - Council
Declared Transitway - RTA
Declared Crown Road By Lands Dept
Proposed Acquisition of Easement Abandoned
Compensatory Habitat
Motorway
Telco / Adv
Hollow boundary frame
STATE_FORESTS
Telstra (Underground)
Optus (Underground)
Essential Energy (Overhead)
Essential Energy (Underground)
Water (Underground)
Sewer (underground)
Powerlines to be De-Commissioned
State Forest
Area 3
1:25,000
0 265 530 1,060 1,590 2,120
Meters


WC2NH: Utility Conflicts / Property Acquisition Status
Date: 13/03/2012
N
State Forest
Legend
RTA_PROPERTY
<all other values>
use_code
To be Acquired
RTA Owned
Declared Freeway
Declared Tollway to Freeway
Residue - RMS Owned
Road by regulation
Sold RTA Property
Dedicated By Deposited Plan
Declared Public Reserve
Declared Tollway
Remembrance Driveway
Easement
Easement Acquired By RTA
RTA Dedicated As Road
Controlled Access Road
Vested Road Widening Order
Gazetted Road Widening Order
Easement Granted By RTA
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RTA Owned Admin Site
Land For Govt Function
Abandoned
Acquired No Road Boundary
RTA Leased Admin Site
RTA Admin Site Lease Expired
Govt Function Land Dedicated
Declared Transitway - Council
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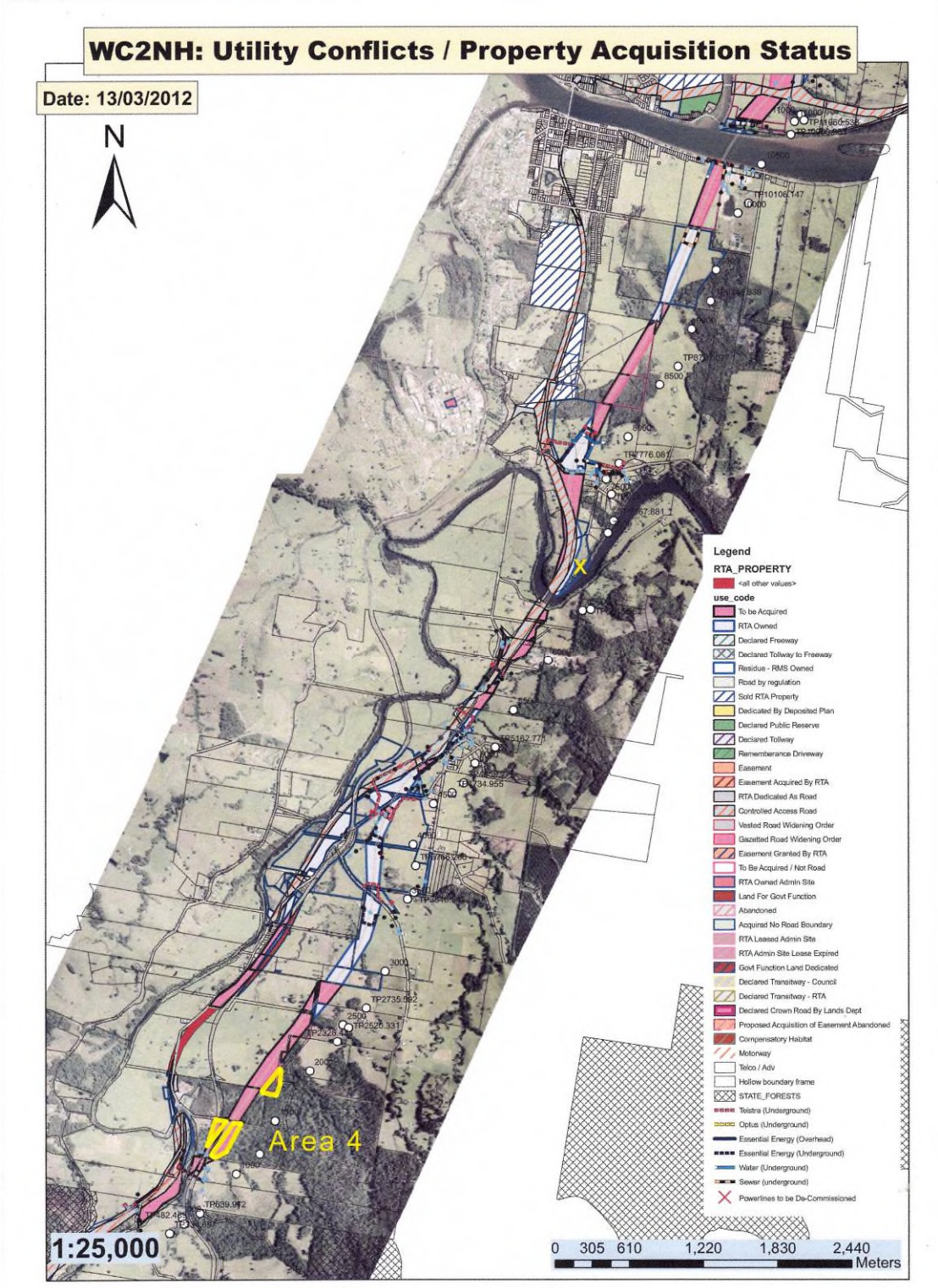
Proposed Acquisition of Easement Abandoned
Compensatory Habitat
Motorway
Telco / Adv
Hollow boundary frame
STATE_FORESTS
Telstra (Underground)
Optus (Underground)
Essential Energy (Overhead)
Essential Energy (Underground)
Water (Underground)
Sewer (underground)
Powerlines to be De-Commissioned
1:25,000
0 305 610 1,220 1,830 2,440
Meters


WC2NH: Utility Conflicts / Property Acquisition Status
Date: 13/03/2012
N
Area 4
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To be Acquired
RTA Owned
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Residue - RMS Owned
Road by regulation
Sold RTA Property
Dedicated By Deposited Plan
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Declared Tollway
Remembrance Driveway
Easement
Easement Acquired By RTA
RTA Dedicated As Road
Controlled Access Road
Vested Road Widening Order
Gazetted Road Widening Order
Easement Granted By RTA
To Be Acquired / Not Road
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STATE_FORESTS
Telstra (Underground)
Optus (Underground)
Essential Energy (Overhead)
Essential Energy (Underground)
Water (Underground)
Sewer (underground)
Powerlines to be De-Commissioned
0 305 610 1,220 1,830 2,440
Meters

APPENDIX 8: THREATENED PLANT SPECIES ASSESSMENT OF SIGNIFICANCE

Addendum to the Environmental Assessment for the Warrell Creek to Urunga Upgrade (RTA 2010):
(yellow highlight indicates new text)

Threatened Species Assessments of Significance

A total of six species listed under the State Threatened Species Conservation Act (TSC Act) were recorded on the approved Warrell Creek to Urunga highway corridor during a targeted threatened species survey conducted in November 2011:-
Marsdenia longiloba
Niemeyera whitei
Maundia triglochinoides
Alexfloydia repens
Tylophora woollsii
Dendrobium melaleucaphilum

A significant number of additional individuals of the two species already recorded (the first two listed above) were also recorded during the targeted survey. The TSC Act and EPBC Act assessments presented in the EA (RTA 2010) are revised below to take into account this new information

Revision of RTA (2010) - Appendix B Assessment of significance (EP&A Act)

Note - As the project is assessed according to Part 3A of the EP&A Act, 7-part Test assessments of significance are not required. The format and section numbering in the informal assessments presented in RTA (2010) is followed below.

B.1 Threatened flora recorded

B.1.1 *Marsdenia longiloba* - Endangered Species: TSC Act
Marsdenia longiloba (Slender Marsdenia) is a small species of vine found in rainforest and wet sclerophyll forest at scattered locations from Barrington Tops north to southeast Queensland (NPWS 2002b). This species has mostly been recorded as occurring in low abundance in small population clusters. The population, or sub-populations recorded in the study area consist of scattered individuals in the understorey of moist eucalypt forest growing with various ferns, herbs and other twiners under an open to dense rainforest sub-canopy.

Translocation and monitoring of *Marsdenia longiloba* for the Bonville Upgrade in the Coffs Harbour LGA provided insight into various aspects of the life history of this species. Life history attributes reported by Benwell and Watson (2011) included:

- *Marsdenia longiloba* is a perennial, rhizomatous vine.

- Sub-populations are composed almost entirely of single-stemmed ramets produced from underground rhizomes, with several stems commonly attached to same rhizome network.

- Above stems are comparatively short-lived (1-3 years), while the rhizomes are probably more long-lived.

- The rhizomes are relatively thin, 10-30cm long and grow horizontally within the soil A1 horizon (occasional vertical rhizomes are also present); the rhizomes ramify through the soil, budding off existing rhizomes and severing connection to form separate plants.

- Plants may die back to the rhizome and remain stem-less and apparently dormant for up to two years (probably longer), then produce new stem shoots.

- Most stem-individuals never grow more than 30cm tall before dying back.

- Only large stem-individuals (ie >1m tall) produce flowers; production of pods and seed is extremely rare; only 1 pod has ever been recorded during several years of monitoring at several locations.

- *Marsdenia longiloba* appears to rely on vegetative reproduction for population persistence; flowering and seed dispersal play a minor role in this process.

- Discrete sub-populations and patches of *Marsdenia longiloba* may originate vegetatively from the same parent plant and spread over a considerable area (e.g. 0.04 ha)

- *Marsdenia longiloba* stems are conspicuously absent from recently (<1-6 yrs) logged or burnt forest, although monitoring of translocation areas has shown that quiescent rhizomes may be present in the soil. This suggests that conditions during early post-disturbance succession are not favourable for growth of *Marsdenia longiloba,* and stem growth may occur mainly during mid to late stages of succession.

The hypothesis implicit in the last dot point requires further study. In particular, the response of *Marsdenia longiloba* to fire has never been monitored.

How is the Project likely to affect the lifecycle of a threatened species and/or population?

The 2011 targeted threatened flora survey of the WC2U road corridor recorded *Marsdenia longiloba* at a total of 69 GPS points, which represented 203 plants and at least 22 different sub-populations ('sub-populations' were defined as geographically discrete records at least 100m apart). This species was comparatively widespread, being recorded at Raleigh south, Newry State Forest, Little Newry State Forest, Valla south, Nambucca State Forest and Warrell Creek. Of the total 203 plants recorded,

161 were directly impacted and 22 were indirectly impacted. The number of plants in the road reserve outside the construction zone was under-recorded, as the survey focused on the construction footprint. It is estimated that another 50 plants would probably occur in the outer part of the road reserve where they would not be impacted by roadworks.

The EA survey showed that sub-populations of *Marsdenia longiloba* extend outside the road corridor. Throughout Newry, Little Newry and Nambucca State Forest, as well as in larger vegetation remnants on private property, scattered individuals of *Marsdenia longiloba* are likely to occur where suitable habitat is present. Suitable habitat consists of gullies and lower slopes in wet sclerophyll forest, particularly on a southerly aspect. Wildlife Atlas reports other several locations for *Marsdenia longiloba* surrounding the WC2U highway corridor, including areas west of the project in Nambucca State Forest and surrounding the Nambucca waste management facility; south of the Project area in Ngamba Nature Reserve; and north of the project in the Bellingen district. Much habitat for *Marsdenia longiloba* is found in State Forest in logging exclusion zones along creeks and gullies, where it receives a measure of protection.

Significant numbers of *Marsdenia longiloba* would remain in the local area and thereby maintain large-scale population processes that may be important to the life cycle and persistence of the species. Individuals in close vicinity to the road corridor may be indirectly impacted through changes in micro-climatic, potential increases in weed invasion and sedimentation, and potential changes in hydrology. This may adversely affect the ability of individuals within 10 metres of the roadside (i.e. indirectly disturbed habitat) to remain healthy and complete their life cycle. Mitigation measures including confining vegetation clearing strictly to the construction footprint, sediment and erosion control measures and ecologically designed landscaping would minimise these indirect impacts. Potential decline in population number due to clearing would be also be mitigated by undertaking translocation of the species .

Marsdenia longiloba belongs to the plant family Asclepiadaceae. Pollinators of this family are typically butterflies and moths. The specific pollinators of *Marsdenia longiloba* and whether they are diurnal or nocturnal has not been determined. Several sub-populations would be intersected by the Project and therefore impact on pollinator movements between individuals on either side of the Project. Therefore the movement of genetic material may be impacted in these subpopulations, and could potentially lead to some inbreeding depression. However, the observed life history attributes of *Marsdenia longiloba* indicate this species relies on vegetative reproduction for population persistence, and that pollination and seed dispersal play a minor role in its persistence at a locality. Project interference with the very limited pollination activity in this species is unlikely to significantly affect the life cycle of *Marsdenia longiloba* by altering the genetic structure of populations through processes such as inbreeding.

How is the Project likely to affect the habitat of a threatened species, population or ecological community?

The Project would remove habitat for this species in several areas and potentially lead to biophysical changes to other areas of habitat. There is potential for the Project to alter habitat attributes of surrounding areas through indirect impacts of changes in hydrological and nutrient regimes within habitats downstream of the proposed development and through edge effects. This could result in habitat changes, including increases in weed abundance, altered soil conditions and sedimentation. These changes may potentially lead to the area of occupancy of the population to be significantly reduced. However mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts. These would include: (i) measure to ensure that vegetation clearing is confined strictly to the construction footprint, (ii) measures to control sediment run-off (particularly sedimentation fencing) and (iii) ecologically designed landscaping.

Does the Project affect any threatened species or populations that are at the limit of its known distribution?

The distribution of *Marsdenia longiloba* extends from Barrington Tops to southeast Queensland (NPWS 2002b). Therefore *Marsdenia longiloba* is in the central portions of its distribution in the Nambucca-Urunga area.

How is the Project likely to affect current disturbance regimes?

