Flora Translocation Strategy (Sections 1 & 2)

Woolgoolga to Ballina Pacific Highway upgrade

April 2015

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Glossary and Abbreviations

Ameliorative enhancement	An attempt to increase population size by adding individuals to an existing population to ameliorate the loss of part or all of that population due to development.
CoA	Conditions of Approval
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 conservation introduction.
Conservation introduction	Attempts to establish a taxon, for the purpose 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.
Construction footprint	The direct area of the design alignment (also referred to as the clearance limits)
DECCW	NSW Department of Environment, Climate Change and Water (now known as OEH)
Direct impact	An impact that causes direct harm within the project boundary (i.e. clearing of vegetation)
DoE	Commonwealth Department of the Environment (previously known as the Commonwealth Department of Sustainability, Environment, Water, Population and Communities)
DP&E	NSW Department of Planning and Environment (previously known as of Planning and Infrastructure)
EPA	NSW Environment Protection Authority
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EIS	Environmental Impact Statement (Biodiversity Assessment Working Paper)
Enhancement	An attempt to increase population size or genetic diversity by adding 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.
Indirect impact	An impact that causes harm outside of the project boundary (i.e. edge effects, erosion etc.)
MCoA	NSW Ministers Condition of Approval
NSW	New South Wales
OEH	NSW Office of Environment and Heritage
Offset	An offset may be an area of land that is protected and managed to improve biodiversity values or an action that compensates for adverse impacts to biodiversity. Requirements for offsets are determined using an objective assessment of predicted loss of biodiversity at the development site and expected gain in biodiversity to be achieved at the offset site.
Performance threshold	This is a prescribed outcome that should it be reached, an assessment as to why the objectives are not being met will be undertaken and then appropriate corrective actions implemented.
The Project	Refers to all the proposed works in all eleven sections which includes the construction footprint with a 10 metre construction buffer, ancillary and compound sites and design changes.
Receival site	This is the site where plant populations would be translocated to, or revegetated in a new area outside the project boundary.
Roads and Maritime	NSW Roads and Maritime Services
Salvage dig	The transplantation of mature plants or soil stored seed bank to an area not affected by the development. Also referred to as transplantation or rescue dig.
SPIR	Submissions / Preferred Infrastructure Report
Targeted surveys	Field surveys completed in 2014 for Sections 1 to 11 for threatened flora species listed under the EPBC Act and TSC Act.

Threatened species	Any organism listed as vulnerable, endangered or critically endangered under State and/or Commonwealth legislation.
TSC Act	*Threatened Species Conservation Act 1995*
Translocation	Deliberate transfer of plant material from one area to another for conservation purposes
W2B	Woolgoolga to Ballina Pacific Highway Upgrade
Weeds	Plants that may threaten agricultural land adjacent to the Project, have detrimental effects on the natural environment or impact human health. Includes noxious weed species under the *Noxious Weeds Act 1993* as categories W1, W2, W3 or W4.

1. Background

1.1 Project overview

New South Wales Roads and Maritime Services are upgrading the Pacific Highway between Woolgoolga to Ballina on the NSW North Coast. The Project was approved under the NSW Environmental Planning and Assessment Act 1979 (EP&A Act) by the NSW Minister for Planning on 26 June 2014. It was also approved under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) on 14 August 2014.

Key features of the upgrade include:

- Duplication of 155 kilometres of the Pacific Highway to a motorway standard (Class M) or arterial road (Class A), with two lanes in each direction and room to add a third lane if required in the future
- Split-level (grade-separated) interchanges at Range Road, Glenugie, Tyndale, Maclean, Yamba / Harwood, Woombah (Iluka Road), Woodburn, Broadwater and Wardell
- Bypasses of South Grafton, Ulmarra, Woodburn, Broadwater and Wardell
- About 40 bridges over rivers, creeks and floodplains, including major bridges crossing the Clarence and Richmond rivers
- Bridges over and under the highway to maintain access to local roads that cross the highway
- Access roads to maintain connections to existing local roads and properties
- Structures designed to encourage animals over and under the upgraded highway where it crosses key animal habitat or wildlife corridors
- Rest areas located at about 50 kilometre intervals at Pine Brush (Tyndale), north of Mororo Road and north of the Richmond River
- A heavy vehicle checking station near Halfway Creek and north of the Richmond River.

New South Wales Roads and Maritime Services (Roads and Maritime) has approval for the Woolgoolga to Ballina (W2B) Pacific Highway upgrade project under Part 5.1 of the NSW Environmental Planning and Assessment Act 1979 (EP and A Act) and the Commonwealth Environment Protection and Biodiversity Act 1999 (EPBC Act). In accordance with the NSW Minister's Conditions of Approval (MCoA) A8, the required translocation strategy will be submitted in stages. The Commonwealth MCoA require compliance with NSW conditions as they apply to species listed on schedules of the EPBC Act and assessed as likely to suffer a significant impact as result of the proposal.

Compliance with conditions of approval and responses to comments on a draft of this strategy are provided in Appendix 1.

The project is divided into 11 sections (**Figure 1**), of which Section 1, from Woolgoolga to Halfway Creek (17 km), and Section 2, from Halfway Creek to Glenugie (15 km), are the subjects of this translocation strategy.

The Project Area is defined by mapped boundaries broadly encompassing a corridor of approximately 1 km in width. Within the Project Area, a Clearing Boundary is also defined and mapped. Vegetation and individual plants of threatened flora species within the Clearing Boundary are considered to be directly impacted by the proposal.

The project will be constructed in sections. Sections 1 and 2 are from Woolgoolga to Glenugie, 32 km.

Figure 1 Woolgoolga to Ballina Project Sections

1.2 Purpose of the strategy

This Translocation Strategy has been developed to meet the requirements of MCoA D7. This Translocation Strategy specifically addresses Sections 1 and 2 of the Project which are due to commence construction in mid-2015.

Table 1 sets out the requirements of MCoA and where each has been addressed in this strategy.

Table 1: Project approval requirements and where addressed

Approval requirement		Where addressed
NSW approval		
MCoA D7	The Applicant shall prepare and implement **Flora Translocation Strategy** to determine the feasibility and potential efficacy of translocation measures (as identified in the threatened species management plans required under condition D8), prior to the commencement of construction work that would result in the disturbance of threatened flora species for which translocation is proposed. The strategy shall be prepared by a suitably qualified and experienced ecologist, in consultation with the EPA and DoE, and to the satisfaction of the Secretary. The Strategy shall include: (a) a feasibility assessment of timeframe and staging requirements, availability of expertise, risk effectiveness analysis and availability/suitability of translocation sites; (b) detail of species specific information on the proposed methods of, and discussion of results of past recorded responses to, translocations; (c) a framework for the translocation process applicable to each affected species; and (d) consideration of appropriate compensatory habitat in the Biodiversity Offsets Package required under condition D5 where translocation is not reasonable for feasible.	The requirements of this condition are addressed in this plan. Details on the ecologist expertise for preparation of the strategy is provided in Section 1.3. Consultation with EPA and DoE is included in Appendix 1. (a) is addressed in Table 2, Table 4, Table 8, Section 5and Appendix 5. (b) is addressed in Table 4, Section 3.2 and Appendix 3. (c) is addressed in Sections 3,Table 4 and Appendix 3 and 6. (d) is addressed in Section 1.2 below.

The Project Area is defined by mapped boundaries broadly encompassing a corridor of approximately 1 km in width. Within the Project Area, a Clearing Boundary is also defined and mapped. Vegetation and individual plants of threatened flora species within the Clearing Boundary are considered to be directly impacted by the proposal.

At the time of the preparation of this translocation strategy for Sections 1 and 2, the project design for the relevant sections had been finalised and compilations of survey data were available to quantify estimates of impacts on threatened flora species (see also Threatened Flora Management Plan Sections 1 and 2 and Soft Soil Work Areas, Roads and Maritime 2015). Potential translocation receiving sites were under investigation and some results were available.

Translocation is defined as the “deliberate transfer of plant material from one area to another for conservation purposes” (Vallee *et al.,* 2004). The purpose in this project is to apply a range of translocation techniques to impacted populations of threatened species so that declines in numbers and genetic diversity can be avoided to the best extent possible. The overall objective of threatened plant translocations is to establish populations that are self-sustaining over the long-term.

Despite the potential for translocation to make valuable contributions to conservation objectives and to mitigate some of the impacts of development, it is recognised that translocations are generally experimental and success cannot be guaranteed, although every effort is made to maximize the chance of success. Accordingly, translocation is not considered a mitigation measure under the EPBC Act, and the flora individuals to be removed/translocated are considered to be impacted for the purposes of the EPBC Act. This impact will be compensated for with the provision of suitable offsets in accordance with the EPBC Act Offsets Policy. Roads and Maritime (2015) have prepared a Biodiversity Offset Strategy.

Translocation of threatened plants is being considered for those threatened plants that are within the clearing boundary and would be undertaken for threatened species that have suitable life history traits that make translocation a viable option, with monitoring to measure success.

1.3 Plan author

The Strategy was prepared by:

Barbara Stewart of Landmark Ecological Services Pty Ltd. Barbara has a Ph D in forest ecology, a B Sc (Hons) in botany and more than 20 years' experience in research, consultancy and land management on the NSW north coast and more widely. Her research specialisations are in seed and seedling ecology.

In addition, she has authored/co-authored Recovery Plans for threatened species and has extensive survey and management planning experience for flora species of conservation significance. Barbara was formerly the proprietor of a native plant nursery.

Rhonda James - Bushland Restoration Services Pty Ltd. Rhonda has a B Business, M Env Man and Cert IV Bushland Restoration. Rhonda has 15 years' experience in ecological restoration specializing in the recovery of threatened species and endangered ecological communities. Rhonda co-authored the SEQ Ecological Restoration Framework.

She has extensive experience in habitat restoration, translocation and monitoring of threatened species. These projects include Hairy Joint Grass at Koala Beach and Lennox Head, Green-leaved Rose Walnut at Koala Beach, RTA works at Alstonville bypass, Sleepy Hollow Rest Area, Banora Point bypass and Murnanes Bridge, OEH Coastal Fontainea and Hairy Quandong and extensive works for Gold Coast City Council and SEQWater related to translocation of threatened species during construction of the Hinze Dam.

1.4 Consultation and updates

This strategy provides a framework for implementation of any translocation of threatened species impacted by the Project. The plan would be updated as required during pre-construction or during the construction stage of the Project. Any updates to the strategy would be undertaken in accordance with the Project Staging Plan submitted under Ministers Condition of Approval A7.

Roads and Maritime has consulted with the NSW Environment Protection Authority, and Commonwealth Department of Environment, during the development of this strategy. Both agencies were provided a copy of the Draft Report on 2 December 2014. Feedback received and Roads and Maritime response to issues raised have been included in **Appendix 1** of this report.

1.5 Previous studies

Section 2 of the Threatened Flora Management Plan includes a summary of the previous studies in the EIS, SPIR and baseline survey information since 2006.

The most recent relevant ecological studies that have been conducted for Sections 1 and 2 are as follows:

- Vegetation Survey Report for Section 1 (Biosis 29 July 2014)
- Vegetation Survey Report for Section 2 (Ecosure June 2014)

- Preconstruction threatened flora surveys and baseline monitoring (Jacobs 2014)
- Biodiversity Offset Strategy (Roads and Maritime 2015)

A combined spatial database incorporating preconstruction survey data and data collected for the EIS preparation was used for the purposes of the current translocation strategy.

From these reports and surveys, it has been determined that nine (9) threatened flora are impacted in Sections 1 and 2 of the Woolgoolga to Ballina Upgrade (**Figure 2**):

- Hairy joint-grass (*Arthraxon hispidus*)
- Maundia *(Maundia triglochinoides)*
- Moonee Quassia (*Quassia* sp. *Moonee Creek*)
- Noah's false chickweed (*Lindernia alsinoides*)
- Square-fruited Ironbark (*Eucalyptus tetrapleura*)
- Slender screw fern (*Lindsaea incisa*)
- Square-stemmed Olax (*Olax angulata*)
- Square-stemmed spike-rush (*Eleocharis tetraquetra*)
- Water nutgrass (*Cyperus aquatilis*)

Not all of the threatened species are proposed for translocation. Sections 2.4 and 2.5 of this report discuss the feasibility, translocation methodology and sites and justifications).

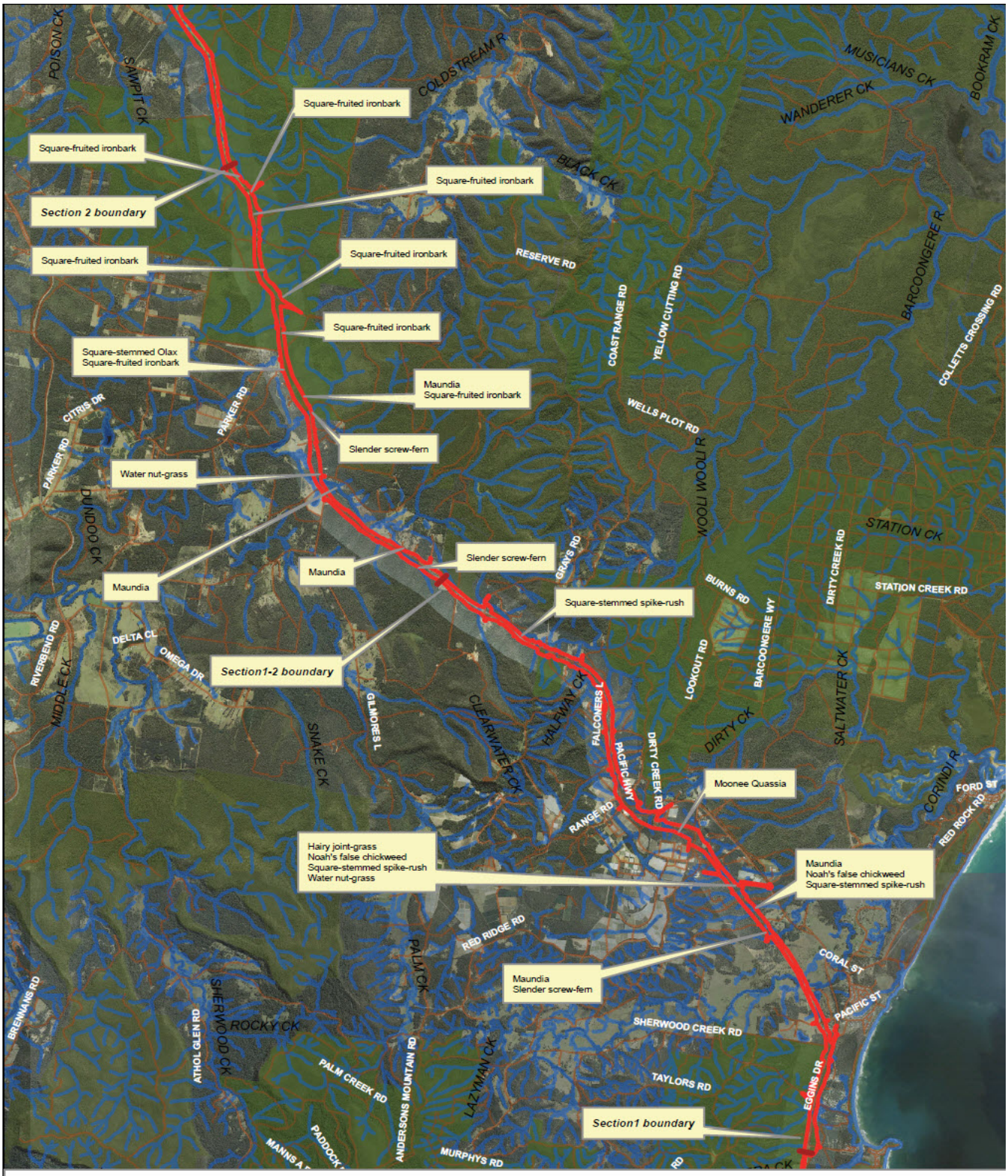

Figure 2
Threatened Flora locations

Project: RMS Translocation

Date: March 2015

Map Grid of Australia - Zone 56

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2 Translocation overview

2.1 Translocation background

Guidelines for translocation of flora species have been developed generally and in Australia over several decades e.g. Cropper (1993), ANPC (1997) and Vallee *et al.* (2004). The latter reference recognises the increasing role that translocation is now expected to play in the amelioration of the impact of development.

Section 5.3 and 5.4 of the Threatened Flora Management Plan outline the process and management measures for this Translocation Strategy.

Types of translocation action identified by Vallee *et al.* (2004) are as follows:

Translocation action undertaken for conservation purposes
Enhancement
Re-introduction
Conservation introduction

Translocation action undertaken as an ameliorative measure for development
Salvage dig
Ameliorative enhancement
Compensatory introduction (this type is noted to, in the majority of cases; meet the definition of conservation introduction as above).

In addition, recent translocation planning for Roads and Maritime's projects recognise the conservation benefits that suitably planned salvage operations can make to knowledge of the biology and ecology of threatened flora species and improved management of future translocations e.g. Benwell (2013).

The decision process to precede a translocation process (Vallee *et al* 2004) is set out for species proposed for translocation (**Appendix 2**).

2.2 Translocation aims and objectives

The proposed translocations are guided by the overall aims set out by Vallee *et al.* (2004) as follows:

All translocations should aim to maintain or create a self-sustaining population.

Translocation may also lead to:

- Increased knowledge of the threatened plant species
- Development of new management techniques
- Initiation of debate on conservation policy
- Education of the public
  (Pavlik 1996 quoted in Vallee *et al.* 2004)

In addition, the Threatened Flora Management Plan - Section 1, Section 2 and Soft Soil Work Areas (Roads and Maritime 2015) states that translocation should aim to achieve no net loss in local plant populations being impacted by the project.

For the proposed salvage translocation, it is also appropriate to aim to make the best possible use of all plant material with potential conservation value.

2.3 Survey and assessment

Background information for each of the nine threatened flora species detected within the Project Area in Sections 1 and 2 has been compiled and includes profiles and compilation of translocation history (**Appendix 3**). The background informed assessments of the feasibility of translocation and the risks associated with translocation.

This strategy identifies that translocation is feasible, within some timing constraints, for six species (**Table 2**).

Table 2: Summary of translocation feasibility

Common name	Scientific name	TSC Act	EPBC Act	Section 1	Section 2	Translocation feasibility
Hairy joint-grass	*Arthraxon hispidus*	V	V	x		feasible, assuming seed and/or above ground plant material is available
Maundia	*Maundia triglochinoides*	V		x	x	not feasible (compensatory habitat management will be conducted)
Moonee Creek Quassia	*Quassia* sp Moonee Creek	E	E	x		feasible
Noah's false chickweed	*Lindernia alsinoides*	E		x		feasible, assuming seed and/or above ground plant material is available
Slender screw-fern	*Lindsaea incisa*	E		x	x	feasible
Square-fruited ironbark	*Eucalyptus tetrapleura*	V	V		x	feasible
Square-stemmed Olax	*Olax angulata*	V			x	outside clearing boundary, translocation not required
Square-stemmed spike-rush	*Eleocharis tetraquetra*	E		x		feasible, assuming above ground plant material is available
Water nutgrass	*Cyperus aquatilis*	E				not feasible

Note: Refer to **Table 4** for more detailed feasibility assessment.

The abundance and extent of the nine species has been detected during surveys and documented by way of counts of individuals and/or area of occurrence, depending on the growth habit of the species and the nature of the occurrence (**Table 3**.)

The detailed survey data collected for the Project Area is complemented by limited information about occurrences in immediately adjacent land. Whilst most of the corridor has been acquired by Roads and Maritime, there is some remaining land within the corridor, including possible translocation receiving sites, for which access has not always been possible. Some broader contextual information about the occurrence of the threatened flora species is available from Atlas records.

Table 3: Survey results for threatened flora species within Sections 1 and 2 of the Project

Species	Clearing area		Project area (not including clearing area)		Outside project area	
	No individuals	Area (ha)	No individuals	Area (ha)	No individuals	Area (ha)
SECTION 1						
Hairy joint-grass	2	0	0	0	0	0
Maundia	5	0.075	0	0.015	78	0.248
Moonee Quassia	73	0.080	765	0.415	449	0.169
Noahs false chickweed	1,811	0	1	0	269	0
Slender screw fern	2,820	0.013	0	0	1,217	0.034
Square-stemmed spike-rush	253	0.815	37	0.034	184	1.170
Water nutgrass	1	0.021	0	0	0	0.011
SECTION 2						
Maundia	34	0.075	20	0.064	155	1.047
Noahs false chickweed	0	0	0	0	104	0
Slender screw fern	0	0	410	0.024	1,022	0.045
Square-fruited ironbark	823	20.285	396	13.290	150	extensive
Square-stemmed Olax	0	0	1	0	0	0
Square-stemmed spike-rush	0	0	4	0.008	0	0
Water nutgrass	6	0.003	0	0	0	0

The abundance and distribution data obtained from surveys require interpretation, depending on growth form and survey methods. Ephemeral annuals (such as Maundia and Water nutgrass) vary in their distribution and abundance within and between years, depending on seasonal conditions. In addition, data has been combined from surveys using differing recording methods.

- Point data for species such as Noah's false chickweed are likely to underestimate the number of individuals present since GPS points recorded in a meandering survey will have documented only a small proportion of the plants. Individuals can be difficult to distinguish and usually occur in clumps. Point data for Slender screw fern is likely to over-estimate the number of individuals as above-ground fronds are connected underground.
- Polygons for species such as Hairy joint-grass and Noah's false chickweed have usually been drawn to enclose the individual points and can be considered to represent an area where the soil stored seed density is relatively high.
- Some polygons do not include points, while polygons have not always been drawn around groups of points.

Details of survey data at proposed translocation donor sites are provided in **Appendix 4** and mapped (**Appendix 5**).

2.4 Feasibility and risk assessment

The feasibility of translocation is based on:

- biological characteristics of species of relevance to translocation
- practicality of propagule collection and other techniques to potentially be employed for translocation
- prospects for successful establishment
- availability of suitable receiving sites (appropriate habitat and tenure)
- past translocation success
- an assessment of risk considers:
- extent that mixing of populations may result in outbreeding depression
- introduction of pathogens and disease
- displacement of other species
- impacts to other species from translocation activities, including site preparation and monitoring (Vallee *et al.* 2004)

Appropriate sampling of propagule sources, hygiene, nursery protocols and vegetation management will be employed as standard practice and will mitigate against the risks. Appropriately skilled personnel will be employed.

Other risks include:

- climatic stochasticity and unpredicted extreme weather events, to the species in the recipient sites (adverse impacts of newly created edges and disruption to connectivity, marsupial and stock grazing)
- failure to understand the ecological requirements of the target species
- inadequate timeframes for establishment and ongoing management.

The risk to individual species depends on:

- the importance of the local population for the species
- the extent of the local population (will numbers be critically reduced?)
- the likelihood that unique genetic material may be lost
- context of the plants proposed for translocation (isolated or connected to plants on adjacent lands).

Table 4 summarises the process of translocation feasibility assessment for threatened flora within the construction footprint of section 1 and 2 of the Project.

Table 4: Translocation feasibility

Species	Relevant biological and ecological characteristics	Seasonal constraints	Previous translocations	Receiving sites (see also s2.5, Table 4 and Appendices 5 and 6)	Translocation feasibility	Risk assessment
Hairy joint-grass	• seeds can be collected and germinated readily • Individual plants or clumps can be transplanted • seepage or swamp habitat is required	• above ground material visible during wet season dies back April-May • seed collection summer autumn • plant out/ transplant during growing season (in wet conditions).	• nursery grown seedlings have been planted out • direct seeding has been successful • turf transplant • establishment and persistence depends on site suitability, management to maintain competitive biomass at low levels and recruitment microsites	Suitable site available.	Technically feasible though success will be dependent on management that maintains biomass reduction and habitat suitability.	Failure of translocation from this small population may jeopardise the persistence of this apparently isolated southern occurrence.
Maundia	• seeds difficult to germinate • seeds stored in soil • lateral vegetative spread • patch extent changes with hydrology	• detectable all year round but die back in dry conditions • seeds December and January	Translocations have been unsuccessful. An alternative approach to population enhancement through hydrological management at locations where soil stored seed and/or mature plants are present is preferred.	n/a	Compensatory actions other than translocation are preferred – hydrological management to enhance another existing population.	Maundia is considered to be relatively secure in the Mid North Coast region, especially to the south of the project. Occupied habitat lies to the east of the project boundary at Halfway Creek.

Species	Relevant biological and ecological characteristics	Seasonal constraints	Previous translocations	Receiving sites (see also s2.5, Table 4 and Appendices 5 and 6)	Translocation feasibility	Risk assessment
Moonee Quassia	• seeds germinate readily • can vegetatively reproduce by suckers and coppicing	• detectable all year • fruiting March-April • fruiting may not be reliable	Presumed to have been propagated and planted successfully but no case studies available, except for plantings in botanic gardens.	A potential receiving site has been identified at adjacent to the donor site.	Translocation is feasible, using propagation from seed, cuttings and root sucker transplants. Success via seed propagation is more predictable though will be limited by seed availability. Seed may be collected from nearby plants.	Very restricted distribution, low population numbers and probable clonality suggest very low genetic variability. The patch from which translocation is proposed is isolated and thus may include unique genetic material. However, only a part of the population will be removed.
Noah's false chickweed	• dust-sized seeds • seeds persist in soil • transplants readily	• flowers most of year • dies back or hard to detect in dry conditions	Successfully transplanted by clump transplant, persistence demonstrated during one year's monitoring	Suitable receiving sites are available	Feasible. Suitable swampy receiving site essential	Local distribution unknown, possibly unique genetic material.
Slender screw-fern	• lateral educated spread • resistant to disturbance	• dies back in dry conditions but is claimed to be detectable • planting about requires wet conditions	• Generally difficult to cultivate • Short term translocation success reported from transplant conducted in wet season (recent Roads and Maritime's project). • Possibility for transplant. May also recommend salvage of material for nursery trials.	Receiving sites with suitable microsite conditions available.	Short term success reported for one trial, but generally regarded as a difficult candidate for translocation. Trialling of value for research purposes.	Moderately abundant in the vicinity of the populations to be translocated. Unlikely that unique genetic material will be lost should translocation be unsuccessful.

