Woolgoolga to Ballina Pacific Highway upgrade

Construction Monitoring of In-situ Threatened Flora (non-rainforest flora)

Annual Report 2017-18

NSW GOVERNMENT

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Woolgoolga to Ballina Pacific Highway Upgrade

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Contents

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The sole purpose of this report and the associated services performed by Jacobs is to provide the results of flora monitoring for Roads and Maritime in accordance with the scope of services set out in the contract between Jacobs and Roads and Maritime. That scope of services, as described in this report, was developed with Roads and Maritime and Pacific Complete.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Roads and Maritime Trust and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

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Glossary of terms

Definitions

Development footprint	The area of land that is directly impacted on by a proposed development, including access roads, and areas used to store construction materials
Direct impact	An impact on biodiversity values that is a direct result of vegetation clearance and loss of habitat for a development. It is predictable, usually occurs at or near to the development site and can be readily identified during the planning, design, construction, and operational phases of a development.
Habitat	An area or areas occupied, or periodically or occasionally occupied, by a species, population or ecological community, including any biotic or abiotic component.
Indirect impact	An impact on biodiversity values that occurs when development related activities affect threatened species, threatened species habitat, or ecological communities in a manner other than direct impact. Compared to direct impacts, indirect impacts often: • occur over a wider area than just the site of the development • have a lower intensity of impact in the extent to which they occur compared to direct impacts • occur off site • have a lower predictability of when the impact occurs • have unclear boundaries of responsibility.
In situ	A Latin phrase that's translates literally to "on site" or "in position". It can mean "locally", "on site", or "in place" to describe where the plants are located.
Local population	The population that occurs in the study area. In cases where multiple populations occur in the study area and/or a population occupies part of the study area, impacts on the entirety of each population must be assessed separately.
MNES	A matter of national environmental significance (MNES) protected by a provision of Part 3 of the EPBC Act
Mitigation	Action to reduce the severity of an impact.
Mitigation measure	Any measure that facilitates the safe movement of wildlife and/or prevents wildlife mortality.
Population	A group of organisms, all of the same species, occupying a particular area.
Project area/ Project site	The area of land that is directly impacted on by a proposed Major Project that is under the EP&A Act, including access roads, and areas used to store construction materials.
Subject land	Land to which the BAM is applied in Stage 1 to assess the biodiversity values of the land. It includes land that may be a development site, clearing site, proposed for biodiversity certification or land that is proposed for a biodiversity stewardship agreement.
Study area	The subject land and any other areas surveyed and assessed for biodiversity values which may be subject to indirect impacts.
Target species	A species that is the focus of a study or intended beneficiary of a conservation action or connectivity measure.

Abbreviations

BC Act	Biodiversity Conservation Act 2016 (NSW)
CEMP	Construction Environmental Management Plan
DP&E	Department of Planning and Environment
DPI	Department of Primary Industries
EEC	Endangered ecological community
EIS	Environmental Impact Statement
EPBC Act	Environmental Protection and Biodiversity Conservation Act 1999 (Federal)

IBRA	Interim Biogeographically Regionalisation of Australia
MNES	Matters of National Environmental Significance
OEH	Office of Environment and Heritage
PCT	Plant Community Type
TECs	Threatened Ecological Communities
VIS	Vegetation information system (BioNet Vegetation Classification)
W2B	Woolgoolga to Ballina

1. Introduction

1.1 Background and objectives

As part of the Woolgoolga to Ballina (W2B) Pacific Highway upgrade project, a Threatened Flora Management Plan (TFMP) was developed to meet approval of the NSW condition requirements of MCoA D8 and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Condition of Approval (CoA) 12. The TFMP identified potential impacts to threatened flora species listed under the EPBC Act and formerly under the *Threatened Species Conservation Act 1995*, now the *Biodiversity Conservation Act 2016* (BC Act). Threatened plant species are being managed in two ways, 1) by the protection, monitoring and management of plants that remain in-situ adjacent to the W2B upgrade, and 2) by the translocation, monitoring and management of plants that are located within the road construction footprint. This report addresses the monitoring requirements for in-situ plant species.

The in-situ plant monitoring program documented in the TFMP outlines the methods and timing for targeted surveys of threatened plant species that are located in proximity to the project. The program aims to identify potential direct and indirect impacts during construction and the early stages of operation of the project by monitoring the performance of mitigation measures against management goals and implementing required corrective actions for adaptive management of the program.

The program commenced during the pre-construction phase in which (baseline) data was collected for a series of impact and control plots for each threatened species. This report outlines the methods and results of monitoring conducted in the first year of construction (2017). The report presents the data collected from two monitoring events (summer and winter) for section 1 to 2 of the W2B upgrade and four quarterly monitoring events for sections 3 to 10. An assessment of the performance of the first stage of construction in avoiding and minimising impacts to threatened plant species is discussed with reference to the goals in the TFMP. Suggestions for adaptive management and corrective actions is also provided where deemed to be required.

The in-situ flora monitoring program is specific to 20 threatened flora species, these are listed in Table 1-1.

Table 1-1 Threatened flora species (in situ) targeted in the construction monitoring program

Species	Common Name	Status		W2B Project section for monitoring
		EPBC Act	BC Act	
Angophora robur	Sandstone Rough Barked Apple	V	V	3
Arthraxon hispidus	Hairy Joint Grass	V	V	8, 9, 10
Cyperus aquatilis	Water Nutgrass	-	E	1, 2, 3, 6, 7
Eleocharis tetraquetra	Square-stemmed Spike-rush	-	E	1, 2, 3
Endiandra muelleri subsp. *bracteata*	Green-leaved Rose Walnut	-	E	4
Eucalyptus tetrapleura	Square-fruited Ironbark	V	V	2
Grevillea quadricauda	Four-tailed Grevillea	V	V	3
Lindernia alsinoides	-	-	E	1, 2, 3
Lindsaea incisa	Slender Screw Fern	-	E	1, 2, 3, 6
Macadamia tetraphylla	Rough-shelled Bush Nut	V	V	7, 8
Maundia triglochinoides	-	-	V	1, 2, 3, 6, 7
Melaleuca irbyana	Weeping Paperbark	-	E	7
Oberonia complanata	-	-	E	8
Oberonia titania	-	-	V	10
Persicaria elatior	Tall Knotweed	V	V	4, 5

Species	Common Name	Status		W2B Project section for monitoring
		EPBC Act	BC Act	
Phaius australis	Southern Swamp Orchid	E	E	9
Prostanthera cineolifera	Singleton Mint Bush	V	V	6
Quassia sp. Moonee Creek	Moonee Quassia	E	E	1, 3
Rotala tripartita	-	-	E	6
Streblus brunonianus (syn. Streblus pendulinus)	Siah's Backbone	-	-	4, 8
V=vulnerable, E=endangered				

2. Methods

2.1 Timing and conditions

2.1.1 Survey timing

The timing of surveys followed in accordance with the monitoring program in the TFMP which prescribes that monitoring be undertaken every three months during the first year of construction, every six months during the second year of construction and every 12 months thereafter for a minimum of three years post-construction (subject to achieving three consecutive monitoring periods as per MCoA D8(k).

As different sections of the W2B upgrade are being constructed independently, the timing of monitoring events described have occurred at different construction phases. For example, this report documents monitoring data at Year 1 and Year 2 of construction as follows

- Section 1-2 – Year 1 construction (2016). Surveys were completed, and results reported by Landmark Ecological Consultants reporting on two surveys conducted on winter and spring/summer.
- Section 1-2 – Year 2 construction (2017). Biannual survey completed by Jacobs with first summer survey reported by Landmark Ecological Consultants.
- Section 3-10 – Year 1 construction (2017). Quarterly surveys completed by Jacobs.

This information is summarised in Table 2-1.

Table 2-1 Timing of data collection during different project phases for all sections/portions

Project sections	Timing of data collection for each project phase*						
	2014	2016		2017			
		Winter	Spri - Sum	Summer	Autumn	Winter	Spring
Section 1	PC	C1 (LM)	C1 (LM)	C2 (LM)	-	C2	-
Section 2	PC	C1 (LM)	C1 (LM)	C2 (LM)	-	C2	-
Sections 3-4	PC	-	-	C1	C1	C1	C1
(Sections 5	PC	-	-	C1	C1	C1	C1
Section 6	PC	-	-	C1	C1	C1	C1
Sections 7,8,9	PC	-	-	C1	C1	C1	C1
(Sections 10-11	PC	-	-	C1	C1	C1	C1
*PC = Pre-construction, C1 = Construction Year 1, C2 = Construction Year 2, LM Landmark							

2.1.2 Climatic variability

Given the long length of the study area, localised climatic conditions vary across the extent of the project and is important to document for detecting trends in natural variation and changes in health, abundance and occurrence of threatened flora described. This is particularly important for threatened flora that grow in wetland and riparian habitats and depend on rainfall.

Total annual rainfall for 2017 ranged from 1229 mm at Grafton Airport (058161) (Sections 3-5), 1719 mm at Lower Bucca (0592006) (Sections 1 and 2) and 2155 mm at Woodburn (058061) (Sections 6-10). All sites received above average annual rainfall (4-37%), with the greatest increase at Woodburn. Monthly rainfall trends were similar across the region showing above average totals in March, June and October 2017. This was representative of survey observations, except for summer (February) monitoring which experienced dry conditions preceding high rainfall in March. Overall mean maximum and minimum temperatures were average for majority of 2017.

2.1.3 Summary

A summary of all monitoring events, survey timing and local weather conditions is presented in Table 2-2

Table 2-2 Survey timing and weather conditions experienced for each monitoring event

Monitoring event (2017)	Monitoring period		Mean rainfall over survey period (mm)*			Total mean rainfall three months preceding survey (mm)*		
	Section 1-2	Section 3-10	Lower Bucca	Grafton	Woodburn	Lower Bucca	Grafton	Woodburn
Summer	17-28 Feb and 1 Mar	6-17 Feb	23.2	61.6	41	285	189	303
Autumn	-	1-6 May	N/A	1.6	13.8	N/A	519	960
Winter	18-20 Aug	14-25 Aug	1.4	0.2	8	343	232	523
Spring	-	13-25 Nov	N/A	13.2	14.6	N/A	126	201

2.2 Adaptive monitoring actions

The pre-construction baseline surveys undertaken by Jacobs (2014) identified 93 threatened flora species occurrences (sites) as the basis of the in-situ monitoring program. This comprised 69 impact monitoring sites and 24 control sites (outside of the impact area). Two or three threatened flora species sites may occur in the same site location. All site locations are displayed in Appendix A.