Current disturbance regimes potentially affecting *Marsdenia longiloba* include:-
(i) weed invasion by *Lantana camara*, (ii) bushfire, (iii) logging and clearing, as follows:-

(i) The Project is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Project where there would be increased sunlight availability. Other indirect impacts such as increased water and nutrients may also aid the growth of *Lantana camara*. Weed control during construction and operation of the highway would greatly reduce this threat to *Marsdenia longiloba* habitat.

(ii) Bushfires in *Marsdenia longiloba* habitat can start from arson, accidental ignition, control burning and lightning strikes. The Project may result in an increase in fire frequency due to fires started by arson or accidental ignition. At the same time, the new highway corridor may result in a barrier to the spread of fire, resulting in a decrease in fire frequency. Increase in fire intensity may result from changes in fuel characteristics in roadside vegetation, causing increased flammability. However, the number of fires resulting from roadside ignition has decreased significantly in recent decades due to greater environmental awareness, harsh penalties and roadside maintenance.

(iii) Vegetation clearing is likely to change microclimatic conditions in forest to a depth of 10-20 metres from the edge of the road corridor (Benwell 2010). This may in turn lead to an increase in weeds and sclerophyllous plants, producing a general increase in forest understorey density, which appears to create unsuitable habitat

conditions for *Marsdenia longiloba*. Such changes in habitat structure are reduced if no soil disturbance occurs beyond the limits of clearing. This can be ensured by mitigation measures such as strict controls on clearing, No Go zones and use of sedimentation fencing.

How is the Project likely to affect habitat connectivity?

Marsdenia longiloba generally occurs in gully areas running perpendicular to the Project. Therefore suitable areas of habitat would be fragmented from the Project, with some subpopulations being dissected. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however as already discussed, populations of *Marsdenia longiloba* persist by vegetative reproduction rather than pollination and seed production, as evidenced by the extreme rarity of seed production. Individuals would generally remain on either side of the road corridor following direct impact to individuals through clearing of the construction footprint. Substantial numbers of plants are likely to occur in surrounding habitat not affected by the highway construction.

How is the Project likely to affect critical habitat?

No critical habitat has been identified for this species.

B.1.2 *Amorphospermum whitei* (syn. *Niemeyera whitei*) Vulnerable: TSC Act
Amorphospermum whitei is a medium size rainforest tree found on the coast and adjacent ranges of northern NSW from the Macleay River into southern Queensland, and its distributional stronghold is on the mid north coast in the Coffs Harbour district (NPWS 2002b). Rusty Plum is found in rainforest and the rainforest understorey of wet sclerophyll forest, generally below 600 m altitude and on low to moderate fertility soils derived from metasediments and rhyolite (Floyd 1989).

Limited information on the life history of *Amorphospermum whitei* was reported by Novello and Klohs (1998). They reported that the large seed of this species is supposedly dispersed by mammal species and is viable for a period of 1-3 months, and that once seedlings are established it can take up to six years for the tree to reproduce. More rigorous information on the life history of *Amorphospermum whitei* was recorded during translocation and monitoring of this species for the Bonville and Sapphire to Woolgoolga Pacific Highway upgrade projects. As part of the Sapphire to Woolgoolga project, 68 seeds of *Amorphospermum whitei* were direct seeded into suitable, regrowth wet sclerophyll forest habitat. After 6 months, 75% of the seed had germinated, 12% had rotted, 6% was either eaten or removed (dispersed?) and 7% were ungerminated, but still intact and presumably viable. Of the germinated seedlings, a third were grazed by possums or wallabies in the first 3 months then all reshot again, as the large seed still contained stored food. The seedlings were subsequently protected under wire cages (Benwell 2011).

Ninety, one year old *Amorphospermum whitei* seedlings were introduced to potential habitat during the Bonville Upgrade. The mean height of three year old seedlings in three different planting treatments ranged from 33 to 40cm. This is a slow growth rate indicating that seedlings would be unlikely to reach reproductive maturity in six years

as reported by Novello and Klohs (1998). It is estimated that the fastest growing seedlings would require 10-20 years to reach reproductive maturity (i.e. start seed production).

A single isolated tree of *Amorphospermum whitei* in the Coffs Harbour Botanical Gardens has been observed to produce normal sized fruits with seeds inside, indicating the species can set seed by self-pollination. Whether this still requires an insect pollinator and the role and importance of cross-pollination in maintaining genetic diversity is unknown.

How is the Project likely to affect the lifecycle of a threatened species and/or population?

Amorphospermum whitei was recorded at three locations: Boggy Creek near Valla, north of the railway line at the Nambucca turn-off and Cockburns Lane south of Warrell Creek. A single small tree was recorded at Boggy Creek and a population of 17 trees and saplings, plus seedlings were recorded at Cockburns Lane in a 150 meter long section of the road corridor. The trees were up to 10 metres in height with a maximum diameter of about 30 cm. Of the 17 individuals at Cockburns Lane, Warrell Creek, 14 are directly impacted, three are indirectly impacted and two would remain in situ. The single tree at Boggy Creek is reported to require removal in the EA, although spatial impact analysis indicated it was outside the impact zone.

At Cockburns Lane, a few *Amorphospermum whitei* would remain in situ in the road reserve and others probably occur in forest east of the road alignment. Also, *Amorphospermum whitei* probably occurs at other locations in the Boggy Creek catchment on private land to the west of the road alignment. There are two records of *Amorpospermum whitei* higher in the Boggy Creek catchment in Nambucca State Forest approximately two km to the southwest of the individual recorded in the Project area (NSW DPI 2007). In addition, Wildlife Atlas indicates that *Amorphospermum whitei* is found in the Bellingen district, in Newry State Forest <5km west of the Project, other locations at Valla, Nambucca State Forest and Ingalba State Forest <5km west of the Project. Habitat for *Amorphospermum whitei* is largely protected in State Forest areas in logging exclusion zones along creeks and gullies.

The impact of the WC2U highway upgrade on *Amorphospermum whitei* at two locations is therefore comparatively minor in terms of the local distribution of this species. Significant numbers of *Amorphospermum whitei* would remain in the local area within 10km of the project, thereby maintaining large-scale population processes such as gene flow via pollination between sub-populations. In the immediate vicinity of the WC2U highway upgrade a small number of individuals would be indirectly impacted through changes in micro-climatic, potential increases in weed invasion and sedimentation, and potential changes in hydrology. This may adversely affect the ability of a small number of individuals to complete their life cycle and maintain population number through seedling recruitment. A decrease in population number can be avoided by undertaking translocation of the species, which has been shown to be successful on other projects (Benwell 2011).

How is the Project likely to affect the habitat of a threatened species, population or ecological community?

The Project would remove habitat for this species in several areas and potentially lead to biophysical changes to areas of habitat. There is potential for the Project to alter habitat attributes of surrounding areas through indirect impacts which potentially include altering of hydrological and nutrient regimes in habitats downstream of the proposed development and edge effects. This could result in habitat changes, including increases in weed abundance, altered soil conditions and sedimentation. Considering that *Amorphospermum whitei* was recorded in only two locations in the study area and the substantial wider distribution of the species in the local area, it is unlikely that the Project would lead to the area of occupancy of the population to be significantly reduced from potential changes to areas of suitable habitat. Mitigation measures during construction, and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

Does the Project affect any threatened species or populations that are at the limit of its known distribution?

The distribution of *Amorpospermum whitei* is characterised by separate northern and southern meta-populations (NPWS 1998). The northern meta-population is restricted to the Mt Warning Shield on the NSW-Qld border. The southern meta-population occurs from the Coffs Harbour district south to Ingalba State Forest, inland to the Dorrigo and Upper Bellinger districts (Wildlife Atlas). It is also reported from the Port Macquarie district (Harden 2000), which appears to represent a small, disjunct, southern population.

The *Amorpospermum whitei* occurrence at Cockburns Lane, Warrell Creek South is therefore at the southern limit of the southern meta-population, along with occurrences in Ingalba State Forest.

How is the Project likely to affect current disturbance regimes?

Current disturbance regimes potentially affecting *Amorpospermum whitei* habitat include:-
(i) invasion by woody weeds, including *Lantana camara*, *Ligustrum sinense* and *Cinnamomum camphora*. The Project is likely to contribute to further invasion of woody weeds along the edges of the Project where there would be increased sunlight availability, water and nutrients. Weed control specifically targeted to threatened species habitat during construction and operation of the highway would greatly reduce this threat to *Amorpospermum whitei* habitat.

(ii) bushfire - the thick rough bark of *Amorpospermum whitei* indicates it can survive fire and recover by resprouting. This is also consistent with its response to transplanting, where it regenerates by epicormic and basal shoot resprouting. Therefore, fire is unlikely to have a significant adverse impact on this species, as long as they are not too frequent or intense.

(iii) logging and adjacent clearing - vegetation clearing is likely to change microclimatic conditions in forest to a depth of 10-20 metres from the edge of the road corridor (Benwell 2010). This may adversely affect habitat conditions for *Amorpospermum whitei* located near the road edge. Degradation of forest habitat

adjoining roadside habitat can be reduced by measures to minimise clearing and soil disturbance, and ecologically compatible landscaping after the finish of construction.

How is the Project likely to affect habitat connectivity?

Amorpospermum whitei generally occurs in gully areas running perpendicular to the Project. Therefore suitable areas of habitat would be fragmented from the Project. Although no individuals were recorded in the study area in most areas of suitable habitat, individuals are potentially present in areas beyond the study area, and there are records to the west of the Project in several areas. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown. Seed dispersal across the proposed development is likely to be impacted to some degree, as terrestrial fauna movement is likely to be impacted, however seed dispersal by flying mammals and birds is unlikely to be significantly impacted.

As the species already has a naturally patchy or fragmented distribution in the local area according to the landscape pattern of hill slopes and drainage lines, the WC2U highway corridor, would not significantly increase the current level of habitat dis-connectivity.

How is the Project likely to affect critical habitat?

No critical habitat has been identified for this species.

B.1.4 *Maundia triglochinoides* - Vulnerable Species: TSC Act

Maundia triglochinoides is a emergent aquatic plant of coastal floodplains, found from Sydney (Botany Bay) north to southern Queensland (Wildlife Atlas; DECC 2002). Maundia grows in swamps, creeks and shallow freshwater, 30-60 centimetres deep, on heavy clay alluvium of low to medium nutrient levels. Flowering occurs during summer. *Maundia triglochinoides* is similar in appearance to *Triglochin procerum* (now split into several species). *Maundia triglochinoides* can be distinguished by its leaves which are convex and hollow (not flat as in *Triglochin procerum*)*;* it has white rhizomatous roots to 10 cm+ long; and the flower spike is shorter and comprised of capsules rather than schizocarps as in *Triglochin* species.

How is the Project likely to affect the lifecycle of a threatened species and/or population?

Maundia triglochinoides was recorded at two locations south of Macksville. One location is on Williamson's Creek where it crosses the highway corridor. The second location is a freshwater swamp just south of Macksville. The Williamson's Creek population follows the creek for approximately 150 metres across the road corridor and extends further upstream and downstream outside the road corridor. *Maundia triglochinoides* appears to spread vegetatively from its rhizome system and hundreds of plants were present at both locations.

Under the current concept plan design, Maundia is unlikely to be directly impacted by construction of the WC2U upgrade. The population on Williamson's Creek is located

under footprint of the new highway bridge, within the stream and along its edge and it should be possible to manage this species in situ without the need for translocation. Sedimentation fencing installed on either side of the creek and attention to water quality entering the creek from the construction site through the use of retention basins should maintain current habitat conditions during construcion.

It was initially thought that overhead bridge works would adversely affect the population by shading, however, further study of this species in the Frederickton to Eungai area indicates this may not be the case. Direct sunlight would still reach the stream from the eastern and western sides of the highway bridge in early morning and late afternoon. In the Frederickton to Eungai area, Maundia occurrences have been found in shaded open-forest situations, demonstrating the species does not require full sun exposure (Benwell 2012). The populations on WC2U could still be adversely impacted by possible changes in hydrology, water quality and weed invasion,

The second population occurs in a freshwater wetland on the Nambucca River floodplain south of Macksville. This population just overlaps with the project's eastern boundary and is only marginally affected. Large numbers of plants outside the road corridor, particularly on the eastern side, would remain undisturbed, enabling normal population processes such as pollination, seed set, dispersal and seedling establishment to continue.

Road construction has the potential to impact indirectly on *Maundia triglochinoides* populations at both locations through sedimentation and changes to water quality (e.g. nutrient levels and pH) in its freshwater aquatic habitat. These factors can be controlled by mitigation measures including minimising vegetation clearing and strict adherence to marked clearing boundaries, drainage plans incorporating sediment capture structures, artificial wetlands to absorb nutrients, weed management planning, and ecologically compatible landscaping.

How is the Project likely to affect the habitat of a threatened species, population or ecological community?

The Project would result in the removal of only a small area of unoccupied potential habitat for this species comprising up to two hectares of dams, creeks and wetland areas.

Does the Project affect any threatened species or populations that are at the limit of its known distribution?

Maundia triglochinoides is restricted to coastal NSW north from Sydney (Botany Bay) extending into southern Queensland. Therefore this species would not be at the limit of its distribution in the WC2U locality.

How is the Project likely to affect current disturbance regimes?

Natural and anthropogenic disturbance regimes are currently operating in *Maundia triglochinoides* habitat. The main natural disturbance is flood events that submerge plants and expose them to risk of erosion and sedimentation. Anthropogenic disturbances comprise impacts from grazing and agricultural weeds. Creek lines in

cleared land and wetland areas have been highly impacted from grazing. Aquatic weed species such as *Salvinia molesta* infest some wetland areas south of the Nambucca River.

These impacts would be minimised within and adjoining the road corridor by grazing exclusion fencing, drainage, erosion and sedimentation controls and weed control.

How is the Project likely to affect habitat connectivity?

Potential breaks in the *Maundia triglochinoides* population on Williamson's Creek due to the new bridge would be comparatively minor (i.e. 50-100 metres wide) and substantial numbers of plants and area of habitat in this population would remain unaffected. This level of impact would not greatly affect habitat connectivity or disrupt processes such as pollination, seed dispersal and seedling establishment that rely on habitat connectivity.