Species	Relevant biological and ecological characteristics	Seasonal constraints	Previous translocations	Receiving sites (see also s2.5, Table 4 and Appendices 5 and 6)	Translocation feasibility	Risk assessment
Square-fruited ironbark	• seed collection reliable and germinates readily • seedling and sapling transplants possible but identification difficult to confirm	• Seed available year round and retains viability in dry storage.	• Presumed to have been propagated and planted successfully but no case studies available. Eucalypts are regularly and easily propagated and cultivated.	Residual land on Glenugie Biodiversity Offset site considered suitable	Translocation is feasible using standard horticultural techniques for propagation from seed, growing on in nursery and planting out.	The population is towards the southern extremity of the species' range and continues into adjacent land where a fairly extensive occurrence is present. Unique genetic material is unlikely to be lost if the translocation were to fail.
Square-Stemmed spike-rush	• lateral vegetative spread • seed stored in the soil	• detected year round • seed summer and autumn	Experience is limited and has limited success	Suitable receiving sites are available.	Translocation is feasible if suitable swampy microsites are chosen and management to prevent shading out, to remove weed competition and to open up gaps for recruitment can be maintained. Transplants are practically difficult in aquatic environments.	Any loss of plant numbers or unique genetic variation may be of severe consequence to the Section 1 local population and the species.
Water nutgrass	• ephemeral, recorded sparsely and intermittently in known habitat • soil-stored seed, presumed primarily water-dispersed	Seasonally wet habitat conditions required for development	Limited, no successful examples	n/a	It is not practically feasible to translocate a species of uncertain occurrence and extent, where above ground plants are rarely observed.	Water nutgrass is sparsely distributed as far as is known for the southern part of its range (though extensive unsurveyed suitable habitat is available). Unique genetic material may be lost.

2.5 Receiving sites

Receiving sites have been identified on Roads and Maritime owned and public land, in disturbed areas of offset sites and compensatory habitat, and on land remaining within the project boundary. Details of the receiving sites (**Table 5**), maps (**Appendix 5**) and descriptions and management requirements and actions (**Appendix 6**) are provided.

Table 5: Receiving sites

Species	Receiving Site	Translocation type	Area (ha)	Tenure	Suitability	Threats/Risks
Hairy joint grass	Kangaroo Trail (Priority 1)	Salvage dig, compensatory introduction	1.4	Roads and Maritime Project area	3km from Redbank north tributary donor site. Suitable habitat - vegetation mapped as swamp forest of coastal lowlands.	Disturbance from weed invasion
	Halfway Creek Crossing (Priority 2)	Salvage dig, compensatory introduction	4.0	Roads and Maritime Project area	1km from Redbank north tributary donor site. Suitable habitat - vegetation mapped as swamp forest of coastal lowlands.	Disturbance from weed invasion hydrological management may be necessary
Moonee Creek Quassia	Dirty Creek road reserve	Salvage dig, ameliorative enhancement	0.33	Roads and Maritime Project area	Very close proximity to the donor site. Moonee Quassia already present indicating that site characteristics suit requirements of the species. Expand on the existing northern population extending south east to link with southern population.	Exposure post clearing. Will be adjacent to corridor, may require protective barrier.
Noah's false chickweed	Yuraygir Conservation Area	Salvage dig, compensatory introduction	0.27	OEH	12km from Redbank northern tributary donor site. Vegetation monitoring and site inspection indicate site suitable for the species.	Proximity to road possible disturbance from roadworks and weed invasion.
Slender screw fern	Kangaroo Trail (Priority 1)	Salvage dig, compensatory introduction	1.5	Roads and Maritime Project acquisition	1.5km from Corindi Creek donor site. Suitable habitat - vegetation mapping classifies site as swamp sclerophyll forest with poor drainage.	Disturbance from weed invasion
	Halfway Creek (Priority 2)	Salvage dig, compensatory introduction	0.04	Roads and Maritime Project area	14km from Corindi Creek donor site. Suitable habitat - vegetation mapping/ monitoring data classifies site as swamp sclerophyll forest with poor drainage.	Disturbance from weed invasion.
Square-fruited ironbark	Glenugie offset property	Ameliorative enhancement	4.4	Roads and Maritime Offset area	11km north east of the seed collection sites at Wells Crossing and Wells Crossing north. Square-fruited ironbark already present indicating that habitat is suitable.	Pasture grasses dominate areas. Grazing by stock. Seedlings will require fencing or individual sturdy plant guards.
Square-stemmed spike-rush	Halfway Creek Crossing (Priority 1)	Salvage dig, compensatory introduction	4.0	Roads and Maritime Project area	9km from Redbank Creek and Redbank northern tributary donor sites. Vegetation monitoring indicate sites suitable for the species	Disturbance from weed invasion.
	Halfway Creek (Priority 2)	Salvage dig, ameliorative enhancement	0.40	Roads and Maritime Project area	9km from Redbank Creek and Redbank northern tributary donor sites. Vegetation monitoring indicate sites suitable for the species	Disturbance from weed invasion.

2.6 Translocation planning

Planning for each translocation operation commences with a statement of aims for each and identification of objectives. Performance criteria to guide monitoring and the evaluation of success of the translocation are developed from the objectives and corrective actions are specified for the adaption of management (**Table 6**).

Table 6: Translocation planning

Species	Hairy joint-grass	Moonee Creek Quassia	Noah's false chickweed	Slender screw-fern	Square-fruited ironbark	Square-stemmed spike-rush
Aim	Create a self-sustaining population	Maintain an self-sustaining population (augment remainder of an existing self-sustaining population by expanding and linking existing patches)	Create a self-sustaining population	Maintain or create a self-sustaining population (augment an existing patch)	Maintain a self-sustaining population (expand existing population)	Maintain or create a self-sustaining population (augment existing small patch or create new population)
Objectives	Plants complete their lifecycle and regenerate successfully	Patches are expanded and linked	Plants complete their lifecycle and regenerate successfully	Plants complete their lifecycle and regenerate successfully	Cleared land adjacent to existing forest is vegetated	Plants complete their lifecycle and regenerate successfully
Performance criteria	At least 50 plants germinate and set seed each year	At least 20 plants are established in each identified section of the receiving sites	At least 100 plants germinate and set seed each year	Spore production observed each year (compare with control populations). Lateral vegetative growth observed from all transplants.	At least 500 plants are established	At least 20 plants germinate and set seed each year
Threshold	Less than 30 plants germinate and set seed in any one year	>10 plants are established in any identified section of the receiving sites	Less than 50 plants germinate and set seed in any one year	No spore production, lateral growth from <50% of transplants	< 300 plants are established by Year 3, similar lack of progress towards targets in subsequent years	Less than 10 plants germinate and set seed in any one year
Corrective action	Undertake searches for suitable local donor populations, collect seed, nursery propagate or clump transplant. Re-evaluate site moisture gradients to best target suitable planting sites.	Transplant additional specimens from seed collected in later years of the project.	Undertake searches for suitable local donor populations, collect seed, nursery propagate or clump transplant. Re-evaluate site moisture gradients to best target suitable planting sites.	Undertake searches for suitable local donor populations, clump/slab transplant. Re-evaluate site moisture gradients to best target suitable planting sites.	Propagate additional seedlings from stored seed	Undertake searches for suitable local donor populations, clump transplant. Re-evaluate site hydrology for best planting site selection or modify hydrology.
Aim	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species	Increased knowledge of the threatened plant species

Species	Hairy joint-grass	Moonee Creek Quassia	Noah's false chickweed	Slender screw-fern	Square-fruited ironbark	Square-stemmed spike-rush
Objectives	Relevant project results and observations documented.	Relevant project results and observations documented.	Relevant project results and observations documented.	Relevant project results and observations documented.	Relevant project results and observations documented.	Relevant project results and observations documented.
Performance criteria	Reporting to Include e.g. detail of growth and seeding periods and results of nursery tasks.	Reporting to Include e.g. detail of growth and seeding periods and results of nursery tasks.	Reporting to Include e.g. detail of growth and seeding periods and results of nursery tasks.	Reporting to Include e.g. detail of growth and seeding periods and results of nursery tasks.	Reporting to Include e.g. detail of growth and seeding periods and results of nursery tasks.	Reporting to Include e.g. detail of growth and seeding periods and results of nursery tasks.
Threshold	Reporting incomplete	Reporting incomplete	Reporting incomplete	Reporting incomplete	Reporting incomplete	Reporting incomplete
Corrective action	Project manager to address with sub-contractors	Project manager to address with sub-contractors	Project manager to address with sub-contractors	Project manager to address with sub-contractors	Project manager to address with sub-contractors	Project manager to address with sub-contractors
Aim		Development of new management techniques				
Objectives		Stem and root cutting trials conducted with at least 10 cuttings x 2 types (root/stem) x 3 treatments (2 hormone treatments, I control)				
Performance criteria		Sufficient material collected, treated and set up in specialist nursery facilities				
Threshold		Less than 60 cuttings set up				
Corrective action		Re-collect if practical				
Aim	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project	Achieve no net loss in local plant populations being impacted by the project
Objectives	Original number of individuals and area re-established	Original number of individuals and area re-established	Original number of individuals and area re-established	Original number of individuals and area re-established	Original number of individuals and area re-established	Original number of individuals and area re-established

Species	Hairy joint-grass	Moonee Creek Quassia	Noah's false chickweed	Slender screw-fern	Square-fruited ironbark	Square-stemmed spike-rush
Performance criteria	Compare with donor site: 70% of original cover of plants established over an area equivalent to original in Year 1, increasing to 100% cover by Year 5	Compare with donor site: 70% of original number planted out and established by year 4, 100% by Year 5	Compare with donor site: 70% of original cover of plants established over an area equivalent to original in Year 1, increasing to 100% cover by Year 5	Compare with donor site: 70% of original cover of plants established over an area equivalent to original in Year 1, increasing to 100% cover by Year 5	Compare with donor site: 70% of original number planted out and established by year 4, 100% by Year 5	5
Threshold	>50% of original cover of plants established over an area equivalent to original in Year 1 or similar levels below target in subsequent year	>50% individuals planted out and established by year 4 or similar levels below target in subsequent year	>50% of original cover of plants established over an area equivalent to original in Year 1 or similar levels below target in subsequent year	>50% of original cover of plants established over an area equivalent to original in Year 1 or similar levels below target in subsequent year	>50% individuals planted out and established by year 4 or similar levels below target in subsequent year	>50% of original cover of plants established over an area equivalent to original in Year 1 or similar levels below target in subsequent year
Corrective action	Undertake searches for suitable local donor populations, collect seed, nursery propagate or clump transplant.	Evaluate options for sourcing more propagation material from neighbouring patches, collect additional seed, following guidelines for sampling	Evaluate options for sourcing more propagation material from neighbouring patches, collect additional seed, following guidelines for sampling	Evaluate options for sourcing more propagation material from neighbouring patches, collect additional seed, following guidelines for sampling	Evaluate options for sourcing more propagation material from neighbouring patches, collect additional seed, following guidelines for sampling	Evaluate options for sourcing more propagation material from neighbouring patches, collect additional seed, following guidelines for sampling
Aim	Make the best possible use of all plant material with potential conservation value	Make the best possible use of all plant material with potential conservation value	Make the best possible use of all plant material with potential conservation value	Make the best possible use of all plant material with potential conservation value	Make the best possible use of all plant material with potential conservation value	
Objectives	Soil associated with above-ground plants transplanted.	All available seeds collected, stems harvested and roots excavated to best extent practical	Above-ground plants transplanted together with associated soil likely to contain soil-stored seeds.	All available plants harvested and transplanted to best extent practical	Seed collected from a representative sample of donor trees in sufficient quantity for all project requirements	
Performance criteria	No unsalvaged material present on ground inspection	No unsalvaged material present on ground inspection	No unsalvaged material present on ground inspection	No unsalvaged material present on ground inspection		
Threshold	More than 10% of the original material present.	More than 10% of the original material present.	More than 10% of the original material present.	More than 10% of the original material present.		
Corrective action	Project manager to address with contractors	Project manager to address with contractors	Project manager to address with contractors	Project manager to address with contractors		

3 Translocation procedures

3.1 Guidelines

Florabank Guidelines and Model Code of Practice (www.florabank.org.au) will guide seed collection, storage and basic germination techniques. The guidelines are designed for general revegetation and will be especially relevant to plantings required for general habitat restoration. Deviations from the guidelines may be appropriate when genetic management is required for threatened species and Vallee *et al.* (2004) s. 5.2.1 recommend greater restrictions on the percentages of seed to be collected from individual plants when dealing with threatened species. Reference is also made to RTA Seed Collection QA Specification R176 (also more appropriate for general habitat plantings).

The collection of seed of threatened flora species will also be guided by NSW OEH's Checklist For Bush Regeneration Activities in Habitats Including Threatened Species, Endangered Populations and Endangered Ecological Communities.

For a salvage operation, however, there is no imperative to limit collection from plants proposed for destruction

3.2 General methods

Three methods would be employed in translocating the subject species (**Table 7**):

- transplanting individuals, clumps or slabs from the project footprint to the receiving sites;
- propagation of individuals from locally collected seed; and
- propagation from cuttings.

Two species - Hairy joint-grass, Noah's false chickweed are annual species with life cycles that are driven by seasonal soil moisture variations. Accordingly, seeds may not be reliably available even during documented seeding periods. Also, Slender Screw-fern dies back in dry periods, and Square-stemmed Spike-rush develops from primarily water-dispersed seed, fresh and soil-stored and dies back in dry conditions. Two or multiple translocation options are presented for such species for adoption depending on the availability of seed and above-ground plant material when translocation is scheduled. Generally speaking, the preferred option is to slab translocate those species where this is viable (Hairy-joint grass, Noah's false chickweed, Slender screw fern and Square-stemmed spike-rush). It should also be noted that seed is available for all species suited to seed collection from other populations in proximity.

In terms of translocation schedule, the work will be done in close consultation with the construction contractor with a view to prioritising actions to meet with construction timetables and species requirements

Table 7: Translocation methods

Species	Clump/slab transplant	Seed	Cuttings
Hairy joint-grass	Clump/slab transplant	If available	
Moonee Creek Quassia		If available	Trial stem, basal stem and root cuttings
Noah's false chickweed	Clump/slab transplant		
Slender screw-fern	Clump/slab transplant		
Square-fruited ironbark		Expected to be available	
Square-stemmed spike-rush	Clump transplant		

3.3 Seed collection and propagation

Seed collection will be conducted with reference to available information of likely seeding times for the target species (**Table 8**).

Table 8: Seed availability

Species	Time for collection	Notes
Hairy joint-grass	Late autumn to early winter.	Timing of seed production is poorly documented and assumed variable as life cycle depends on timing of summer rains
Moonee Creek Quassia	March-April	Variable between years and within sites
Noah's false chickweed	Possible at any time	No information but will follow flowering, which may occur year round.
Square-fruited ironbark	All year	

Individual plants or clumps for translocation should be selected from donor site. The aim should be to maximize the capture of the genetic variation from the donor site, using spatial spread as a surrogate for genetic variation in absence of specific genetic studies or biological characteristics that suggest otherwise. In general, no constraints to collection of seed from plants proposed for destruction are necessary.

The biology of Hairy joint-grass and Noah's false chickweed indicates that fine scale genetic structuring within populations, and between nearby populations (e.g. on the same floodplain) is unlikely. For both species, seeds will disperse in floodwaters (and via other dispersal mechanisms) and can be predicted to result in constant genetic mixing over short to relatively long distances. In addition, for Hairy joint-grass, genetic research reported by Benwell (2012) concluded that there is low genetic variation between populations in Hairy joint-grass from the Ballina-Byron region.

For Moonee Creek Quassia, clonality is suspected. All available seeds should be collected from plants proposed for removal. No more than 10% of the total seed crop from remaining plants should be collected.

For Square-fruited ironbark seed collection should be undertaken from a minimum of 10 trees, avoiding hybrids, isolated trees and employing a minimum distance of 50 metres between trees identified for collection. Fruit should be inspected to ensure that shape conforms with that of Square-fruited ironbark.

A greater number of source trees is desirable but recent fire damage to the trees proposed for removal may limit options. Where seed collection from adjacent populations is necessary, similar spacing precautions to minimise risk of inbreeding should be employed.

For species unlikely to exhibit genetic structuring (Hairy joint-grass, Noah's false chickweed), supplementary seed collection from adjacent populations can take place from available sources regardless of spacing of the source plants, but should be spread to avoid local depletion of seeds. The total will be restricted to 10% of the available crop.

3.3.1 Labelling

Batches of seed will be labelled to identify origin, collector and date of collection (Vallee *et al.* 2004, s.5.2.3).

3.3.2 Seed storage

Seeds will usually be sown fresh and no special storage arrangements are required (Hairy joint-grass, Moonee Creek Quassia, Square-fruited ironbark).

If necessary, seeds of Square-fruited ironbark can readily be stored (under refrigeration) and will retain viability (Appendix 3).

3.3.3 Nursery propagation from seed

Seeds will be sown in suitable commercial seed raising mix. As no specific information is available to suggest that the inoculation with soil mycorrhizae is essential for successful nursery raising of the species for which nursery propagation and growing on is proposed, natural soil from the collection site will not be added to the seed-raising and potting mix. In several cases, the receiving sites are within or adjacent to known occurrences of the translocated plants and can be expected to contain appropriate soil fungi.

(Unnecessary soil introduction may conflict with nursery hygiene protocols. Soil in seedling mixes will introduce weeds that will be difficult to distinguish from the target species when small seedlings.)

Large seeds to be sown in trays and covered to approximately the diameter of the seed.

Medium seeds are to be sown in trays and lightly covered.

Fine seed – use the 'saturated soil medium method' whereby the pot containing the seeds is placed into a container of water until germination occurs.

Label according to species, origin and date of sowing.

3.4 Cuttings

Stem and root cuttings will be rooted with hormone treatment in specialist misting facilities. Cuttings will be employed for Moonee Creek Quassia and will be experimental, employing a number of treatments according to the quantity of material to be salvaged (excavation needed to establish availability of root material).

The project presents a unique opportunity to investigate below ground structures of this species, as one means of contributing to understanding the extent of clonality and the nature of below ground structures. The plants proposed for removal provide material for trialling of techniques for stem and root cutting propagation. A recent license for horticultural trials (**Appendix 3**) permitted the taking of only six stem cuttings per year.

All cutting material should be labelled to indicate plant of origin. Below-ground connections should be mapped as far as practical.

More information about the clonality within the patches may be available as a result of excavations. To the best extent possible with information available about sources of seedlings and rooted cuttings, plantings will be designed to mix genetic material. The existing patches are likely to already be inbred and lacking in genetic variability, but no information is available to guide recommendations to introduce material from outside the site.

3.5 Potting and growing on

Seedlings or rooted cuttings will be transplanted to pots or tubes. All plants will be labeled with ID indicating origin.

Hairy joint-grass and Noah's false chickweed (seedlings)
Transplant to pots or tubes. Seedlings should be pricked out when 0.5 to 2 cm tall.
Grow on in nursery until about 10 cm tall (Hairy joint-grass) and 7 cm tall (Noah's false chickweed).

Square-fruited ironbark (seedlings)
Prick out to large tubes when 0.5 to 2 cm tall. Grow on in nursery until about 40 cm tall.

Moonee Creek Quassia (cuttings)
Remove from mist for one week when new leaves are produced and pot on. Grow on until plants exhibit vigorous above-ground growth and have a strong root system. The species appears to be very slow growing.

3.6 Club/slab transplant

Identify the location of the sites for planting or clump/slab transplant and mark with bamboo stake and flagging tape. Site preparation will include control of weeds through the whole of the mapped area and a 5m buffer area so that site is weed free when material is introduced. Prior to arrival of slab or clump transplants areas slightly larger than the slab/clump to be excavated ready for receival. Watering may be necessary depending on the season. In the case of planting seedlings the holes will be dug on the planting day.

Where impacts from stock or feral animals are likely then fine mesh fencing is to be erected around the translocation site. The Square stemmed ironbark seedlings may require individual strong plastic tree guards to protect from browsing by wallabies or kangaroos. The Moonee Creek Quassia and other species to be planted in close proximity to the motorway may require protective barrier.

3.7 Pre-translocation receiving site preparation

Identify the location of the sites for planting or clump/slab transplant and mark with bamboo stake and flagging tape. Site preparation will include control of weeds through the whole of the mapped area and a 5m buffer area so that site is weed free when material is introduced. Identify the location of the sites for planting or slab/clump and mark with bamboo stake and flagging tape. Site preparation will include control of weeds through the whole of the mapped area and a 5m buffer area so that site is weed free when material is introduced. Prior to arrival of slab or clump transplants areas slightly larger than the slab/clump to be excavated ready for receival. Watering may be necessary depending on the season. In the case of planting seedlings the holes will be dug on the planting day.

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3.8 Transplant to field and planting

Sun-harden all nursery stock.

Slabs/clumps will be transported in plastic tubs or trays by utility to the site and where possible planted on the same day. The transplant material is to be kept moist and protected from wind during delivery.

The translocated species generally do not require fertiliser to be added on planting. Weed free mulch maybe be required for the planted Moonee Quassia and Square-fruited ironbark to assist in retaining moisture and suppress weed. Watering of these two species will be necessary on planting and may be ongoing depending on the season. The other species prefer moist soil and if season is dry then watering may be necessary.

After transplanting, individuals will be tagged with their ID code. A map of the receiving site showing the transplanted individuals identified by ID code will be prepared.

3.9 Post translocation management

After translocation all sites will require regular inspections to identify if plants require watering or protection from impacts such as grazing, fence repairs, drainage, exposure or weed invasion. If threats are identified they are to be rectified immediately. A regular weed control program is required for all receiving sites.

4 Personnel, expertise and resources

Personnel, expertise and resources have been identified and sourced to ensure the best possible outcome from the translocations (**Table 9**).

The translocations will be managed by a restoration ecologist and supervising bush regenerator who are experienced in the translocation of threatened species within the region.

Site preparation will be undertaken by a team of experienced bush regenerators who are familiar with the native and weed species which occur on the sites.

Personnel engaged to undertake the translocations hold:

- Certification at Levels 3-4 in Conservation and Land Management
- Licences to undertake seed collection, other translocation tasks and bush regeneration (Section 132C NPW Act)
- Chemical Users Certificates.
- White card

Works will be supervised by a suitably qualified restoration ecologist.

Table 9: Personnel and resources

Action	Personnel	Equipment and materials
Weed management at receiving sites	Supervising bush regenerator	Spray packs, drills and injectors, hand tools
Traffic control, signage and protective barriers/fencing	Ecologist and Principal contractor	Signs, webbing or fencing
Locate and identify receiving sites and access	Ecologist and Supervising bush regenerator	GPS Bamboo stakes and flagging tape
Map access, extent of receiving site and locations for transplanting	GIS operator	ArcGIS
Collect propagation material, seed and/or cuttings	Ecologist	Secateurs, bags, labels, esky, spray bottle water, spray bottle disinfectant.
Propagation of seed or cuttings	Certified nursery personnel and Ecologist	Nursery facilities Pots, containers, labels
Receiving site preparation	Ecologist and Bush regeneration team	Bush regeneration tools and chemical Fencing – pest exclusion or protective barrier – if required
Transplanting	Ecologist and Bush regeneration team Excavator, contractor Principal contractor – if required	Shovels, saws, secateurs, plastic tubs Utility Excavator Watering system – water cell and hoses Mulch and fertiliser – if required Bamboo stakes and tags
Receiving site maintenance	Ecologist and Bush regeneration team	Bush regeneration tools Watering system
Monitoring	Ecologist	IPad, data sheets and maps

5 Timeframe, schedule and staging

The schedule for steps in translocation is set out in **Table 10**.

Table 10: Schedule for translocation

Year	15									16											17										18										19									
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Hairy Joint-grass Section 1																																																		
Seed collection/collection of individual plants	x	x																																																
Transplant clump		x																																																
Germination/nursery growing on	x	x	x	x	x	x	x	x	x	x	x	x	x																																					
Transplant seedlings receiving site													x																																					
Receiving site preparation	x	x										x	x																																					
Habitat maintenance			x	x	x		x		x		x			x			x			x		x		x			x			x			x			x			x			x			x			x	
Monitoring measurements					x			x					x					x							x													x												
Reporting													x												x													x												
Moonee Creek Quassia Section 1																																																		
Seed collection/collection of individual plants	x	x	x																																															
Germination/nursery growing on	x	x	x	x	x	x	x	x	x	x	x	x	x																																					
Transplant into receiving site													x																																					
Receiving site preparation												x	x																																					
Habitat maintenance													x	x			x			x		x			x			x			x			x			x			x			x			x			x	
Monitoring measurements													x					x							x													x												
Reporting													x												x													x												
Noah's False Chickweed Section 1																																																		
Seed Collection/Collection of individual plants	x	x	x																																															
Transplant slab/clump		x	x																																														
Germination/nursery growing on	x	x	x	x	x	x	x	x	x	x	x	x	x																																					
Transplant into receiving site		x	x										x																																				
Receiving site preparation	x	x										x	x																																					
Habitat maintenance			x	x									x	x	x		x			x		x			x			x			x			x			x			x			x			x			x	
Monitoring measurements													x					x							x													x												
Reporting													x												x													x												
Slender Screw-fern Section 1																																																		
Collection of slab/clumps		x	x																																														
Germination/nursery growing on																																																		
Transplant into receiving site		x	x										x																																				
Receiving site preparation	x	x	x									x	x																																					
Habitat maintenance			x	x	x		x		x		x			x			x			x		x			x			x			x			x			x			x			x			x			x	
Monitoring measurements													x																																						
Reporting													x																																						
Square-fruited Ironbark Section 2																																																		
Seed collection/collection of individual plants	x	x	x	x	x																																													
Germination/nursery growing on	x	x	x	x	x	x	x	x	x	x	x	x	x																																					
Transplant into receiving site								x	x	x	x	x	x																																					
Receiving site preparation								x	x																																									
Habitat maintenance										x		x		x			x			x		x			x			x			x			x			x			x			x			x			x	
Monitoring measurements													x					x							x													x												
Reporting													x																									x												
Square-stemmed Spike-rush Section 1																																																		
Collection of individual plants	x	x																																															
Germination/nursery growing on																																																		
Transplant into receiving site	x	x																																															
Receiving site preparation	x	x																																															
Habitat maintenance			x	x	x		x		x				x	x	x				x	x	x	x	x	x	x	x			x			x			x			x			x			x			x	
Monitoring measurements						x		x					x																																					
Reporting													x																																						

6 Monitoring, evaluation and reporting

6.1 Background

Monitoring involves detecting changes and patterns overtime. This requires identifying the parameters to be monitored, gathering information and interpreting the information gathered. Monitoring will enable the identification of problems and allow early response to any problems or threats. Monitoring is also vital for evaluating translocation success (Vallee *et al.* 2004).