All in-situ sites monitored during the pre-construction phase were established during the concept design. During the construction monitoring period some of these pre-construction sites could not be accessed due to landowner restrictions or sites were completely or partially cleared as a result of refinements to the detailed design. Through the detailed design process, the project construction footprint was reduced. This resulted in a significant reduction to the overall impacts to threatened flora compared to quantities reported in the approved EIS (refer Appendix B for details on changes).

The minor changes to the construction footprint affected the previous placement of some impact monitoring plots established in the early pre-construction phase. As part of an adaptive monitoring approach additional and/or replacement monitoring sites were established where there was opportunity to incorporate other known individuals or populations of the subject species nearby. This allowed for threatened species adjacent to the project boundary to be continually monitored and addressed the refinements of detailed design. Additionally, it was agreed with Roads and Maritime to establish new control sites to allow for additional data to be collected where sites were on private land with access restriction. A total of 85 sites are being monitored in the revised program comprising 66 impact and 19 control sites.

In total, ten original pre-construction monitoring sites were directly or indirectly affected due to changes to the clearing limits approved with the modified detailed design. These sites have subsequently been removed from the monitoring program. Six of these were replaced with new impact monitoring sites nearby, but outside the limits of clearing, where further individuals of the threatened species were known to be present. Details of the adaptative monitoring actions are outlined in Table 2-3.

In addition to the amendments discussed, other in-situ threatened plant sites were identified (additional finds to the EIS/SPIR), during the detailed design and early construction phase. Further to this, ceased private land access agreements restricted access to previous monitoring sites. To account for this, five new sites were added to the program as follows:

- Two new sites (Rt-6.1 and Rt-6.2) for identified *Rotala tripartita* individuals observed in flooded drainage swales near Tulymorgan-Jacybulbin Road in Section 6.
- One site established during summer surveys for *Cyperus aquatilis* (Ca-6.1) in Section 6 next to the Pacific Highway, 200 metres north of Tulymorgan-Jacybulbin Road.
- Permanent access restrictions to 10 sites in Section 1, 2 and 3 and temporary restrictions in Section 4 and 10. This warranted establishment of two new control sites La-C1.3a located on Mahogany Drive,

Pillar Valley and Mt-C1.2a located in Yuraygir National Park and has allowed for monitoring of natural conditions for *L. alsinoides* and *M. triglochinoides* for remaining in-situ sites (refer to Table 2-3).

Two subject species (comprising three sites) described in the TFMP have been removed from the monitoring program, the reasons for this are described below.

- *Streblus pendulinus* has been re-defined as a distinct species restricted to Norfolk Island (listed Endangered under EPBC Act) in contrast to the morphological variations of *Streblus brunonianus* which occurs as a common species on east coast of Australia and within the construction footprint (Conn, 2015). As a result, *S. brunonianus* is removed from monitoring program and excludes two sites (Sp-4.1 and Sp-8.1).
- *Phaius australis* has been removed from the monitoring program where it was found to be misidentified. This species was observed flowering late in summer surveys and in full flower during spring surveys. Flowers are necessary to positively identify *P. australis* where leaf shoots are very similar in shape and size to *Calanthe triplicata* (non-threatened species). Flowers were distinguished as all white with a yellow calli on the labellum and lacked a brown inside of lateral sepals and petals, as well as absence of shorter pink labellum found in *P. australis*. Using the flowers, Jacobs botanists positively identified the orchid species in Site Pa-9.1 as *C. triplicata*.

Adaptive measures to address the refinement of the detailed design, new species identification/listing status and sites with access restrictions are summarised in Table 2-3.

Table 2-3 Status of sites with adaptive monitoring approaches required to address the detailed design, species identification and access restrictions

Section	Sites (ID code)				
	Refined detailed design impact		New sites added to the program	Permanent access restrictions	Temporary access restrictions
	Removed	Replaced			
1	Elt-1.1, Elt-1.2, La-1.1, Mt-1.2	Elt-1.1a (Elt-1.1), Mt-1.2a (Mt-1.2)	-	Elt-1.2, Elt-C1.1, Elt-C1.2, La-1.1, La-C1.1, La-C1.2, La-C1.3, Mt-C1.1, Mt-C1.2	-
3	Ar-3.10, Ar-3.11	Ar-3.10a (Ar-3.10), Ar-3.11a (Ar-3.11)	La-C1.3a, Mt-C1.2a	Mt-3.3 (since May)	-
4	Pe-4.2, Sp-4.1	Pe-4.2a (Pe-4.2)		-	Pe-4.1 and Pe-C4.1 (May)
5	Pe-5.2	-	-	-	-
6	Pc-6.2, Pc-C6.1, Pc-6.2a	Pc-6.2a (Pc-6.2), Pc-C6.1a (Pc-C6.1),	Ca-6.1, Rt-6.1, Rt-6.2	-	-
8	Oc-8.1, Sp-8.1	-	-	-	-
9	Pa-9.1	-	-	-	-
10	-	-	-	-	Ah-10.2 and Ah-10.5 (November), Ot-10.1 and Ot-C10.1 (February)
Total	15	7	5	10	6
Note: Roads and Maritime is continuing to work with stakeholders and landowners to resolve access issues have implemented adaptive measures such as adding and/or replacing sites with no access. Access issues are out of Roads and Maritime control.					

2.3 Sampling methods

2.3.1 Targeted surveys and species detection

The sampling approach ensured that different plant life stages were targeted over four monitoring events (seasonal). The surveys focused on monitoring the health and condition of known individuals as well as investigate recruitment of new individuals. Detection of cryptic threatened flora was reliant on suitable climatic and seasonal conditions, particularly *Cyperus aquatilis* and *Rotala tripartita*. Climate variability also has an effect on *Lindernia alsinoides, Lindsaea incisa* and *Maundia triglochinoides,* however these species were generally detected throughout the monitoring period under suitable conditions. *Persicaria elatior* and *Arthraxon hispidus* have an annual life cycle and were only detectable at certain times of the year. *P. elatior* would generally show signs of natural dieback in late autumn with few plants remaining in winter and seedlings would appear in late spring. *A. hispidus* would dieback in winter and seedlings would appear in spring and begin to set seed in late autumn. *C. aquatilis* and *R. tripartita* are also short-lived annuals and appear in wet summer periods. All other subject species were detectable in all seasons throughout 2017.

2.3.2 Sampling technique

The baseline monitoring established in-situ plot locations next to the clearing boundary and control plot locations were established greater than 50 metres from the clearing boundary. The technique of sampling each was the same and followed the TFMP and the baseline surveys, with some additional techniques as described below.

A 20 x 20 metre plot with a central 20 metre transect was used at each site. Where possible, transects were aligned from north to south. At each monitoring event a photograph was taken at the northern end of the transect looking along the transect. Additional photographs were taken of the general habitat condition, individual plants and/or clusters of plants, and where insect attack and plant dieback was noted.

A tape measure was laid along the plot midline to record habitat condition (vegetation cover and structure) and used as a reference for plant locations. Vegetation condition was recorded along the transect with the canopy and midstorey (greater than one-metre high) cover recorded as percentage foliage cover every five metres (four points) along the transect and groundcover attributes were recorded at every metre (20 points) as either forb, grass, shrub (less than one-metre high), bare/water, litter or exotic. The central transect was also used to describe the distribution of threatened flora within the plot. Weed species and cover of abundance was recorded within the whole plot.

Habitat condition parameters and plant health indicators were recorded within the plot and the transect and associated with individuals in relation to threatened plants. This included but was not limited to:

- Genus, species and subspecies.
- Identifier – unique plant number.
- Location – location; easting, northing & description.
- General condition – score on a scale of 0 to 5, where 0 is dead and 5 is excellent.
- Leaf condition – healthy/unhealthy, colour, vigour.
- Flower/fruit – flower/fruit presence.
- Length of new shoots – average length of new shoots (estimate) and abundance of new shoots (counts or basic scale).
- Disease symptoms – evidence of disease (including presence / absence of Myrtle Rust, Cinnamon Fungus).
- Recruitment.
- Evidence of any other damage or disturbance.
- Plant community type.
- Canopy cover.
- Mid-storey cover.
- Ground-layer cover and composition.

- Weed cover of abundance and weed ground cover percentage.
- 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.

Data collected during the 2014 baseline monitoring of threatened plants used a coarse cover rating (low to high) to measure the abundance of high density groundcover species such as *M. triglochinoides*, *L. incisa* and *L. alsinoides*. The resulting data was found to be problematic when determining any real change with the subsequent construction monitoring data. Therefore, plant distribution was drawn onto a plot diagram and combined with plot photos to identify current species cover and abundance for direct comparison.

In addition to this, a new quantitative measurement was also incorporated to more accurately measure the abundance and distribution of groundcover plants (and annuals) that are difficult to count and/or grow in clusters. This was specifically used for *C. aquatilis* and *R. tripartita*. *L. alsinoides, L. incisa* and *M. triglochinoides.* The technique involved the measurement of an area of occupancy across the plot and from a series of 1x1 metre quadrats to estimate percentage ground cover and determine mean cover. Any plots with continual low abundances of individuals were directly counted. Mean cover was not used for *A. hispidus* to keep data consistent with previous baseline monitoring. Instead grass stems were directly counted within specified patches or mean number of stems determined in 1 x 1m quadrats for larger populations.

To measure consistent change (increase/decline) of in-situ plants, the mean percentage ground cover (or mean number of stems) was multiplied by the division of the area of occupancy (AoO) over the plot size (AoO / 400m^2 x mean cover). Densities were analysed as an index of abundance measured at plant cover or stems /m^2.