How is the Project likely to affect critical habitat?

No critical habitat has been identified for this species.

B.1.5 *Alexfloydia repens* - Endangered Species: TSC Act

Alexfloydia repens is a grass with a restricted distribution between Coff Harbour and Macksville, on or near the banks of creeks within 10 km of the sea where it occurs in Swamp Oak forest and Floodplain Open Forest. It is generally found adjacent to the upper limit of the king tide zone of coastal estuaries and its habitat floods after heavy rain at least once a year on average, sometimes several times (Benwell 2009). The following information on the life history and population dynamics of *Alexfloydia repens* was recorded during translocation and monitoring of the species for the Bonville Upgrade (Benwell 2006-2011):

Alexfloydia repens is a perennial, matt-forming grass.

- The species spreads by stolons or runners. Small plants of Floyds Grass planted into Swamp Oak Forest after clearing the ground of exotics, produced runners up to 2.4 metres long in 12 months.
- On bare ground created either artificially, or by flood-induced dieback of ground layer vegetation, Floyds Grass regenerates rapidly from runners to form a dense cover.
- Established ground cover vegetation of grass and fern species forms a barrier which stops the spread of runners.
- Flowers are produced very sparsely in forested situations (ie. habitat with a tree canopy) and abundantly in more open habitat, where the vegetation structure has been simplified by disturbance (ie. tree clearing).
- To persist at a location *Alexfloydia repens* relies on vegetative regeneration after disturbance rather than seedling recruitment; it is possible new bare sites are by seed dispersal and seedling establishment, although there is little evidence that this occurs frequently.

How is the Project likely to affect the lifecycle of a threatened species and/or population?

Alexfloydia repens was recorded at one location where the project boundary meets the northern bank of Warrell Creek. Plants were found on either side of the road corridor. No plants were found within the road corridor at the edge of Warrell Creek, although suitable habitat is present. *Alexfloydia repens* occurs upstream of the road corridor for at least 20 metres. No plants were found downstream of the patch on the eastern boundary, for 50 metres, although a large population was recently located approximately 1 km downstream of the road corridor. It is likely that other patches of *Alexfloydia repens* are present along Warrell Creek upstream and downstream of the highway corridor.

Impact analysis of the RMS concept design found that one gps point is directly impacted and two are indirectly impacted, comprising a total of approximately 6 m² of Floyds Grass. All points would probably require translocation as Floyds Grass is unlikely to survive long-term in the indirect impact zone, where it would be threatened by weed invasion and increased cover of native species such as grasses and ground ferns. As noted above, this species can be translocated with a high likelihood of success. Indirect impacts such as run-off from the construction zone and soil eutrophication could also be a problem, although sed and erosion control measures would minimise such impacts.

Construction related factors with potential to adversely effect the life cycle of *Alexfloydia repens* growing adjacent to the road corridor at Warrell Creek include clearing encroachment, sediment run-off, micro-climate change, soil eutrophication and weed invasion. These factors can be controlled using mitigation measures such minimising vegetation clearing and strict adherence to marked clearing boundaries, drainage plans incorporating sediment capture structures, artificial wetlands to absorb nutrients, weed management planning, and ecologically compatible landscaping.

How is the Project likely to affect the habitat of a threatened species, population or ecological community?

Alexfloydia repens inhabits a narrow zone 1-3 metres wide on the edge of Warrell Creek, in Swamp Oak forest. The soil type is a humus-enriched, alluvial clay loam. The road corridor directly and indirectly impacts on approximately 6 m² of actual habitat within the project boundary. This is a very small area in comparison to the known extent of *Alexfloydia repens* at Warrell Creek, where the species occurs directly upstream of the road corridor and a large population has recently been found approximately 1km downstream of the road corridor. Further occurrences are likely in between these two locations. The road corridor directly and indirectly impacts on <1% of the known distribution of *Alexfloydia repens* at Warrell Creek.

Potential adverse effects of the WC2U project on adjoining habitat include clearing encroachment, sediment run-off, soil eutrophication and weed invasion. Any potential adverse impact arising from these factors can be controlled using measures such minimising clearing and strict adherence to marked clearing boundaries, drainage plans incorporating sediment capture structures, soil nutrient management to minimise increases in nutrient levels, weed management planning and ecologically compatible

landscape design. Weed control and habitat restoration can be used to improve the condition of *Alexfloydia repens* habitat adjacent to the bridge site at Warrell Creek and within the road corridor if considered appropriate.

Does the Project affect any threatened species or populations that are at the limit of its known distribution?

The *Alexfloydia repens* population at Warrell Creek is at the extreme southern limit of its distribution. Highway construction would impact directly and indirectly on a very small portion of this population, which likely extends upstream and downstream of the project for some distance.

How is the Project likely to affect current disturbance regimes?

The main disturbance process currently affecting *Alexfloydia repens* at Warrell Creek is weed invasion, particularly by *Lantana camara* and *Paspalum wettsteinii.* The Project has the potential to contribute further to the invasion exotic species, particularly along the edges of the Project where there would be increased sunlight availability and localised changes in soil water and nutrients may also aid the growth of weed species.

Minimisation of clearing, sed and erosion control, weed control and ecologically compatible landscaping would greatly reduce the impact of the WC2U project on the Warrell Creek population.

How is the Project likely to affect habitat connectivity?

The road corridor bisects a narrow stip of *Alexfloydia repens* habitat, the width of the road corridor, at Warrell Creek. This is unlikely to have a significant impact on habitat connectly for this species, as being a species of floodplains, seed and runners are probably dispersed by water movement, particularly during floods. *Alexfloydia repens* occurs both upstream and downstream of the highway impact site.

Removal of *Paspalum wettsteinii* and other ground species would probably allow *Alexfloydia repens* to re-colonise the creek bank within the road corridor and re-connect occurrences on the eastern and western sides of the project.

How is the Project likely to affect critical habitat?

No critical habitat has been identified for this species.

B.1.6 *Dendrobium melaleucaphilum* - Endangered Species: TSC Act

Dendrobium melaleucaphilum, an epiphytic orchid, occurs in coastal districts and nearby ranges, extending from Queensland to its southern distributional limit in the lower Blue Mountains. In NSW, it is currently known from seven recent collections. There has been no subsequent confirmation from the locations of three earlier (pre-1922) collections and it is possible that these are now extinct (OEH website).

How is the Project likely to affect the lifecycle of a threatened species and/or population?

Dendrobium melaleucaphilum was recorded at two locations within the project boundary, in Newry State Forest and a site approximately 4km north of the Kalang River. Only plant was found at the latter site, whereas a substantial population occurs at the Newry State Forest location. Ten Spider Orchid flora points comprising 15-30 Spider Orchid plants are directly impacted by construction and possibly another 20 Spider Orchid plants would be indirectly impacted by increased exposure to the extent that eventual mortality would be likely. A significant area of potential habitat for *Dendrobium melaleucaphilum,* including swamp sclerophyll and moist open forest is present on the road corridor.

As part of the management of this species, additional individuals would be propagated from locally collected seed and introduced to suitable habitat adjoining the road corridor, or to a suitable translocation receival site. This would allow life cycle processes such as pollination, seed dispersal and recruitment to be re-established.

How is the Project likely to affect the habitat of a threatened species, population or ecological community?

The habitat of *Dendrobium melaleucaphilum* comprises swamp sclerophyll forest and rainforest understorey in wet sclerophyll/moist open forest. The Project will impact directly on this habitat by clearing and indirectly by creating new forest edges, which would alter the microclimate of adjoining *Dendrobium melaleucophilum* habitat by allowing greater sunlight and wind penetration. Indirect impacts can be reduced to some extent by minimising vegetation clearing and landscape planting to restore protective buffer vegetation on the roadside after construction has finished. *Melaleuca stypheloides* would be widely used in landscaping to provide the favoured host plant for *Dendrobium melaleucaphilum.*

Does the Project affect any threatened species or populations that are at the limit of its known distribution?

The distribution of *Dendrobium melaleucaphilum* extends from the Hawksbury River to Southeast Qld. The WC2U highway upgrade is approximately in the centre of its distribution.

How is the Project likely to affect current disturbance regimes?

The Project will cause an increase in disturbances including vegetation clearing, Lantana invasion and change in micro-climate of adjoining vegetation. Increased vegetation clearing has the potential to result in an increase in fire frequency and intensity by changing the characteristics of fire fuels (e.g. increase in dry grass on the roadside). *Dendrobium melaleucaphilum* is likely to be adversely impacted by an increase in bushfires. Minimisation of clearing, weed control and roadside slashing maintenance (fuel reduction) can be all be used to reduce direct and indirect impacts on the habitat and surviving population of this species.

Perhaps the most severe disturbance affecting *Dendrobium melaleucaphilum* is illegal orchid collecting. The WC2U project has the potential to increase this activity by

enabling easier access to forest areas, however, fauna fencing should largely prevent access from the edge of the new highway.

How is the Project likely to affect habitat connectivity?

Potential habitat for *Dendrobium melaleucaphilum* includes swamp sclerophyll forest and the rainforest understorey in wet sclerophyll forest. Fragmentation of this habitat would result from construction of the WC2U upgrade, but the level of fragmentation would be relatively low considering that areas of continuous potential habitat would remain in Newry State Forest, Nambucca State Forest and other areas. These would allow population processes such as pollination, seed dispersal and seedling establishment to operate and thereby maintain and increase population numbers. The functionality of habitat connections is severely comprised by the extreme rarity of the species, due to orchid collecting, fire, past logging and habitat clearance.

How is the Project likely to affect critical habitat?

No critical habitat has been identified for this species.

B.1.7 *Tylophora woollsii* - Endangered Species: TSC Act

Tylophora woollsii is a small species of vine found in rainforest and wet sclerophyll forest from the Hawkesbury River north to the Qld border, and from the coast inland to the Great Escarpment Ranges. There is a concentration of records in an arc extending from the Coffs Harbour-Bellinger Valley area northwest to the Dorrigo district and the Gibraltar Range. Wildlife Atlas reports 60 records of the species in NSW.

How is the Project likely to affect the lifecycle of a threatened species and/or population?

Tylophora woollsii was recorded at three locations on the WC2U corridor:- between Raleigh and the Kalang River, Newry State Forest and Nambucca State Forest. Nine individuals would be directly impacted and six would remain in-situ within the Road Reserve. Generally, the species appears to be rare in the local area; all individuals were small plants unlikely to flower in the near future. Note – there is an element of uncertainty regarding the identification of this species as its leaves are very similar to *Marsdenia longiloba*. Flowers are required for postive identification but have not been observed.

Information on the life history of *Tylophora woollsii* recorded during translocation of this species for the Bonville project showed it has similar life history attributes to *Marsdenia longiloba*. One contrasting feature was that *Tylophora woollsii* did not appear to spread vegetatively like *Marsdenia longiloba,* although rhizomes were present. It appeared to regenerate by resprouting from these, but without multiplying into ramets.

Construction related factors with potential to adversely affect the life cycle of *Tylophora woollsii* at Warrell Creek include clearing encroachment, sediment run-off, micro-climate change, soil eutrophication and weed invasion. These factors can be

controlled using mitigation measures such minimising vegetation clearing and strict adherence to marked clearing boundaries, drainage plans incorporating sediment capture structures, artificial wetlands to absorb nutrients, weed management planning, and ecologically compatible landscaping.

How is the Project likely to affect the habitat of a threatened species, population or ecological community?

The habitat of *Tylophora woollsii* on the WC2U corridor comprises wet sclerophyll forest. The Project would remove habitat for this species in several areas and potentially lead to biophysical changes to areas of habitat. There is potential for the Project to alter habitat attributes of surrounding areas through indirect impacts which potentially include altering of hydrological and nutrient regimes within habitats downstream of the proposed development and edge effects. This could result in habitat changes, including increases in weed abundance, altered soil conditions and sedimentation. These changes may potentially lead to the area of occupancy of the population to be significantly reduced. However mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts. These would include: (i) measure to ensure that vegetation clearing is confined strictly to the construction footprint, (ii) measures to control sediment run-off (particularly sedimentation fencing) and (iii) ecologically designed landscaping.

Does the Project affect any threatened species or populations that are at the limit of its known distribution?

The distribution of *Tylophora woollsii* extends from the outskirts of Sydney north the Qld border and into southeast Queensland, from the coast west to the Great Escarpment Ranges (Wildlife Atlas). *Tylophora woollsii* is in the central part of its coastal distribution in the Nambucca-Urunga area.

How is the Project likely to affect current disturbance regimes?

Current disturbance regimes potentially affecting *Tylophora woollsii* include:- (i) weed invasion by *Lantana camara*, (ii) bushfire, (iii) logging and adjacent clearing, as follows:-

(i) The Project is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Project where there would be increased sunlight availability. Other indirect impacts such as increased water and nutrients may also aid the growth of *Lantana camara*. Weed control during construction and operation of the highway would greatly reduce this threat to *Tylophora woollsii* habitat.

(ii) Bushfires in *Tylophora woollsii* habitat can start from arson, accidental ignition, control burning and lightning strikes. The Project may result in an increase in fire frequency due to fires started by arson or accidental ignition. Increase in fire intensity may result from changes in fuel characteristics in roadside vegetation, resulting in increased flammability. However, the number of fires resulting from roadside ignition has decreased significantly in recent decades due to increased environmental awareness, harsh penalties for causing fires and maintenance of roadside vegetation

(iii) Vegetation clearing is likely to change microclimate conditions in forest to a depth of 10-20 metres from the edge of the road corridor (Benwell 2010). This may in turn lead to an increase in weeds and sclerophyllous plants, producing a general increase in forest understorey density, which appears to create unsuitable habitat conditions for *Tylophora woollsii*. Such changes in habitat structure are reduced if no soil disturbance occurs beyond the limits of clearing. This can be ensured by mitigation measures such as strict controls on clearing, No Go zones and use of sedimentation fencing.