Translocations have been evaluated by measuring:

- vital rates (survival, growth, fecundity) of propagules (seeds, transplants)
- completion of the life cycle through flowering, fruiting, dispersal and subsequent seedling recruitment
- modeling population viability of translocated populations (Menges 2008)

The monitoring data collection outlined below will serve to measure vital rates in the relatively short timeframe (5 years) generally allocated to monitoring and evaluation tasks in a typical highway construction project.

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

- Identification
    - Genus, species and subspecies.
    - Identifier – unique plant number.
    - Location – location; easting, northing & description.
- Plant condition
    - General condition – score on a scale of 0 to 5, where 0 is dead and 5 is excellent.
    - Leaf condition – healthy/unhealthy, colour, vigour.
    - Flower/fruit – flower/fruit presence.
    - Length of new shoots – average length of new shoots (estimate) and abundance of
    - new shoots (counts or basic scale).
    - Disease symptoms – evidence of disease (including presence / absence of Myrtle
    - Rust, Cinnamon Fungus).
    - Recruitment.
    - Threats from erosion and sedimentation, dust and water quality.
    - Evidence of any other damage or disturbance.
- Site conditions
    - Plant community type.
    - Canopy cover.
    - Mid-storey cover.
    - Ground-layer cover and composition.
    - Weed abundance and composition.
    - Recruitment of canopy and mid-storey species.
    - Climatic events (e.g. drought, flood, unusually cold winter temperatures etc.).
    - Maintenance carried out – when and what kind of maintenance carried out at the site
    - since the last monitoring.
    - Any other ecological impacts.
- Site photos (from same reference locations throughout monitoring period)

Hairy joint-grass, Noah's false chickweed, Square-stemmed spike rush and Slender screw fern have good potential to complete their life cycles in the same timeframe and suitable monitoring data can be usefully evaluated. Menges recommends that comparisons with reference populations be incorporated into the evaluation.

Ideally, Menges' recommends long-term perspectives on success and an experimental framework that can provide both practical and basic knowledge. He notes that demographic data collection and analysis in restorations has great potential to elucidate causes of translocation failure and improve the prognosis of future restorations.

In drawing conclusions about the success or failure of translocations, the following factors should be considered:

- bio-physical site characteristics
- stochastic weather events, and ability to control or supplement e.g. water availability during establishment
- genetic issues (affecting the likelihood of inbreeding depression, achievement of reproductive viability, retention of local adaptation, and maintenance of evolutionary potential of translocated populations.
- ecological factors, including herbivory, disturbance and competition

Timeframe

Monitoring of the translocations would be conducted during and after construction for a minimum of 3 years, a total of approximately 5 years.

Independent oversight

Monitoring and reporting will be conducted (or overseen) by personnel independent of those undertaking the on-ground works.

Record of translocation actions and results

- Record of collection of propagules/transplants
- Germination time and %, cutting strike rate and time required,
- Nursery conditions
- Growing on period
- Planting out
- Post-planting care
- Baseline measurements of translocated plants as below.

Receiving site

- Biophysical description
- Threats (e.g. weeds, grazing)
- Management actions
- Regeneration/planting of habitat components

Reference populations

Identify and mark a sample of a reference population that can be used to compare growth and development of plants that have been translocated.

Monitoring data

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

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

- Plant condition
    - General condition – score on a scale of 0 to 5, where 0 is dead and 5 is excellent.
    - Leaf condition – healthy/unhealthy, colour, vigour.
    - Flower/fruit – flower/fruit presence.
    - Length of new shoots – average length of new shoots (estimate) and abundance of
    - new shoots (counts or basic scale).
    - Disease symptoms – evidence of disease (including presence / absence of Myrtle
    - Rust, Cinnamon Fungus).
    - Recruitment.
    - Threats from erosion and sedimentation, dust and water quality.
    - Evidence of any other damage or disturbance.
- Site conditions
    - Plant community type.
    - Canopy cover.
    - Mid-storey cover.
    - Ground-layer cover and composition.
    - Weed abundance and composition.
    - Recruitment of canopy and mid-storey species.
    - Climatic events (e.g. drought, flood, unusually cold winter temperatures etc.).
    - Maintenance carried out – when and what kind of maintenance carried out at the site
    - since the last monitoring.
    - Any other ecological impacts.
- Site photos (from same reference locations throughout monitoring period)

Note that, for species with growth forms not suited to counts and measurements of individual stems, eg Hairy joint-grass and Slender screw fern, it may be more appropriate to measure growth and development with area- and density-based measurements.

Monitoring frequency

Monitoring of the translocations would be conducted as follows: every 3 months for the first year; every 6 months in the second year and once a year thereafter.
Monitoring would be conducted during construction and after construction for a minimum of 3 years.

6.2 Performance criteria and adaptive management

The following performance criteria are derived from Vallee *et al*. (2004) with adaptation to suit the circumstances of the current project.

Propagation and record keeping
Criteria for successful propagation would include:

- the required number of transplants was available for the translocation
- correct labeling and documentation was maintained through cultivation
- techniques for successful propagation are determined
- a genetically representative collection was maintained (Vallee et al. 2004).

Salvage

All material with potential conservation value is salvaged prior to construction works having direct impact on the plants. The material is available for:

- backup in the case of failed translocation establishment
- seed banking (note additional seed can be sourced from other populations in proximity)
- trialing and research.

Short Term Criteria (to 5 years)

The translocation of each species:

- at least 70% of the transplants and enhancement introductions are surviving after the first year and 60% after five years (and arrangements for replacement from backup stock are underway in case of failure to meet this target);
- flowering and seed production (or spore production) occurs in transplanted individuals (if appropriate to species, timeframe and maturity of transplanted material)
- the translocated populations display similar growth, development and vigour to naturally occurring populations
- regeneration occurs in transplanted individuals (if appropriate to species, timeframe and maturity of transplanted material)

Habitat and threat management:

- good quality habitat restored in and surrounding the receival site;
- maintenance carried out at suitable intervals; and
- threatening processes including weed invasion controlled or eradicated.

Long Term Criteria (decades)

The timeframe of the current project will not permit the development of slow-growing species such as Moonee Creek Quassia to be followed to reproductive maturity. Annual plants, however, will complete many life cycles in timeframes of a decade or more. Details of long-term criteria are provided for information and adoption where feasible.

- translocated individuals survive to reproductive maturity;
- new seedlings or vegetative offspring are established;
- the number of individuals in the population is sustained or increased by natural recruitment;
- adequate levels of genetic fitness are maintained through generations;
- reproduction, including the production of flowers and fruit (or spores), and seed viability (spore viability) is consistent with levels in naturally occurring plants;
- natural habitat conditions are restored or maintained at the receival site.

The practical difficulties in maintaining surveillance and management over ecological timeframes contribute to uncertainties in predicting translocation success. The establishment and continuing development of plants over a period of 5 years is a realistic goal for long-lived species.

Species-specific performance criteria, thresholds signaling the need for adaptation of management and actions to correct divergence from progress towards targets are identified in Table 6.

6.3 Translocation monitoring report

An annual translocation monitoring report will be prepared and submitted to OEH.

The report will include: -

- Background and description of the translocation project (initial report)
- Translocation methods (initial report)
- Monitoring methods
- Monitoring results
- Evaluation of translocation success to date
- Identify any corrective actions required
- Recommendations for immediate and ongoing management
- General recommendations for future translocation projects

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Appendix 1 Translocation strategy comments table

Pacific Highway Upgrade – Woolgoolga to Ballina

Flora Translocation Strategy Sections 1 and 2 – 2 December 2014 to 10 March 2015

AGENCY REVIEW COMMENTS –

1) **Commonwealth Department of the Environment (DoE), 10 March 2015**
2) **Environment Protection Authority (EPA), 16 December 2014**
3) **Department of Planning and Environment (DP&E), 9 February 2015**

No.	Agency	Comments	Where addressed in report
1.	DoE	General - As previously stated, translocation is not considered a mitigation measures under the EPBC Act, and the flora individuals to be removed/translocated are considered to be impacted for the purposes of the EPBC Act. This impact must be compensated for with the provision of suitable offsets in accordance with the EPBC Act Offsets Policy.	Noted, the Strategy refers to the Biodiversity Offset Strategy for EPBC Act listed species in Section 1.1. The Biodiversity Offset Strategy, Biodiversity Offset Status Report; Biodiversity Offset Package will be submitted for approval by the Commonwealth Minister for the Environment and the Secretary of the Department of Planning and Environment.
2.	DoE	General - Based on the information outlined in this document, the Department considers that insufficient information is provided regarding the likelihood of success of the proposed translocation, as well as the suitability of sites within which the plants would be translocated. Furthermore, insufficient site specific and species specific monitoring is proposed. The information within the document is still very general and would not be considered sufficient at this stage to meet the requirements of long term trials to be undertaken to demonstrate potential success of translocation for the species.	Additional detail is provided in response to this comment: At least one and sometimes two translocation receiving sites has been identified for each specie requiring translocation, These sites are identified in section 2.5, Appendices 5 and Appendix 6 In response to concerns about species specific monitoring additional details has been included. Section 2.6 and Section 6.2 provide further detail on monitoring of translocated species, performance criteria and corrective actions. Likelihood of success of the translocation has been assessed and considered and further information has been provided in Table 4 and background in Appendix 3. The translocations are mostly salvage operations and are considered valuable experimental trials even where likelihood of success is low. (Note that impacts on the species are compensated for through the Biodiversity Offsets regardless of translocation outcome).

3.	DoE	General - Reference and comparison against the requirements of the Australian Network Plant Conservation guidelines for translocation is required in this document.	A checklist against the Australian Network Plant Conservation Guidelines has been included in Appendix 2. Further references have updated as required throughout Sections 2, 3 and 6.
4.	DoE	Page 8 - Not all threatened flora species identified within the Threatened Flora Management Plan for sections 1 and 2 are included in table. Please review and update.	Noted and the report has been updated to match with those plants identified in the Threatened Flora Management Plan. Threatened flora to be translocated is firstly identified in section 1.5 and referred to throughout the strategy.
5.	DoE	Page 11 - On what basis has *Moonee Quassia* and *Eucalyptus tetrapleura* been presumed to be successful? Please provide further justification regarding this statement, or this presumption cannot be made. Further information is required regarding the proposed translocation site and its suitability.	Translocation background is included in Appendix 3. Evidence of success is limited and likelihood of translocation success is relatively low for the slow-growing Moonee Quassia. An experimental salvage translocation will provide valuable assessment of propagation and establishment methods. Square-fruited ironbark is considered likely to establish as readily as other eucalypts, though species-specific information is not available. In both cases, translocation is proposed into habitat currently occupied by the donor species, indicating suitable habitat.
6.	DoE	Monitoring until survival and reproduction demonstrated is required.	Updated, performance criteria to demonstrate survival included in Table 6. Reproduction to be demonstrated in species with short life cycles. For Moonee Creek Quassia and Square-fruited ironbark, the five-year monitoring period will be inadequate to demonstrate reproduction, but will be adequate for establishment.
7.	DoE	Please include corrective actions.	Updated, corrective actions included in Table 6.
8	EPA	Hairy Joint-grass – the EPA supports seed collection, propagation and direct seeding. As the species is purportedly an annual it would be ineffectual to attempt direct transplanting individuals. Trials from the Ballina Bypass indicate that management of translocation sites and in-situ remnants is the critical factor in ensuring persistence.	Noted. Clump/slab transplant, even of dead material, is proposed since presence of above ground material will be indicative of soil-stored seed. Management recommendations from Ballina Bypass trials, or equivalent, will be followed to the best extent possible. (Noting that a slashing regime appropriate for pasture trials will require modification in more natural swamp sclerophyll forest edge habitat.) (Table 7, Appendix 3)
9	EPA	Maundia – the EPA agrees with the recommendations in the report, i.e. not to transplant. However as previously commented on other Pacific Highway upgrade projects effort should be directed at maintaining hydrological flows to facilitate seed dispersal. In addition drainage design should intentionally include the creation of suitable habitat to expand the known population of Maundia at the site.	Occupied Maundia habitat is present in Roads and Maritime-acquired land at Halfway Creek Crossing. Hydrological management is proposed to ensure habitat suitability is maintained and expanded. Management of the site is detailed in Appendix 6. The location is also proposed as a receiving site for additional wetland/swamp species.
10	EPA	Moonee Quassia – the EPA supports seed collection/cuttings and attempts at supplementing suitable habitat within 'likely seed dispersal and pollination range'. Although it is unclear what distance this equates to? Bolstering an existing population on conservation land may also present as a suitable option if one can be located and suitable unoccupied habitat exists. However this action may most likely be considered as part of biodiversity offset management at an offset property.	The Strategy has been revised to propose ameliorative enhancement of an existing population at Dirty Creek Range. The proposed receiving sites are adjacent to donor sites (section 2.5, Table 5, Appendix 6). Impacts to threatened species will be fully offset. These translocation management actions are additional to offsetting requirements and will not be considered as a mitigation measure to offsetting.
11	EPA	Noah's False Chickweed – the species appears to be readily translocated into areas of suitable habitat. Although suitable habitat may vary dependent on climatic conditions. The EPA supports translocation of plugs or clumps however assessment of the receiving site must consider likelihood of maintaining soil moisture regimes.	Strategy has been updated to propose a receiving site in suitable swamp habitat in Yuraygir State Conservation Area (section 2.5, Table 5, Appendix 6).
12	EPA	Slender Screw-fern – the EPA supports attempts at translocating clumps of the species that are likely to be directly impacted by the upgrade. Methodology should be consistent with those recently used on the S2W project. Given the species appears to occupy a	The strategy has been updated to include receiving sites at Kangaroo Trail Road and Halfway Creek, selected to incorporate moisture gradients associated with swamps and drainage lines (section 2.5, Table 5, Appendix 6). Roads and Maritime's experience in

		linear micro-niche adjacent to drainage lines it is critical that the upgrade does not alter the drainage in these situations at any time during construction or operation.	translocating Slender screw-fern during the Sapphire to Woolgoolga project has informed the selection of methods and receiving sites (Appendix 3).
13	EPA	Square Fruited Ironbark – the EPA supports seed collection, propagation and planting out in nearby conservation land. Salvaging of saplings/juveniles is not supported.	Noted, strategy restricted to seed propagation and planting out in a Roads and Maritime Biodiversity Offset property.
14	EPA	Square-stemmed Olax – the EPA supports the recommendation not to salvage this species.	Noted, salvage is not proposed.
15	EPA	Square-stemmed Spike-rush - the EPA supports attempts at translocating clumps of the species that are likely to be directly impacted by the upgrade. However receiving site selection must be thoroughly assessed to ensure a high likelihood that suitable conditions are likely to persist.	Updated. Receiving sites have been selected at two locations where conditions are suitable and hydrological management will ensure that habitat is maintained and expanded where possible (Appendix 6).
16	EPA	As a general comment, please ensure that impacts to extant vegetation at receiving sites is minimised and excludes any impact to threatened or ROTAP species.	Specific placement areas for species translocation will be selected in degraded areas where native vegetation is sparse and readily avoided, or in gaps between native plants. Personnel undertaking detailed planning and on-ground works will be suitably licensed and trained to ensure that impacts to threatened or ROTAP species are excluded.
17	DPE	CoA D7(a): The Strategy should be amended to include discussion on the availability of expertise.	Ecologists and bush regenerators who are licensed to collect propagation material for threatened flora species are available locally to undertake collection of seed and cuttings. Restoration ecologists and bush regenerators with relevant translocation experience with the target species or others with similar biology are also available locally (Section 4)
18	DPE	Section 4 only discusses potential translocation sites for four of the six threatened flora species. The discussion is not definitive on the suitability of the sites. The Strategy should discuss potential sites for all of the six species to be translocated, including their location and suitability (including factors taken into consideration in selecting sites), and the order of preference for each translocation site. The Strategy should also indicate the mechanisms that would be employed to ensure that the sites are not subjected to clearing and/or grazing. It is considered that if the site cannot be protected from external impacts, the site should not be deemed suitable.	Strategy is updated. Receiving sites are identified for the six species for which translocation is proposed (Table 5, Appendix 6). At least one receiving site has been selected for each species and two prioritised sites for several. Site selection and prioritisation has been based on site suitability (vegetation community and abiotic environmental conditions, proximity to donor site, security of land tenure, threats and practicality of mitigation). Security is in place for some sites (Yuraygir State Conservation Area) and will be arranged on Roads and Maritime acquired land, including an offset property and acquisitions adjacent to and within the project corridor.
19	DPE	CoA D7(b): Table 4 indicates the proposed type of translocation (e.g. by seeds, cuttings, direct planting etc) for each species and Section 3 outlines translocation procedures. To satisfy the requirements of this condition, the Strategy should include further species specific information on the methodology. For example, where it is proposed that plants will be transplanted, the Strategy should indicate whether individuals or clumps would be collected and the proportion of plants that would be transplanted, including minimum numbers. The minimum number of cuttings should also be documented along with the minimum number of plants from which seeds would be collected. In addition, any maximum limits (e.g. on the number of seedlings from any one source individual or individuals from an impacted construction area) should be described.	Strategy has been updated. Please refer to Table 7 for translocation methods, Table 6 for translocation numbers, thresholds and corrective actions.

		Details should also be provided on the number of plants, cuttings and seeds that would be collected and maintained in nurseries in the event of mortalities in the translocated species. Refer to comments on Section 3 below for additional comments on the translocation procedures.	Numbers for collection are identified to the best extent possible, based on an aim of salvaging material of conservation value. Four of the species fluctuate in their numbers seasonally, however, and precise counts and areas of clump/slab available for donor species are not possible. Methods are set out in Section 2 and Appendix 6 with species-specific objectives and performance criteria are provided in section 2.6. Seeds and cuttings will be collected from neighbouring populations should additional planting material be required in subsequent years.
20	DPE	CoA D7(d): The Strategy should indicate the process that would be implemented to ensure that appropriate compensatory habitat would be provided for Maundia and Square-stemmed Olax considering translocation is not feasible or reasonable for these species.	The Biodiversity Offset Strategy currently prioritises for EPBC Act-listed species for which a significant impact has been identified as a result of the proposal. Later developments of the strategy will address offsets for NSW listed species. Maundia and Water nutgrass are two species to be impacted but for which translocation is not proposed. Design refinements have now removed direct impact from Square-stemmed Olax. All species proposed for translocation will be included in the offsetting strategy. As an alternative to translocation, habitat enhancement including hydrological management to maintain and possibly expand habitat for Maundia at Halfway Creek Crossing (Roads and Maritime-acquired land) is planned and will be developed further through preparation of a threatened species management plan for the parcel (Appendix 6).
21	DPE	Section 1.2: This section sets out the requirements of condition D7. The condition requirements should be set out in a table with the requirements being listed in rows in the first column and the second column indicating where the conditions have been addressed in the Strategy.	Strategy updated, table included in Section
22	DPE	Section 3: This section should commence with an introductory paragraph which states that three methods would be employed in translocating the subject species: transplanting individuals from the project footprint to the recipient sites; propagation of individuals from locally collected seed and spores, and propagation from cuttings, and list which methods would be used for the different species. This section should reference the document Guidelines for the Translocation of Threatened Plants in Australia (ANPC) as appropriate. The section should then be divided into three subsections - Seed Propagation, Propagation from Cuttings and Direct Transplanting, followed by those subsections that are applicable to all species – i.e site preparation, ID code, tagging and mapping, and post-translocation management. The recommended subheadings and scope of text are described below. Section 3.1 – Seed Propagation Seed Collection This section should note that experienced, licensed seed collectors would carry out all seed collection. It should also state if any recognised guidelines would be used e.g. RTA Seed Collection QA Specification R176 (in addition to the Florabank Guidelines noted on page 14). The optimum months for seed collection should be listed for each species which will be propagated using seed collection. The section should indicate whether any types of plants would be avoided (e.g isolated plants), the proposed spatial spread for collection (e.g. more than XXX metres apart), the maximum percentage of seed crop to be collected from any one plant (where the entire	The Strategy is updated to list three methods would be employed in translocating the subject species: transplanting individuals from the project footprint to the recipient sites; propagation of individuals from locally collected seed and spores, and propagation from cuttings, and list which methods would be used for the different species. Please refer to section 3.2 and table 7. ANPC Guidelines are referenced where appropriate throughout Section 3. Section 3.1 identifies additional guidelines for seed collection. Strategy is updated to include required sections – refer sections 3.3 through to section 3.9 Seed collection and optimum timing is addressed in s.3.3. Qualifications and experience of personnel undertaking tasks are set out in Section 4. As per section 3.1, Florabank Guidelines and Model Code of Practice will guide seed collection, storage and basic germination techniques. Reference is also made to the Seed Collection QA Specification R176 and OEH's Checklist for Bush Regeneration Activities Including Threatened Species, Endangered Populations and Endangered Ecological Communities. Selection of plants for collection or avoidance is discussed in section 3.3. Seeds may be collected from outside the clearing boundary in later years if additional propagation material is required.

		plant is not proposed to be removed during construction), and whether seeds would only be collected from the plants to be impacted during construction or also include nearby plants outside of the impacted area (in the event that seed resources are insufficient). The method of seed storage should also be stated. (Also refer to comments above on condition D7(b).)	
		Include the current statement on page 14 which states that batches of seed and spore would be labelled to identify origin.	We have determined that seed storage is not likely to be necessary (section 3.3). However, a statement has been included in section 3.3 on labelling requirements for seed and spore.
		Nursery Seed Germination	
		This step should indicate if seeds would be planted in a soil mixture containing the natural soil from the collection site. It should indicate at what stage seeds propagated in seedling trays would be transplanted to tubes/pots.	The seed raising mix is discussed in section 3.3.3. It has been determined that a commercial seed raising mix will be used for seed germination as there is no mycorrhizae requirements from the natural soil bank and because of problems differentiation between weeds and threatened plants in the early growth stages.
		Transplant to Field	
		This section should indicate the height that seedlings would attain prior to transplanting.	Section 3.3 describes the height /growth requirements to be met prior to planting out seedlings/cuttings.
		3.2 Propagation from Cuttings	
		Collection Sample Strategy	
		This section should identify the maximum number of cuttings to be collected, and that stems would be rooted with hormone treatment in specialist misting facilities. It should indicate the human resources (number and specialist type) required to undertake the cuttings.	Cuttings are proposed for Moonee Quassia (refer Table 7) and at least 20 are to be placed in receiving sites (refer Table 6). The management of cuttings is detailed in section 3.4
		Growing On	
		As per text on page 14.	Section 3.5 describes the height / growth requirements to be attained before seedlings/cuttings are transplanted into the receiving sites.
		Transplant to Field	
		As per last line of text under this heading on page 14.	Section 3.8 details the transplanting to field and planting. All slab translocations into the receival sites will be undertaken within one day of their removal from the donor sites. Planting of Moonee Quassia and Square Fruited ironbark is also discussed.
		3.3 Direct Transplanting of Species	
		Collection Sample Strategy	
		Refer to comments above under condition D7(b).	
		This section should indicate the resources (human and plant and equipment) required to remove the plants, and how the plants would be preserved once collected.	Species specific information relating to the translocation of the various threatened species. The clump/slab transplant described in section 3.6 which will be used for Hairy Joint Grass, Noah's false chickweed, Slender screw fern, square-stemmed spike-rush if conditions are favourable. Seed collection and labelling is described in section 3.3 (for Hairy joint grass, Moonee Creek Quassia Square fruited ironbark, if available). Cuttings are to be used for Moonee Creek Quassia and the method is described in section 3.8. Section 3.7, 3.8 and 3.0 describe the preparation of receiving sites, the transportation and transporting needs and section 3.9, post translocation management. Table 4 details results of previous translocations. Refer also to Table 10 for a revised indicative schedule for translocation. Translocation successes are detailed in Appendix 5 for each species.