The remaining shrubs, trees and orchids were directly counted as per the TFMP. A summary of plant health and habitat condition factors was recorded based on observing leaf condition, any notable dieback or insect attack, plant height, width, diameter at breast height (DBH) for tree species, number of trunks and habitat conditions.

Weed cover was measured using a modified Braun-Blanquet cover abundance score (Poore 1955), refer Table 2-4.

Table 2-4 Cover abundance score used for measuring weeds

Score	Cover of abundance
1	Rare, few individuals present (three or less) and Cover <5%;
2	Common and cover <5%;
3	Very Abundant and Cover nearing 5% OR Cover from 5% to <25%;
4	Cover from 25% to less than 50%;
5	Cover from 50% to less than 75%;
6	Cover 75% or more

Other general information recorded at each plot included observations of the dominant flora species in each structural layer, prevailing site conditions (i.e. soil moisture, surface water levels and observed flow velocity for macrophyte species) and landscape parameters (i.e. landform, drainage, slope and aspect).

2.4 Performance thresholds and corrective actions

The TFMP details an adaptive management approach to achieve management goals and mitigate impacts in-situ threatened flora. The data from the construction phase of the project has been analysed and interpreted to evaluate any impacts and the effectiveness of any management measures used. This is assessed in the context of the performance measures identified in the plan.

Specific goals for mitigating impacts using performance thresholds and corrections actions during construction management for in-situ threatened plants are outlined in Table 2-5 summarised from the TFMP.

Table 2-5 Mitigation measures and corrective actions for threatened flora during construction

Performance goals	Proposed mitigation measure	Monitoring/timing frequency	Trigger for corrective actions	Corrective actions
Zero mortality of threatened plants from in situ populations (from physical damage during construction) and no loss of threatened plants directly adjacent to the project.	Implementation of the Roads and Maritime clearing protocol. Clearing areas identified and approved as required under the clearing protocol.	Clearing areas identified and approved prior to clearing activities being undertaken.	Clearing areas have not been marked out and approved prior to construction.	Delay construction until clearing areas have been marked out.
	Exclusion zones fenced off to protect in situ threatened plants. Induct all construction staff at the commencement of construction works. Induct new staff as appropriate	Exclusion zone fencing monitored at least weekly during construction. Faults rectified as soon as noticed.	Exclusion zone fencing is damaged or ineffective.	Stop construction in the area of the fencing breach until exclusion fencing has been repaired. Investigate why breach in fencing occurred and implement corrective actions as required to prevent reoccurrence.
	Monitor in-situ plants at established monitoring sites during construction.	Every three months during the first year of construction. Every six months during the second year of construction.	Any loss of retained in situ threatened plants.	Commence assessment of potential reasons for mortality, including seasonal fluctuations, natural events such as drought and fire within one month of trigger being identified. Compare with paired control site. Identify potential threats, implement corrective actions and modify monitoring as necessary.
No notable increase in the abundance of weeds within threatened plant habitat during monitoring of in situ populations.	Implementation of weed management as described in the CEMP and FFMP. Up to date Sensitive Area Plans.	Every three months during the first year of construction. Every six months during the second year of construction.	Noxious and environmental weeds reported in areas adjacent to threatened plants. Spread of noxious and environmental weeds into properties adjoining the project noted in monitoring activities.	Review the weed management maintenance schedule and update as required. Implement appropriate weed measures as required within one month of the trigger for corrective action.

Performance goals	Proposed mitigation measure	Monitoring/timing frequency	Trigger for corrective actions	Corrective actions
Adequately planned translocation carried out such to maximise the chance of survival of the translocated plants.	Salvage and planting of identified plants for translocation undertaken prior to clearing, into suitable habitat, and using appropriate methods that maximise the chance of plant survival.	At the optimal time of year for species prior to clearing works commencing. Once salvaged, plants would need to be monitored throughout the construction phase at least three times a year (summer, autumn, spring).	All plants identified for translocation have not been translocated prior to commencement of construction.	Stop construction in vicinity of threatened plants. Investigate appropriate translocation activities. If translocation cannot be undertaken use reserves of species tube stock or seed to supplement and enhance populations.
The landscaping design includes details on revegetation requirements for areas adjacent to threatened plants and translocation/offset areas.	Revegetation and habitat management requirements included in the landscape design for areas adjacent to threatened plants. Specifically includes revegetation maintenance planned in consultation and implemented by experienced bush regenerators for areas adjacent to in situ populations.	Appropriate measures incorporated into the Urban Design and Landscape Plan.	Landscape design has not included specific revegetation requirements for areas adjacent to threatened plants and translocation/offset areas	Plan to be updated to include specific requirements prior to commencement of implementation of plan.
Dust managed in accordance with the CEMP.	Dust impacts would be managed in accordance with the CEMP including dust suppression measures.	Dust suppression would be implemented in accordance with the CEMP. Monitoring of dust on plants considered as part of plant health monitoring. Dust deposition is to be monitored monthly.	Dust exceedances recorded from dust monitoring within sections containing threatened plants.	Review dust suppression procedures to ensure adequate dust management. Where appropriate, shade cloth screening installed on edge of construction footprint to protect low growing threatened flora.
Water and soil quality managed in accordance with the CEMP.	Adequate soil and water quality controls installed surrounding retained threatened plants. Procedures for maintenance and monitoring of erosion and sediment controls included in the CEMP.	Erosion, sediment and water quality controls would be monitored weekly throughout the construction period and as soon as practical after storm events.	Breaches of erosion, sediment and water quality controls recorded. Loss of ecological condition recorded from plant health monitoring particularly from altered water quality.	Review adequacy of the erosion, sediment and water quality controls and implement appropriate corrective actions. Commence review of monitoring procedures for controls and implement appropriate corrective actions.

Performance goals	Proposed mitigation measure	Monitoring/timing frequency	Trigger for corrective actions	Corrective actions
Reduce impacts to threatened orchid species through illegal collection.	Restrict the availability of information identifying where orchids occur within the project area, and in close proximity to the project area. Limit site access to areas where orchids naturally occur and may be being managed in situ.	Threatened orchid populations will be regularly monitored during construction and post construction as part of the overall monitoring program.	There is evidence of public access to the orchid areas and/or evidence of illegal collection.	Discuss potential corrective measures with the regulatory authorities.

3. Results and Discussion

3.1 Comparison between pre-construction and construction (Year 2) (Section 1 and 2)

3.1.1 Eleocharis tetraquetra

No individuals or clumps of *E. tetraquetra* were detected in winter 2017 monitoring at Sites Elt-1.1a, Elt-1.3 and Elt-1.5. As noted in the previous annual report (Landmark, 2017), direct project impacts have resulted in the removal of Sites Elt-1.1, Elt-1.2 and partly removed Site Elt-1.3. This comprises a loss of 185 plant clumps. Site Elt-1.4 had access restrictions.

Site Elt-1.4 was visited with RMS personnel during spring surveys to assess future direct impacts from an access track next to the plot. This removed approximately 25 m^2 from the plot, however no plants have been detected since the pre-construction and are not expected to be impacted.

This species seems to dieback during the winter months and has only been detected at Sites Elt-1.3 and Elt-1.5 during construction monitoring in summer 2017. Elt-1.3 had four clumps and Elt-1.5 had 8 clumps. Sites Elt-1.3, Elt1.1 and Elt-1.1a (new) were heavily modified by detailed design impacts, changed hydrology and increased sunlight as well as flow of sediment into associated streams (example of Elt-1.1 shown in Photograph 5) Weed abundance has remained low. Direct impacts to this species was avoided, however ongoing monitoring will identify any future indirect impacts to the species.

Site Elt-1.5 continues to receive project related sediment laden runoff through the culvert. This is expected to cease during the operation phase. Weed abundance has increased slightly to 10% of the ground cover, particularly pasture grasses on introduced soils/gravel. This is not a notable increase compared to weed cover present in pre-construction.

A summary of results is shown in Table 3-1.

Table 3-1 Comparison of pre-construction and construction E. tetraquetra abundance at in-situ and control sites and project related change

Site	Chainage	Pre-construction 2014 abundance (clumps)	Total construction abundance (clumps)	Change in number of clumps (+/-)	Detailed design impact	Inadvertent construction impact
Elt-1.1	5700	170	0	-170	Yes	No
Elt-1.2	6200	15	0	-15	Yes	No
Elt-1.1a	5700	N/A	0	0	No	No
Elt-C1.1	6400	150	No access	N/A	N/A	N/A
Elt-C1.2	6400	100	No access	N/A	N/A	N/A
Elt-1.3	6600	12	4	-8	Yes	No
Elt-1.4	6700	100	No access	N/A	No	N/A
Elt-1.5	14700	0	8	+8	No	No
Total project related loss				-193	Yes	No

3.1.2 Eucalyptus tetrapleura

Majority of sites with *E. tetrapleura* are in good condition with low or no weed cover/abundance and intact structure and native species diversity. Two sites (Et-2.1 and Et-2.2) have been burnt in last 1-2 years but younger saplings have regenerated. Site Et-2.1 had two trees removed by clearing activities where the project boundary penetrated the plot (refer to Photograph 1).

Evidence of project related erosion and fast flowing surface water run-off was observed at Site Et-2.3. Run-off was sourced to a nearby overflow pipe from a sedimentation basin, this has washed away top soil within the plot. No decline of tree health was observed but any potential loss of top soil may in affect the establishment of seedlings (refer to Photograph 2). A summary of results is shown in Table 3-2.