How is the Project likely to affect habitat connectivity?

Tylophora woollsii generally occurs in gully areas running perpendicular to the Project. Therefore suitable areas of habitat would be fragmented from the Project, with some subpopulations being dissected. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however as already discussed, populations of *Tylophora woollsii* persist by vegetative regeneraration rather than pollination and seed production. Individuals would generally remain on either side of the road corridor following direct impact to individuals through clearing of the construction footprint. Substantial numbers of plants are likely to occur in surrounding habitat not affected by the highway construction.

How is the Project likely to affect critical habitat?

No critical habitat has been identified for this species.

Revision of RTA (2010) - Appendix C Assessment of significance (EPBC Act)

C.1 Endangered species

C.1.2 *Tylophora woollsii*

Is the action likely to lead to a long-term decrease in the size of an important population

Tylophora woollsii was recorded at three locations on the WC2U corridor:- between Raleigh and the Kalang River, Newry State Forest and Nambucca State Forest. Nine individuals would be directly impacted and six would remain in-situ within the Road Reserve. Generally, the species appears to be rare in the local area; all individuals were small plants unlikely to flower in the near future. Note – there is an element of uncertainty regarding the identification of this species as its leaves are very similar to *Marsdenia longiloba*. Flowers are required for postive identification but have not been observed.

A population is defined as an occurrence of a species in a particular geographical area. There are no guidelines as to the size of this area, but usually it would cover relatively uniform habitat (i.e. vegetation and geology) and have distinctive geographical boundaries. On this basis, two populations of *Tylophora woollsii* can be recognised from the results of flora survey work:-

- Urunga to the Kalang River;
- Kalang River to the Nambucca River.

Substantial areas of potential habitat exist between the road corridor and the coast, which are likely to support further individuals.

An 'important population' is defined by DEH (2009) as a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in Recovery Plans, and/or that are:

• key source populations either for breeding or dispersal;
• populations that are necessary for maintaining genetic diversity; and/or
• populations that are near the limit of the species range.

The populations recorded in the study area are regarded as being "important populations", as relatively few populations have been recorded close to the coast. Several of the coastal occurrences are protected in reserves.

Road construction would impact directly on nine individual plants. In an attempt to avoid a decrease in the size of populations, translocation would undertaken to salvage and re-establish directly impacted individuals at suitable receival sites.

Reduce the area of occupancy of an important population

The area of occupancy would be reduced in these two impacted populations, although the linear nature of the Project limits the direct impacts to these populations. There is potential for the Project to contribute to indirect impacts through altering hydrological and nutrient regimes in habitats downstream of the proposed development which could potentially result in habitat changes, leading to the area of occupancy of the

population to be significantly reduced. However mitigation measures during construction and the implementation of specific design features into the proposed development would potentially minimise these indirect impacts.

Fragment an existing important population into two or more populations

The project would intersect and cause some degree of fragmentation to two populations. Generally *Tylophora woollsii* has a sporadic distribution and occurs in low abundance. The species therefore has a naturally patchy or fragmented distribution, which is probably governed by soil type, topography and disturbance. A measure of connectivity would still remain between occurrences similar to that currently existing and probably enabling processes such as cross-pollination to occur.

Adversely affect habitat critical to the survival of the species

Habitat critical to the survival of a species refers to areas that are necessary:

- For activities such as foraging, breeding, roosting, or dispersal.
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators.
- To maintain genetic diversity and long-term evolutionary development.
- For the reintroduction of populations or recovery of the species.

Habitat supporting populations is directly impacted by the project, but loss of this habitat is not considered critical to the survival of the species, as the area of habitat is not great relative to the extent of potential habitat available and there does not appear to be anything particularly special or different about the habitat to be removed. Direct impacts would be limited to the proposed development area comprising a relatively small area of the available habitat for this species in the local area. There is potential for the Project to contribute to indirect impacts through altering hydrological and nutrient regimes. Mitigation measures would limit the degree of indirect impacts to the surrounding areas of *Tylophora woollsii* habitat.

Disrupt the breeding cycle of an important population

Breeding cycle processes such as pollination and seed production have not been studied in this species. The road corridor by reducing the area of occupancy and the extent of potential habitat may reduce the potential for cross-pollination between sub-populations. The vigour of *Tylophora woollsii* may be indirectly impacted by changes in hydrology and soil nutrient status, thereby affecting the breeding cycle of individuals. Mitigation measures including sediment and erosion control and weed control would limit the degree of indirect impacts on this species.

Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The Project would decrease the area of habitat available for *Tylophora woollsii*, including moderately disturbed or degraded areas impacted by logging and weed invasion. Indirect impacts from the Project would potentially contribute to these existing threatening processes through altering hydrology and nutrient regimes; however these impacts can be limited through the implementation of mitigation measures. Although *Tylophora woollsii* seems to be resilient to some habitat

disturbance, further disturbances may lead to declines in the population. Considering the linear nature of the proposed development which runs perpendicular to most of the gully habitats where *Tylophora woollsii* occurs, habitat removal would be limited to the direct impact area and relatively extensive areas of habitat would remain surrounding the Project.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat

The Project could potentially result in the spread and aid the growth of invasive species currently present such as *Lantana camara*. Changes to hydrological and nutrient regimes in these areas as a result of the Project may further encourage weed growth.

Mitigation measures would be implemented to minimise impacts from nutrient loads, sedimentation and altered hydrology regimes. Weed management should be implemented during the construction phase of the Project to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.

Introduce disease that may cause the species to decline

Diseases potentially affecting native vegetation in the study area include Root Rot Fungus (*Phytophora cinnamomi*) and Myrtle Rust. *Phytophora* is not a threat to plant communities on the NSW North Coast where this pathogen appears to be indigenous and the flora adapted to it. Myrtle Rust would not affect *Marsdenia longiloba* as it only affects plants in the plant family Myrtaceae (not the Apocynaceae). To minimise the chance of introducing new plant pathogens, machinery would be washed down before moving from area to area and personnel excluded from walking through habitat areas unless necessary.

Interferes substantially with the recovery of the species

The Project would not conflict with the recovery actions proposed for *Tylophora woollsii*. Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protecting fencing, ongoing monitoring of populations and weed control within habitat areas.

Conclusion

Based on the above assessment, *Tylophora woollsii* is unlikely to be significantly impacted by the WC2U project. As such a referral under the provisions of the EPBC Act is not recommended for this species.

C.3 Vulnerable species

C.3.1 *Marsdenia longiloba*
Marsdenia longiloba (Slender Marsdenia) is a small species of vine found in rainforest and wet sclerophyll forest at scattered locations from Barrington Tops north to southeast Queensland (NPWS 2002b). This species has mostly been recorded as

occurring in low abundance in small population clusters. The populations recorded in the study area consist of scattered individuals occurring in the understorey with various ferns, herbs and other twiners in moist eucalypt forest with an open to dense rainforest subcanopy.

Translocation and monitoring of *Marsdenia longiloba* for the Bonville Upgrade in the Coffs Harbour LGA provided insight into various aspects of the life history of this species. Life history attributes reported by Benwell and Watson (2011) included:

- *Marsdenia longiloba* is a perennial, rhizomatous vine.
- Sub-populations are composed almost entirely of ramets or single stemmed plants produced from an underground rhizome; several plants or ramets may be attached to the same rhizome system.
- Above ground stems are comparatively short-lived (1-3 years), while the rhizomes are probably more long-lived.
- The rhizomes are relatively thin, 10-30cm long and grow horizontally within the soil A1 horizon (occasional vertical rhizomes may also be present); the rhizomes branch off each other, often at right angles, and may separate to form discrete plants.
- Stems may die back to the rhizome and the plant remain stem-less and apparently dormant for up to two years (probably longer), then produce new stem shoots.
- Most stems never grow more than 30cm tall before dying back.
- Only large stems (ie >1m tall) produce flowers; production of pods and seed is extremely rare; only 1 pod has ever been recorded during several years of monitoring at several locations.
- *Marsdenia longiloba* appears to rely on vegetative reproduction for population persistence; flowering and seed dispersal play a minor role in this process.
- Discrete sub-populations and patches of *Marsdenia longiloba* probably originate vegetatively from the same parent plant and spread over a considerable area (e.g. 0.04 ha)
- *Marsdenia longiloba* stems are conspicuously absent from recently (<1-6 yrs) logged and contolled burned forest. Monitoring of translocated plants showed that dormant, stem-less rhizomes may persist in recently disturbed forest. This suggests that conditions during early post-disturbance succession may not be favourable for growth of *Marsdenia longiloba,* and stem growth and flowering may occur mainly during mid to late stages of succession.

The last hypothesis requires further study. In particular, the response of *Marsdenia longiloba* to fire has never been systematically monitored.

Is the action likely to lead to a long-term decrease in the size of an important population

A population is defined as an occurrence of a species in a particular geographical area. There are no guidelines as to the size of a population or the area the population is contained in, but usually it would cover a relatively uniform area of habitat or terrain (i.e. vegetation and geology) and have distinctive geographical boundaries. On this basis, four populations of *Marsdenia longiloba* can be recognised from the results of the targeted survey of the WC2U corridor conducted in 2011:

- between Urunga and the Kalang River;
- Newry SF, Little Newry SF and adjoining private property;
- Nambucca SF and adjoining private property; and
- Warrell Creek South (which likely extends to the Mt Yarrahappini area).

The road corridor intersects a considerable number of sub-populations within each of these populations. However, substantial areas of potential habitat extend beyond the road corridor, which are likely to support additional individuals. The EA showed that sub-populations extended for at least 250 metres from the highway centreline. Generally this species has been recorded as occurring in low abundance in small population clusters throughout its range.

An 'important population' is defined by DEH (2009) as a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in Recovery Plans, and/or that are:

• key source populations either for breeding or dispersal;
• populations that are necessary for maintaining genetic diversity; and/or
• populations that are near the limit of the species range.

The populations recorded in the study area are regarded as being "important populations" as they are relatively large populations. The populations are likely to extend further upstream and downstream of the road corridor where it intersects drainage lines in hill and gully topography, and therefore consist of larger populations than recorded.

Individuals in close vicinity to the road corridor may be indirectly impacted through changes in micro-climatic, potential increases in weed invasion and sedimentation, and potential changes in hydrology. This may adversely affect individuals within 10-20 metres of the roadside. These indirect (edge) impacts can be minimised by confining vegetation clearing strictly to the construction footprint, sediment and erosion control measures and ecologically designed landscaping. Translocation of directly impacted *Marsdenia longiloba* to adjacent habitat will be undertaken to maintain population size and genetic diversity. This would also be undertaken in conjuction with research on aspects of the species ecology and population dynamics.

Reduce the area of occupancy of an important population

In the four impacted populations, individuals would be retained on one or both sides of the road, with direct impacts limited to the road footprint. The area of occupancy would be reduced in these four impacted populations, although the linear nature of the Project limits the direct impacts to these populations. There is potential for the Project to contribute to indirect impacts through altering hydrological and nutrient regimes in habitats downstream of the proposed development which could potentially result in

habitat changes, leading to the area of occupancy of the population to be significantly reduced. However mitigation measures during construction and the implementation of specific design features into the proposed development would potentially minimise these indirect impacts.

Fragment an existing important population into two or more populations

The project would intersect four populations causing breaks in habitat up to 80-150 metres wide. Generally this species has been recorded as occurring in low abundance in small population clusters, therefore it tends to have a naturally patchy or fragmented distribution. This patchiness is governed by topography and disturbance (logging, clearing and fire). A measure of connectivity would still remain between plants on either side of the road corridor, enabling processes such as cross-pollination to occur, although as discussed, *Marsdenia longiloba* appears to rely on vegetative reproduction for population persistence at a given locality. Also, substantial areas of potential habitat would remain on either side of the road corridor allowing large-scale population processes to continue such as changes in population dynamics at different stages of secondary succession.

Adversely affect habitat critical to the survival of the species

Habitat critical to the survival of a species refers to areas that are necessary:

- For activities such as foraging, breeding, roosting, or dispersal.
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators.
- To maintain genetic diversity and long-term evolutionary development.
- For the reintroduction of populations or recovery of the species.

Habitat supporting important populations is directly impacted by the project, but loss of this habitat is not considered critical to the survival of the species, as the area of habitat is not great relative to the extent of habitat available and there does not appear to be anything particularly special or different about the habitat to be removed compared with the area remaining.

The habitats where *Marsdenia longiloba* was recorded included moderately disturbed and degraded areas impacted by weed invasion, logging activities, fire and cattle grazing. There were better quality pockets of native vegetation cover where the majority of *Marsdenia longiloba* individuals were recorded. Direct impacts would be limited to the proposed development area comprising a relatively small area of the available habitat for this species in the local area. There is potential for the Project to contribute to indirect impacts through altering hydrological and nutrient regimes in habitats downstream of the proposed development, which could potentially result in habitat changes, leading to further weed invasion in areas of habitat downstream. Although mitigation measures would potentially limit the degree of indirect impacts to the surrounding areas of habitat for *Marsdenia longiloba*, the Project is likely to contribute to existing threatening processes in close vicinity to the road corridor (i.e. <20-50m). *Marsdenia longiloba* is reserved in several National Parks in northern NSW and southeast Queensland. Better quality examples of habitat are likely to be present within these conservation reserves where threatening processes are limited.

Disrupt the breeding cycle of an important population

Marsdenia longiloba appears to rely on vegetative regeneration and reproduction for persistence at a location. Growth appears to be suppressed during the early stage of post-disturbance secondary succession, for example after fire or logging. Flowering is uncommon and seed production is extremely rare at any time. Clearing would tend to induce secondary succession close to the cleared road corridor and therefore suppress it growth and reproduction. This effect can be reduced to a narrow band only a few metres wide if clearing is confined strictly to marked clearing boundary and soil disturbance beyond the boundary does not occur. Sedimentation fencing is very effective in this regard, by preventing soil spillage. The project is unlikely to disrupt the breeding cycle of *Marsdenia longiloba* as vegetative reproduction can continue and in the event of any flowering there would be opportunities for cross-pollination amongst individuals remaining on one or both sides of the road corridor.

Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The Project would decrease the area of habitat available for *Marsdenia longiloba*, including moderately disturbed and degraded areas impacted by weed invasion, logging activities and fire. Indirect impacts from the Project would potentially contribute to these existing threatening processes through altering hydrology and nutrient regimes. These impacts can be limited through the implementation of suitable mitigation measures. Although *Marsdenia longiloba* seems to be resilient to some habitat disturbance, further disturbances may lead to declines in the population. Considering the linear nature of the proposed development, which runs perpendicular to most of the gully habitats where *Marsdenia longiloba* occurs, habitat removal would be limited to the direct impact area and relatively extensive areas of habitat would remain surrounding the Project.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat

The Project could potentially result in the spread and aid the growth of invasive species currently present in the population of *Marsdenia longiloba* such as *Lantana camara*. Changes to hydrological and nutrient regimes in these areas as a result of the Project may further encourage weed growth.

Mitigation measures would be implemented to minimise impacts from nutrient loads, sedimentation and altered hydrology regimes. Weed management should be implemented during the construction phase of the Project to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.

Introduce disease that may cause the species to decline

Diseases potentially affecting native vegetation in the study area include Root Rot Fungus (*Phytophora cinnamomi*) and Myrtle Rust. *Phytophora* is not a threat to plant communities on the NSW North Coast as cases of Phytophora dieback are rarely reported from this region. *Phytophora cinnamomi* has been isolated from rainforest in eastern Australian soils where appears to be indigenous and the local flora adapted to its presence in the soil.

Myrtle Rust would not affect *Marsdenia longiloba* (family Apocynaceae) as it only affects plants in the plant family Myrtaceae. To minimise the chance of introducing new plant pathogens, machinery would be washed down before moving from area to area and personnel excluded from walking through habitat areas unless necessary.

Interferes substantially with the recovery of the species

The Project would not conflict with the recovery actions proposed for *Marsdenia longiloba*. Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protecting fencing, ongoing monitoring of populations and weed control within habitat areas.

Conclusion

Given the linear footprint of the WC2U project and the widespread distribution of *Marsdenia longiloba* in the Nambucca district and the Mid North Coast, it is considered unlikely this species would be significantly impacted by the project. As such a referral under the provisions of the EPBC Act is not recommended for this species.

APPENDIX 9: DETAILS OF CONSULTATION- RESPONSE TO EPA COMMENTS

ENVIRONMENT PROTECTION AUTHORITY - COMMENT SHEET

RMS response dated 12/12/2012 to EPA comments dated 20/7/2012

Project:	Pacific Highway Upgrade Warrell Creek to Urunga		
Document title:	Threatened Plant Species Management Plan		
Revision No.:	22 April 2012		
Reviewer name:	Craig Harré	Review date:	20/07/12

Report Reference	EPA Comments	Response
3.5.5 Maundia	Clarify if the in-situ population is included in the monitoring proposal.	The in-situ population is included in the monitoring proposal - see Section 3.5.5 (p.84), specifically, "(iii) Inclusion of *Maundia triglochinodes* into the Ecological Monitoring Program required for the WC2U project to determine the impact on adjoining *Maundia triglochinoides* during construction and operation, which is to include a component investigating and clarifying the life history attributes and population dynamics of the species" (p. 46)
3.5.6 Floyds Grass	Advise how the translocated Floyds Grass is performing now. Is long term management needed?	The translocated Floyds Grass at Bonville is still performing well. It covers about 80% of the low lying area within the fenced enclosure up to the creek bank. There has been increase of the native fern species Hypolepis muelleri (Harsh Ground Fern) which can smother Floyds Grass, but it is only likely to displace part of the translocated population. Monitoring of the population is due again in October 2012.
3.5.9 Other species	Refer to Herons Creek apparently successful translocation efforts or any lessons with *Artanema fimbriatum.*	Rachael Bannister of BMD was contacted regarding the outcome of the Artanema fimbriatum translocation at Herons

Report Reference	EPA Comments	Response
		Creek. She said there had been no systematic monitoring or reporting on the translocation, but that translocated plants had reshot after dying back in winter. The translocation was carried out using the direct transplanting method – ie transplanting directly into the receival site.
3.6.2 Assessing Translocation Outcomes	The document recognises the inconsistency between biodiversity offsetting requirements which are to be informed in some future time by translocation feasibility and success. EPA agrees with the rationale presented in this discussion and notes that translocation is a mitigation measure, not an offset. Therefore by following the suggested approach by establishing viable translocated populations, plus acquiring offset land containing targeted threatened species at a ratio of 4:1 there should be a net gain for the species.	Yes I would agree with this assessment – ie. the conservation status of the species would be improved.
3.6.4 Process for….8) 4th dot point	The timing is unlikely to be favourable to facilitate this process.	4) Determine the area of habitat of the threatened species impacted. Habitat of the threatened species could be determined from vegetation and terrain mapping – e.g Slender Marsdenia occurs in moist to wet sclerophyll forest on mid to lower hill slopes. This could be done manually then digitised to calculate the area.
4.2.3 Designing Translocated Populations	What is the size of the original population that these threatened species will be removed from? Also, will this remnant population maintain an effective MVP?	The boundary of the original population area would have to be defined, for example: "Plants found within a radius of 2 to 5km on the same habitat (ie geology and vegetation type)" has been used as a definition of a local population in previous translocation plans for the purposes of local impact assessment and for provenance seed collection. In the case of MVP's the population unit may be smaller depending on how it is defined, such as the area in which cross-pollination between individuals, or seed dispersal can occur, probably <1km. MVP's differ according to plant growth form and breeding system – ie trees have different MVPs to herbs. It's a complicated subject, as discussed in Sec. 4.2.3. Pavlick

Report Reference	EPA Comments	Response
		1996 provides some general guidelines.
4.3.3 Selection of the Receival Site	State Forest – this seems to offer the greatest number of benefits in terms of protection as long as the site is in FMZ 3 or better. However, the feasibility and likelihood of this occurring should be explored now by RMS to gain an understanding on whether this is likely to be permitted in SF. Road Reserve – not preferred given the problems cited in the document unless there are plans for larger areas of road reserve in the appropriate locatin to facilitate this action. RMS purchased properties	Preliminary discussions will be conducted with Forests NSW to determine the feasibility of using receival sites in management zones FMZ3 or similar, specifically the visual amenity strip adjoining the new highway corridor. Agreed that the Road Reserve is generally not suitable as a receival site.

ENVIRONMENT PROTECTION AUTHORITY - COMMENT SHEET

RMS response dated 25/2/2013 to second round of EPA comments dated 17/12/2012

Project:	Pacific Highway Upgrade Warrell Creek to Urunga		
Document title:	Threatened Plant Species Management Plan		
Revision No.:	12/12/2012		
Reviewer name:	Craig Harré	**Review date:**	17/12/2012

EPA Comments	Response
1. The EPA does not support attempts to	Translocation is defined by ANPC (2004) as 'The deliberate transfer of plants or

translocate *Maundi triglochinoides*. Please refer to EPA comments for the Frederickton to Eungai section of the Pacific Highway Upgrade regarding translocation feasibility and the RMS justification for not attempting translocation. In summary the EPA believes *Maundia* presents as a 'boom and bust' species that is highly responsive to favourable rainfall conditions. Rather than undertaking a risky and uncertain translocation exercise under conditions and within habitat that may not be favourable for *Maundia* proliferation, the EPA suggests the following points for consideration as an alternative: identify or facilitate creation of suitable habitat adjacent to the upgrade, ensure there is hydrological connectivity to remnant or other known *Maundia* populations, salvage directly impacted *Maundia* seed (purportedly viable for long periods) and sow within the adjacent habitat under ideal conditions. Also focus on protecting in situ individuals and encouraging '*Maundia* friendly' design features in drainage areas and under bridges.	regenerative plant material from one place to another, including existing or new sites or sites where the taxon previously occurred." Translocation can be implemented using a range of different methods including transplanting and seeding into habitat. The seed introduction method would be just as risky and uncertain as transplanting, as it has never been tried for this species and there are other difficulties such as identifying suitable long-term habitat or creating such habitat. Maundia produces a hard seed, which is relatively large for a wetland herb (2-3mm long), and the seed is reported by the Royal Botanical Gardens to be difficult to germinate. Maundia appears to have undergone large population expansion in the F2E area on the Collombatti floodplain, which is probably because swamp habitat on this floodplain is subject to large fluctuations in extent (it has a network of drains so isn't as stable as it originally was). However, Maundia is also found in relatively deep and permanent water bodies including lagoons, sluggish drainage lines and farm dams where it does not exhibit boom and bust. On WC2U, the population on Williamson's Creek grows in a permanent drainage line in deep water (>0.5m); plants have been observed there for two seasons. Rather than boom and bust, it is more true to say that Maundia has a capacity for rapid population increase under favourable habitat conditions. This is due to its rhizomatous growth habit as well as seed dispersal – see photos 21&22 in Benwell report for F2E. The latter report attributed the apparent increase in Maundia at F2E to several years of above average rainfall and consequent increase in swamp habitat (Benwell 2012 sec.3.3 ver. 1). Given the poor results from previous translocation attempts for this species it is recommended that only those plants within the footprint be removed and that the threats for the remaining individuals be managed. (Pasons Brinkerhoff 2007, Technical Report 2, Appendix A, p. A-9). Management would focus on Maundia remaining in the road reserve and on directly adjoining land.

	During detailed design, emphasis would be placed on minimising impacts to threatened species such as Maundia and Floyds Grass to protect in situ individuals. Management measures on WC2U would be similar to those adopted for Maundia on F2E, as follows: (a) investigate engineering solutions, undertake design optimisation and adopt design and construction solutions which: (i) minimise the footprint of the Project Works and Temporary Works adjacent to areas of Maundia triglochinoides; (ii) precisely locate proposed construction and operational water quality treatment facilities to avoid direct and indirect impacts on Maundia triglochinoides; and (iii) ensure that, during construction and operation of the Project Works, the drainage paths and the quantity and quality of water, both surface and subsurface, are maintained to Maundia triglochinoides populations; (b) identify all Maundia triglochinoides populations on environmentally sensitive area mapping and in the Design Documentation as exclusion zones; (c) locate ancillary facilities for the Contractor's Work to avoid direct and indirect impacts on Maundia triglochinoides; (d) address any of the Contractor's Work that is undertaken within 100 m of Maundia triglochinoides in a site specific environmental work method statement; (e) Erect and maintain sediment fencing around all areas of Maundia triglochinoides that are affected by the Contractor's Work; and (f) include in the urban and landscape design specific landscaping / revegetation measures to buffer the areas adjacent to Maundia triglochinoides populations with appropriate vegetation. Also, in line with the F2E report ver.1 section 3.3, point (iii): The Ecological Monitoring Program for WC2U would include monitoring of in-situ Maundia within and adjoining the project boundary to assess the effectiveness of management measures (a) to (f) listed above. This will entail a series of 'control' and 'potential impact' (ie adjoining construction) reference plots to be monitored for a minimum of five years.

2. The EPA draws attention to the Floyds Grass population on this project. Given the presence of Floyds Grass, has the project considered the possible impact on the Black grass-dart? Has this endangered species been recorded on this local population of Floyds Grass? If this species is recorded on Floyds Grass, the case for translocation would be strengthened.	2a. The design of the Warrell Creek bridge crossing currently does not directly impact on Floyds Grass and the Threatened Flora MP (sec. 4.4.5) does not propose to translocate the species, rather manage it in-situ unless this proves to be impractical in light of the detailed design. 2b. If it became necessary to translocate Floyds Grass, a targeted survey for the Black grass dart would be conducted by an appropriately qualified and experienced expert who would also advise on how best to manage the Black grass dart in this context. 2c. Floyd's Grass habitat was examined for presence of the Black grass-dart during survey work for the WC2U MP, but none were observed. The Warrell Creek site was surveyed in November-December 2011. The Black grass-dart was observed at Bonville between Feb and April on sunny days (Ecos Environmental 2009), so the survey at Warrell Creek may have been too early to detect the species. Any survey would be conducted at a time and during weather when the butterfly is known to be active – ie sunny days in Feb-March.
3. The EPA notes the high number of proposed *Marsdenia* individuals proposed for translocation. Given the low to moderate translocation success rate for this species is it prudent to translocate 151 individuals? Rather than attempting to translocate all impacted individuals why not take a representative sample of each sub-population?	3a. Yes, the translocation success rate for this species in the past was low. Previously on the Bonville project the species was transplanted to pots then stabilised and grown-on under nursery conditions before planting-out in the wild. The plants thrived under pot cultivation and after introduction for the first year, but then tended to go into decline (not all individuals). A likely reason for this decline is considered to be root competition from surrounding species which grew into the root space of Slender Marsdenia because of the soil amelioration/enrichment applied at planting-out, including slow release fertiliser. The latter attempt to stimulate growth in Slender Marsdenia appeared to have the opposite effect by promoting root competition from other species. The translocation proposal for WC2U is designed to test this hypothesis by directly transplanting the species (rather than growing it pots first) and not adding fertiliser. A subset (~25%) would receive fertiliser to provide a comparison which could be tested statistically. 3b. Most Slender Marsdenia individuals are small plants and can be transplanted with a spade and mattock, so a substantial number can be moved in a relatively short time

	compared to trees that require machinery. 3c. A good sized sample would provide a better test of different translocation methods/introduction conditions. 3d. The WC2U upgrade will be built in two stages. According to the MP a total of 105 Slender Marsdenia were directly impacted on the northern half and ~60 on the southern half. RMS proposes to under-take translocation of Slender Marsdenia on the northern section (NH2U) as described in the Threatened Flora Management Plan. Translocation of Slender Marsdenia on the southern half (probably to commence 2-3 years after NH2U) would not be carried out unless testing of the revised translocation method resulted in a marked improvement in survival rate and establishment. Note - the numbers of Slender Marsdenia requiring translocation is likely to be subject to slight variation between 2011(the targeted survey for the MP) and when the translocation is carried out, as some 'shoot-individuals' will die back and other new ones appear. (A pre-clearing/pre-translocation survey conducted by the contractor will update this data.)