		Transportation Process This section should indicate the process of transporting the plants. Transplant to Field This section should indicate whether the collected plants would be directly transported to the translocation site for replanting or whether interim storage would take place at the collection and/or translocation site. According to Table 4, individual plants of Hairy-joint grass, Moonee Creek Quassia, Slender Screw-fern and Square-fruited Ironbark would be collected in the first part of 2015 but not transplanted until January 2016. 3.4 Preparation and Management of Translocation Sites This section should detail the activities that would be involved in site preparation e.g. what is involved in "habitat enhancement" as listed on page 14, fencing requirements, and establishment of buffer zones. It should also detail the management practices that would be employed at the translocation sites e.g. tagging, watering systems, fertilising, weed control etc. This section should also identify the ongoing resources that would be required	Section 3.8 of the report has been updated to show transportation. Generally speaking seed and cuttings will be grown on in a nursery before being transported to the receival site. Species that are proposed for slab translocation will be removed from the donor site and transported to the receival site and planted within the day. As above, clump/slab transplant described in section 3.6 which will be used for Hairy Joint Grass, Noah's false chickweed, Slender screw fern, square-stemmed spike-rush if conditions are favourable. Seed and tube stock re to be grown on in a nursery until growth/height requirements described in section 3.5 are achieved. Table 10 provides an indicative schedule of timings involved. Site-specific details for each receival site are provided in Appendix 6.These management actions include weed removal, establishment of buffer zones and fencing with mesh. The results of previous translocation successes (Appendix 3) have been used to guide translocation methods and locations. Monitoring is detailed in the performance criteria in Table 6, monitoring periods in Table 10 and the information required in monitoring reports in Section 6.
23	DPE	Table 4: Confirmation is required as to the proposed method of translocation for Hairy-joint grass, Moonee Creek Quassia, Slender Screw-fern and Square-fruited Ironbark, in particular whether individual plants would be collected and transplanted as indicated in Table 4. The table should indicate from which species cuttings would be taken and the amount of time that they would spend in the nursery.	Options for methods are provided and final choice of method will depend on timing and seed availability. Translocation methods are identified in table 7. Nursery growing on is addressed in section 3.5. Generally speaking and where feasible and possible slab translocation will be used as it relocates plants and also seed stock in the soil. Where slab translocation is not a viable option, seed collection and cuttings will be sourced for growing on in an nursery will be utilised.

Appendix 2 Compliance with translocation guidelines

Checklist for determining whether to translocate (Vallee *et al.* 2014)

A decision regarding whether or not to translocate should not be made until all the following questions have been answered:

Have all alternative management options been attempted or considered?	Alternative route options have been investigated and deign refinements have minimized impacts on threatened species
Is the taxonomic status of the taxon certain?	Yes, for all species. Some caution has been flagged re possible hybridization between *Eucalyptus tetrapleura* and *E. siderophloia.*
Is the distribution of the taxon adequately understood?	The study area has been surveyed intensively. Atlas records provide local context and the broader distributions of the species are adequately understood from survey and herbarium records.
Are threatening processes understood and can they be controlled?	Clearing and changes to hydrology are two relevant threatening processes. Management of hydrology, in particular, will be a focus of management for wetland species and possibly Slender Screw Fern.
Have potential suitable recipient sites been identified?	Yes
If considering population enhancement, do you have evidence of population decline and have you considered or attempted alternative means of increasing population size?	Population enhancement is considered here as a component of salvage translocations, in particular for Square-fruited Ironbark and Moonee Creek Quassia. Declines have been documented for both.
Have you considered the success of any previous translocation programs?	Documented in Section 9. Long term success of translocation programs has rarely been demonstrated.
Have you determined the cost of implementing the translocation program, including post translocation monitoring and management, and have sufficient funds been secured?	Roads and Maritime will be responsible for funding.

If the answer to any of the above questions is no, then the benefits and risks of proceeding without that information are to be assessed prior to making a decision to translocate.

In the context of a series of salvage translocations, the translocation is an alternative to destruction of plant material with conservation value and benefits will accrue even if all translocation objectives cannot be met. E.g. trialing of methods will provide new information about the species and improve prospects for future translocation success.

Appendix 3 Background for threatened flora species

Species are listed alphabetically by common name.

Hairy Joint-grass

Description

Hairy joint grass is a creeping grass with branching, erect to semi-erect purplish stems. Leaf-blades are 2–6 cm long, broad at the base and tapering abruptly to a sharp point. Long white hairs project around the edge of the leaf. The seed-heads are held above the plant on a long fine stalk (OEH 2014). This source considers Hairy joint grass to be a perennial which tends to die down in winter. In contrast, others believe that Hairy joint grass is predominantly an annual plant species on the North Coast of NSW, and completes its life cycle in one year (Benwell 2012, Geolink 2007). Other detail of phenology and development is provided by Geolink (2007). Seed germinates in late winter after a short dormant period. Growth occurs mainly during the summer wet season, with flowering in autumn before the whole plant dies.

Distribution

Occurs over a wide area in south-east Queensland, and on the northern tablelands and north coast of NSW, but is never common. Also found from Japan to central Eurasia (OEH 2014). Hairy Joint-grass is not known from the vicinity of the occurrence in Section 1 though it is possibly present and undetected. The nearest Atlas records are at Copmanhurst and inland from Minnie Water.

Habitat and ecology

Moisture and shade-loving grass, found in or on the edges of rainforest and in wet eucalypt forest, often near creeks or swamps (OEH 2014).

Benwell (2012) notes, however, that Hairy joint-grass now appears to have adapted to agricultural habitat, occurring mainly in grazing pasture dominated by exotic grasses. Hairy joint-grass commonly persists under a grazing regime which keeps co-occurring exotic pasture grasses low in height. In forest understorey situations, Hairy joint-grass appears to require high light levels and occurs under sparse canopies or forest edges.

Results of pre-construction surveys

Section 1

Biosis (2014) recorded Hairy joint-grass (not previously recorded in the section, probably as a result of seasonal and environmental factors):

- a single population recorded along a drainage line
- relatively small population, sparse i.e. <25% coverage
- median height 40 cm
- not reproductive

- habitat: drainage line within Swamp Forest –Swamp Mahogany/Forest Red Gum community.

Translocation history

Hairy joint-grass has been the subject of a number of translocations, most of which have been from pasture situations with receiving sites also in open grasslands. The current situation involves a population on a drainage line within a Swamp Mahogany woodland (Biosis 2014).

Large clumps of Hairy joint-grass and exotic grasses using an excavator were successfully transplanted into a prepared receiving site at Lennox Head (B. Smeuninx pers.comm).

Benwell and Mallee (2014) report successful establishment through direct seeding (limited by the availability of required seed volume) and through transplant of nursery-raised seedlings.

Trials of grazing and or slashing regimes to reduce competitive biomass produced mixed results which were confounded by an overall reduction in abundance during the dry years experienced during the trials. As well as a recognition that biomass must be maintained at a low level; the need to generate gaps in dense turf to facilitate recruitment was recognised. Any management regimes will need to be site and condition specific and adapt to climatic variables.

Maundia

(Sections 1 and 2)

Description
Perennial with rhizomes about 5mm thick and emergent tufts of leaves arising along their length. Leaves are spongy, inflated and triangular in cross section, to 80 cm long, sometimes longer, 5 - 10mm wide. Inflorescence to 10cm long and 2.5 cm wide. Carpels (female parts of flower) 6 - 8mm long, sessile, each with a spreading beak. The fruit is 1cm long to 8mm wide (OEH 2014).

Distribution
Restricted to coastal NSW and extending into southern Queensland. The current southern limit is Wyong; former sites around Sydney are now extinct (OEH 2014).

Habitat and ecology
Grows in swamps, lagoons, dams, channels, creeks or shallow freshwater 30 - 60 cm deep on heavy clay, low nutrients (OEH 2014).

- Flowers generally November to January (Benson and McDougall 2002). Northern populations rarely flower and are thought to reproduce largely vegetatively and to have limited dispersal capacity (S. Jacobs, Royal Botanic Gardens quoted in Parsons Brinkerhoff 2006).
- Flowering is in November-January and flowers are thought to be wind pollinated (Benson and McDougall 2002).
- Numerous seeds are produced between December and January in a smooth shiny dehiscent capsule (Benson and McDougall 2002).
- Diaspore is the seed and root tubers, which are probably dispersed by water (OEH 2014).
- Spreads vegetatively, with tufts of leaves arising along rhizome. Populations expand following flood events and contract to more permanent wetlands in times of low rainfall (OEH 2014).
- Associated with wetland species e.g. *Triglochin procerum* (OEH 2014).

Maundia has been reported to form dense stands rapidly and be invasive under some conditions (Romanowski 1998). The colonization and spread through a constructed drain at Port Stephens has been documented (Section 91 license application TSC Act NEHUO46) and rapid change in the distribution of Maundia has been reported in staged surveys conducted for the present highway upgrade project.

Benwell (2013) notes that recent surveys in the mid north coast have found Maundia to be more common than previously thought. The surveys investigated changes to the Maundia populations since surveys conducted by Pressey (1989) in the Lower Macleay, and found local gains and losses relating largely to changes in hydrology. Craig Harré (OEH, pers. comm. 8 Aug 14) advised that the sites surveyed included 30 wetlands where Maundia had been present.The surveys indicated that Maundia is apparently quite secure on the NSW Mid North Coast, albeit a little south of the current project. Similar intensive targeted surveys have not been conducted in the same way in the vicinity of the current Project Area, but the Threatened Species Management Plan states that moderately large populations occur within or adjacent to the project.

Implications for translocation
The biological and ecological characteristics of Maundia would appear to facilitate translocation from seed collection and nursery propagation or transplant of clumps. However, sources quoted in Benwell (2013) describe difficulties in germinating seeds, and there are practical difficulties in transplanting into a swamp environment.

Results of pre-construction surveys
The Threatened Species Management Plan documents occurrences of Maundia at 15 locations of which 11 are within the Project Area.

Section 1
The EIS records that relatively large populations were recorded in swamp forest near Cassons Creek and medium sized populations along an unnamed drainage line north of Cassons Creek.

Biosis (2014) found some variation in the location and extent of Maundia recorded during their surveys in comparison with the records provided within the EIS. They attributed the differences to temporal fluctuation in rainfall and the current extent of suitable habitat. Some previous locations were not relocated while new locations were added, for a total of seven locations.

Section 2
The Threatened Species Management Plan noted that large populations were present at Halfway Creek and Wells Crossing.

Ecosure (2014) noted comparable dissimilarities with earlier surveys. The Wells Crossing Flora Reserve population was no longer present in locations observed as dry at the time of the 2014 survey. Deeper pools adjacent (that still held standing water) still contained a large population of Maundia.

In addition, Ecosure documented:

- four small populations in pools associated with Halfway Creek
- four small populations along a permanent creek on Lot2/DP558503.

Plants were found within and adjacent to the Study Area.

Jacobs (2014) found no major changes from the EIS survey data in terms of distribution and abundance.

Translocation history
There is limited previous translocation experience to draw from. Practical difficulties of transplanting into aquatic environments have been used as a basis for not attempting translocation in a location where Maundia was found to be relatively abundant locally (Warrell Creek to Urunga)

Parsons Brinkerhoff (2006) prepared a translocation assessment for Maundia as part of the Pacific Highway upgrade, Kempsey to Eungai. By way of background, they noted that

- no translocations of this species have been successful in the past (S. Jacobs, Royal Botanic Gardens personal communication 4/4/07)
- previous attempts at cultivation of *Maundia triglochinoides* have failed (Sainty and Jacobs 2003).
- previous attempts have included collection and germination of seed with subsequent death of seedlings when transplanted.
- mature plants that have been translocated have also failed to survive. germination of seed has proved difficult (S. Jacobs, Royal Botanic Gardens personal communication 4/4/07).

While there have been trials including digging of rhizomes, a focus on seed in soil and water dispersal has appeared more fruitful. The extent of shading has also proved to influence the distribution of Maundia. The conclusion from ongoing observations of contraction in dry periods and later expansion is that the best approach may be to design hydrology carefully rather than translocating. (Options may be limited for management within the Project Area as design for this highway section is complete, but management of other known habitat could be of population enhancement value.) Local surveys may also be advisable – most of the large populations documented lie to the south of the current Project Area.

Moonee Quassia

(Section 1)

Photo by Hugh Nicholson

Description

Moonee Quassia is a slender or bushy shrub growing to about 1.5 m tall. Its stems are often kinked, showing periodic halts to growth. Its tough leaves are very narrow, about 10 cm long, and arranged alternately along the stems. They are glossy dark green above and paler below, with numerous veins at a wide angle to the midrib. Flowers are small and green tinged reddish, developing into distinctive finely hairy fruits made up of one to five radiating segments which are red when mature. Moonee Quassia is also known as *Quassia* sp. B (OEH 2014).

Distribution

Scattered distribution from the Moonee Creek area north of Coffs Harbour to north-east of Grafton (OEH 2014). Moonee Quassia is fairly locally common west of Woolgoolga. The patch from which translocation is proposed is isolated.

Habitat, ecology and horticulture

Shrubby layer below tall moist eucalypt forest and tall dry eucalypt forest, including forest edges, mostly at lower altitudes (OEH 2014).

Moonee Quassia is the larval food plant of the moth *Atteva albiguttata*. Larvae form loose webbing around branchlets of the food plant where they feed on growing tips, young growth and flower buds (Britton and Cooper 2009).

According to the Recovery Plan (DEC 2005), seeds germinate readily in horticultural situations and have been established in small numbers in e.g. botanic gardens. The species fruits March-April. Fruiting may not be reliable, apparently varying between years and within the population, perhaps according to the light environment of the plants (DEC 2005). Biosis (2014) did not observe flowering or fruiting in their surveys conducted in February and/or March (many of the plants were small and probably not reproductively mature).

OEH (2011) summarizes results of State Forests monitoring plot surveys which showed that, after 13 years, most Quassia plants persisted and grew, albeit at a very slow rate. 41% of Quassia increased or stayed the same in size over the 13 year period, 19% were smaller and 19% could not be found, and therefore were presumed to have died. 22% of plants appeared to be new recruits, and notably three new plants appeared to be seedlings, as opposed to root suckers believed to be the primary recruitment method.

To grow Moonee Quassia, fruit should be harvested when well-coloured and seeds are firm. Fruit should be soaked for several days to soften flesh and flesh removed. Seeds should be assumed to have limited viability, in absence of clear information to the contrary, and therefore sown promptly. Steve Malloy (horticulturalist, pers. comm. 18 March 2015) has observed that seedlings send down a single tap root until they strike an obstacle, at which point they divide. Tap roots may go down to a depth of 1 m.

DEC (2005) notes that the root system of mature Moonee Quassia is massive and it is likely that the plant can vegetatively reproduce by suckers and coppicing in response to disturbance. Together with other field observations of small shoots in radial configurations around main stems, it appears likely that many patches and clumps of the plants are clonal.

In limited trials, Steve Malloy has had no success with cuttings (using misting and a variety of treatments. He reports complete failure with green material and one short term success with a cutting from basal material. He considers transplant to be impossible. Micropropagation is recommended for trial.

Results of pre-construction surveys
The Threatened Species Management Plan documents an occurrence along a rocky drainage line and surrounding rocky slopes in Section 1. A total of 899 stems and 2 clusters were recorded.

Biosis recorded occurrences of Moonee Quassia that were additional to the locations recorded in the EIS. Moonee Quassia was documented on private land (Lot 241 on DP705683 and Lot 1021 in DP 1150718) with locations identified in seven patches.

The habitat was the Needle bark – Stringy bark community.
Jacobs (2014) found no major changes from survey data reported in the EIS.

Translocation history
No examples of translocations are available. The species has a very restricted distribution, and, while it occurs close to the highway to the south of the current project, impacts were avoided during Coffs2Woolgoolga construction (Craig Harré OEH pers. comm. 8 Aug 14)

Seed propagation and establishment at the Coffs Harbour Botanic Gardens is documented in the Recovery Plan.

Noah's False Chickweed

(Section 1)

Description
Diffuse or erect annual herb to 15 cm high (OEH 2014) or 30 cm in height (Mamott 2011).
Leaves are opposite, 5-10 mm long and 1.5-5 mm wide, oval-shaped to more or less circular at the base of the plant and almost linear near the flowers. There are 3 veins from the base of the leaf. The leaf stalk is 3 mm long. There are 1-8 blue and white hooded and lobed flowers, approximately 5.5-8.5 mm long. Flowers spring and autumn (OEH 2014). Capsule 2mm long, ovoid with numerous dust sized seed. Generally less than 10 flowers per plant. Tends to flower year round in most populations (Mamott 2011).

Distribution
Recorded in coastal areas from Bulahdelah to Coopernook and with occurrences further north at Shannon Creek west of Coutts Crossing and also at Bungawalbyn (OEH 2014). Williamstown is its known southern extent with confirmed populations known from Pacific Palms, Forster and Coopernook in Port Stephens, Great Lakes and Greater Taree LGAs (Mamott 2011). Noah's False Chickweed is also found in Queensland (Scientific Committee's determination). Population sizes vary from low thousands to low hundreds to <10 plants at a Port Stephens site (Mamott 2011). A small occurrence was documented adjacent to the project area in Section 2 (Jacobs 2014).

Habitat and ecology
Grows in swamp forests and wetlands along coastal and hinterland creeks (OEH 2014). Mamott (2011) states that Noah's False Chickweed is thought to be a post-disturbance coloniser, and is typically found around the edges of dunal Swamp Sclerophyll Forest communities *(Eucalyptus robusta – Melaleuca quinquenervia)* that fringe freshwater wetlands and within regenerating Swamp Sclerophyll Forests that have been subject to disturbance events (eg. storms that have created canopy gaps or slashing/clearing). Also found in shallow dunal depressions (swales), generally waterlogged (or in moist soils) with surface water depths up to 50mm (occasionally completely inundated for short periods).

Mamott (2011) provides details of co-occurring species and notes that the plants tend to gradually senesce once a canopy re-establishes and that the species is thought to remain dormant in the soil seedbank until favourable germination conditions return.

The occurrence of Noah's false chickweed at an inland location at Shannon Creek suggests that habitat tolerances must be broader than suggested by the quoted sources.

Mamott also notes that:

- most populations appear to be hermaphroditic (androgynous)
- pollinator(s) unconfirmed but suspected to be small native bees
- localised distribution, stamen-stigma morphology and suspected low to moderate pollen/ovule ratios suggest a degree of self crossing pollination
- successfully hand pollinated
- suspected to be fire sensitive.

Results of pre-construction surveys
Noah's false chickweed was not recorded from the Project Area prior to Jacobs' surveys, apparently reflecting optimal habitat conditions at the time of Jacobs' surveys. Relatively large areas of swampy habitat were shallowly inundated along Red Bank Creek and tributaries in Section 1.

Translocation history
Mamott (2011) reported successful *ex situ* cultivation and re-introduction into suitable habitat (successful salvage and re-introduction). Clumps or plugs can be harvested, grown in cultivation and re-introduced to suitable (carefully selected, swampy) habitat. Success was demonstrated over approximately 12 months of monitoring (Isaac Mamott, Sclerophyll Flora Surveys and Research Pty Ltd, pers. comm. 27 October 2014).

Slender Screw Fern

(Sections 1 and 2)

Photo by Hugh Nicholson

Description

Slender screw-fern is a delicate-looking ground fern with a creeping underground root. The light-green fronds are slender, up to 30 cm long, and stand erect or tangled through other vegetation. Divided fan-shaped leaflets are spaced along the stems, often in pairs. The leafless part of the stem is straw-coloured, darker at the base, and is much shorter than the frond length. The spores are produced under membranous flaps on the lobes of some of the leaflets (OEH 2014).

Translocation could involve transplants from the field and/or propagation from spores. To collect spores for propagation, place a mature frond in a folded sheet of paper and keep in a warm dry position for a few days (Jones and Clemesha 1989). The same reference provides details for germination and growing on (there are many other references and specialist nurseries or research institutions with necessary facilities must be engaged). These are general methods. No specific information for *Lindsaea* species is available.

Distribution

In NSW it is known only from a few locations between Woombah and just south of Coffs Harbour. Also occurs in north and south-east Queensland (OEH 2014). Slender screw-fern is moderately abundant in the vicinity of the Section 2 population to be translocated. The fern is fairly widely distributed, though in restricted habitat, being quite abundant around Glenreagh, the south end of Yuraygir National Park and at Tucabia. There are scattered occurrences further north.

Habitat and ecology

Dry eucalypt forest on sandstone, and moist shrubby eucalypt forest on metasediments. It is usually found in waterlogged or poorly drained sites along creeks, where ferns, sedges and shrubs grow thickly (OEH 2014).

Although endangered, individual populations can be very large, with thousands of individuals growing amongst sedge- and grass-dominated communities close to creeks and gullies. As the species is small and grows amongst dense and taller rush and sedge communities, it can be difficult to detect (Ecosure 2014). Roads and Maritime's EIS found that the species was readily detectable irrespective of season and reproductive status. Slender Screw Fern dies off during times of drought and re-grows following rain events.

Results of pre-construction surveys

Section 1

Jacobs' (2014) record for Slender Screw Fern was the first and only documentation of the species in Section 1, and was attributed to optimal habitat conditions at the time of the survey.

Section 2

The Threatened Species Management Plan documents two populations along the edges of drainage swales with sandy soils. They were:

- a large population extending into the boundary on the western side of the highway opposite Lemon Tree Road
- a small patch 12 metres upstream to the east of the project on an elevated area in the centre of Halfway Creek.

Ecosure (2014) recorded three populations

- a large population containing some hundreds of plants was found in swamp mahogany forest in the Wells Crossing Flora Reserve (Lot111/DP751368), in the same location as recorded in the EIS.
- two populations of 5 x 5 m and 3.5 x 10 m each containing some hundreds of plants in swamp mahogany forest in Lot13/DP879175.
- Jacobs (2014) recorded plants in Section 2.

Translocation history

Background references suggest that members of the genus generally do not tolerate disturbance and are difficult to cultivate (Jones and Clemesha 1989). For the Tugun bypass (SMEC), translocation was attempted for *Lindsea ensifolia* – 18 plants were salvaged and grown in nursery pots for an unspecified time. Of 15 plants planted out in 2005, none were surviving in 2011.

Ecos Environmental has, however, recently successfully translocated Slender Screw Fern. The translocation was conducted in a very wet period, and it is too early to evaluate (Craig Harré, OEH, pers. comm. 8 August 2014). The methods are set out in Ecos Environmental (2010) with evidence of early expansion of some transplanted clumps provided in Benchmark (2013).

Square-fruited Ironbark

(Section 2)

Photo by Hugh Nicholson

Description

This tree may grow to over 30 m tall but is usually smaller than other ironbarks. The deeply furrowed bark is dark brown or black and extends to the small branches. It is more flaky than the typically hard bark of other ironbarks. Adult leaves are up to 20 cm long, curved and dull green on both sides. The four-angled buds have distinctively small caps that protrude at the end. The 1 cm long, conical or pear-shaped fruits also have four angles (OEH 2014). The year round availability of seeds (as is typical for eucalypts at the general latitude of the study area) is confirmed from examination of specimens and a seed collection at the Coffs Harbour Regional Botanic Gardens (Lindy Hills and Alex Floyd, CHRBG, pers. comm., September 2014). They further advise that seeds retain viability in storage and should be kept under refrigeration. Seeds collected in 1991 still germinate at 30% at 28 days.

Capsules can be collected at any time of the year, enclosed in large paper bag and kept in a warm dry location for several days until seeds are released.

Ecosure (2014) note a superficial resemblance to Grey ironbark *E. siderophloia* and Red ironbark *E. fibrosa,* both of which commonly occur in similar habitat.

Distribution

Restricted to the coastal lowlands and foothills of northern NSW around Casino and Grafton (OEH 2014). Square-fruited ironbark is well documented to the north of Halfway Creek and inland from Coutts Crossing, also around Tucabia. The Section 2 population continues into the adjacent land where a fairly extensive occurrence is present. Ecosure (2014) recommend seed collection from the two southerly sub-populations since they detected a possibility of hybridisation (with Grey ironbark) from the most northerly stands of the species.

Habitat and ecology

Dry or moist eucalypt forest on moderately fertile soil, often in low areas with poor drainage (OEH 2014). Square-fruited ironbark occurs in a wide range of habitats, from sandstone escarpments to drainage lines and clayey soils. Where habitats appear to be well-drained, it is possible there is a layer of sand or loam covering seepage or clay impede drainage (A. Carty, Jacobs, pers. comm. 26 May 2015).

Results of pre-construction surveys

The Threatened Species Management Plan reported that several populations are known near the

existing Pacific Highway in Section 2. The population was found to extend into the surrounding private properties and state forest including Wells Crossing Flora Reserve.

Ecosure (2014) noted the similarity of Square-fruited ironbark to other co-occurring ironbarks, so that identification was difficult in absence of fruits or buds (both of which are very distinctive).

The Square-fruited ironbark occurred in a range of vegetation communities and a few were located along the roadside. Vegetation communities were:

- spotted gum/ironbark forest,
- orange gum forest including areas of regrowth,
- needlebark stringybark/red bloodwood woodland
- narrow-leaved red gum forest
- swamp mahogany forest
- spotted gum/grey box forest.

Ecosure (2014) found three distinct sub-populations, all north of Halfway Creek.

The most northerly sub-population contained trees that were possible hybrids with Grey ironbark (based on bud and fruit characteristics) but no evidence of hybridisation was found in the two more southerly populations.
Jacobs (2014) found no major changes from previous (EIS) surveys in terms of distribution and abundance.

Translocation history
No examples of translocations are available. Square-fruited ironbark is assumed readily propagated from seed and amenable to establishment from nursery grown stock.

The difficulty in establishing a confident identification may not prove to be an impediment to successful translocation, as, if seed propagation is pursued, fruiting material is a pre-requisite and identification will be confirmed.

Square-stemmed Olax

(Section 2)

Photo by Hugh Nicholson

Description

Square-stemmed Olax is an upright shrub, which may be parasitic on the roots of other plants. Its stiff branches are often yellowish in colour, with prominent U-shaped ridges. The branchlets are square in cross-section and are yellow-green or blue-green like the leaves. The leaves are stalkless, arranged alternately, and are smooth, brittle and oval-shaped with a tiny point at the end. Small white flowers are often present with the fleshy, egg-shaped, one-seeded fruits (OEH 2014).

Distribution

Known from a small area east of Grafton, near Minnie Water and Wooli, mainly in Yuraygir National Park and on nearby leasehold land. Locally common. Also known from an area north of Grafton in Banyabba Nature Reserve, Fortis Creek National Park and adjoining freehold land (OEH 2014). The species is locally common in these areas, with the main population near Minnie Waters comprising about 5500 individuals, while only about 10 plants are known from Banyabba NR (DEH 2008).