Table 3-2 Comparison of pre-construction and construction E. tetrapleura abundance at in-situ and control sites and project related change

Site	Chainage	Pre-construction May 2014 (trees/seedlings)	Construction 2016-2017 (trees/seedlings)				Change in abundance (+/-)	Detailed design impact	Inadvertent construction impact
			Jun 2016	Dec 2016	Feb 2017	Aug 2017			
Et-1.1	9200	1/0	1/0	1/0	1/0	1/0	0	No	No
Et-C2.1	28400	8/0	8/1	8/1	8/2	8/2	0 (+2 seedlings)	N/A	N/A
Et-2.1	23000	7/0	5/0	5/0	5/0	5/0	-2	Yes	No
Et-2.2	24100	9/0	9/0	9/0	9/0	9/0	0	No	No
Et-2.3	28400	8/0	8/0	8/0	8/0	8/0	0	No	No
Total in-situ							33		
Total project related loss							-2 trees	Yes	No

Photograph 1: Project boundary edge within Site Et-2.1 (loss of two trees) showing plot on right side during summer surveys (summer 2017).

Photograph 2: In-situ Site Et-2.3 with bare ground caused by surface water runoff that has washed away top soil (summer 2017)

3.1.3 Lindernia alsinoides

Construction related clearing has affected two sites with complete removal of Site La-1.1 and partial clearing of Site La-1.2. Changes to hydrology and potential water quality of surface water run-off was observed at sites La-1.2 and La-1.3, however there is lack of evidence to support indirect impacts to habitat or species decline. Refer to photographs 3 and 4. Results are summarised in Table 3-3.

A private boundary track was constructed on the edge of Site La-1.3 in late 2017. This removed approximately 25 m^2 from the plot (*L. alsinoides* habitat) and impacted an estimated 20 plants or loss of a mean cover 0.01%/m^2. Impacted individuals were translocated prior to clearing works for the access track.

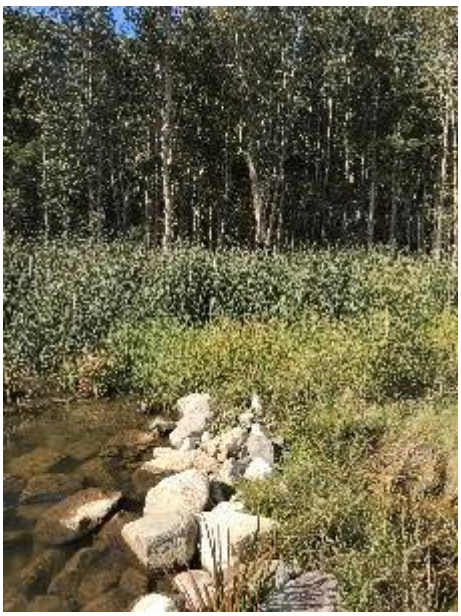
Given the lack of access to *L. alsinoides* control sites in Section 1, any indirect or subtle impacts to the species at these locations cannot be compared. This warranted the search and establishment of an additional control Site La-C1.3a located at an RMS offset site at Mahogany Drive in Pillar Valley. Targeted searches couldn't locate a closer population to the in-situ sites. The habitat is similar comprising a canopy of *Eucalyptus robusta*, *Melaleuca quinquenervia*, *M. alternifolia* on a drainage line with a low water level and rich organic soil. However, this habitat's understorey species composition differs from in-situ sites with a dominance of *Gahnia clarkei*, *Baloskion tetraphyllum, Imperata cylindrica and Gonocarpus micranthus*. No notable change in weed abundance has occurred at *L. alsinoides* sites.

A summary of results is shown in Table 3-3.

Table 3-3 Comparison of pre-construction and Year 2 construction mean cover of L. alsinoides at in-situ and control sites and project related change in mean cover

Site	Chainage	Pre-construction (mean cover % / m^2 in plot)	Construction (mean cover % / m^2 in plot)			Mean change in % cover / m^2 (+/-)	Detailed design impact	Inadvertent construction impact
			Jun 2016	Feb 2017	Aug 2017			
La-1.1	6200	0.05 (est.)	N/A	0	0	-0.05	Yes	No
La-C1.1	6400	0.1 (est.)	No access			N/A	N/A	N/A
La-1.2	6600	0.13 (est.)	N/A	0.02	0.01	-0.12	Yes	No
La-C1.2	6400	0.7 (est.)	No access			N/A	N/A	N/A
La-1.3	6700	5 (est.)	N/A	1.5	No access	-3.5	No	No
La-C1.3		5 (est.)	No access			N/A	N/A	N/A
La-C1.3a		N/A	N/A	0.07	0.02	N/A	N/A	N/A
La-2.1	22400	0.13 (est.)	N/A	0.1	0	-0.08	No	No
Total project related loss						-3.75	Yes	No

Photograph 3: Edge of Site La-1.3 showing project related run-off flowing into site (winter 2017)



Photograph 4: Edge of Site La-1.2 shows modified hydrology with installation of rocky basin (winter 2017)

3.1.4 Lindsaea incisa

There was no notable change in *L. incisa* mean cover or weed abundance at both in-situ and control sites relating to the construction of the project. All sites had shown the fern thriving in most conditions. Further evidence from Site Li-2.2 has shown that fire is beneficial for stimulating growth from rhizomes as observed in Site Li-3.2. Results are summarised in Table 3-4.

Table 3-4 Comparison of pre-construction and Year 2 construction mean cover of L. incisa at in-situ and control sites and project related change in mean cover

Site	Chainage	Pre-construction (mean cover % / m^2 in plot)	Construction (mean cover % / m^2 in plot)			Mean change in % cover / m^2 (+/-)	Detailed design impact	Inadvertent construction impact
			Jun 2016	Feb 2017	Aug 2017			
Li-1.1	5000	0.3 (est.)	N/A	0.06	0.3	0	No	No
Li-2-1	17600	3 (est.)	N/A	2.8	6.5	+1.7	No	No
Li-2.2	22400	1.25 (est.)	N/A	1.25	1.25	0	No	No
Li-C2.1	17500	1.25 (est.)	N/A	2	2.25	+0.6	No	N/A
Total project related change						0	No	No

3.1.5 Maundia triglochinoides

Dry conditions were observed at sites with *M. triglochinoides* populations in Year 2 construction monitoring, particularly in winter where most aquatic habitats had no surface water.

M. triglochinoides plants at Site Mt-1.1 have not been observed since baseline surveys. Early construction monitoring in July 2016, observed banked up water laden with sediment in swamp forest habitat with no sediment control fence. A modified hydrology is assumed to have caused decline in this population with future risk of overflow flooding as a result of construction. This site has remained mostly dry in Year 2 of construction with no evidence of *M. triglochinoides*, however the population may still be present in the intact soil seedbank.

The previous Site Mt-1.2 had been cleared by the project in 2016, a second site (Mt-1.2a) was established 20m to the east to monitor remaining *M. triglochinoides*. Many plants were situated in sediment-laden water and declining in health. Very dry conditions during winter surveys found that all plants within plot had died (refer to Photograph 5).

Access restrictions to Sites Mt-C1.1 and Mt-C1.2, prompted the establishment of an additional control site in to collect monitoring data of a *M. triglochinoides* populations under natural conditions. This is particularly important for *M. triglochinoides* which can be sensitive to environmental changes such as climate and water quality. Control Site Mt-C1.2a was selected in May 2017 on the edge of Yuraygir National Park along Yellow Cutting Road. There was a healthy *M. triglochinoides* population in a waterway comprising similar habitat features as in-situ sites, including a canopy of *M. quinquenervia*, *M. alternifolia* and *Lophostemon suaveolens*.

Site Mt-2.1 was re-located nearby in June 2016 where plot makers could not be found. The replaced site contains a mean cover of 0.2%/m^2. Minor impacts were observed in February of installed geo-fabric smothering *M. triglochinoides* plants on edge of plot (refer to Photograph 6). No notable effects of construction were observed in habitat quality of main water body. Although this site has seen a minor decline in plant mean cover during construction monitoring, this is negligible and is likely related to natural variation in climate experienced over the region where minor declines were also observed in nearest control Site Mt-C2.1.

Declines of *M. triglochinoides* mean cover were observed at clustered in-situ sites Mt-2.2, Mt-2.3 and Mt-2.4. Site observations provided no evidence relating to project impacts.

Summary of mean cover percentage of *M. triglochinoides* populations in each plot of Sections 1-2 is presented in Table 3-5.

Table 3-5 Comparison of pre-construction and Year 1-2 construction mean cover of M. triglochinoides at in-situ and control sites and project related change in mean cover

Site	Chainage	Pre-construction (mean cover % / m² in plot)	Construction (mean cover % / m² in plot)			Mean change cover % / m² (+/-)	Detailed design impact	Inadvertent construction impact
			Jun 2016	Feb 2017	Aug 2017			
Mt-1.1	4900	0.15 (est.)	0	0	0	-0.15	No	Yes
Mt-C1.1	4900	0.3 (est.)	N/A	No access	No access	N/A	N/A	N/A
Mt-1.2	5700	12.5 (est.)	0	0	0	-12.5	Yes	No
Mt-1.2a*	5700	N/A	N/A	0.4	0	-0.4	Yes	No
Mt-C1.2	5700	3.1 (est.)	N/A	No access	No access	N/A	N/A	N/A
Mt-C1.2a	20500	N/A	N/A	1.6 (May)	0.4	N/A	N/A	N/A
Mt-2.1	20700	N/A*	0	0.3	0.1	N/A	N/A	N/A
Mt-C2.1	20600	0.25 (est.)	N/A	0.06	0.06	-0.19	N/A	N/A
Mt-2.2	22300	0.75 (est.)	N/A	0.13	0.1	-0.64	No	No
Mt-C2.2	22400	4.9 (est.)	N/A	16	3.75	+4.98	N/A	N/A
Mt-2.3	22400	0.63 (est.)	N/A	0.33	0	-0.46	No	No
Mt-2.4	22400	10 (est.)	N/A	12.24	7.5	-0.13	No	No
Total project related change						-13.1	Yes	Yes
*Old site replaced nearby								

Photograph 5: Project boundary edge within new Site Mt-1.2a established in summer 2017 scour rock design beyond culvert apron in place of original monitoring plots (Mt-1.2 and Elt-1.1).