APPENDIX 10: SPECIFIC BACKGROUND INFORMATION AND MANAGEMENT MEASURES FOR SLENDER MARSDENIA (*MARSDENIA LONGILOBA*) FOR THE WARRELL CK TO NAMBUCCA HEADS PROJECT (STAGE 2 OF THE WC2U PROJECT)

(Note – the information below is taken from the main body of the WC2U TFM Plan above. Additional generic measures to be applied to management of threatened flora, including *Marsdenia longiloba,* are set out in the complete WC2U TFM Plan)

3.4 SURVEY RESULTS

3.4.1 Summary

Five threatened species, one ROTAP species and one species recommended for threatened species listing were recorded during the targeted survey:-

Threatened
Slender Marsdenia (*Marsdenia longiloba*), a small vine.
Rusty Plum (*Niemeyera whitei*), a medium sized rainforest tree.
Maundia (*Maundia triglochinoides*), an aquatic, emergent herb.
Floyds Grass (*Alexfloydia repens*), a mat forming grass.
Wooll's Tylophora (*Tylophora woollsii*), a small vine.

ROTAP
Ford's Goodenia (*Goodenia fordiana*), a mat forming herb.

Potential Threatened Species Listing
Koala Bells (*Artanema fimbriatum*), a perennial herb of coastal forests.

Results of spatial impact analysis for WC2NH are summarised in Table 3B. These show the number of individuals of species directly impacted, indirectly impacted and to remain in situ for the WC2NH Project. Threatened and rare flora records were classed as either:
(i) directly impacted:-

- Under the concept design footprint plus **15 metres**.
- Under the operational water quality basins plus 10 metres.
- Under new or reconstructed access roads within Nambucca State Forest plus 10 metres.
- For utility adjustments within clearing requirements of utility authorities.
- Within three metre clearing width for boundary fencing - excluding within Nambucca State Forest and swamp forest where a flying fox camp is located.

(ii) indirectly impacted (within 10m of the direct impact zone) or
(iii) in-situ within the road reserve (outside the indirect impact zone but within the project boundary).

Detailed maps of threatened and rare species locations on WC2NH showing the type of impact (direct, indirect and in-situ) can be found in Appendix 1, Sheets 8 to 13.

Table 3B - Threatened and rare flora impacted by the WC2NH project

Southern WC2NH section	**Directly Impacted**		**Indirectly Impacted**		**Road Reserve - in-situ**	
Threatened Species	points	no.	points	no.	Points	no.
Slender Marsdenia (E) (*Marsdenia longiloba*)	43	75	2	4	1	1
Rusty Plum (V) (*Niemeyera whitei*)	10	10 +sdg	0	0	0	0
Maundia (V) (*Maundia triglochinoides*)	~500+ m^2		~50 m^2		~50 m^2	
Floyds Grass (E) (*Alexfloydia repens*)	1	~2m^2	2	~2m^2	1	~2m^2
Wooll's Tylophora (E) (*Tylophora woollsii*)	2	2	0	0	0	0
Spider Orchid (E) (*Dendrobium melaleucaphilum*)	3	10	0	0	0	0
ROTAP						
Ford's Goodenia (*Goodenia fordiana*)	2	2m^2	1	1m^2	0	0
Potential Threatened Species Listing						
Koala Bells (*Artanema fimbriatum*)	2	13	0	0	0	0

3.4.2 Slender Marsdenia (*Marsdenia longiloba*)

Locations

Slender Marsdenia was recorded in small sub-populations scattered along the length of the WC2NU road corridor. Eighty individuals ('stem-individuals) were recorded and 15 different sub-populations identified between Warrell Creek and Nambucca Heads. (Sub-populations' were defined as geographically separate records at least 100m apart). The great majority of recorded points were within the zone of direct and indirect impact, as survey work was concentrated on the construction footprint and indirect impact zone.

Directly impacted

- A total of 43 gps points representing 75 individuals ('stem-individuals) are directly impacted. These represent 11 different sub-populations (4 identified sub-populations were outside but close to the project boundary).

Indirectly impacted

- A total of 2 gps points representing 4 individuals are indirectly impacted.

In-situ within road reserve

- One point representing 1 individual would remain in-situ within the road reserve. Additional individuals may be present in the outer part of the road reserve, as survey work was focused on the footprint.

Slender Marsdenia is a small vine growing to a maximum height of about 5m. Most plants recorded during the survey were much smaller than this, generally less than 0.5m tall and with few leaves (Table 4). Two plants with flowers were recorded and one plant with seed pods was recorded. Seed pods of this species are extremely rare (Harden 1992), so reproduction appears to occur vegetatively by root spread and suckering and only very rarely by seedling recruitment, although this requires further studies to confirm.

Plate 1: Small individual Slender Marsdenia plant with smooth, hairless, opposite leaves.

Plate 2: Typical Slender Marsdenia habitat in wet sclerophyll forest with understorey of small rainforest trees, shrubs and ground ferns, and open litter or fern covered ground layer, the roughed barked tree is Turpentine.

Plate 3: Only one plant of Slender Marsdenia was found with flowers. ML-42

Table 4: Size class distribution of Slender Marsdenia points

Size Class - Height (largest stem-individual if more than one present)	**Number of Individuals (Percent)**
<0.5 m	70%
0.5 - 1 m	14%
1 - 1.5 m	12%
1.5 - 2 m	4%

Habitat

Found in moist open forest and gradational subtropical and warm temperate rainforest, mostly below 200m altitude (Quinn *et al.* 1995). Characteristics of Slender Marsdenia habitat recorded on the WC2U road corridor included: -

- soil type a yellow to red clay podzol formed on Permian metasediments;
- soil A-horizon 15-30cm deep, dark brown, humus enriched topsoil;
- wet sclerophyll forest with an open to mid dense rainforest understorey usually on a lower slope;
- sloping (gentle to moderate) and well drained, often with a southern aspect;
- understorey moderately well lit and open, not dense or heavily shaded;
- topsoil only slightly acidic (pH >6).

The total area of modelled potential habitat of Slender Marsdenia on the southern half of the WC2U project (WC2NH) has been estimated as 17.8 Ha (Jacobs SKM 2014).

5

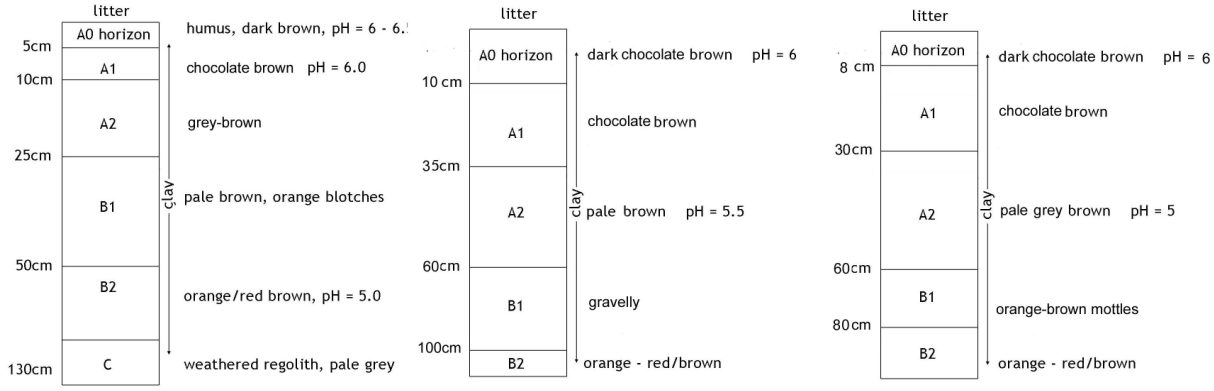

Figure a: Soil Profile at Mardenia longiloba site in Nambucca State Forest

Figure b: Soil Profile at *Niemeyera whitei* site at Cockburns Lane, Warrell Creek

Fiigure c: Soil Profile at *Acronychia littoralis* site at Deep Creek near Valla Beach

Figure 2: Representative soil profiles at threatened species sites on the WC2U/ WC2NH corridor.

3.5 DISCUSSION - Translocation Feasibility

3.5.1 Introduction

This section discusses the feasibility of undertaking salvage translocation of each of the threatened species directly impacted by the WC2NH project, as required by Condition of Approval B7. (Translocation of some additional individuals, indirectly impacted under the current road design, may become necessary if the detailed road design changes after awarding the contract.) The feasibility of undertaking salvage translocation is assessed in terms of several factors including: -

- technical feasibility;
- potential for generation of new and useful scientific information; and
- availability of receival sites with suitable habitat and security of tenure.

These factors were drawn from the translocation principles set out in DECC (2007) "Translocation Policy and Guidelines" (Draft), specifically Policy Principles 1 to 4 ('General') and 22 ('Translocation in context of development consent and approval'). The overall thrust of these principles is that the potential conservation, scientific and educational benefits of translocation should outweigh the potential risks and costs.

3.5.2 Slender Marsdenia (*Marsdenia longiloba*)

Technical feasibility

Slender Marsdenia has been translocated on two previous highway upgrade projects: Bonville Deviation (Benwell and Watson 2011) and Sapphire to Woolgoolga (Benwell 2011). Results for the latter two projects demonstrated that this species has the potential to be translocated successfully.

Bonville Upgrade
Approximately 100 Slender Marsdenia were translocated from the road corridor of the Bonville Upgrade south of Coffs Harbour to two receival sites in 2006-7. Excavation of plants revealed that stems grew from a horizontal rhizome network at a depth of 5-10cm. Stems connected to a piece of rhizome ('stem-individuals') and stemless rhizome pieces were transplanted to pots in October 2006 and grown-on before planting out in the field. Ninety percent of plants and rhizomes survived transplanting to pots and grew rapidly in response to watering and fertiliser.

The potted plants were introduced to two translocation receival sites. The first site (TA1) was planted with 27 vines in February 2007 and the second site with 64 vines in February 2008.

In TA1, the vines grew well for the first six months, but had declined noticeably in vigour after 12 months. After 2 years the survival rate of stem individuals in TA1 was 33%.

In TA2, the 64 vines were planted ou to compare the species' performance on two soil types present at this site – grey clay loam with quartz gravel in the northern half of the site and brown clay loam in the southern half. A similar pattern of stem dieback and decline as recorded in TA1 was recorded in TA2, on both soil types. Plants showing

stem dieback were excavated in winter 2009 and the rhizome system was found to be alive and healthy, but apparently in a dormant or suppressed state, at nearly all planting points. As the rhizome was still alive, the actual survival rate of transplants appeared was substantially higher (~ 80%) than that based on live stems (~25%). Live rhizomes were also found in a sample of plants that had died back in TA2. The decline was even more rapid, the survival rate falling to 22% after one year. After 4 years (2011) the survival rate of stem individuals was 26%, (minor re-shooting in TA2) about the same as TA1.

Monitoring of naturally growing local Slender Marsdenia populations in the road reserve showed no evidence of a seasonal growth pattern, rather new shoot growth could be found at any time of year, even in spring when the soil was relatively dry. There was no obvious relationship between shoot dieback and planting depth, or site variables such as aspect or soil type. However, stem dieback did appear to be induced by the planting treatment. Slow release fertilizer and hay mulch were used at both TA1 and TA2 to stimulate the growth of Slender Marsdenia. After the poor performance of Slender Marsdenia at TAI (planted a year earlier), larger planting holes were dug at TA2 and filled with humus enriched topsoil gathered from the adjacent forest. Slow release fertiliser was again added to the soil, as at TA1. This additional site preparation appeared to result in faster rate of decline after planting out.

The following hypothesis was proposed to explain the decline of Slender Marsdenia recorded in the Bonville translocation project. Slender Marsdenia is a small vine able to compete and co-exist with shrubs and trees by utilizing nutrients released in the topsoil by decomposition of organic matter. It can apparently do this efficiently when nutrients are produced steadily at very low concentration, as in humus enriched topsoil. When artificial fertiliser is added to the soil, it stimulates the roots of shrubs and trees to grown into the root zone of Slender Marsdenia causing increased interspecific root competition with Slender Marsdenia. This suppresses Slender Marsdenia growth and prevents stem growth and replenishment of rhizome food storage, causing the plant to eventually die. In summary, it is hypothesized that Slender Marsdenia is unable to absorb sufficient nutrient under conditions of high interspecific root density or competition.

To test this hypothesis, Slender Marsdenia translocated on WC2U will be directly transplanted to receival sites and planted with and without slow release fertiliser; no other soil improvement will be carried out. If the hypothesis is correct, then Slender Marsdenia plants translocated without addition of slow release fertiliser should show a higher survival rate.

Sapphire to Woolgooga Upgrade
A small number of Slender Marsdenia was transplanted on the Sapphire to Woolgoolga Upgrade. As on the Bonville project, the plants were transplanted first to pots and grown-on before planting out. Eight stem-individuals were introduced to the receipient site in March 2011. Five of these were transplanted stem-individuals and three were grown from rhizome pieces. The plants were introduced without fertiliser or any other nutrient enrichment except for a small amount of cane mulch. All were surviving in October 2011, but by October 2012 most had died back. Although the number of replicates was small, the results show a similar translocation response to

the Bonville project (Ecos Environmental 2012). This could be related to the use of cane mulch, which if fairly rich in nutrient, or the cultivation in pots prior to planting out may be the operative factor leading to dieback.

Translocation Benefits

The following conservation, scientific and educational benefits would flow from the salvage translocation of this species on the WC2NH project: -

- Preservation of a high conservation value species (Endangered). Relatively few populations are known to exist.

- Translocation of this species is technically feasible as successful transplanting, propagation and introduction have been carried out before (Benwell and Watson 2011), although further research and trials are required to improve translocation results.