Habitat and ecology

Low-lying coastal heaths and heathy woodlands on sandy soils near swamps, often in association with Wallum Banksia *Banksia aemula* (OEH 2014). Mixed responses to fire have been reported, including recovery from basal stem buds and from soil-stored seed (Sheringham and Westaway 1995), but also apparent failure to recover from severe burning Quinn *et al.* (1995).

Results of pre-construction surveys

Jacobs (2014) found no major change from the survey data reported in the EIS. One individual was located in the Project Area – the plant had died back being smothered by a fallen tree and with only 1-2 shoots regenerating.

Ecosure (2014) did not locate this plant.

Square-stemmed Spike-rush

(Section 1)

Description
A tufted perennial plant distinguished by its slender four-angled stem and broad spikelet on top of the stem. Stems grow 30 to 100 cm tall and are 1 – 1.5 mm in diameter (OEH 2014).

Approximately 5-7 new culms arise from the rhizome, grow up to one metre in height and complete flowering and fruiting in one year, after which the culms die and decay. (NSW NPWS 1999).

Dissection of a clump of Square-stemmed Spike-rush indicates that clumps arise form the continued formation of axillary buds from the established rhizomes. Axillary buds are known to be capable of elongating up to 100 mm before forming a new rhizome and a tuft of culms (NSW NPWS 1999).

The leaves are at the base of the stem and are not very conspicuous, being reduced to tubular sheaths. The spikelet is 10 – 20 mm long and 3.5 – 5mm in diameter. The seeds are contained within the spikelet and are a shining yellow or brown colour, approximately 1.5 mm long and 1 mm wide (OEH 2014).

Observations at Boambee near Coffs Harbour (NSW NPWS 1999), were that flowering spikelets are present and obvious in October and flowering was completed by April. On average, a spikelet of Square-stemmed Spike-rush contained approximately 60 flowers of which 75% contained a seed. Mature seed was found in spikelets collected in early January and at the end of April, though not all seed was mature in fruit collected in April. Seeds remain on the spikelet and until such time as the glume and its enclosed flower separates from the spikelet, thus releasing the seed for dispersal. Most spikelets observed at Boambee had not begun to separate by the end of April, whereas separation of spikelets from the previous year's flowering was generally complete. Fruiting inflorescences thus appear to be present for much of the year and dispersal could take place at any time.

Likely dispersal mechanisms are through water (short distances), attachment to, or ingestion by, birds or mammals (NSW NPWS 1999).

Vegetative reproduction may be an essential strategy for maintenance of a local population following initial establishment from seed (NSW NPWS 1999). The species is probably wind-pollinated and unlikely to be to be obligatorily out-breeding (NSW NPWS 1999).

Habitat and ecology
Square-stemmed Spike-Rush is found in damp locations on stream edges and in and on the margins of freshwater swamps (OEH 2014).

Bell *et al.* (2000) undertook trials of management and disturbance treatments at Boambee and found some evidence that hand weeding and mowing benefited the growth and development of Square-stemmed Spike-Rush, and that the species is very sensitive to glyphosate. Seed distribution in the soil seed bank was very patchy and concentrated near existing above-ground plants.

In the case of translocation of Square-stemmed Spike-rush, Cardno (2008) recommend that rhizomes be dug during the dormant phase of the lifecycle (winter) when plants appear to be least impacted by root disturbance. Bell *et al.* (2000) found that plants are relatively resilient to disturbance events and can be translocated and grown in pots with a high survival rate.

Distribution
Thought to be extinct in NSW until it was rediscovered in 1997 at Boambee. It has since been found in other north coast localities near Grafton and Murwillumbah (OEH 2014), also Lennox Head (Cardno 2012). The species also occurs in south-east Queensland (OEH 2014). The Copmanhurst (near Grafton) population is the occurrence nearest to the plants proposed for translocation.

Results of pre-construction surveys
On edges of ponds and in riffle habitats between ponds along several creek lines at Corindi Creek. In around 11 different locations in moderate to high abundance (Biosis 2014).

There was some variation in the location and extent of Square-Stemmed Spike-Rush recorded during Biosis' surveys in comparison to the records provided within the EIS. This species is a wetland plant and the observed differences in its occurrence within the Study Area can be attributed to temporal fluctuation in rainfall and the current extent of suitable habitat.

Biosis (2014) found that a number of small sparsely distributed clumps of this species were recorded within Swamp Forest –Swamp Mahogany/Forest Red Gum where previous locations had been recorded. However, plants were not always at the previous recorded locations, which may be a result of seasonal fluctuations in inundation and individuals becoming dormant in the soil. A new population of this species was also recorded from within a culvert associated with the existing Highway.

Jacobs (2014) similarly found differences from the survey results reported in the EIS, attributable to optimal habitat conditions at the time of the Jacobs survey.

Translocation history
There is limited previous translocation experience to draw from. Translocation has been proposed at the Pacific Pines estate, Lennox Head, but has not yet been implemented (Cardno 2008; Ian Gaskell, Ballina Shire Council, pers. comm.).
Di Brown, OEH (pers. comm. 15 Oct 2014) reports that Square-stemmed Spike-rush translocates fairly easily by clump transplant, but dies back when habitat conditions change, eg when canopy closes. Lightly grazed pasture is suitable habitat.

Water nutgrass

(Sections 1 and 2)

Photo by Hugh Nicholson

Scientific name: *Cyperus aquatilis*
Conservation status in NSW: Endangered
Commonwealth status: Not listed
Profile last updated: 07 Sep 2012

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

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

Habitat and ecology
Grows in ephemerally wet sites, such as roadside ditches and seepage areas from small cliffs, in sandstone areas (OEH profile).

Results of pre-construction surveys
The identification and location of this ephemeral species is uncertain (Ecosure 2014, Jacobs 2014).

Translocation history
Water nutgrass was translocated during the Tugun Bypass using soil seed bank translocation techniques, incorporating smoke water and/or fertiliser treatments as well as untreated controls. The translocation was unsuccessful, partly attributed to run-off impacts during construction as well as weed competition (SMEC 2011).

Appendix 4 Site summary

Section	Northing	Location	Species	Clearing Area		Project Area (outside clearing)		Outside project area		Receiving site
				No individuals	Area (ha)	No individuals	Area (ha)	No individuals	Area (ha)	
1	6679600	Corindi Creek	Maundia	3	0.075	0	0.013	57	0.120	n/a
	6679600	Corindi Creek	Slender screw fern	2820	0.013	0	0	1217	0.003	Kangaroo Trail
	1									Halfway Creek
1		Redbank Creek	Maundia	2	0.028	0	0.002	21	0.048	n/a
1	6680300	Redbank Creek	Noahs false chickweed	0	0	0	0	30	0	n/a
1	6680300	Redbank Creek	Square-stemmed spike-rush	185	0.041	0	0	30	0.014	Halfway Creek Crossing
										Halfway Creek
1	6680900	Redbank northern tributary	Hairy joint-grass	2	0	0	0	0	0	Kangaroo Trail
										Halfway Creek Crossing
1	6680900	Redbank northern tributary	Noahs false chickweed	1811	0	1	0	239	0	Yuraygir SCA
1	6680900	Redbank northern tributary	Square-stemmed spike-rush	68	0.774	37	0.034	154	1.155	Halfway Creek
										Halfway Creek crossing
1	6680900	Redbank northern tributary	Water nutgrass	1	0.021	0	0	0	0.011	n/a
1	6682000	Dirty Creek Range south	Moonee Quassia	0	0	161	0.110	21	0.021	n/a
1	6682200	Dirty Creek Range north	Moonee Quassia	73	0.080	604	0.305	428	0.1478	Dirty Creek Road Reserve
	6686780	Halfway Creek	Square-stemmed spike-rush	0	0	4	0.008	0	0	n/a
2	6688400	Halfway Creek rest area	Slender screw fern	0	0	410	0.024	20	0.034	n/a
2	6688800	Halfway Creek rest area north	Maundia	7	0	0	0	3	0	n/a
2	6690400	Halfway Creek crossing	Maundia	12	0.020	7	0.033	34	0.980	n/a
2	6690650	Halfway Creek crossing nth	Water nutgrass	5	0.003	0	0	0	0	n/a
2	6692400	Wells Crossing	Square-fruited ironbark	302	4.355	238	4.510	99	extensive	Glenugie offset property
2	6692400	Wells Crossing	Maundia	15	0.056	13	0.031	118	0.067	n/a
		Wells Crossing	Noahs false chickweed	0	0	0	0	104	0	n/a
		Wells Crossing	Slender screw fern	0	0	0	0	1002	0.011	n/a

Section	Northing	Location	Species	Clearing Area		Project Area (outside clearing)		Outside project area		Receiving site
				No individuals	Area (ha)	No individuals	Area (ha)	No individuals	Area (ha)	
2	6693150	Wells Crossing north	Square-fruited ironbark	7	0.022	1	0	0	0.057	Glenugie offset property
		Wells Crossing north*	Square-stemmed Olax	0	0	1	0	0		n/a
2	6694000	Bald Knob Tick Gate Road south*	Square-fruited ironbark	170	5.045	28	1.436	16	extensive	
	6694000	Bald Knob Tick Gate Road south	Water nutgrass	1	0	0	0	0	0	n/a
2	6695100	Bald Knob Tick Gate*	Square-fruited ironbark	3	0.215	18	2.595	2	extensive	
2	6695500	Glenugie south*	Square-fruited ironbark	2	0.341	0	0.058	2	extensive	
2	6696500	Glenugie*	Square-fruited ironbark	83	7.128	16	2.650	0	extensive	
2	6697300	Franklins Road*	Square-fruited ironbark	205	3.320	62	1.364	23	extensive	
2	6697800	Franklins Road north*	Square-fruited ironbark	52	0.426	33	0.678	8	extensive	

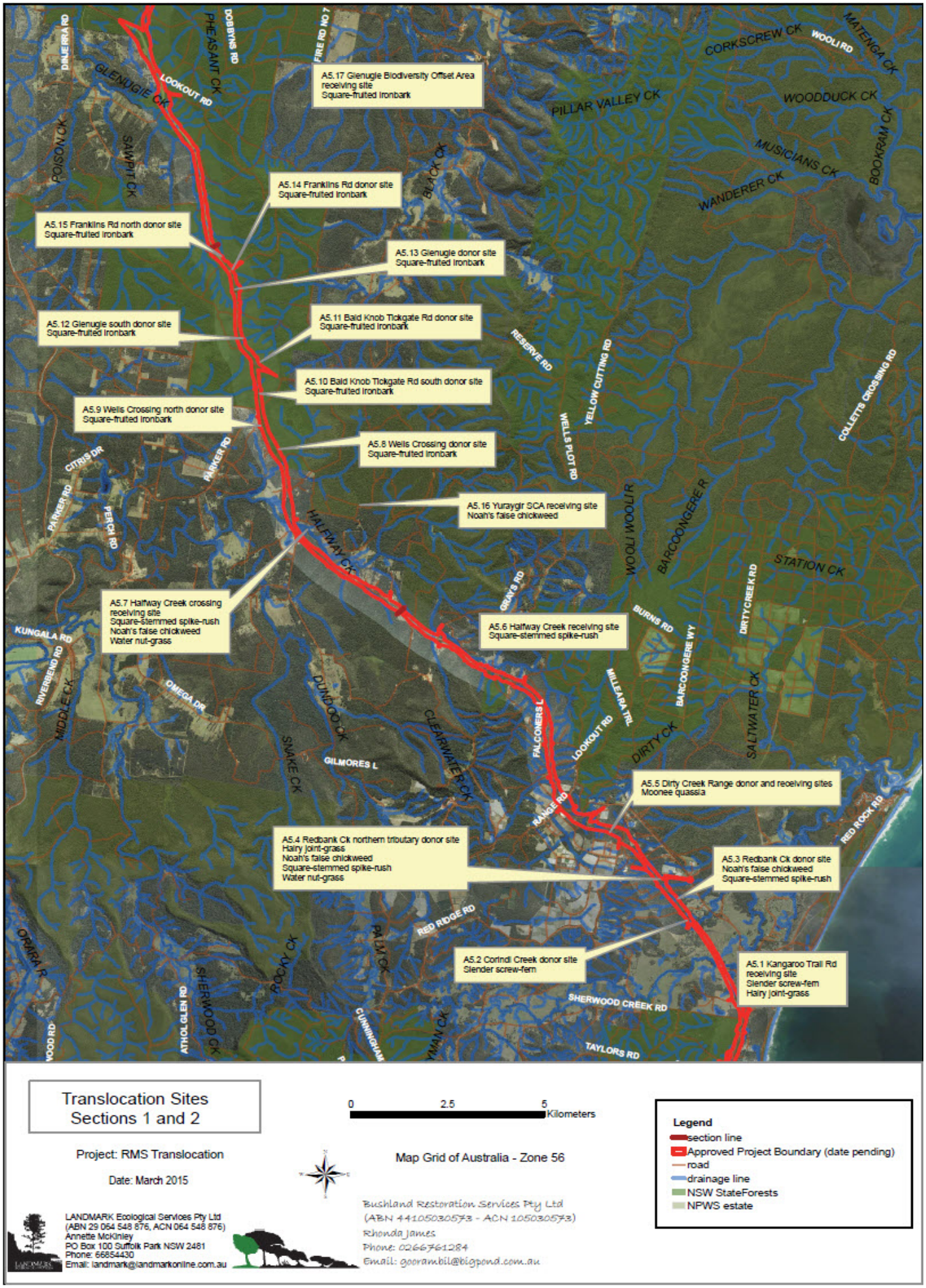
* seed not collected where hybrids are suspected

Appendix 5 Maps of donor and receiving sites

Donor and receiving sites overview

Map Name	Donor Site	Receiving Site	Donor species	Candidate species for receiving site
A5.1 Kangaroo Trail Rd	n	y		Slender screw-fern, Noah's false chickweed
A5.2 Corindi Ck	y	n	Slender screw-fern	
A5.3 Redbank Ck	y	n	Square-stemmed spike-rush	
A5.4 Redbank Ck northern tributary	y	n	Square-stemmed spike-rush, Noah's False Chickweed, Slender screw-fern	
A5.5 Dirty Creek Range north and south	y	y	Moonee Quassia	Moonee Quassia
A5.6 Halfway Creek	n	y		Square-stemmed spike-rush
A5.7 Halfway Creek crossing	n	y		Square-stemmed spike-rush, Noah's false chickweed, Water nutgrass
A5.8 Wells Crossing	y	n	Square-fruited ironbark	
A5.9 Wells Crossing north*	y	n	Square-fruited ironbark	
A5.10 Bald Knob Tickgate south*	y	n	Square-fruited ironbark	
A5.11 Bald Knob Tickgate*	y	n	Square-fruited ironbark	
A5.12 Glenugie south*	y	n	Square-fruited ironbark	
A5.13 Glenugie*	y	n	Square-fruited ironbark	
A5.14 Franklins Rd*	y	n	Square-fruited ironbark	
A5.15 Franklins Rd north*	y	n	Square-fruited ironbark	
A5.16 Yuraygir SCA	n	y		Noah's false chickweed
A5.17 Glenugie offset	n	y		Square-fruited ironbark