Photograph 6: Sediment and erosion control geo-fabric smothering some M. triglochinoides individuals next to Mt-2.1 (summer 2017)

3.1.6 Quassia sp. Moonee Creek

The health and abundance of *Quassia* sp. Moonee Creek has remained unchanged and plants are doing well at both in-situ and control sites (chainage: 8000-8300). Plants were in late flower with some fruiting buds during summer surveys and new flowers were also evident in winter surveys. Some plants had fresh shoots from apical meristem and new sprouts from lignotubers at every monitoring event. A high cover of leaf litter and a dense understorey of shrubs indicates lack of fire at all sites and may be required to open groundcover for seed propagation. Adults plants would likely re-shoot from lignotuber in the event of an appropriate ecological burn.

No weeds have penetrated Quassia sites. Project related indirect impacts were observed during summer surveys where there was a lack of appropriate water quality and erosion controls in place to protect nearby in-situ sites. This included ineffective erosion control outside of in-situ Site QM-1.1 (chainage: 8000) and sediment-

laden runoff flowing into associated habitat drainage line outside of in-situ Site QM-1.2 (chainage: 8400) (refer to Photographs 7 and 8).

Photograph 7: Overtopping erosion control leading into a drainage line associated with in-situ Site QM-1.1 (summer 2017)

Photograph 8: Sediment-laden runoff during a high rainfall event flowing into nearby habitat linked to in-situ Site QM-1.2 (summer 2017)

3.2 Comparison between pre-construction and construction (Year 1) (Section 3-9)

3.2.1 Angophora robur

The overall project impacts to this species were around 8% less than predicted in the approved EIS/SPIR resulting from detailed design refinements (refer to Appendix B). Two new *A. robur* monitoring sites (Ar-3.10a and Ar-3.11a) were established in summer 2017 due to changes with the detailed design within the project boundary at sites Ar-3.10 and 3.11. In spring surveys Site Ar-3.10a had two trees removed during construction activities for installing a permanent boundary fence. Numerous more trees are likely to have been impacted outside of the plot. This site has also received past habitat clearing and under-scrubbing with edge effects within the project boundary (refer to Photograph 9). Exclusion fencing protecting this site was damaged in autumn surveys but was re-established in spring after impacts (refer to Photograph 10). Numerous *A. robur* seedlings are regenerating in this area next to the site.

Two other sites also sustained a loss of trees prior to summer surveys (13 trees at Ar-3.2 and 4 trees at Ar-3.5) due to impacts from refined detailed design within the project boundary. This disturbance has increased sunlight onto the ground and increased bare ground (up to 25% cover) which has allowed suitable propagation conditions for *A. robur* and recruitment of six new juveniles was observed in spring 2017 (refer to Photograph 11 and 12). Appropriate exclusion fencing at in-situ Site Ar-3.2 was removed in winter and has not been replaced around *A. robur* habitat.

The hot dry weather preceding summer surveys caused heat related plant stress at dry sandy sites with *A. robur* particularly sites Ar-3.4 and Ar-3.7. As a result, native plant species in the understorey had severe leaf dieback and insect damage, including *A. robur* seedlings, *Duboisia myoporoides*, *Banksia oblongifolia*, *Pteridium esculentum* and *Alphitonia excelsa*. The understorey had recovered in autumn surveys after heavy rainfall in March.

Non-project related indirect impacts were also observed at a couple of sites. In summer Site Ar-C3.1 was evident of private landholder clearing on edge of plot, this has had no impact on trees, but edge effects may have increased sunlight and promoted *A. robur* regeneration with 18 new seedlings observed. Evidence of a hot fire was observed at Site Ar-3.3 in winter which burnt many small trees including young juveniles, however surveys in spring identified new shoots coppicing from base of all affects plants.

A summary of all in-situ and control *A. robur* sites is presented in Table 3-6.

Table 3-6 Comparison of pre-construction and construction A. robur abundance at in-situ and control sites and project related change in abundance

Site	Chainage	Pre-construction 2014 (trees/seedlings)	Year 1 Construction 2017 (trees/seedlings)				Mean change in abundance (+/-)	Detailed design impact	Inadvertent construction impact
			Feb	May	Aug	Nov			
Ar-3.1	44600	7/0	7/4	7/4	7/4	7/4	0 (+4 seedlings)	No	No
Ar-C3.1	44600	6/10	6/24	6/16	6/16	6/28	0 (+18 seedlings)	No	No
Ar-3.2	48800	18	5	5	5	5	-13	Yes	No
Ar-C3.2	65400	7	7	7	7	7/1	0 (+1 seedling)	No	No
Ar-3.3	49200	15/2	15/2	15/2	15/0	15/2	0	No	No
Ar-3.4	50000	20/10	20/11	20/11	20/11	20/11	0 (+1 seedling)	No	No
Ar-3.5	52500	13	13	9	9	9/6	-4 (+6 seedling)	Yes	No
Ar-3.6	55900	10	10	10	10	10	0	No	No
Ar-3.7	59000	10/26	10/26	10/26	10/26	10/26	0	No	No
Ar-3.8	61700	9	9	9	9	9	0	No	No
Ar-3.9	64700	6/6	6/6	6/6	6/6	6/9	0 (+3 seedlings)	No	No
Ar-3.10	66500	20	0	N/A			-20	Yes	No
Ar-3.10a (new)	66500	N/A	16	16	16	14	-2	Yes	No
Ar-3.11	67700	3	0	N/A			-3	Yes	No
Ar-3.11a (new)	67700	N/A	3	3	3	3	0	No	No
Total project related loss							-42 trees	Yes	No

Photograph 9: Clearing and under scrubbing of Site 3.10a for fence construction

Photograph 10: Project boundary edge next to Site Ar-3.10a showing damaged exclusion fence, A. robur trees and seedlings in mulch on edge during autumn surveys.

Photograph 11: Direct impacts to Site Ar-3.2 showing introduced rock inside plot next to A. robur trees and lack of exclusion fencing (spring 2017)

Photograph 12: Direct impacts to Site Ar-3.5 showing constructed fence and drain inside plot next to flagged A. robur tree (spring 2017)

3.2.2 Arthraxon hispidus

Seasonal data was collected for A. *hispidus* during 2017 surveys. This provides an insight into the grass' life cycle and the effect of local climatic conditions. Summer and autumn tend to be the best seasons for detecting the grass in these locations as the species would develop seed in late autumn, died back in winter and seedlings then appeared in late spring depending on conditions in the preceding winter.

All sites (including control sites) exhibited non-project related indirect impacts from weeds and competitive pasture grasses, and grazing pressures, as well as easement slashing and earthworks at sites Ah-8.1 and Ah-10.6. Spring 2017 was not an ideal season to survey for *A. hispidus* and the results are only indicative of the grass' life-history' through winter and spring. Major declines in mean densities for both in-situ and control sites were calculated for the whole 2017 monitoring period, however there is no evidence to support impacts from construction at all sites (refer to Table 3-7).

Table 3-7 Comparison of pre-construction and construction mean density of A. hispidus at in-situ and control sites and project related change in abundance

Site	Chainage	Density (stems/m^2 in plot)						Mean change in density (+/-)	Detailed design impact	Inadverten construcli impact
		2014 (Pre-construction)		2017 (Year 1 Construction)						
		May	Sept	Feb	May	Aug	Nov			
Ah-8.1	129300	-	0	0.02	0.20	0	0	+0.05	No	No
Ah-10.1	156200	0.12	-	0.27	0.04	0	0.10	-0.02	No	No
Ah-C10.1	157200	0.20	-	0.20	0.15	0	0.06	-10	No	No
Ah-10.2	156900	0.10	-	N/A	0.10	0	No access	0	No	No
Ah-C10.2	157500	0.50	-	0.30	0.13	0	0.14	-0.36	No	No
Ah-10.3	157300	0.10	-	0.19	0.07	0	0.03	-0.03	No	No
Ah-10.4	157400	0.10	-	0.10	0.10	0	0.01	-0.05	No	No
Ah-10.5	157500	0.50	-	0.20	0.10	0	No access	-0.40	No	No
Ah-10.6	157900	1.25	-	0	0	0	0.01	-1.24	No	No
Total project related change								-12.1	No	No

All sites (including control sites) remained high in weed abundance scoring five and six in cover of abundance for *Ambrosia artemisiifolia*, *Verbena littoralis*, *Axonopus compressus*, *Paspalum dilatatum*, *Cuphea carthagenensis*, *Setaria sphacelata*, *Ageratum houstonianum* and *Paspalum mandiocanum*. There were slight increases in weed cover and richness at in-situ sites Ah-10.1, Ah-10.3 and Ah-10.6 likely to be related to climatic conditions and land use change such as livestock grazing. In particular, Site Ah-10.3 had increased by six additional weeds, including priority weed (formerly noxious weed) *Senecio madagascariensis*. Priority weed *Lantana camara* appeared in low abundance at Site Ah10.2. Further data is required to analyse change in weed abundance over time to eliminate seasonal bias. Non-project related easement slashing and earthworks at Site Ah-8.1 has continued through the construction phase. Results of weed abundance is summarised in and Table 3-8.

Table 3-8 Comparison of pre-construction and construction weed abundance (ground cover and richness) in Arthraxon hispidus habitat at in-situ and control sites

Site	Mean weed ground cover (%) / weed richness (spp.)		Change (%) in mean weed ground cover (+/-)	Difference in number of weed species (+/-)	Detailed design impact
	Pre-construction	Construction (spring 2017)			
Ah-8.1	100/8	67.5/8	-31	0	No
Ah-10.1	100/6	99/10	-1	+10 spp.	No
Ah-C10.1	20/4	31.5/4	-36	0	No
Ah-10.2	85/3	75/3	-10	0	No
Ah-C10.2	72.5/9	35/9	-52	0	No
Ah-10.3	65/3	82.5/11	+17.5	+8 spp.	No
Ah-10.4	75/5	64/9	-11	+4 spp.	No
Ah-10.5	60/3	100/6	+40	+3 spp.	No
Ah-10.6	65/2	96/9	+31	+7 spp.	No

3.2.3 Cyperus aquatilis

Although no *C. aquatilis* was recorded during the establishment of site Ca-6.1 (chainage: 102900), it allows for monitoring of known habitat to examine in-situ changes that may indicate detection (i.e. suitable climatic conditions) as well as potential project-related habitat change. *C. aquatilis* was not observed, despite suitable rainfall preceding autumn and winter surveys. Mean weed groundcover was initially 55% in summer and declined to 15% cover in winter and spring. Flooding and cooler weather is likely to have reduced active weed growth.