- Translocation could build on insights into the species' ecology gained from the Bonville Translocation Project (Benwell and Watson 2006)

- Suitable translocation receival sites are available in the road reserve and/or adjacent State Forest at no additional cost to the taxpayer.

- Maintenance of (putative) genetic diversity in an endangered species by salvage and reestablishment of individuals that would otherwise be destroyed.

- Maintenance of population numbers of an endangered species by salvage and reestablishment of individuals that would otherwise be destroyed.

Translocation Risks

- The translocated individuals may fail to establish over the long-term.

Various choices are available for recipient sites to establish new or expanded populations of Slender Marsdenia, as detailed in Section 4.3.2 below. Details of performance criteria to assess the success or failure of translocation are presented in Section 4.6.8.

4 TRANSLOCATION PLAN

4.1 Introduction

This section of the Threatened Flora Management Plan sets out a plan to translocate threatened plant species directly impacted by construction of the Warrell Creek to Urunga Upgrade of the Pacific Highway (Table 6), in accordance with Ministers Condition of Approval B7.

In addition to the two species specified in MCoA B7 (*Marsdenia longiloba* and *Niemeyera whitei*), RMS would also undertake the translocation of other threatened

and rare (ROTAP) species recorded during the targeted flora survey, which are directly impacted by project works, as described in Section 3.

Table 6: Threatened and rare species directly impacted by the WC2NH upgrade and included in this translocation plan.

Species	**Conservation Status**
Threatened Species	
Slender Marsdenia (*Marsdenia longiloba*)	TSC Act (V); EPBC Act (E)
Rusty Plum (*Niemeyera whitei*)	TSC Act (V)
Floyds Grass(*Alexfloydia repens*)	TSC Act (E)
Wooll's Tylophora(*Tylophora woollsii*)	TSC Act (E); EPBC Act (E)
Spider Orchid (*Dendrobium melaleucaphilum*)	TSC Act (E)
Other Species	
Ford's Goodenia (*Goodenia fordiana*)	ROTAP
Koala Bells (*Artanema fimbriatum*)	Potential Threatened Species Listing

The translocation plan has been structured according to the format recommended by the Australian Network for Plant Conservation (2004), as summarised below:

- Section 4.1 - Introduction.
- Section 4.2 - General Considerations - discusses the type of translocation action to be carried out, the objectives of the translocation project, designing translocated populations, genetic management and the advantages of incorporating experimental design.
- Section 4.3 - Pre-translocation Assessment - describes the selection of receival sites and the ecology of the subject species.
- Section 4.4 - The Translocation Proposal - outlines the overall translocation approach.
- Section 4.5 – The Species Proposals – outlines the proposals for each species to be to be translocated
- Section 4.6 - The Translocation Action - details how the translocations will be carried out.
- Section 4.7 - Post-translocation Actions - describes follow-up measures including maintenance, habitat restoration, monitoring and project evaluation.

4.3 PRE-TRANSLOCATION ASSESSMENT

4.3.1 Species Ecology

4.3.1.1 Slender Marsdenia (*Marsdenia longiloba*)

Regional Distribution: Slender Marsdenia occurs between the Hastings River district (Port Macquarie) and southeast Qld and from the coast inland to the Great Escarpment ranges, at widely scattered locations.

Local Distribution: Slender Marsdenia was recorded a several locations between Warrell Creek and Nambucca Heads the WC2NH corridor. A total of 80 stem-individuals were recorded in 11 different sub-populations. Additional sub-populations were identified outside but close to the project boundary.

Habitat: Found in moist open forest and gradational subtropical and warm temperate rainforest, mostly below 200m altitude (Quinn *et al.* 1995). Characteristics of Slender Marsdenia habitat recorded on the WC2NH road corridor included: -

- soil type a yellow to red clay podzol formed on Permian metasediments;
- soil A-horizon 15-30cm deep, dark brown, humus enriched topsoil;
- wet sclerophyll forest with an open to mid dense rainforest understorey usually on a lower slope;
- sloping (gentle to moderate) and well drained, often with a southern aspect;
- understorey moderately well lit and open, not dense or heavily shaded;
- topsoil only slightly acidic (pH >6).

Life History and Population Dynamics: Benwell and Watson (2011) have recorded the life history attributes of Slender Marsdenia during translocation and monitoring of this species for the Bonville upgrade near Coffs Harbour, as follows:-

- Slender Marsdenia is a small, perennial, rhizomatous vine.
- Sub-populations are composed of single-stemmed ramets growing from underground rhizomes; several stems may be attached to the same branching rhizome.
- Above ground stems are comparatively short-lived (1-10 years), while the rhizomes are probably more long-lived.
- The rhizomes are relatively thin, 10-30cm long and grow horizontally within the soil A1 horizon (occasional vertical rhizomes are also present); the rhizomes ramify through the soil, budding off and separating from the parent rhizome to form separate plants.
- Plants may die back to the rhizome and remain stem-less and dormant for up to two years (probably longer), then produce new stem shoots.
- Most stem-individuals never grow more than 30cm tall before dying back.
- Only large stem-individuals (ie >1m tall) produce flowers; production of pods and seed is extremely rare; only 1 pod has ever been recorded during several years of monitoring at several locations.
- *Marsdenia longiloba* appears to rely on vegetative reproduction for population persistence; flowering and seed dispersal play a minor role in this process.

- Discrete sub-populations and patches of *Marsdenia longiloba* may originate vegetatively from the same parent plant and spread over a considerable area (e.g. 0.04 ha).
- *Marsdenia longiloba* stems are conspicuously absent from recently (<1-6 yrs) logged or burnt forest, although monitoring of translocation areas has shown that quiescent rhizomes may be present in the soil. This suggests that conditions during early post-disturbance succession are not favourable for growth of *Marsdenia longiloba,* and stem growth may occur mainly during mid to late stages of succession. The response of *Marsdenia longiloba* to fire has never been monitored.

Transplanting potential: Slender Marsdenia has been transplanted successfully (Benwell and Watson 2011).

Propagation potential: Slender Marsdenia has been propagated successfully from rhizome pieces (Benwell and Watson 2011).

Recovery Plan: A Draft Recovery Plan has been prepared for the Slender Marsdenia.

4.4 THE TRANSLOCATION PROPOSAL

4.4.1 General Approach

The WC2NH translocation project would involve salvage transplanting of five threatened species and two rare species (Table 6) with the aim of establishing populations at new locations, which are self-sustaining over the long-term. As well as transplanting, this will require propagation and introduction of additional individuals to establish minimum viable population (MVP) sizes and adequate levels of genetic diversity. Further integral aspects of the translocation process include restoration of good quality habitat to the receival sites where required, adequate maintenance to ensure transplants and population enhancement individuals become established and monitoring and reporting of the translocation results.

4.4.2.5 Research and Experimentation

Slender Marsdenia (*Marsdenia longiloba*)
In the context of the detailed data recorded on the local distribution of Slender Marsdenia within the WC2U road corridor and the considerable number of individuals impacted by construction, a research project looking at the population genetics of Slender Marsdenia is being conducted by the Ecos Environmental Pty Ltd and the Genecology Research Centre of the University of the Sunshine Coast, as part of the offset package and in conjunction with the translocation plan for this species. The aim of genetic research is to identify patterns of genetic variation within and between populations of Slender Marsdenia at local and regional scales and to use this information to better understand the population genetic structure, life history, breeding system and population dynamics of this cryptic and poorly understood species. Such information can be used to improve management and science-based conservation of the species

The Bonville translocation project produced significant new information on the life history of Slender Marsdenia (see below), but the population processes by which Slender Marsdenia persists at a site remain poorly understoood. As well as providing information on spatial variation in genetic diversity, genetic analysis techniques can provide indirect evidence of rates and direction of pollen flow, levels of out-crossing and therefore method of reproduction – ie. vegetative or sexual/by seed. This type of research has been conducted by RMS previously for Scented Acronychia (*Acronychia littoralis*) on the Chinderah Bypass and the DoP consider research a valid 'offset' initiative.

Slender Marsdenia is an interesting plant as it appears to rarely if ever form seed. The Flora of NSW states the fruit has never been recorded, although the writer has observed the fruit on one occasion in a decade of surveying and monitoring vegetation where the species occurs. Patterns of genetic variation within and between sub-populations can be used to indicate levels of sexual and vegetative reproduction, which can provide insight into a species demographics and how it is able to persist in an area. The surveys conducted for whole WC2U project represent a 42km longitudinal sample of the species' distribution. Detailed mapping of sub-populations, the essential first stage of recording spatial data, has in effect been completed. Analysis of patterns of genetic variation within and between sub-populations along this geographic transect would greatly improve understanding of this species genetics and therefore the breeding system and processes by which populations are maintained. Research on these aspects of species ecology is consistent with Priority Recovery Actions recommended for Slender Marsdenia by the Commonwealth Department of Environment and Heritage (DEH) and the Environmental Protection Authority.

The genetic research project currently underway is titled Analysis of genetic variability in the endangered species Slender Marsdenia (*Marsdenia longiloba*) at fine, medium and broad geographic scales, and research is being directed at answering the following questions: -

- Given that Slender Marsdenia rarely if ever produces seed, how much genetic variation exists in this species within and between sub-populations within the Nambucca area and across the species distribution?

- What do patterns of genetic variation within and between sub-populations of Slender Marsdenia tell us about levels of sexual and vegetative reproduction, and levels out-crossing and inbreeding in Slender Marsdenia?

- Are sub-populations of Slender Marsdenia in adjacent gullies genetically different from each other? If they are genetically different, how did they become different when seed production (sexual reproduction/chromosomal recombination) is so rare? If they are genetically the same, how did they disperse to two adjacent gullies when seed production is so rare?

- What do patterns of genetic variation across the species distribution tell us about the frequency of pollination and direction of pollen flow in Slender Marsdenia across the landscape at different scales?

- What does the spatial distribution of genetic variability within and between populations indicate about present and past population dynamics of this species?

- Do patterns of genetic variation in Slender Marsdenia indicate any significant risk of causing inbreeding or outcrossing depression by undertaking translocation of the species?

- What other practical implications do the research findings have for conservation and management of Slender Marsdenia? Such as where are the areas of higher genetic diversity found within the species and how significant are the populations to be translocated for the genetic diversity of the species as a whole.

Approximately 360 samples have been collected across the species range from the Nambucca valley to northwest of Brisbane and patterns of genetic variation are being analysed using microsatellite and chloroplast DNA techniques. The latter is being used to elucidate the identification of Tylophora woollsii and Slender Marsdenia (Marsdenia longiloba), these species being very similar vegetatively and difficult to identify from vegetative features alone.

The translocation project for WC2U (NH2U/WC2NH has been planned to carrying on from the research conducted for the Bonville translocation project and has been designed to examine the survival response of Slender Marsdenia to different methods of translocation and micro-habitat type.

4.5 SPECIES PROPOSALS

4.5.1 Slender Marsdenia (*Marsdenia longiloba*)

Slender Marsdenia occurs in small, sparse sub-populations scattered along the length of the WC2U road corridor. Approximately 200 individuals ('stem-individuals) were recorded in 23 different sub-populations along the whole WC2U road corridor.

A total of 80 individuals were recorded and 15 sub-populations identified within or close to southern WC2NH project. Plans showing the location of recorded occurrences are provided Appendix 1.

Translocation of Slender Marsdenia for the northern (NH2U) project was undertaken in December 2013. In version one of the WC2U TFMP in was proposed that any further translocation of Slender Marsdenia on the southern half/WC2NH would be dependent on the results of Slender Marsdenia translocation on NH2U and that this would be assessed over a monitoring period of two years. This fitted in with initial information that the likely start of construction on the two sections would be two years apart. The project scheduling has since changed and construction of the southern section is likely to commence late 2014 or early 2015, only about 12 months since the NH2U translocation of Slender Marsdenia. This has necessitated an earlier decision whether or not to translocate Slender Marsdenia on the southern section based on monitoring results up to September 2014 – see Table 12b.

The previous attempt to translocate Slender Marsdenia (and Woolls Tylophora) on the Bonville project was unsuccessful after five years. Without going into detail, it was hypothesised that the poor result was due to the adverse of effect of slow release fertiliser and soil amelioration on Slender Marsdenia establishment at the receival site. A different approach has been applied on the NH2U project involving direct transplanting and no use of fertiliser. The results to September 2014 in Table 12b show no evidence of a marked decline in the health and vigour of Slender Marsdenia transplants during the first 9 months, despite a dry autumn and cold and dry winter in 2014. However, based on the survival pattern recorded on the Bonville translocation project, it is too early to say if results are definitely improved. Given the monitoring results recorded to Sept 2014 on NH2U and since construction of WC2NH is likely to start late 2014, translocation of Slender Marsdenia will also proceed on the WC2NH project so as not to delay the start of construction.

Table 12b: Results of the NH2U translocation of Slender Marsdenia after 3, 6 and 9 months after translocation.