* will not be used as donors where hybrids are present


A5.17 Glenugie Biodiversity Offset Area receiving site
Square-fruited Ironbark
A5.14 Franklins Rd donor site
Square-fruited Ironbark
A5.15 Franklins Rd north donor site
Square-fruited Ironbark
A5.13 Glenugie donor site
Square-fruited Ironbark
A5.12 Glenugie south donor site
Square-fruited Ironbark
A5.11 Bald Knob Tickgate Rd donor site
Square-fruited Ironbark
A5.10 Bald Knob Tickgate Rd south donor site
Square-fruited Ironbark
A5.9 Wells Crossing north donor site
Square-fruited Ironbark
A5.8 Wells Crossing donor site
Square-fruited Ironbark
A5.16 Yuraygir SCA receiving site
Noah's false chickweed
A5.7 Halfway Creek crossing receiving site
Square-stemmed spike-rush
Noah's false chickweed
Water nut-grass
A5.6 Halfway Creek receiving site
Square-stemmed spike-rush
A5.5 Dirty Creek Range donor and receiving sites
Moonee quassia
A5.4 Redbank Ck northern tributary donor site
Hairy joint-grass
Noah's false chickweed
Square-stemmed spike-rush
Water nut-grass
A5.3 Redbank Ck donor site
Noah's false chickweed
Square-stemmed spike-rush
A5.2 Corindi Creek donor site
Slender screw-fern
A5.1 Kangaroo Trail Rd receiving site
Slender screw-fern
Hairy joint-grass
GLENUGIE CK
LOOKOUT RD
PHEASANT CK
DOBBYNS RD
FIRE RD NO 7
DINUERRA RD
POISON CK
SAWPIT CK
BLACK CK
PILLAR VALLEY CK
CORKSCREW CK
WOOLI RD
MATENGA CK
WOODDUCK CK
MUSICIANS CK
BOOKRAM CK
WANDERER CK
RESERVE RD
YELLOW CUTTING RD
WELLS PLOT RD
COLLETTE CROSSING RD
CITRIS DR
FARRER RD
PERCH RD
HALFWAY CK
WOOLI WOOLI R
BARCOONGERE R
STATION CK
GRAYS RD
BURNS RD
DIRTY CREEK RD
KUNGALA RD
RIVERBEND RD
MIDDLE CK
OMEGA DR
DUNDOO CK
SNAKE CK
GILMORES L
CLEARWATER CK
FALCONERS L
LOOKOUT RD
MILLEARA TRL
BARCOONGERE WY
DIRTY CK
SALTWATER CK
RANGE RD
RED ROCK RD
RED RIDGE RD
ORARA R
PALM CK
ROCKY CK
SHERWOOD CK
ATHOL GLEN RD
CUNNINGHAM
SHERWOOD CREEK RD
TAYLORS RD
WOOD RD
Translocation Sites
Sections 1 and 2
Project: RMS Translocation
Date: March 2015
0
2.5
5
Kilometers
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Legend
section line
Approved Project Boundary (date pending)
road
drainage line
NSW StateForests
NPWS estate
LANDMARK Ecological Services Pty Ltd
(ABN 29 054 548 876, ACN 054 548 876)
Annette McKinley
PO Box 100 Suffolk Park NSW 2481
Phone: 66654430
Email: landmark@landmarkonline.com.au
Bushland Restoration Services Pty Ltd
(ABN 44105030573 - ACN 105030573)
Rhonda James
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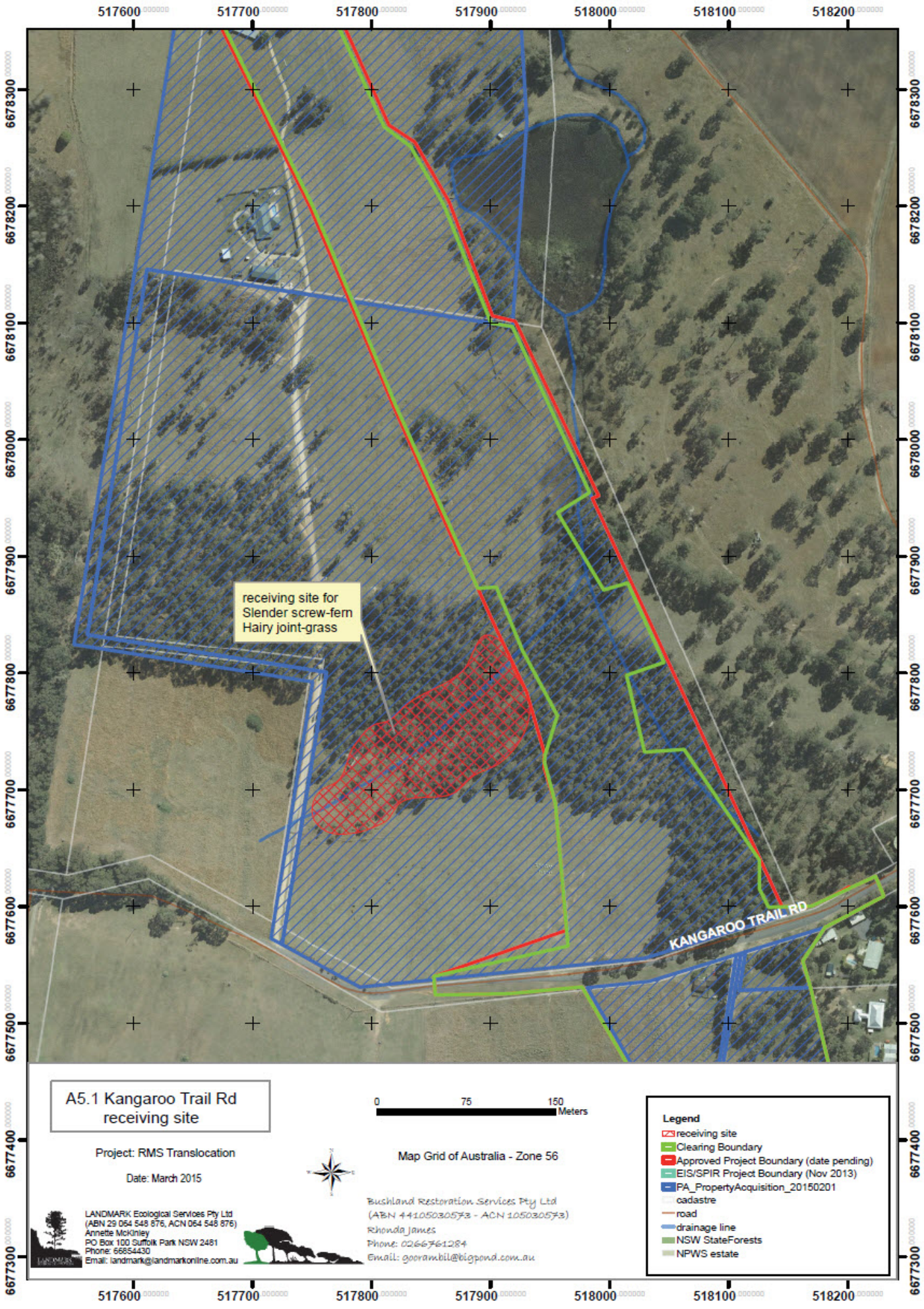
Email: goorambil@bigpond.com.au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6677600
6677500
6677400
6677300
receiving site for
Slender screw-fern
Hairy joint-grass
KANGAROO TRAIL RD
A5.1 Kangaroo Trail Rd
receiving site
Project: RMS Translocation
Date: March 2015
0
75
150
Meters
Map Grid of Australia - Zone 56
LANDMARK Ecological Services Pty Ltd
(ABN 29 064 548 876, ACN 064 548 876)
Annette McKinley
PO Box 100 Suffolk Park NSW 2481
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Email: landmark@landmarkonline.com.au
Bushland Restoration Services Pty Ltd
(ABN 44105030573 - ACN 105030573)
Rhonda James
Phone: 0266761284
Email: goorambil@bigpond.com.au
Legend
receiving site
Clearing Boundary
Approved Project Boundary (date pending)
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road
drainage line
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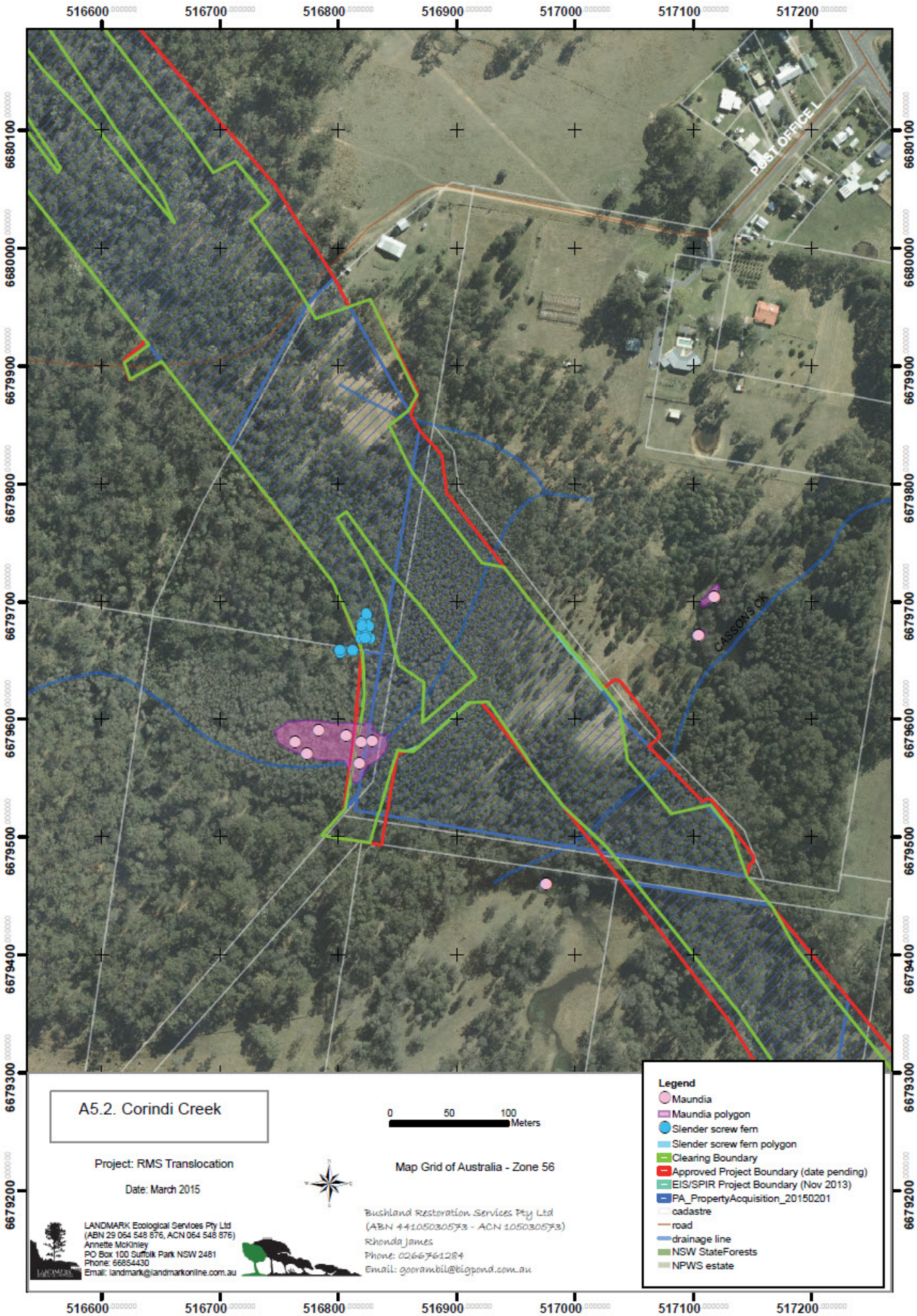
NPWS estate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6679200
POST OFFICE L
CASSONS CK
A5.2. Corindi Creek
Project: RMS Translocation
Date: March 2015
0 50 100 Meters
Map Grid of Australia - Zone 56
LANDMARK Ecological Services Pty Ltd
(ABN 29 064 548 876, ACN 064 548 876)
Annette McKinley
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(ABN 44105030573 - ACN 105030573)
Rhonda James
Phone: 0266761284
Email: goorambil@bigpond.com.au
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Maundia
Maundia polygon
Slender screw fern
Slender screw fern polygon
Clearing Boundary
Approved Project Boundary (date pending)
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road
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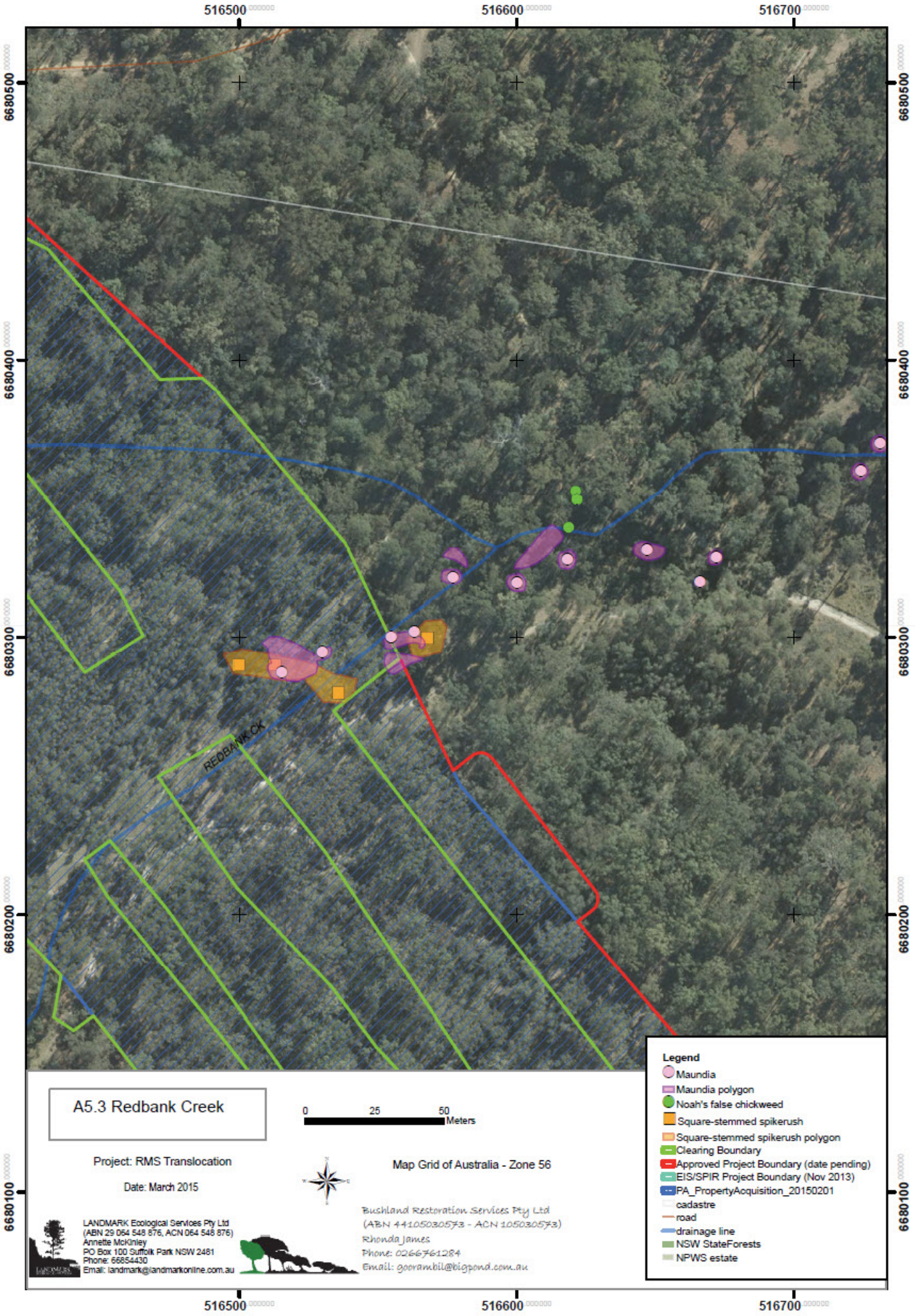
NPWS estate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REDBANK CK
A5.3 Redbank Creek
0
25
50
Meters
Project: RMS Translocation
Date: March 2015
Map Grid of Australia - Zone 56
LANDMARK Ecological Services Pty Ltd
(ABN 29 064 548 876, ACN 064 548 876)
Annette McKinley
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Rhonda James
Phone: 0266761284
Email: goorambil@bigpond.com.au
Legend
Maundia
Maundia polygon
Noah's false chickweed
Square-stemmed spikerush
Square-stemmed spikerush polygon
Clearing Boundary
Approved Project Boundary (date pending)
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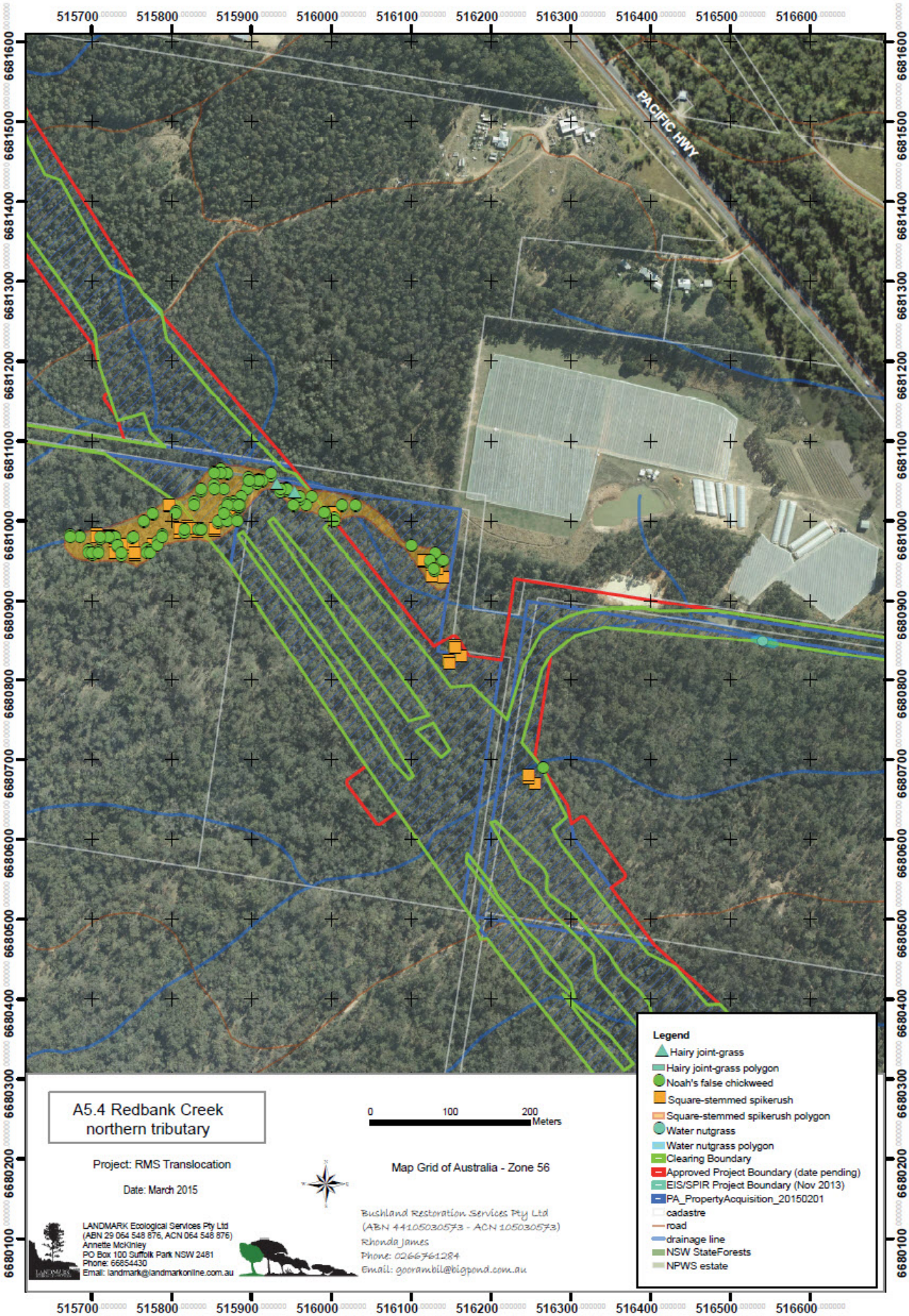
NPWS estate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PACIFIC HWY
A5.4 Redbank Creek northern tributary
Project: RMS Translocation
Date: March 2015
0
100
200
Meters
Map Grid of Australia - Zone 56
LANDMARK Ecological Services Pty Ltd
(ABN 29 064 548 876, ACN 064 548 876)
Annette McKinley
PO Box 100 Suffolk Park NSW 2481
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(ABN 44105030573 - ACN 105030573)
Rhonda James
Phone: 02667761284
Email: goorambil@bigpond.com.au
Legend
Hairy joint-grass
Hairy joint-grass polygon
Noah's false chickweed
Square-stemmed spikerush
Square-stemmed spikerush polygon
Water nutgrass
Water nutgrass polygon
Clearing Boundary
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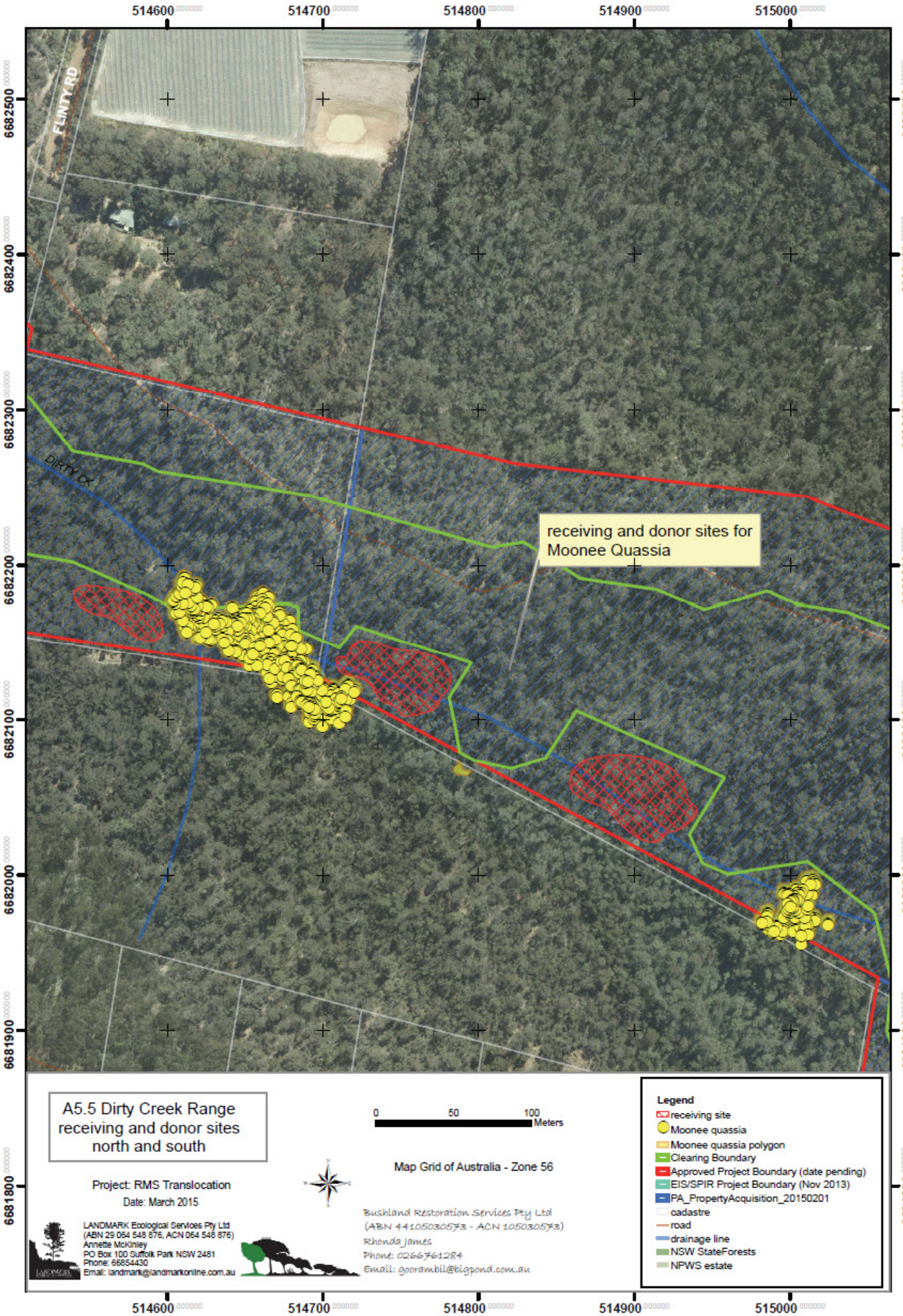
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DIRTY CK
receiving and donor sites for Moonee Quassia
A5.5 Dirty Creek Range receiving and donor sites north and south
Project: RMS Translocation
Date: March 2015
LANDMARK Ecological Services Pty Ltd
(ABN 29 064 548 876, ACN 064 548 876)
Annette McKinley
PO Box 100 Suffolk Park NSW 2481
Phone: 66654430
Email: landmark@landmarkonline.com.au
0 50 100 Meters
Map Grid of Australia - Zone 56
Bushland Restoration Services Pty Ltd
(ABN 44105030573 - ACN 105030573)
Rhonda James
Phone: 02667661284
Email: goorambil@bigpond.com.au
Legend
receiving site
Moonee quassia
Moonee quassia polygon
Clearing Boundary
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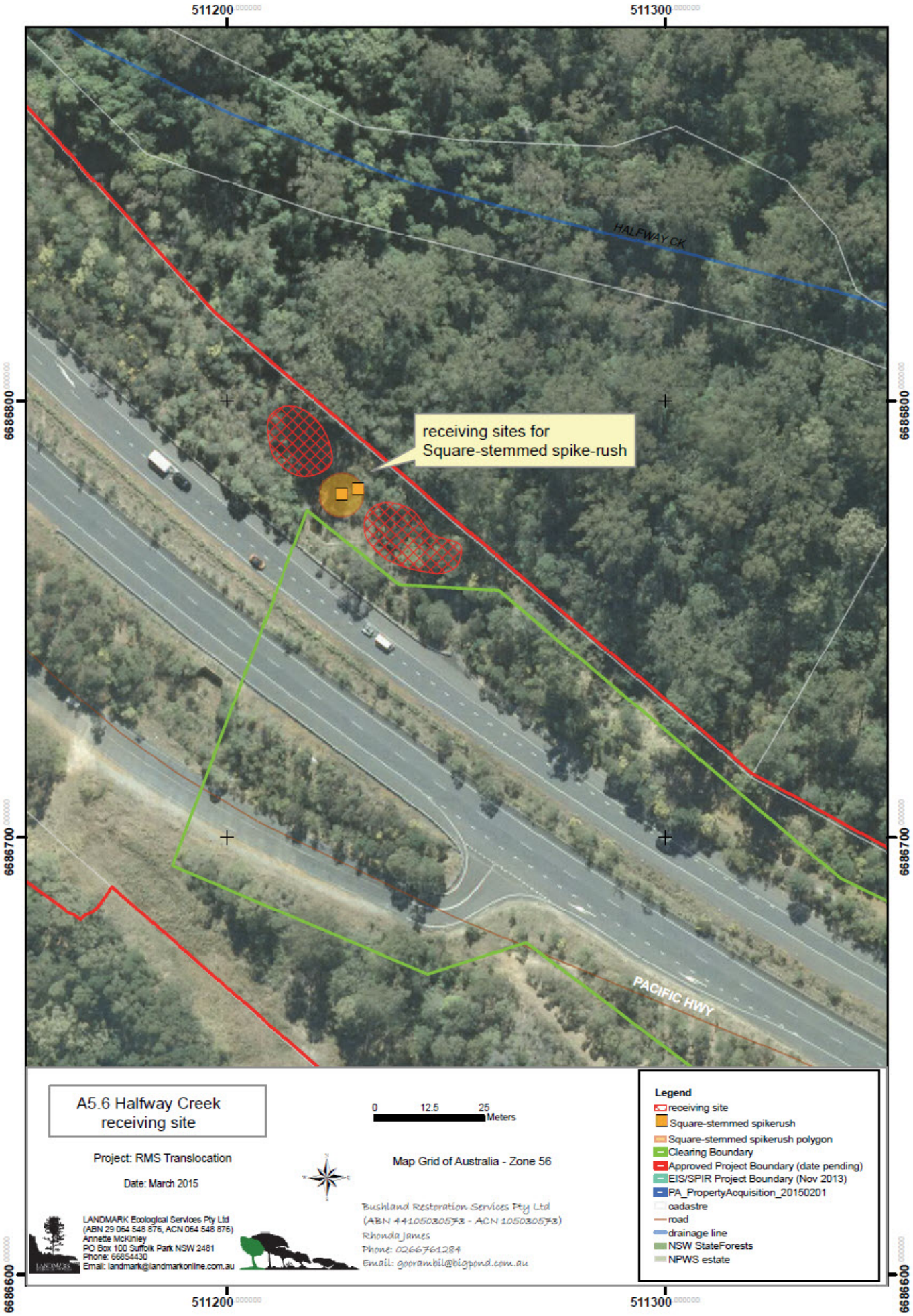
NPWS estate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HALFWAY CK
receiving sites for
Square-stemmed spike-rush
PACIFIC HWY
A5.6 Halfway Creek
receiving site
Project: RMS Translocation
Date: March 2015
0 12.5 25
Meters
Map Grid of Australia - Zone 56
LANDMARK Ecological Services Pty Ltd
(ABN 29 054 548 876, ACN 064 548 876)
Annette McKinley
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(ABN 44105030573 - ACN 105030573)
Rhonda James
Phone: 02667761284
Email: goorambil@bigpond.com.au
Legend
receiving site
Square-stemmed spikerush
Square-stemmed spikerush polygon
Clearing Boundary