3.2.4 Endiandra muelleri subsp. bracteata

The single individual *E. muelleri* subsp. *bracteata* at Site Emb-4.1 (chainage: 81700) is in excellent health and has grown around 60 centimetres since pre-construction surveys (refer to Photograph 13 and 14). Insect activity on shrub has been observed, including caterpillar, moth and ant and aphids. Leaf insect damage has been noted but hasn't caused detrimental harm to plant. Weed ground cover has increased by 20% to nearly half the plot since pre-construction surveys with an increase in cover of the climber weed *Aristolochia elegans* which was observed growing on *E. muelleri* subsp. *bracteata* in autumn 2017. Increases in weed abundance is unrelated to the project, but may cause harm to plant in future if not controlled.

The small tree at Site Emb-4.2 (chainage: 80700) has had continuous new shoot growth on lower and upper branches but has not grown in height with visual crown dieback and moderate dieback of upper branches in spring 2017 (refer to Photograph 15 and 16). Site Emb-4.2 has had no increase in weed cover, but weed species numbers have increased inside the plot, particularly at the lower end around the individual *E. muelleri* subsp. *bracteata* where the site had been cleared to allow for the new embankment. There is potential for future weed invasion and spread.

Photograph 13: E. muelleri subsp. bracteata at in-situ site Emb-4.1 showing new growth in February 2017

Photograph 14: E. muelleri subsp. bracteata at in-situ site Emb-4.1 with weed Aristolochia elegans and new flagging in November 2017

Photograph 15: E. muelleri subsp. bracteata at in-situ site Emb-4.2 showing new growth in February 2017

Photograph 16: E. muelleri subsp. bracteata at in-situ site Emb-4.2 with new fencing and showing new growth (in red) and dieback of upper branches in November 2017

3.2.5 Grevillea quadricauda

In-situ Site Gq-3.1 received partial clearing, compaction and ground slashing observed in summer and autumn surveys (refer to Photographs 17 and 18). Detailed design Impacts resulted in a loss of 14 *G. quadricauda* shrubs and around six seedlings. (refer to Table 3-9). The soil seed bank and some individuals to the south of this site were translocated in October 2016 to salvage part of the population from impacts.

In summer, numerous shrubs and other plants in the habitat of Site Gq-3-1 exhibited stem and leaf dieback due to the preceding dry conditions, which was also observed at the control Site Gq-C3.1.

G. quadricauda was found to benefit from a reduced canopy cover and ground disturbance at Site Gq-3.1 where increased sunlight and bare ground allowed for suitable recruitment conditions. Over the Year 1 construction phase, an additional 14 *G. quadricauda* seedlings in-situ were observed. The control site only recorded three

additional seedlings over this period under natural conditions. Weed canopy and ground cover had no notable change. Remaining in-situ shrubs have been kept in flagged exclusion zone.

Table 3-9 Comparison of pre-construction and construction G. quadricauda abundance at in-situ and control sites and project related change in abundance

Site	Chainage	Pre-construction 2014 (shrubs/seedlings)	Construction 2017 (shrubs/seedlings)				Mean change in abundance (+/-)	Detailed design impact	Inadvertent construction impact
			Feb	May	Aug	Nov			
Gq-3.1	59300	20/7	6/1	6/2	6/14	6/21	-14 (+14 seedlings)	Yes	No
Gq-C3.1	59500	8/2	10/3	10/3	10/3	10/5	+2 (+3 seedlings)	No	N/A
Total project related loss							14 shrubs	Yes	No

Photograph 17: Edge of Site Gq-3.1 showing loss of habitat, introduced rock and concrete drain. (autumn 2017)

Photograph 18: In-situ G. quadricauda seedling (autumn 2017)

3.2.6 Lindsaea incisa

In-situ Site Li-3.1 was directly impacted by detailed design work prior to summer surveys resulting in clearing of 85% of habitat in site. Widespread dieback of *L. incisa* was evident within plot where canopy cover was reduced by habitat clearing (refer to Photograph 19 and 20). Continued monitoring has found the species recovering with new fronds observed in autumn and winter as well as fertile fronds observed in spring. Some fronds are covered with semi-vertically placed geo-fabric on exclusion fencing, this will be monitored closely and should be reviewed. An excavator was observed operating on edge of Site Li-3.1 during spring surveys and the site is expected to have future impacts as part of a proposed sedimentation basin. This site also had 15 clumps of *L. incisa* translocated in December 2016 which may incorporate part of the mean cover loss (0.95%/m^2).

In-situ Site Li-3.2 has remained unaffected by project. A recent fire prior spring surveys burnt all plants in plot and reduced understorey and mid-storey cover. This fire has had a beneficial effect on *L. incisa* by reducing competition with other ferns, particularly *Calochlaena dubia* and *Gleichenia dicarpa* which previously dominated understorey. *L. incisa* had an increased growth in cover with mass re-sprouting from rhizomes.

Mean cover of *L. incisa* populations in Section 6 varied throughout the construction phase for both in-situ and controls sites, likely related to rainfall levels rather than impacts by project. Canopy cover remains unchanged for all sites. Minor trampling of ferns was observed at Site Li-6.1 in spring to install boundary flagging. The absence of fire was a considered a key factor for litter/debris build-up which was observed smothering some ferns at all sites.

Summary of mean cover percentage in each plot of *L. incisa* is presented in Table 3-10.

Table 3-10 Comparison of pre-construction and Year 1 construction mean cover of L. incisa at in-situ and control sites and project related change in mean cover

Site	Chainage	Pre-construction (mean cover % / m^2 in plot)	Construction 2017 (mean cover % / m^2 in plot)				Mean change in % cover / m^2 (+/-)	Detailed design impact	Inadvertent construction impact
			Feb	May	Aug	Nov			
Li-3.1	55800	1.4 (est.)	0.3	0.3	0.5	0.7	-0.95	Yes	No
Li-3.2	60200	0.8 (est.)	2.0	1.75	0.4	3.7	+1.15	No	No
Li-C6.1	98600	10 (est.)	1.5	9	3.4	2.1	-6	N/A	N/A
Li-6.1	98900	0.4 (est.)	0.3	6.9	3	0.7	+2.3	No	No
Li-6.2	99300	0.02	0.01	0.03	0.03	0.01	0	No	No
Total project related change							0.95	Yes	No

Photograph 19: Pre-construction in-situ Site Li-3.1 showing intact habitat (May 2014)

Photograph 20: Construction in-situ Site Li-3.1 showing cleared habitat and geofabirc on exclusion fence smothering some L. incisa (May 2017)

3.2.7 Macadamia tetraphylla

There was no notable change in tree health of M. tetraphylla or change in weed abundance and cover over the first-year construction phase at Site Mac-8.1 (chainage: 134700). Minor browning of leaves, broken and rotting branches were observed throughout construction phase monitoring. Weed cover remains high with 70% mean cover in the plot of which an additional seven weeds were observed absent in during pre-construction. Four weeds species have a high cover of abundance (four to six) including *Senecio madagascariensis*, *Cenchrus clandestinus*, *Bromus catharticus* and *Cirsium vulgare*. Grazing cattle are likely to be the cause of broken branches as well as trampling of tree roots observed on the tree and not related to the project.

3.2.8 Maundia triglochinoides

Notable changes in mean cover and area of occupancy of *M. triglochinoides* occurred during the construction phase at all sites. Many natural events such as fire and heavy flooding were experienced throughout 2017 affecting plant populations.

There was minor habitat clearing (project unrelated) at Site Mt-3.1 which hasn't exacerbated decline of *M. triglochinoides* or reduced overstorey cover at the plot along Coldstream River.

Heavy cattle pugging has continued at Site Mt-3.2 affecting small areas of *M. triglochinoides* in shallow muddy locations of plot. *M. triglochinoides* growing in deeper pools remain unaffected by local land use change. Heavy rainfall during autumn surveys caused high surface water flow laden with sediment from project and associated land. Water from the project was observed being pumped into native vegetation habitat 500 metres upstream of the *M. triglochinoides* population. The water level at this site has remained high with dirty water but *M. triglochinoides* has recovered (refer to Photograph 21). Natural flooding also occurred at control Site Mt-C3.1 causing a temporary reduction. Water had some minor sediment likely from nearby farmland but retained typical tannins in water (refer to Photograph 22).

Survey observations and photographic evidence at Site Mt-7.2 suggests inadvertent indirect impacts to *M. triglochinoides* by the project where 92% of the population had been lost outside the project boundary. Very high above average rainfall (total of 740.2 mm at Woodburn) was recorded during March 2017 causing a major flood event at Tabbimoble creek and bridge overflows. Of this, 298.4 mm was recorded in one day on the 31st March. Deposited sediment and gravel transported by flood waters were observed within the habitat of *M. triglochinoides* during May surveys. This was aligned with a major decline in mean plant cover of 0.09% per metre square in plot compared to an estimated plant cover of 13% per metre square in plot in the pre-construction phase (refer to Photograph 23 and 24). These impacts are also likely associated with a slight

reduction in plant cover at Site Mt-7.3 in the same waterway (Tabbimoble overflow No 1) inside the clearing boundary. (refer to Photograph 25 and 26). Natural impacts from fire and multiple flood events during the construction phase are expected to have caused a decline in plant cover at Site Mt-7.1.

Summary of mean cover percentage in each plot of *M. triglochinoides* in Sections 3-7 is presented in Table 3-11.