NH2U – no fertiliser addition	**3 months** **March 2014**	**6 months** **July 2014**	**9 months** **Sept 2014**
condition - poor	16	14	20
condition – fair	35	45	40
condition – healthy	95	87	86
	146	146	146

Table 13: Directly impacted Slender Marsdenia recorded on the WC2U corridor. Each recorded point may encompass more than one plant, as indicated in column 'No.' Southern Half (WC2NH) as of 10/6/2014

ID	Species	Easting	Northing	No.	Size
AB_2014_1	Marsdenia longiloba	497488.408000	6610582.878000	1	0.1m
AB_2014_2	Marsdenia longiloba	497493.501000	6610586.158000	1	0.1m
AB_2014_3	Marsdenia longiloba	497496.352000	6610583.216000	3	1m
AB2014__ML1	Marsdenia longiloba	489653.000000	6594556.000000	1	0.1m
ml-22	Marsdenia longiloba	496188.410408	6608256.097960	2	0.1m
ml-23	Marsdenia longiloba	496180.251673	6608299.314590	1	1m
ml-24	Marsdenia longiloba	496177.372208	6608314.274170	1	0.5m
ml-25	Marsdenia longiloba	496182.954756	6608331.453140	2	0.8m
ml-26	Marsdenia longiloba	496256.890152	6608315.410310	6	0.5m
ml-27	Marsdenia longiloba	496471.828945	6608754.696510	1	0.4m
ml-35	Marsdenia longiloba	495663.835870	6607571.959330	1	4m
ml-36	Marsdenia longiloba	495660.804035	6607567.525330	1	0.2m
ml-37	Marsdenia longiloba	495671.485200	6607608.163410	3	0.8m
ml-38	Marsdenia longiloba	495684.423981	6607593.392690	1	0.1m
ml-39	Marsdenia longiloba	495702.778781	6607610.022940	1	0.1m
ml-40	Marsdenia longiloba	495744.282604	6607632.942110	1	small
ml-41	Marsdenia longiloba	495722.548309	6607682.802220	10	small
ml-42	Marsdenia longiloba	495722.699901	6607703.119170	1	1.5m
ml-43	Marsdenia longiloba	495716.783427	6607725.280690	1	0.1
ml-44	Marsdenia longiloba	495748.069111	6607748.011070	2	0.3m
ml-5	Marsdenia longiloba	496683.949976	6609585.722830	1	small
ml-63	Marsdenia longiloba	489635.678810	6594537.005010	1	0.1m
ml-68	Marsdenia longiloba	489663.695772	6594588.748820	1	1.5m
ml-7	Marsdenia longiloba	496637.195041	6609472.118760	6	0.6m
ml-71a	Marsdenia longiloba	489553.726825	6594591.727680	3	2m
ml-72	Marsdenia longiloba	489683.316469	6594582.857250	1	1m
ml-8	Marsdenia longiloba	496576.593202	6609216.292200	2	0.6m
ml-9	Marsdenia longiloba	496589.206798	6609222.021860	1	4m
ml-93	Marsdenia longiloba	494336.000000	6604191.000000	1	0.0
V10	Marsdenia longiloba	489584.000000	6594404.000000	1	0.0
V11	Marsdenia longiloba	495058.000000	6606623.000000	1	0.0
V7	Marsdenia longiloba	489559.000000	6594392.000000	2	0.0
V8	Marsdenia longiloba	489560.000000	6594392.000000	3	0.0
V9	Marsdenia longiloba	489567.000000	6594394.000000	1	0.0
GS1	Marsdenia longiloba	489653.000000	6594556.000000	1	1.6
GS10	Marsdenia longiloba	496207.000000	6608368.000000	1	3.0
GS2	Marsdenia longiloba	489660.000000	6594591.000000	1	0.6
GS4	Marsdenia longiloba	495672.000000	6607601.000000	1	0.2
GS5	Marsdenia longiloba	496172.000000	6608264.000000	1	0.2
GS6	Marsdenia longiloba	496185.000000	6608287.000000	1	2.2
GS7	Marsdenia longiloba	496192.000000	6608323.000000	1	0.3
GS8	Marsdenia longiloba	496184.000000	6608313.000000	1	0.3
GS9	Marsdenia longiloba	496212.000000	6608369.000000	1	1.5

It is proposed to conduct the translocation of Slender Marsdenia as follows: -

- Directly impacted plants to be transplanted to adjoining State Forest, road reserve and RMS owned property, which ever is closest, provides suitable habitat and is in a location/tenure suitable for long-term conservation.

- Rhizome pieces dislodged during transplanting (soil breaks up easily) to be used to be used for propagation of population enhancement plants.

- All transplants to be tagged with its donor ID number throughout the translocation process; all propagated plants to be labelled with the parent donor ID number throughout the propagation and introduction process.

- Experimental work to be incorporated in the Slender Marsdenia translocation including:-

    - study of genetic variation within and between sub-populations using shoot material taken during transplanting (stems to be pruned).

    - study of flowering and seed production in transplants under pot cultivation

    - study of plant response to translocation introduction treatments - i.e. direct transplanting vs. planting after initial pot stabilisation; fertiliser/mulch vs. no fertiliser treatment; disturbed vegetation vs undisturbed vegetation.

Monitoring of the translocation would be conducted during construction, as described above, and after construction for a minimum of 5 years, a total of approximately 8 years (also refer to Appendix 11 - Table 4).

APPENDIX 11: SUMMARY OF MANAGEMENT GOALS, CONTROL MEASURES, MONITORING, PERFORMANCE THRESHOLDS AND CORRECTIVE ACTIONS FOR IMPLEMENTATION OF THE WARRELL CREEK TO URUNGA THREATENED FLORA MANAGEMENT PLAN (TABLES 1-4)

Table 1: Summary of pre-construction management goals, mitigation measures, performance thresholds and corrective actions for management of threatened flora.

Main goal	Mitigation / control measure- CEMP to incorporate these measures	Monitoring / timing frequency	Responsibility	Performance threshold	Corrective actions if deviation from performance criteria
• There is no loss or damage to threatened plants within project boundary during the early works period leading up to the start of construction. • Directly impacted threatened plant species are translocated from the clearing zone/ construction footprint according to TFMP prior to the start of clearing/construction near the flora requiring translocation.	• Pre-clearing survey of threatened flora to confirm current location/ numbers of threatened flora requiring translocation and that individual ID tags are in place and correctly numbered. • Exclusion zones identified in CEMP/ temporary fencing put in place to protect any threatened plants to be translocated that are in close vicinity/ potentially impacted by early work activities. • Exclusion zones put in place to protect in situ individuals within 10m of the construction zone/clearing limit prior to the start of construction.	• Pre-clearing threatened flora survey completed. • Exclusion zones checked and signed off. • Receival site agreed to by all parties. • Hold point: Exclusion zones identified and in place before commencement of works.	• Design and construct (D&C) contractor.	• Salvage translocation (transplanting) of all directly impacted threatened flora completed according to the WC2U TFMP, Sections 4.5, 4.6 & 4.7. • No loss or damage to threatened flora occurs prior to translocation being implemented.	• Construction activities not to commence at locations of flora requiring translocation until salvage translocation works are completed. • Review undertaken and correct control measures.

	• Translocation receival site finalised and necessary site preparation carried out at least one month in advance of the start of translocation, and due consideration given to the site selection factors listed in WC2U TFMP Section 4.3.3. • Salvage translocation of directly impacted threatened flora individuals carried out according to procedures described in the WC2U TFMP Sections 4.5, 4.6 & 4.7.				

Table 2: Summary of construction management goals, mitigation measures, performance thresholds and corrective actions for management of threatened flora.

Main goal	Mitigation / control measure	Monitoring / timing frequency	Responsibility	Performance threshold	Corrective actions if deviation from performance criteria
• No damage occurs to indirectly impacted and in situ threatened flora remaining within the project boundary after salvage translocation of directly impacted individuals. • Other works associated with the translocation of threatened flora (ie. in addition to salvage translocation/transplanting) such as propagation, population enhancement, habitat rehabilitation at the receival site, are implemented according to the WC2U TFMP	• Exclusion zones identified on sensitive area plans and fencing barriers maintained during construction. • Signage added to fencing to indicate environmental protection/no-go zones. • Targets and time line for implementation of other translocation works after the (pre-construction) salvage translocation	• 3- monthly monitoring of translocated/ transplanted threatened flora during year 1 of construction, then 6-monthly monitoring thereafter (in accordance with procedure outlined in the TFMP (section 4.7.7) • 3- monthly monitoring of in situ threatened flora during year 1 of construction, then 6-monthly monitoring thereafter, as described in WC2U TFMP Section 5.3. • Annual monitoring report detailing the monitoring results for translocated threatened flora and in situ threatened flora, prepared according to the requirements of the WC2U TFMP Section 4.7.7	• Design and construct (D&C) contractor.	• All translocation actions required during the construction phase are implemented including monitoring and preparation of the annual monitoring report. • Annual monitoring report provides full description of management plan implementation and results, as per the required contents in Section 4.7.7, and an evaluation of outcomes according to criteria listed in Section 4.7.8 of the WC2U TFMP.	• Review any failure to implement or complete translocation actions required during the construction phase and devise appropriate corrective actions.

Table 3: Summary of operation management goals, mitigation measures, performance thresholds and corrective actions for management of threatened flora.

Main goal	Mitigation / control measure	Monitoring / timing frequency	Responsibility	Performance threshold	Corrective actions if deviation from performance criteria
• No damage occurs to in situ threatened flora remaining within the project boundary. • Any remaining works associated with the translocation of threatened flora such as propagation, population enhancement, habitat rehabilitation at the receival site, are implemented according to the WC2U TFMP	• Signage, exclusion fencing installed around in situ threatened flora within project boundary. • Targets and time line for implementation/ completion of other translocation works during the operation phase	• 6- monthly monitoring of translocated/ transplanted threatened flora during years 2 & 3, then monitoring once a year thereafter • 6- monthly monitoring of in situ threatened flora within project boundary during years 2 & 3, then monitoring once a year thereafter	Roads and Maritime Services	• All translocation actions required during the operation phase are implemented, including monitoring and preparation of the annual monitoring report. • Annual monitoring report provides full description of management plan implementation and results, as per the required contents in Section 4.7.7, and an evaluation of outcomes according to criteria listed in Section 4.7.8 of the WC2U TFMP.	• Review any failure to implement or complete translocation actions required during the operation phase and devise appropriate corrective actions.

Table 4: Summary of monitoring program for threatened flora, including performance thresholds and corrective actions. There are Three main monitoring components: - threatened flora translocations, in-situ roadside threatened flora & threatened flora habitat.

Monitoring Component	Main goal	Monitoring / timing frequency	Responsibility	Performance threshold	Corrective actions if deviation from performance criteria
Translocation:– salvage translocation and population enhancement	To record monitoring data that enables an assessment to be made of the success of the threatened flora translocations, implemented as per the TFMP.	<u>Salvage transplants</u> Monitoring frequency:- 1. 3-monthly intervals in first year after introduction 2. 6-monthly intervals in year 2 and year 3. 3. once a year thereafter to the end of monitoring program 4. 8 years in total - ~ 3 yrs during construction and 5 years during operation. <u>Population enhancements</u> Monitoring frequency:- 1. at introduction 2. 6-monthly intervals in first year. 3. once a year thereafter to the end of monitoring program 4. 8 years in total - ~ 3 yrs during construction and 5 years during operation.	Pacifico/Roads and Maritime Services	1. All recorded directly impacted individuals are translocated. 2. At least 60% of transplant and enhancement individuals are surviving after the first year, 50% after five years and 40% after eight years. 3. At the end of the monitoring program at least 50% of surviving individuals have a Condition Class of 3.	1. Identify reasons for failure to translocate individuals and implement corrective measures – eg. translocate if still in situ; inform management of the reasons for failure to avoid occurence on future projects. 2. Assess reasons for failure to reach first year target and implement corrective measures as required - e.g. hessian screening to mitigate over-exposure while revegetation is established; surveillance cameras and signage to deter theft; weed control to counter weed invasion. 3. In the final monitoring report, analyse and discuss the reasons for failure to reach the performance target and evaluate the success of the translocation project in terms of the survival rates, the benefits/risks of conducting the translocation (see Sect.

					3.5) and the economic costs and benefits.
In-situ Roadside Threatened Flora	To record monitoring data that enables an assessment to be made of the effectiveness of mitigation measures for protection of in-situ threatened flora.	Monitoring frequency:- 1. initially after installation of protective fencing 2. 6-monthly intervals in years 1 and year 2. 3. once a year thereafter to the end of monitoring program 4. 8 years in total - ~ 3 yrs during construction and 5 years during operation. Monitoring above to be augmented by monthly site inspections/ checking of fenced in-situ threatened flora to make sure no encroachment/ damage has occurred.	Pacifico/Roads and Maritime Services	1. The survival rate of in-situ threatened flora at the finish of clearing is 100%. No accidental damage occurs during clearing. 2. The survival rate of in-situ threatened flora at the end of years 1-3 of the monitoring program is at least 80% and at least 70% at the end of years 4-8; 3. Of plants surviving at the end of each year, at least 75% are in good condition – i.e. they have healthy foliage, no sign of die-back or disease and exhibit new shoot growth (Condition Class 3 or >)	1. Identify reasons for damage/failure to protect in situ threatened flora and implement corrective actions as necessary. 2. Assess reasons for failure to reach performance threshold and implement corrective actions as required. For example,; hessian screening to protect plants from over-exposure; addition of hay mulch where plants are in poor condition, weed control to counter weed invasion 3. Assess reasons for <75% of in situ plants not being in good condition and apply appropriate mitigation if possible, such as the measures for 2.
Threatened Flora Habitat (Slender Marsdenia and Woolls'	To record monitoring data that enables an assessment to be made of the effectiveness of mitigation measures for protection of Slender	Monitoring frequency:- 1. within one month of finish of clearing (baseline). 2. end of each year/12-monthly intervals for 8 years (ie. 3 years construction, 5 years operation)	Pacifico/Roads and Maritime Services	1. Plot crown-cover of exotic species is no more than 15% (overlapping and/or summed) at the end of Year-1 and no more than 25% at the end of Years- 2	1. Weed control in and around Slender Marsdenia and Woolls' Tylophora habitat representative of such plots where exotic species exceed thresholds; to be applied by

Tylophora)	Marsdenia and Woolls' Tylophora habitat adjacent to construction.			to 8 2. Baseline vegetation structure (height and crown cover) remains the same or increases in height and crown cover at the end of year compared to the previous year. 3. There is no increase in the microclimate exposure class (e.g. 1 to 2, or 4 to 5) compared to the previous year.	an experienced bush regenerator familiar with identification of Slender Marsdenia and Woolls' Tylophora. 2. Prioritise revegetation of batters and bare areas adjacent to Slender Marsdenia and Woolls' Tylophora habitat. Use salvaged topsoil seed bank to minimise weed spread from revegetated areas into adjacent habitat.