Approved Project Boundary (date pending)
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drainage line
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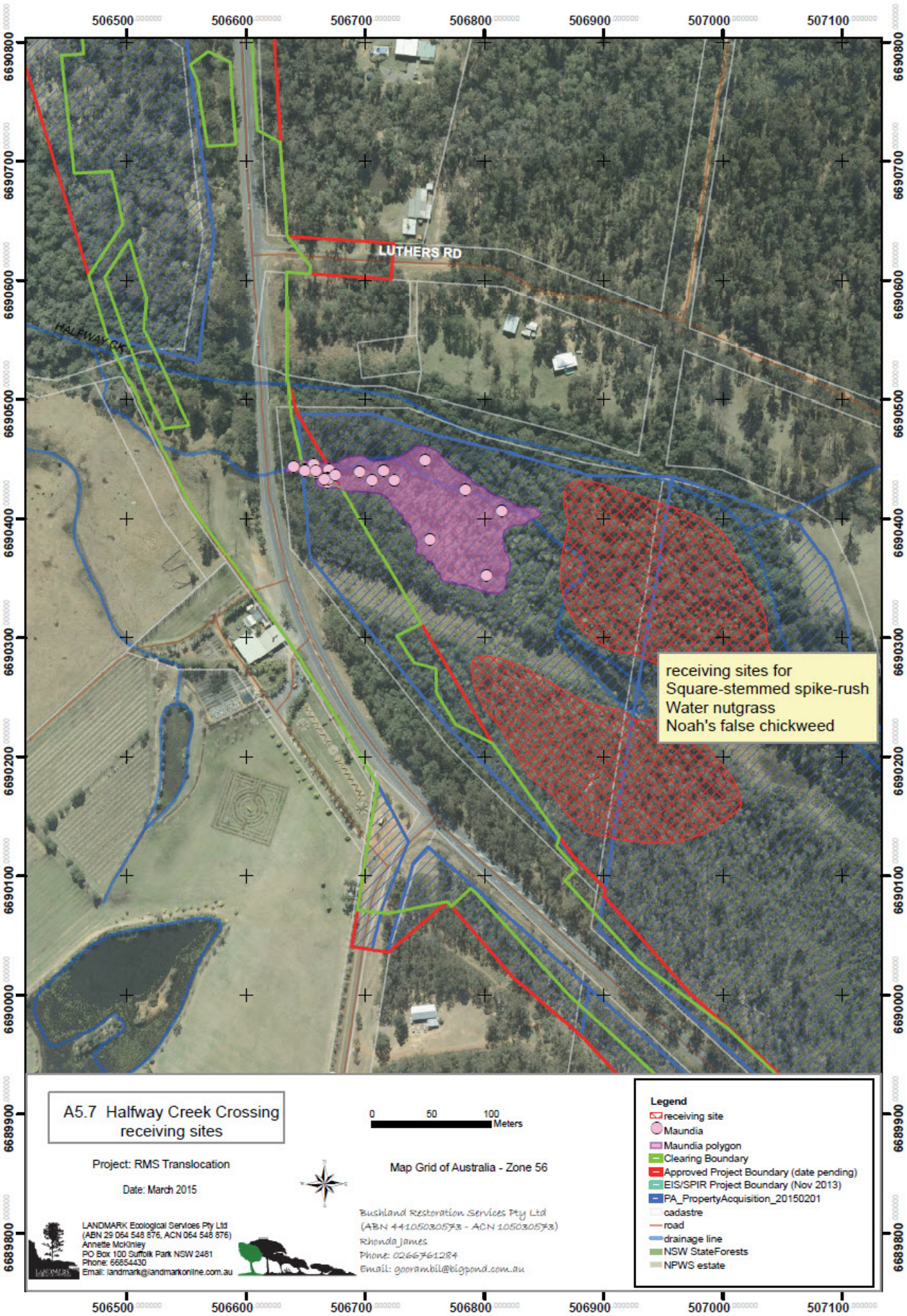
NPWS estate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6689900
6689800
LUTHERS RD
HALFWAY CK
receiving sites for
Square-stemmed spike-rush
Water nutgrass
Noah's false chickweed
A5.7 Halfway Creek Crossing receiving sites
Project: RMS Translocation
Date: March 2015
0 50 100 Meters
Map Grid of Australia - Zone 56
LANDMARK Ecological Services Pty Ltd
(ABN 29 064 548 876, ACN 064 548 876)
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Bushland Restoration Services Pty Ltd
(ABN 44105030573 - ACN 105030573)
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Email: goorambil@bigpond.com.au
Legend
receiving site
Maundia
Maundia polygon
Clearing Boundary
Approved Project Boundary (date pending)
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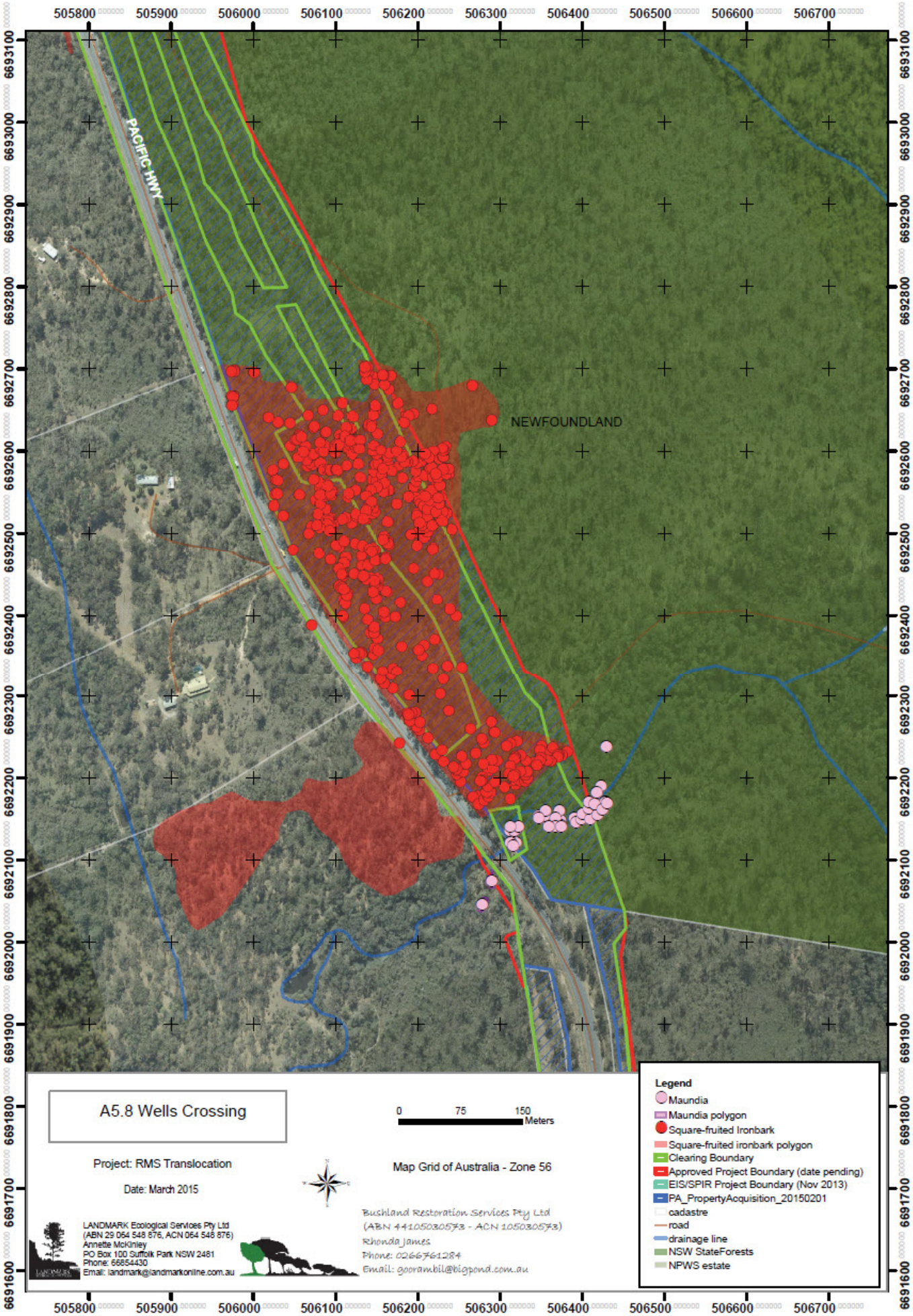
NSW StateForests
NPWS estate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6691700
6691600
PACIFIC HWY
NEWFOUNDLAND
A5.8 Wells Crossing
Project: RMS Translocation
Date: March 2015
0 75 150
Meters
Map Grid of Australia - Zone 56
LANDMARK Ecological Services Pty Ltd
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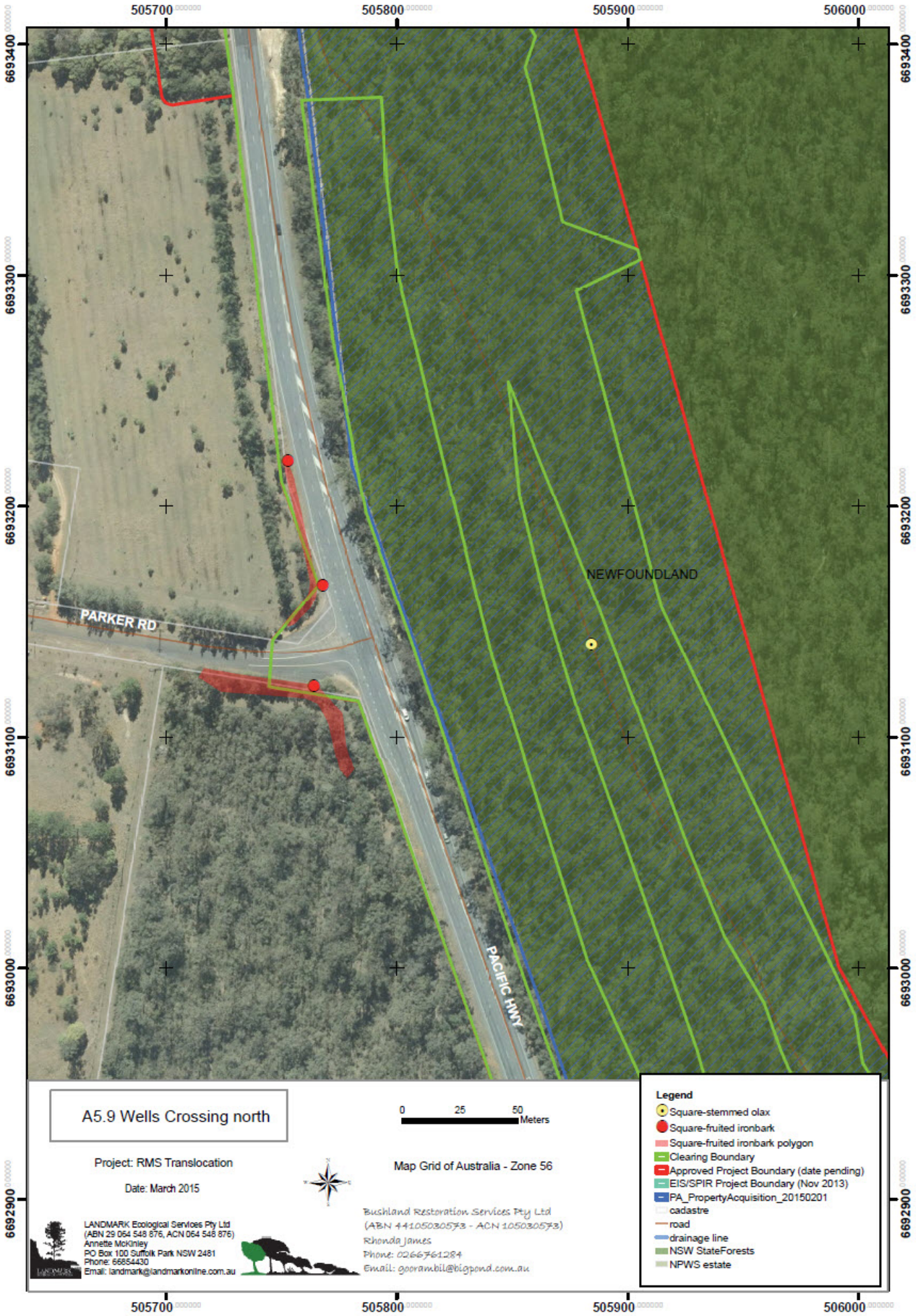
Bushland Restoration Services Pty Ltd
(ABN 44105030573 - ACN 105030573)
Rhonda James
Phone: 02667761284
Email: goorambil@bigpond.com.au
Legend
Maundia
Maundia polygon
Square-fruited Ironbark
Square-fruited ironbark polygon
Clearing Boundary
Approved Project Boundary (date pending)
EIS/SPIR Project Boundary (Nov 2013)
PA_PropertyAcquisition_20150201
cadastre
road
drainage line
NSW StateForests
NPWS estate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PARKER RD
NEWFOUNDLAND
PACIFIC HWY
A5.9 Wells Crossing north
Project: RMS Translocation
Date: March 2015
0 25 50
Meters
Map Grid of Australia - Zone 56
LANDMARK Ecological Services Pty Ltd
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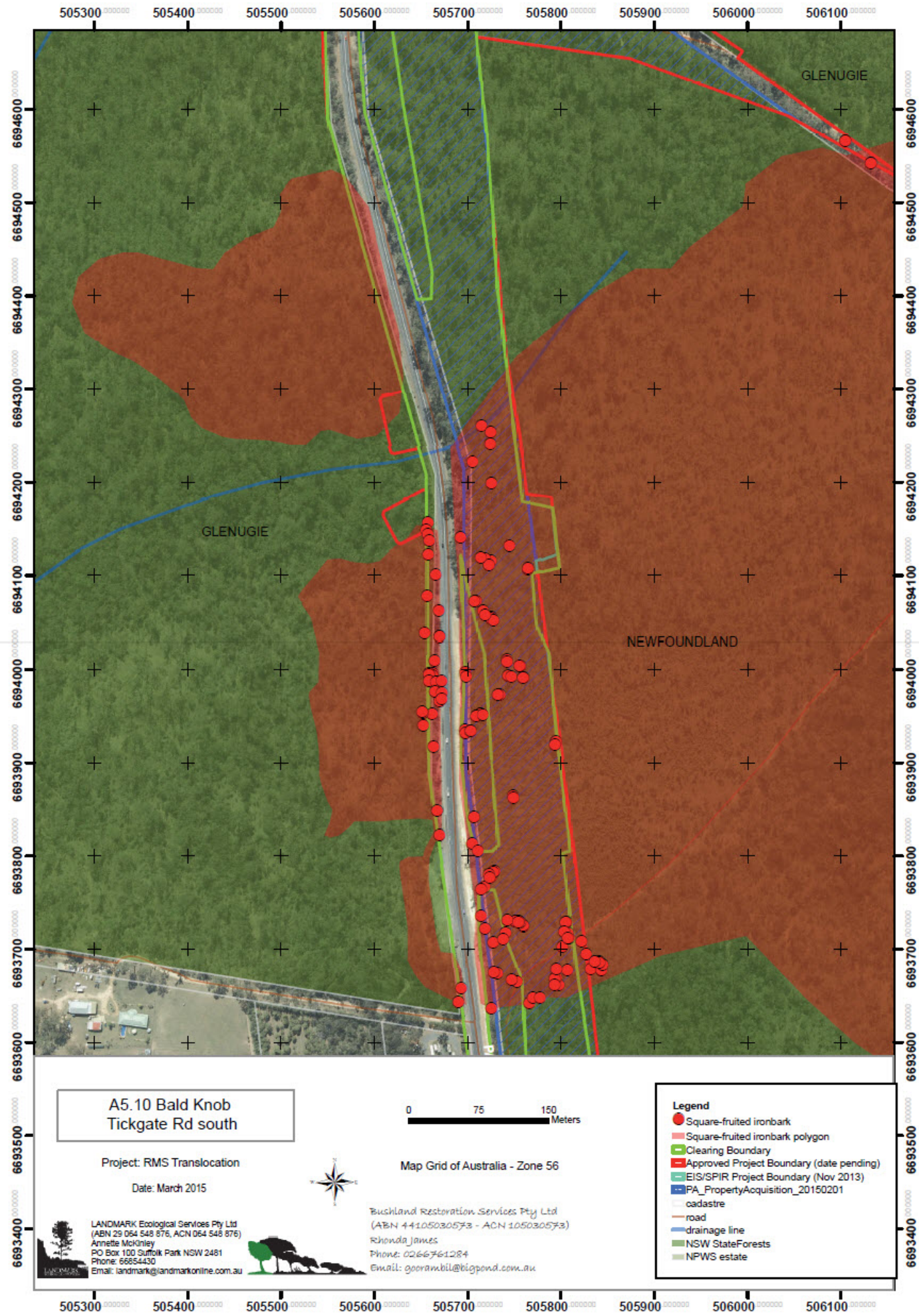
Phone: 0266761284
Email: goorambil@bigpond.com.au
Legend
Square-stemmed olax
Square-fruited ironbark
Square-fruited ironbark polygon
Clearing Boundary
Approved Project Boundary (date pending)
EIS/SPIR Project Boundary (Nov 2013)
PA_PropertyAcquisition_20150201
cadastre
road
drainage line
NSW StateForests
NPWS estate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6693900
6693800
6693700
6693600
6693500
6693400
GLENUGIE
GLENUGIE
NEWFOUNDLAND
A5.10 Bald Knob
Tickgate Rd south
Project: RMS Translocation
Date: March 2015
0
75
150
Meters
Map Grid of Australia - Zone 56
LANDMARK Ecological Services Pty Ltd
(ABN 29 064 548 876, ACN 064 548 876)
Annette McKinley
PO Box 100 Suffolk Park NSW 2481
Phone: 66854430
Email: landmark@landmarkonline.com.au
Bushland Restoration Services Pty Ltd
(ABN 44105030573 - ACN 105030573)
Rhonda James
Phone: 0266761284
Email: goorambil@bigpond.com.au
Legend
Square-fruited ironbark
Square-fruited ironbark polygon
Clearing Boundary
Approved Project Boundary (date pending)
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PA_PropertyAcquisition_20150201
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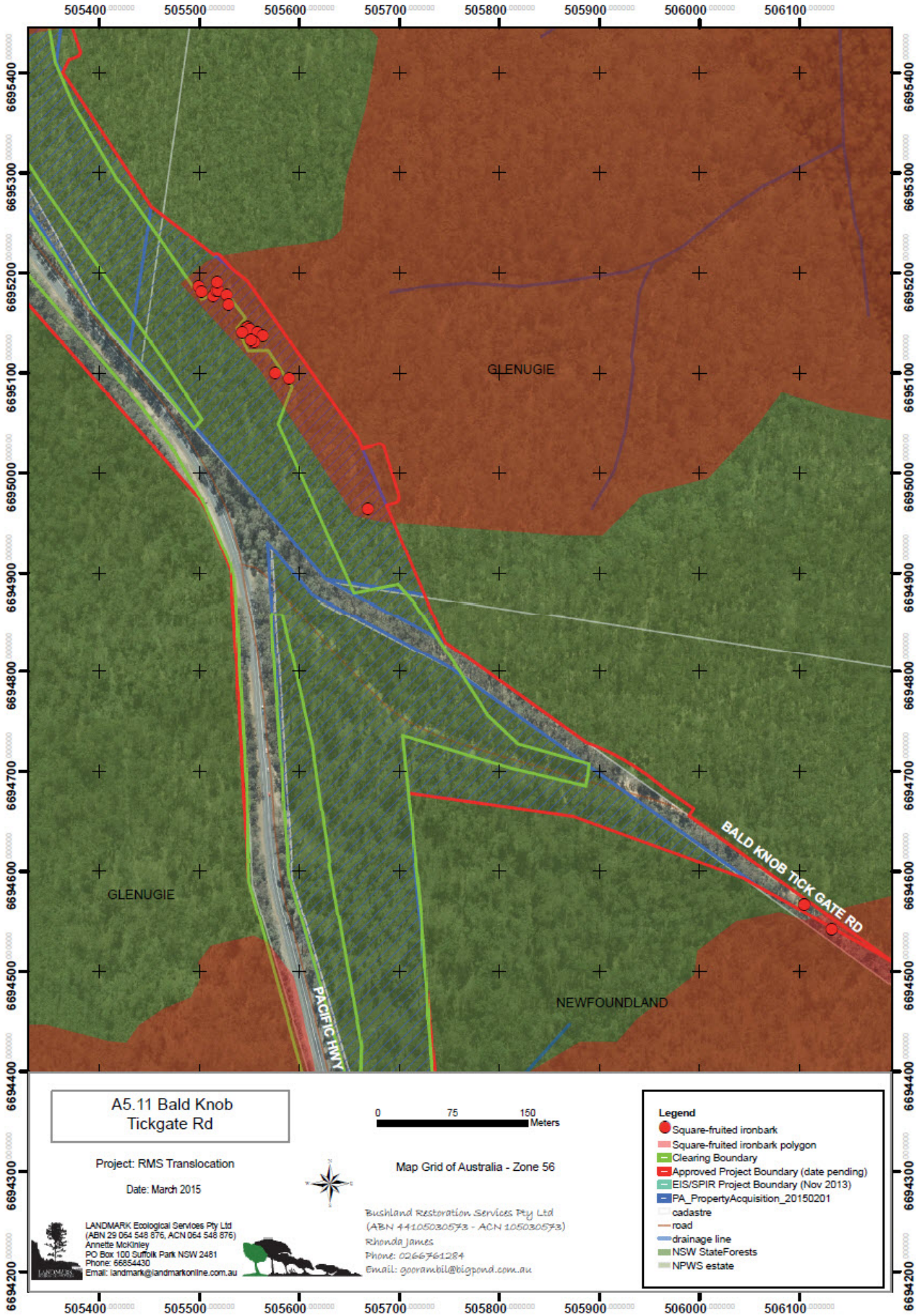
NSW StateForests
NPWS estate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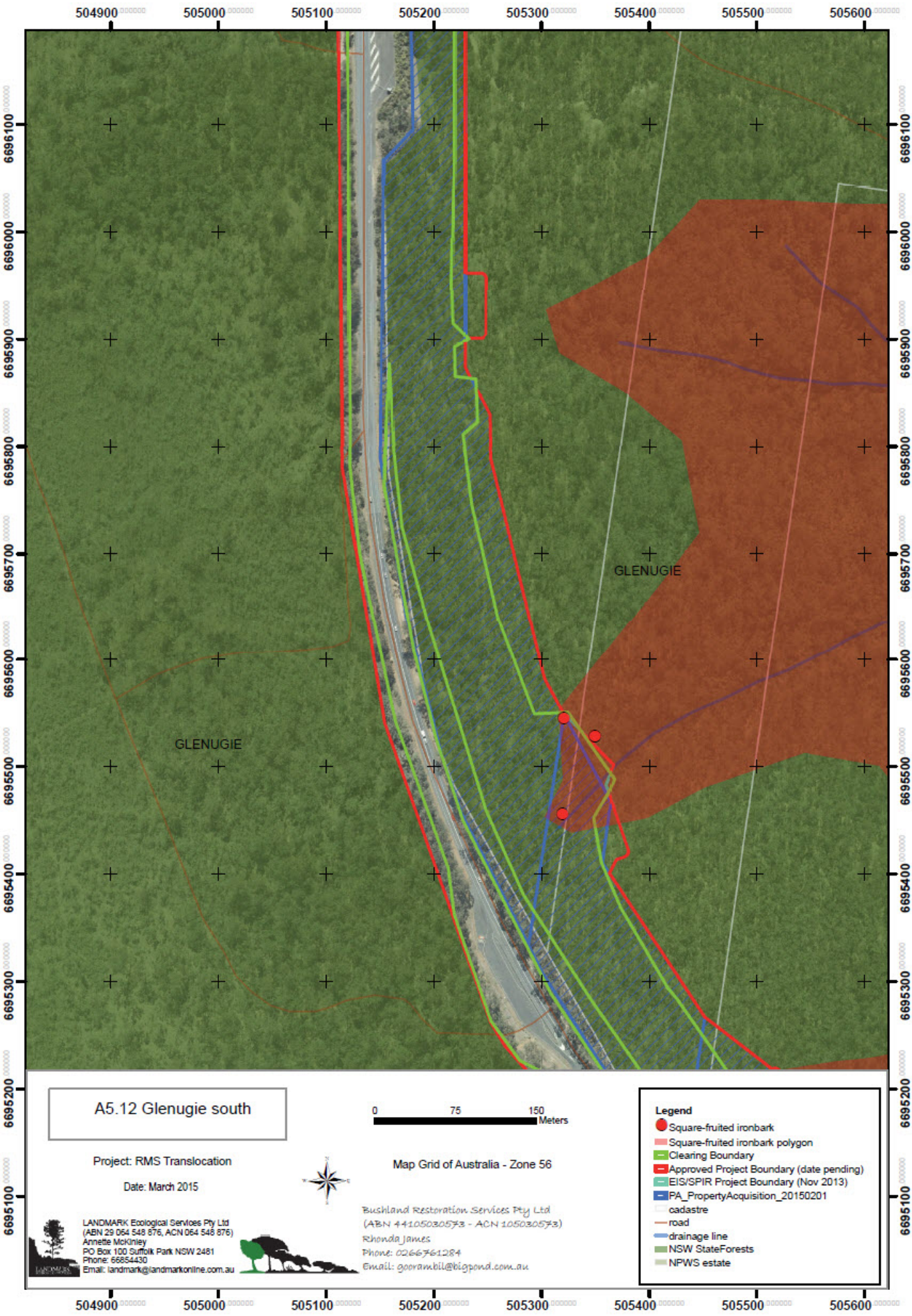
6694400
6694300
6694200
GLENUGIE
GLENUGIE
NEWFOUNDLAND
BALD KNOB TICK GATE RD
PACIFIC HWY
A5.11 Bald Knob
Tickgate Rd
Project: RMS Translocation
Date: March 2015
0
75
150
Meters
Map Grid of Australia - Zone 56
LANDMARK Ecological Services Pty Ltd
(ABN 29 054 548 876, ACN 054 548 876)
Annette McKinley
PO Box 100 Suffolk Park NSW 2481
Phone: 66854430
Email: landmark@landmarkonline.com.au
Bushland Restoration Services Pty Ltd
(ABN 44105030573 - ACN 105030573)
Rhonda James
Phone: 0266761284
Email: goorambil@bigpond.com.au
Legend
Square-fruited ironbark
Square-fruited ironbark polygon
Clearing Boundary
Approved Project Boundary (date pending)
EIS/SPIR Project Boundary (Nov 2013)
PA_PropertyAcquisition_20150201
cadastre
road
drainage line
NSW StateForests
NPWS estate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6695400
6695300
6695200
6695100
GLENUGIE
GLENUGIE
A5.12 Glenugie south
Project: RMS Translocation
Date: March 2015
0
75
150
Meters
Map Grid of Australia - Zone 56
LANDMARK Ecological Services Pty Ltd
(ABN 29 054 548 676, ACN 054 548 676)
Annette McKinley
PO Box 100 Suffolk Park NSW 2481
Phone: 66854430
Email: landmark@landmarkonline.com.au
Bushland Restoration Services Pty Ltd
(ABN 44105030573 - ACN 105030573)
Rhonda James
Phone: 02667761284
Email: goorambil@bigpond.com.au
Legend
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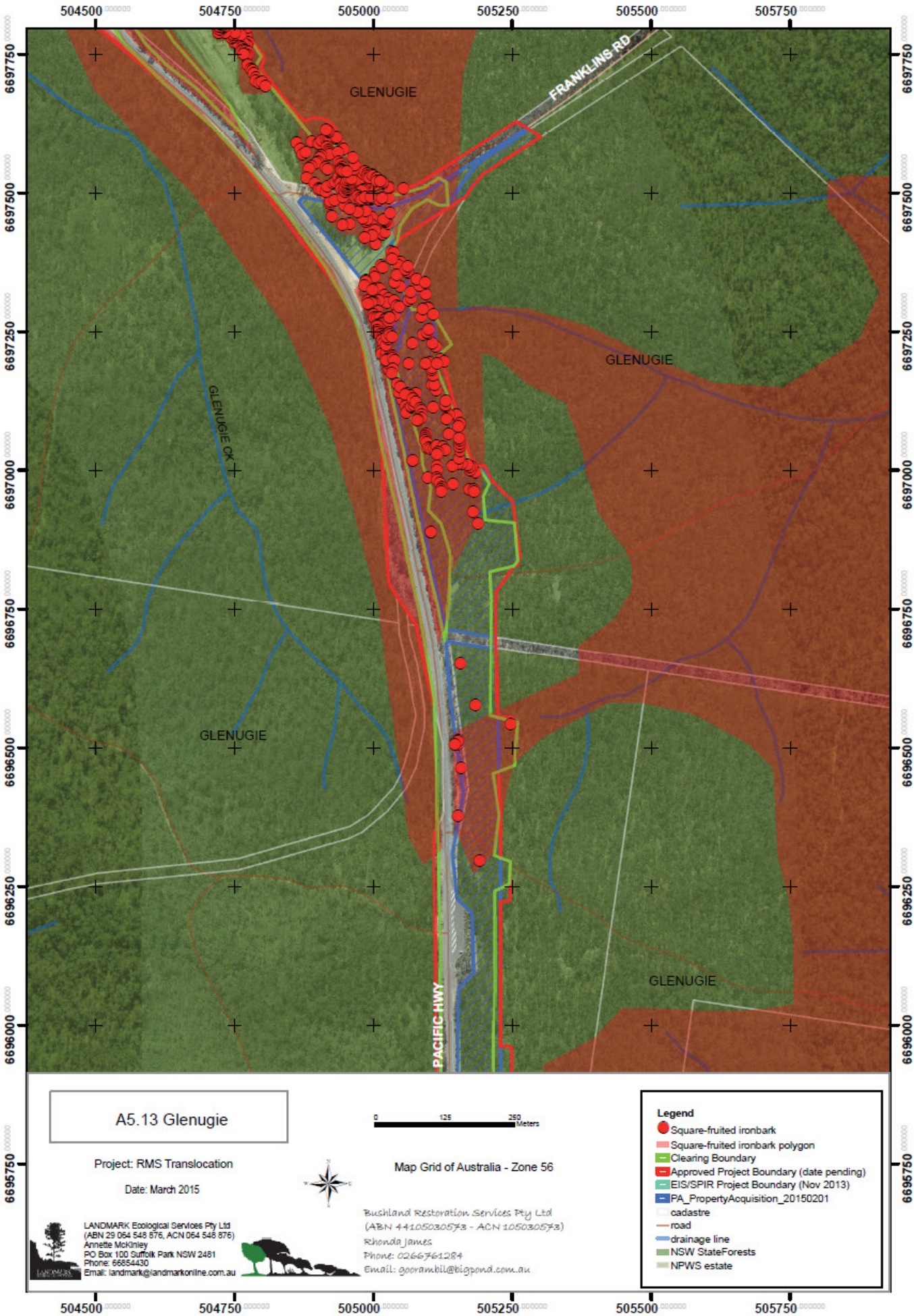
NPWS estate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Date: March 2015
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LANDMARK Ecological Services Pty Ltd
(ABN 29 064 548 876, ACN 064 548 876)
Annette McKinley
PO Box 100 Suffolk Park NSW 2481
Phone: 66854430
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Bushland Restoration Services Pty Ltd
(ABN 44105030573 - ACN 105030573)
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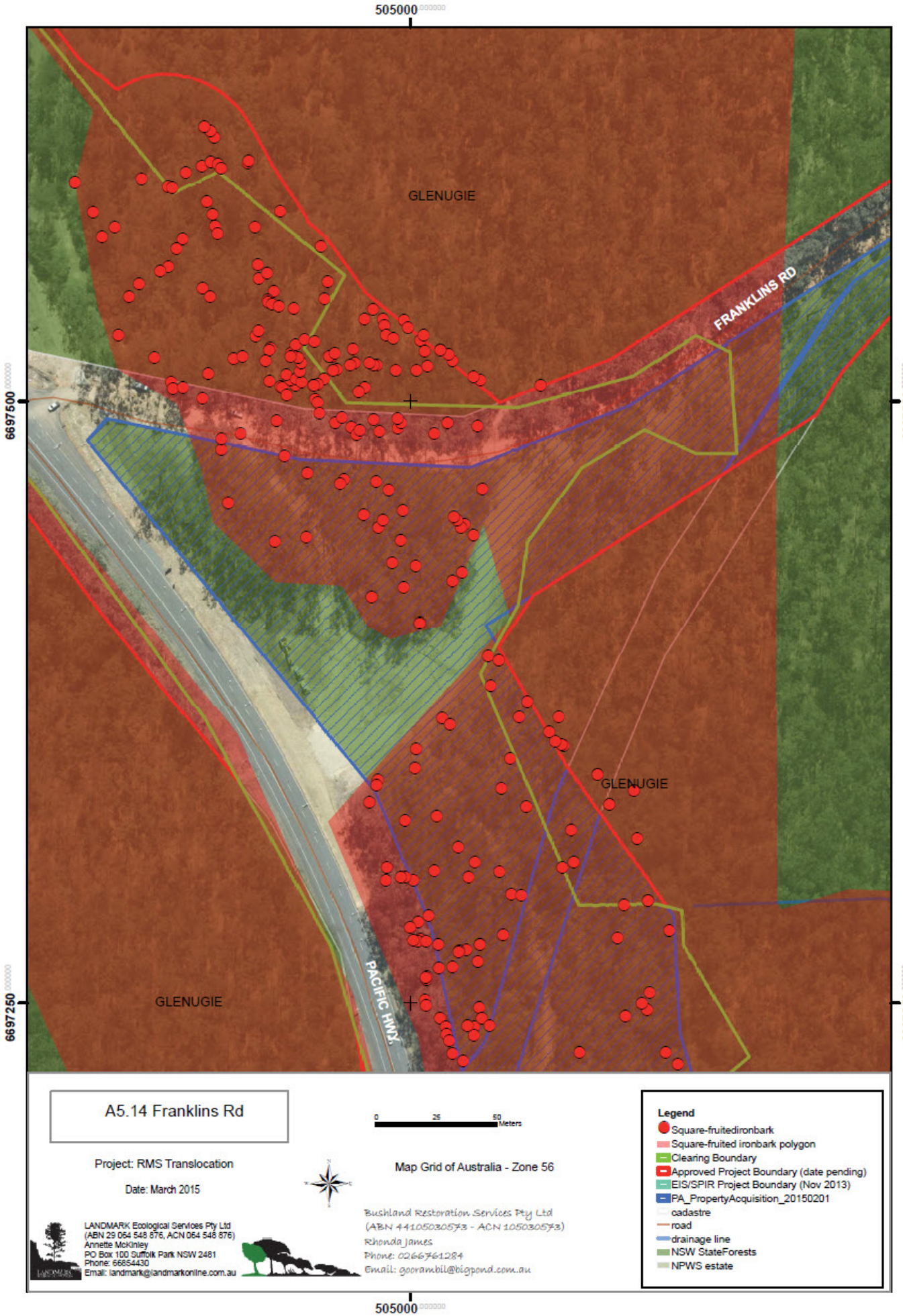
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Map Grid of Australia - Zone 56
LANDMARK Ecological Services Pty Ltd
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Square-fruitedironbark
Square-fruited ironbark polygon
Clearing Boundary
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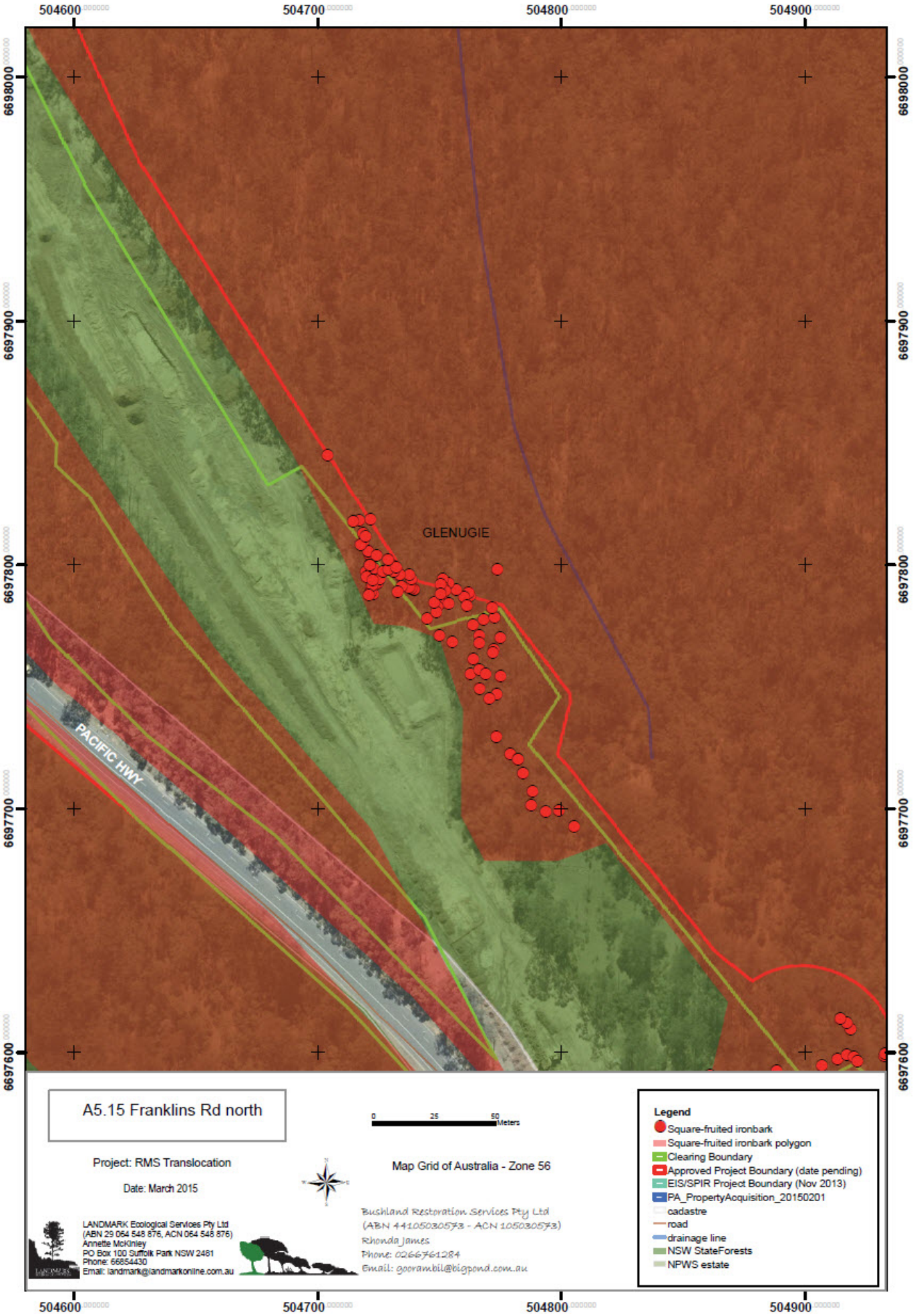
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Meters
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LANDMARK Ecological Services Pty Ltd
(ABN 29 064 548 876, ACN 064 548 876)
Annette McKinley
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Square-fruited ironbark polygon
Clearing Boundary
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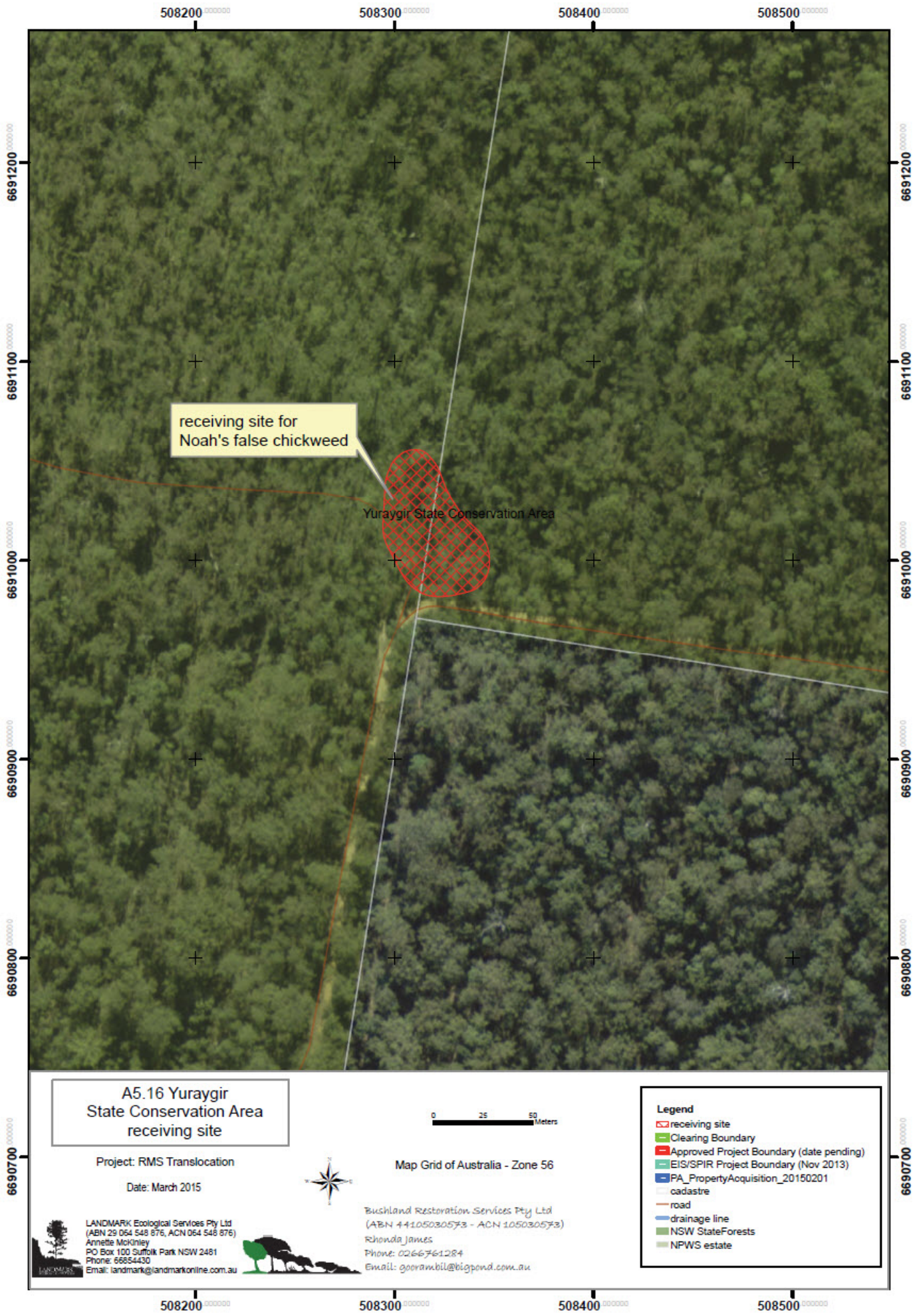
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Yuraygir State Conservation Area
A5.16 Yuraygir
State Conservation Area
receiving site
Project: RMS Translocation
Date: March 2015
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Map Grid of Australia - Zone 56
LANDMARK Ecological Services Pty Ltd
(ABN 29 064 548 876, ACN 064 548 876)
Annette McKinley
PO Box 100 Suffolk Park NSW 2481
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Phone: 0266761284
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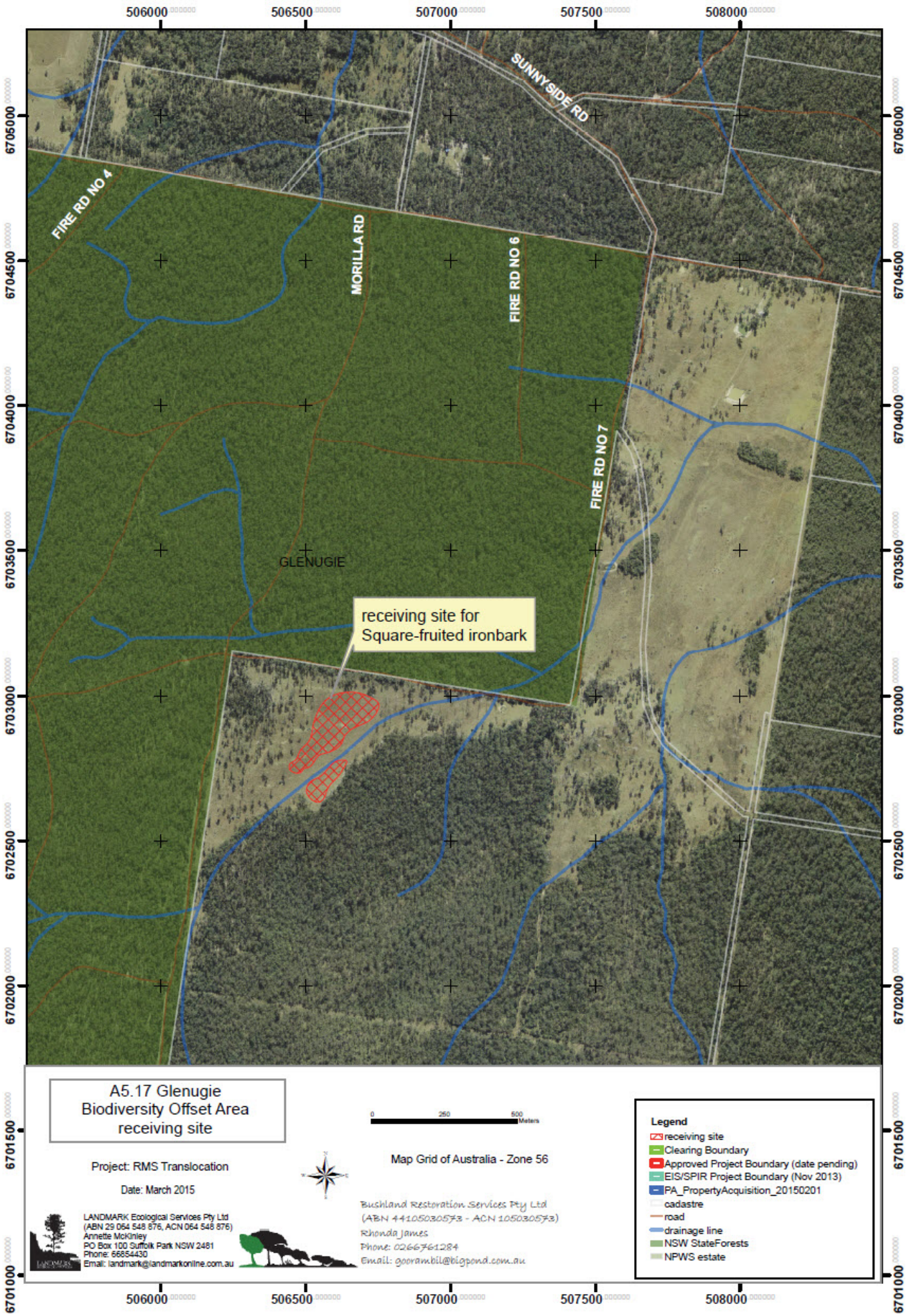
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A5.17 Glenugie
Biodiversity Offset Area
receiving site
Project: RMS Translocation
Date: March 2015
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Map Grid of Australia - Zone 56
Bushland Restoration Services Pty Ltd
(ABN 44105030573 - ACN 105030573)
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Appendix 6 Receiving sites