Table 3-11 Comparison of pre-construction and Year 1 construction mean cover of M. triglochinoides at in-situ and control sites and project related change in mean cover

Site	Chainage	Pre-construction (mean cover % / m^2 in plot)	Construction (mean cover % / m^2 in plot)				Mean change in % cover / m^2 (+/-)	Detailed design impact	Inadvertent construction impact
			Feb	May	Aug	Nov			
Mt-3.1	43200	0.03 (est.)	0.3	1.8	0.9	0.3	+0.80	No	No
Mt-3.2	54900	0.75 (est.)	0.66	0.75	0.38	0.75	-0.11	No	No
Mt-3.3	64300	0.5 (est.)	0	No access	No access	No access	N/A	N/A	N/A
Mt-C3.1	61900	0.75 (est.)	1	0.01	0.01	0.02	0.08	N/A	N/A
Mt-7.1	110900	15 (est.)	1.9	8	9	8	-7	No	No
Mt-7.2	115300	13 (est.)	3.5	0.09	0.05	0.04	-12	Yes	Likely related to natural flood event
Mt-7.3	115300	2.55 (est.)	2.2	1.9	2.4	3.3	-0.10	Yes	Likely related to natural flood event
Total project related change							-12.1	Yes	No

Photograph 21: Sediment-laden water flowing into M. triglochinoides habitat of in-situ Site Mt-3.2 (May 2017)

Photograph 22: Natural flood event at control Site Mt-C3.1 showing typical flooded habitat (May 2017)

Photograph 23: Pre-construction phase at in-situ Site Mt-7.2 showing healthy population of M. triglochinoides (May 2014)

Photograph 24: Construction phase at in-situ Site Mt-7.2 showing major decline of M. triglochinoides population (Nov 2017)

Photograph 25: Pre-construction phase at in-situ Site Mt-7.3 showing healthy population of M. triglochinoides (May 2014)

Photograph 26: Construction phase at in-situ Site Mt-7.3 showing change in habitat of M. triglochinoides population (Nov 2017)

3.2.9 Melaleuca irbyana

The abundance of *Melaleuca irbyana* at in-situ sites (Mi-7.1 and Mi-7.2) has increased slightly with recruitment of three seedlings at Site Mi-7.1 (chainage: 120800). Site Mi-7.2 (chainage: 120900) remains unchanged. Minor flooding occurred during autumn and winter from preceding heavy rainfall but has not affected plants. The control Site Mi-C7.1 (chainage: 120800) had increased slightly in weed ground cover and cover of abundance for *Baccharis halimifolia* and *Polygala paniculata*. This was not observed at in-situ sites.

3.2.10 Oberonia complanata

In 2015, 18 *Oberonia complanata* plant clumps were translocated (chainage: 132200) from in-situ Site Oc-8.1, but appeared to have died in a nursery for reasons unknown. Eleven additional plant clumps were later translocated in 2016 from a single host tree on the edge of the clearing boundary during unexpected finds survey after early work clearing. Approximately 35 plant clumps were unexpectedly found on a *Melaleuca linariifolia* tree south of Lumleys Lane (Section 10) in the clearing footprint in 2017. These were translocated 30 metres away in adjoining swamp sclerophyll forest.

Site Oc-8.1 is no longer monitored with translocated individuals now monitored in the translocation monitoring program.

3.2.11 Oberonia titania

Data was collected for *Oberonia titania* in autumn, winter and spring 2017 for both sites (Ot-10.1 and Ot-C10.1). Access was restricted in summer 2017. Two additional host trees with 18 epiphytic *O. titania* overhanging in-situ Site Ot-10 (chainage: 152300) were included in the monitoring program during autumn surveys.

In winter both sites exhibited similar habitat conditions and weed abundance with a slight increase in weed cover of abundance at the control site since autumn 2014 baseline surveys. Recruitment has been successful at both sites with 17 new juveniles and five new adult plants at in-situ Site Ot-10.1 and 32 new plants recorded at site Ot-C10.1 (chainage: 152300) since 2014. Some minor dieback of orchids and host tree was observed at Ot-C10.1 during winter 2017, possibly caused by below average rainfall in the 3 months preceding survey.

Spring surveys documented an increase in *O. titania* recruitment of eight new juveniles. There was no notable change in abundance or health of plants at control Site Ot-C10.1, except the new occurrence of the *Ochna serrulata* weed found in low abundance.

3.2.12 Persicaria elatior

Two in-situ sites comprising *P. elatior* were impacted during detailed design prior to construction monitoring. Both Site Pe-5.2 at James Creek and Site Pe-4.2 at Maclean was cleared with the latter replaced with Pe-4.2a. Samples of the soil seedbank at in-situ Site Pe-4.2 was collected and translocated in September 2016 to account for loss of plants. In-situ Site Pe-5.2 was not translocated and around 9 plants were cleared within the project boundary.

Plant numbers at in-situ Site Pe-4.2a have remained stable under normal conditions during construction surveys. Other in-situ sites (Pe-4.1 and Pe-5.1) have seen decline in plant abundance overall in absence of plant recruitment whereby some juvenile plants are suspected not to reach maturity and reproduce. Heavy flooding and canopy shade, especially at Pe-5.1 may be the cause of pre-mature death of plants where this species usually prefers more open habitat and requires some juvenile leaves to remain above water level to survive (Benwell, 2017). This decline is not project related, although the control Site Pe-C4.1 has seen an increase in plant abundance. Refer to Table 3-12 for a summary of results.

Table 3-12 Comparison of pre-construction and construction P. elatior abundance at in-situ and control sites and project related change in abundance

Site	Chainage	Pre-construction 2014 (no. of plants)	Construction 2017 (no. of plants)				Mean change in abundance (+/-)	Detailed design impact	Inadvertent construction impact
			Feb	May	Aug	Nov			
Pe-4.1	79400	13	19	No access	8	6	-2	No	No
Pe-C4.1	79400	89	57	No access	1	143	+22	N/A	N/A
Pe-4.2*	80600	0	N/A	N/A	N/A	N/A	0	Yes	No
Pe-4.2a	80600	N/A	35	27	10	30	N/A	N/A	N/A
Pe-5.1	83400	39	5	0	0	7	-36	No	No
Pe-5.2	85500	9	N/A	N/A	N/A	N/A	-9	Yes	No
Total project related loss							-9	Yes	No
*translocated sites									

Weed abundance remained low at most sites during the construction monitoring period. Site Pe-4.2 had a dominating ground weed cover that decreased to 15-20% with natural flooding and during the dry season (winter), however warmer weather in spring increased ground weed cover to 95%.

3.2.13 Prostanthera cineolifera

Prior to construction, future impacts from detailed design were predicted to occur in-situ Pc-6.2 site which was moved to the nearest control site (Pc-C6.1). Portions of the soil seedbank at in-situ Site Pc-6.2 were later translocated to Pc-6-2a prior to impacts. However, loss of 43 adult and juvenile plants was observed. This allowed for additional baseline data at the new Pc-6-2a (chainage: 101700), however this site was later removed from the program and is now monitored in the translocation monitoring program. Site Pc-C6.1a (chainage: 101700) commenced after construction and contains no baseline data.

In summer, in-situ Site Pc-6.1 (chainage: 101700) recorded an additional 56 plants with many large plants up to 5 metres in height, indicating successful recruitment in the last 3 years since previous baseline surveys. Since then, there has been a minor decline of 12 individual plants. Many of these lost plants were senescent and much of the current demographic is now supported by young adults and was unrelated to the project. Control Site Pc-C6.1a has seen an increase in recruitment of 35 juveniles but with also most population comprised of young adults. Weed groundcover had a slight decline at both in-situ and control site, particularly Site Pc-6.1 where pasture grass *Axonopus fissifolius* had died back due to past and recent flooding.

No inadvertent construction impacts had occurred affecting *P. cineolifera*.

3.2.14 Rotala tripartita

Only construction monitoring data was collected for two *R. tripartita* in-situ sites established in autumn 2017. In May, surveys identified 51 individuals at in-situ Site Rt-6.1 (chainage: 102600) and 19 at in-situ Site Rt-6.2 (chainage: 102600). These high numbers were likely in response to high rainfall experienced in March preceding the survey. Later surveys in winter and spring had seen a decline in plant numbers by 64% at Site Rt-6.2 and total loss at Site Rt-6.1 in coincidence with lower rainfall events over this period and not project related. Over the same period weed groundcover had also declined by 40-60% at both sites.

4. Evaluation of performance criteria, mitigation measures and impact thresholds

4.1 Review of impacts and required amendments to the program

As outlined in section 4.1 of the TFMP further pre-clearing flora surveys were undertaken by suitably qualified ecologists to reconfirm the distribution and abundance of threatened flora populations in proximity to the project prior to clearing for construction. Where additional populations of threatened flora were identified these were quantified and could be managed and translocated prior clearing. This has resulted in a revised baseline threatened flora layer and shown in the Appendix B as "*Additional finds & GIS consolidation".*

Through the detailed design process, the project construction footprint was reduced. This resulted in a significant reduction to the overall impacts to threatened flora in situ compared to quantities reported in the approved EIS/SPIR. Where there was an increase this was contained within the project approval boundary and where feasible additional translocation efforts were undertaken. Three in-situ sites (Li-3.1, Pe-4.2, Pc-6.2) within the project boundary established for species *L. incisa*, *P. elatior* and *P. cineolifera* were partly translocated using the collection of soil seedbanks to propagate seedlings from the population and clumps of fronds for *L. incisa*. The soil seedbank was also translocated for *G. quadricauda* nearby in-situ Site Gq-3.1. Twenty nine *O. complanata* plant clumps were translocated nearby from Site Oc-8.1 in 2015 and 2016. Approximately 35 plant clumps were translocated from clearing boundary in Section 10 south of Lumley's Lane, Wardell.

The minor changes to the construction footprint affected the previous placement of some impact monitoring plots established in the early pre-construction phase. Replacement sites were established where there was opportunity to do this and this allowed for threatened species adjacent to the project boundary to be continually monitored and addressed the refinements of detailed design. Additionally, it was agreed with Roads and Maritime to establish new control sites to allow for additional data to be collected where sites were on private land with access restriction. A total of 85 sites are being monitored in the revised program comprising 66 impact and 19 control sites.

The updated clearing boundary as a result of the Detailed Design has changed total number of threatened flora expected to be impacted during construction and has reset the total remaining in-situ populations for the next monitoring years going forward.