Kangaroo Trail Road

Donor species: Slender screw-fern, Hairy joint-grass

Location: Kangaroo Trail Road

The receiving site is approximately 3km from Redbank Creek north tributary donor site for Hairy-joint grass and is approximately 1.5km from Corindi Creek donor site for Slender screw-fern.

Tenure: Roads and Maritime

Threats: Weeds and grazing

Vegetation type: The site is mapped as Swamp Box - Swamp forest and Blackbutt – Bloodwood dry open forest.

Weed species: Unknown

Cover: Unknown

Pre Translocation management

Identify and mark with flagging tape suitable locations for both species within the site. The receiving site to include a buffer zone of 10m where weeds are controlled to reduce invasion into the receiving site.

Slender screw-fern. The donor population covers an area of 0.0127ha. As much as possible of this population will be translocated. Ensure that receiving area is suitable habitat and after weed control excavate an area in preparation for receival of slabs of approximately 30cm x 30cm.

Hairy joint-grass. The donor population is small and within a drainage line. Ensure that selected receiving area is suitable habitat. After weed control excavate similar sized slab in preparation for receival.

Prior to translocation: the site is to be weed free and prepared for receival.

Experienced bush regeneration team to follow hygiene protocols and best practice.

Spot spray groundcover weeds and cut, scrape and paint the woody weeds. Lop cut stems into small billets and leave on site.

Translocation Management

Slender screw-fern. The population to be removed in slabs and taken directly to the receiving site. Keep moist in transit.

Hairy joint-grass. The small donor population to be removed as one slab and taken directly to the receiving site. Propagated seedlings to be planted in well prepared seedbed and bamboo stake placed next to individual plants.

Record and tag the plants with identification used on collection.

Water well on planting. Water as required depending on weather. Monitor plants and site for occurrence of weeds and other impacts.

Dirty Creek Road Reserve

Donor species: Moonee Creek Quassia

Location: Dirty Creek Road Reserve North

Three receiving sites are located in close proximity to the donor site (a distance of approximately 10-220m). The sites expand on the existing northern population extending to the west, east and south east to link and expand the two populations.

Site characteristics: Rocky south facing slope. Moonee Creek Quassia is already present indicating that site characteristics suit the requirements of the taxon.

Tenure: Roads and Maritime

Threats: Exposure post clearing as will be adjacent to corridor, may require protective barrier.

Vegetation type: Large-fruited Blackbutt forest

Stratum	Height (m)	Crown Cover (%)	Species 1	Species 2	Species 3
Upper	20	15	*Eucalyptus pyrocarpa*	*Angophora woodsiana*	
Mid	4	20	*Leptospermum polygalifolium*	*Acacia oshanesii*	*Bursaria spinosa*
Lower	1	20	*Gahnia clarkei*	*Entolasia stricta*	*Aotus ericoides*

Weeds species: 0

Cover: 0

No weeds observed in receiving area. The site will require monitoring along disturbed edges after construction.

Buds were observed on one Moonee Creek Quassia plant in February 2015. Plants in good condition.

Photo: Receiving site, Moonee Creek Quassia in foreground

Pre Translocation Management

Collect seed (if available) for propagation. Bag and tag seed from each individual plant. Transfer to nursery for propagation.

Stem, basal stem and root cuttings to be taken from excavated plants.

Identify and mark with bamboo stakes and flagging tape the three areas identified as suitable for receiving. The receiving site to include a buffer zone of 5m where weeds are controlled to reduce invasion into the site.

Experienced bush regeneration team to follow hygiene protocols and best practice bush regeneration.

Translocation Management

Within the three locations prepare the site for receiving plants which have been propagated in the nursery. Randomly select location for individual plants. The plants to be spaced at approximately 1.5 - 2m spacings within gaps between established native plants.

Depending on success of seed and cuttings the plants to be split between the three sites. Ideally 30-40 plants to be planted in each section to achieve recommended results.

Record and tag all plants with identification used on collection.

Water well on planting. Water as required depending on weather. Monitor condition of plants and site for occurrence of weeds and other impacts.

Halfway Creek

Donor species: Square-stemmed spike-rush, Slender screw fern

This site is priority 2 site for both species.

Location: East side of highway, encompassing (seasonal) open water**.**

The receiving site is located up to 9 km from the donor sites.

Tenure: Roads and Maritime

Threats: Weeds, exposure post clearing as will be adjacent to corridor, may require protective barrier. Hydrology may be altered by works

Vegetation Description: Freshwater wetland (Site Elt1.5 Jacobs 2015)

Stratum	Height (m)	Crown Cover (%)	Species 1	Species 2	Species 3
Upper					
Mid	15	11	*Callistemon salignus*	*Acacia fimbriata*	
Lower	1.5	70	*Lomandra longifolia*	*Hemarthria uncinata*	*Baumea rubiginosa*

Weeds: Species: *Andropogon virginicus*

Cover: Low

Photo Receiving site

Pre Translocation management

Identify and mark with flagging tape a suitable location within the site as close as possible to location of existing records. The receiving site to include a buffer zone of 10m where weeds are controlled to reduce invasion into the receiving site.

Prior to translocation the site is to be weed free and prepared for receival.

Experienced bush regeneration team to follow hygiene protocols and best practice.
Spot spray the exotic grasses within the site.

Translocation Management

See receiving site 1 for both species.
Square-stemmed spike-rush Halfway Creek Crossing and
Slender screw fern Kangaroo Trail.

Halfway Creek Crossing

Donor species: Square-stemmed spike-rush, Hairy joint-grass

The site is also designated for habitat management in lieu of translocation for Maundia. A threatened flora management plan will be required for the property.

The receiving site is located up to 9 km from the donor sites at Redbank Creek and Redbank Creek northern tributary. This site is priority 2 for Hairy joint-grass.

Tenure: Roads and Maritime

Threats: Weeds, exposure post clearing as will be adjacent to corridor, may require protective barrier. Hydrology may be altered by highway works.

Vegetation Description: Swamp sclerophyll forest (Site Mt 2.1 Jacobs 2015)

Stratum	Height (m)	Crown Cover (%)	Species 1	Species 2	Species 3
Upper	20	33	*Melaleuca alternifolia*	*Eucalyptus resinifera*	
Mid					
Lower	2	85	*Blechnum indicum*	*Baumea sp*	*Sparganium subglobosum*

Weeds: Species: *Pinus elliottii*

Cover: Sparse

Pre Translocation management

Identify and mark with flagging tape a suitable location within the site as close as possible to location of existing records. The receiving site to include a buffer zone of 10m where weeds are controlled to reduce invasion into the receiving site.

Square-stemmed spike-rush. Ideally translocate in winter. Remove as much of the donor population as they are mainly in small clumps. Remove in clumps of approximately 20cm x 20cm. If individual plants are located hey could be removed and grown on in pots at nursery.

Prior to translocation the site is to be weed free and prepared for receival.
Experienced bush regeneration team to follow hygiene protocols and best practice.

Drill and inject larger plants or cut and lop into billets the smaller exotic pines and leave in situ. Site may require spot spray of exotic grasses.

Translocation Management

See receiving site 1 Kangaroo Trail for Hairy joint-grass.

Square-stemmed spike-rush

The population to be removed in plugs and slabs and taken directly to the site. Keep moist in transit.

Record and tag all plants with identification used on collection.

Water well on planting. Water as required depending on weather. Monitor plants and site for occurrence of weeds and other impacts.

Yuraygir State Conservation Area

Donor species: Noah's false chickweed

Location: Site is approximately 12km from donor site at Redbank Creek northern tributary.

Site characteristics suit the requirements of the taxon being swamp woodland.

Tenure: OEH NPWS

Threats: edge. Weeds and disturbance along road

Vegetation type: Swamp forest to woodland

Stratum	Height (m)	Crown Cover (%)	Species 1	Species 2	Species 3
Upper	20	5	*Eucalyptus robusta*	*Melaleuca* sp	*Eucalyptus* sp
Mid	6	30	*Banksia oblongifolia*	*Melaleuca* sp	
Lower	1.5	80	*Banksia oblongifolia*	*Lomandra longifolia*	*Lepidosperma* sp

Weeds: Species: 0

Cover: 0

No weeds recorded within the site. Exotic grasses on roadside.

Photo Receiving site

Pre Translocation management

Identify and mark with flagging tape suitable locations for translocated plugs or slabs (approximately 20cm x 20cm) within gaps in the existing vegetation. Take care to minimize impact on the vegetation. The receiving site to include a buffer zone of 10m where weeds are controlled to reduce invasion into the receiving site.

Prior to translocation the site is to be weed free and prepared for receival.
Experienced bush regeneration team to follow hygiene protocols and best practice.
Spot spray exotic grasses on roadside.

Translocation Management

The population to be removed in plugs and slabs and taken directly to the site. Keep moist in transit.

Record and tag all plants with identification used on collection.

Water well on planting. Water as required depending on weather. Monitor plants and site for occurrence of weeds and other impacts.

Glenugie Offset property

Donor species: Square-fruited ironbark

Location: Lot 109 (DP751374) Sunnyside Road, Glenugie

Receiving site identified is up to 11 km from the donor site.

Site characteristics: Square-fruited Ironbark was recorded by Jacobs (2014) as present in all vegetation communities present on the property, including cleared areas where the species was formerly present. Site characteristics therefore suit the requirements of the taxon.

Tenure: Roads and Maritime

Threats: Weeds, grazing by stock and wallabies/kangaroos, disturbance by stock and pigs.

Vegetation Description: The site recommended is within the gradient from Forest Red Gum – Swamp Box open forest to Spotted Gum – Grey Ironbark – Pink Bloodwood open forest. Donor sites are Spotted Gum – Ironbark forest.

Pre Translocation management

Identify and mark with bamboo stakes and flagging tape a suitable location of approximately 2ha within the site. Preferably select a site that is cleared or has minimal established trees and shrubs. The receiving site to include a buffer zone of a minimum 10m where weeds are controlled to reduce invasion into the receiving site.

Prior to translocation the site is to be weed free and prepared for receival.

Experienced bush regeneration team to follow hygiene protocols and best practice.

Spot spray groundcover weeds and cut, scrape and paint the woody weeds. Lop cut stems into small billets and leave on site.

Fence with 1.2m high mesh if determined that there are likely impacts to plantings from grazing or trampling.

Translocation Management

Prepare the site for receiving seedlings which have been propagated in the nursery. Within the selected site plant out 1000 Square-fruited ironbark seedlings at 4 - 6m spacings. Ideally replicate the plant community and include species such as Pink Bloodwood, Swamp Box, Forest Red Gum and Spotted Gum.

Record and tag all plants or groups of plants with identification used on collection.

Water well on planting. Water as required depending on weather. Monitor plants and site for occurrence of weeds and other impacts