Appendix B presents the updated threatened flora impact table, outlining the following:

1. *EIS/SPIR boundary/impact* – Expected impact on threatened flora based off the concept design boundary/EIS and outlined in the Threatened Flora Management Plan.

2. *EIS/SPIR boundary/impact + Additional finds and GIS consolidation* - Expected impact on threatened flora based off the Concept Design/EIS boundary using the revised threatened flora layer.

3. *Current boundary/impact + Additional finds and GIS consolidation* - Expected impact on threatened flora based off the current Detailed Design boundary using the revised threatened flora layer.

4. *Net change* – Comparison between the Concept Design EIS/SPIR boundary and the Detailed Design Clearing boundary using the revised threatened flora layer.

4.2 Measuring performance criteria and assessing impact

The TFMP provides indicative thresholds for measuring the performance of mitigation measures of project construction. It is noted that some of the performance goals do not relate to this monitoring program such as plant translocation and dust monitoring. The relevant construction performance criteria and thresholds (refer to Section 2.4) that trigger corrective actions is presented in Table 4-2 and only relate to those sites situated outside of the updated clearing boundary.

Goals supporting the management of dust, translocation and habitat revegetation is not covered in the construction monitoring program. No dust was observed affecting in-situ sites.

The relevant goals for mitigating impacts addressed by the monitoring program as outlined in section 2.4, include:

- Zero mortality of threatened plants from in situ populations (from physical damage during construction) and no loss of threatened plants directly adjacent to the project.
- No notable increase in the abundance of weeds within threatened plant habitat during monitoring of in situ populations.
- Water and soil quality managed in accordance with the CEMP.
- Reduce impacts to threatened orchid species through illegal collection.

This chapter focuses on addressing these goals relevant to the monitoring program and are summarised below.

As noted in Section 2.3.2, the baseline methods for determining the abundance of threatened groundcover species was coarse and a percentage of mean cover over an area of occupancy for each relevant species was introduced into the method during the construction monitoring surveys to improve the detection of change. This allowed for an effective measure of change to be monitored over each season and identified typical trends in plant dieback in response to rainfall and other climatic factors. A percentage mean cover for relevant species from baseline data was estimated to provide indicative comparisons for measuring performance criteria. Therefore, this information has been viewed with consideration of other site observations and evidence when scrutinising data after each sampling event prior to making and assessment of impact.

4.3 Effectiveness of mitigation measures implemented for in-situ sites

4.3.1 Method of mitigation

Where mitigation measures have been applied during pre-construction and construction, the effectiveness of these were assessed in relation to impacts on in-situ threatened plants at the monitoring sites. The mitigation measures applied to protect threatened plants include:

- Identification of exclusion zones and clearing limits prior to clearing.
- Identification of exclusion zones informed by targeted surveys.
- Exclusion zones fenced off to protect in situ threatened plants.
- Salvage and planting of identified plants for translocation undertaken prior to clearing, into suitable habitat, and using appropriate methods that maximise the chance of plant survival.
- Adequate soil and water quality controls installed surrounding retained threatened plants.
- Procedures for maintenance and monitoring of erosion and sediment controls included in the CEMP.
- Restrict the availability of information identifying where orchids occur within the project area, and in close proximity to the project area.
- Limit site access to areas where orchids naturally occur and may be being managed in situ.

4.3.2 Translocation efforts

An extensive translocation project was implemented to remove plant species that were unable to be mitigated. These species and individuals are subject to a separate maintenance and monitoring program to the in situ monitoring program. This work was extended to include some of the pre-construction monitoring plots that were found to be located in the detailed design boundary.

Three in-situ sites Li-3.1, Pe-4.2, Pc-6.2 within the project boundary for species *L. incisa*, *P. elatior* and *P. cineolifera* were partly translocated using the collection of soil seedbanks to propagate seedlings from the population and clumps of fronds for *L. incisa*. The soil seedbank was also translocated for *G. quadricauda* nearby in-situ Site Gq-3.1. Twenty nine of the *O. complanata* plants from plot Oc-8.1 were translocated,

however 18 died in a nursery and 10 plant clumps remain alive at a recipient site Bundjalung National Park near Evans Head. . Approximately 35 plant clumps were translocated from clearing boundary in Section 10 south of Lumley's Lane, Wardell.

4.3.3 Discussion of impacts

Examples of impacts observed during the first year of construction within and outside the project boundary are described below, with reference to assessment of the effectiveness of the mitigation applied. Much of this discussion relates to the impacts of a significant storm event which occurred in March 2017 and accounted for rainfall totals of between 500 and 1000 mm in a 24-hour period. This significant event resulted in sediment laden surface run-off over-topping the design function and capacity of project sediment and erosion controls in some places as discussed.

1. A population of *Maundia triglochinides* monitored at three in-situ sites (Mt-1.1, Mt-7.2 and Mt-7.3) was inadvertently impacted by the sediment run-off from the March storm event. This impact occurred outside the project boundary and the population has not recovered fully from this flood event.

2. Other examples of impacts from sediment laden run-off were observed at the in-situ sites QM-1.1, QM-1.2, Elt-1.5, Mt-1.2a, La-1.3, Et-2.3 and Mt-3.2. With the exception of new in-situ Site Mt-1.2a, these impacts were minor and not observed to affect the health of plant populations. The overtopping of control measures and minor impacts were also observed at sites QM-1.1, QM-1.2, Elt-1.5 and Mt-3.2.

3. Exclusion fencing was intact at most sites during the duration of construction monitoring. However, two *A. robur* sites Ar-3.2 and 3.10a had damaged and ineffective exclusion fencing. Fencing at Site Ar-3.10a had been re-erected, however permanent wire fence installation on the project boundary had impacted on trees. Appropriate exclusion fencing at in-situ Site Ar-3.2 was removed in winter and has not been replaced around *Angophora robur* habitat, therefore maintenance is required. From an overall impact perspective, the direct impacts to *Angophora robur* has been around 8% less than the approved impacts predicted in the EIS.

4. Minor increases in the abundance and number of weed species was noted at sites with *Arthraxon hispidus* (Ah-10.1, Ah-10.3, Ah-10.4, Ah-10.5, Ah-10.6) and *Endiandra muelleri* subsp. bracteata (Emb-4.1 and Emb-4.2). These changes are not project related, but reflective of the existing condition of sites prior to construction.

4.4 Thresholds triggering corrective actions

As discussed above, three monitoring sites located outside the project boundary the Tabbimoble Creek floodplain were indirectly impacted by the significant volume of surface water run-off associated with the March storm event. Sediment controls were in place to mitigate impacts, however it was evident that the volume of run-off exceeded the design capacity of the sediment controls in place resulting in material from the project mobilising onto the in situ population being monitored. Further monitoring is continuing at this site to record the recovery and resilience of in-situ plants and inform further monitoring of change.

The TFMP identifies the parameters for monitoring performance of in-situ populations during construction and operation. These are described as performance measures and set a threshold whereby if impacts occur and exceed this threshold, specific corrective actions are required. The set of threshold triggers and corresponding corrective actions from the TFMP are outlined in Table 4.1.

Table 4-1 Corrective actions relating to triggered performance thresholds

Threshold triggers	Corrective actions
Any loss of retained in situ threatened plants.	Commence assessment of potential reasons for mortality, including seasonal fluctuations, natural events such as drought and fire within one month of trigger being identified.

Threshold triggers	Corrective actions
	Compare with paired control site. Identify potential threats, implement corrective actions and modify monitoring as necessary.
Breaches of erosion, sediment and water quality controls recorded. Loss of ecological condition recorded from plant health monitoring particularly from altered water quality.	Review adequacy of the erosion, sediment and water quality controls and implement appropriate corrective actions. Commence review of monitoring procedures for controls and implement appropriate corrective actions.
Exclusion zone fencing is damaged or ineffective.	Stop construction in the area of the fencing breach until exclusion fencing has been repaired. Investigate why breach in fencing occurred and implement corrective actions as required to prevent reoccurrence.

Table 4-2 summarises the outcome of the 2017 monitoring of in-situ threatened plant species against each of the four threshold triggers in Table 4-1. Assessment is provided where an impact has occurred and explantation to corrective actions deemed to be required. There was no evidence to suggest a breach of the performance goal ‘reduce impacts to threatened orchid species through illegal collection’ relevant to *O. titania*. Monitoring and location data is kept secure and only reported to Roads and Maritime.

Table 4-2 Impacts within approved project boundary

Species	Thresholds (triggers for corrective actions)*				Impacts within approved project boundary.	Requires corrective actions (inadvertent construction impact)
	Any loss of retained in situ threatened plants .	Noxious and environmental weeds reported in areas adjacent to threatened plants Spread of noxious and environmental weeds into properties adjoining the project noted in monitoring activities	Breaches of erosion, sediment and water quality controls recorded. Loss of ecological condition recorded from plant health monitoring particularly from altered water quality.	Exclusion zone fencing is damaged or found to be ineffective.		
Year 2 construction (Section 1 and 2)						
Eleocharis tetraquetra	Yes – loss of around 193 clumps (63% total loss) from three sites Elt-1.1, Elt-1.2 and Elt-1.3. 253 clumps were translocated prior to impacts.	No	Yes - Elt-1.5	No	Yes	No
Eucalyptus tetrapleura	Yes – loss of 2 trees (6% total loss) at one site (Et-2.1)	No	Yes – Et-2.3	No	Yes	No
Lindernia alsinoides	Yes – loss of 0.17% cover / m^2 from two sites (La-1.1 and La-1.2). 1,811 plants were translocated prior to impacts.	No	Yes – La-2.1	No	Yes	No
Lindsaea incisa	No	No	No	No	Yes	No
Maundia triglochinoides	Yes – loss of 13.1% cover /m^2 from three sites (Mt-1.1, Mt-2.1 and Mt-2.1a)	No	Yes - Mt-1.1, Mt-1.2a	No	No – Site Mt-1.1 was indirectly impacted outside the project boundary	Yes
Quassia sp. Moonee Creek	No	No	Yes - outside of sites QM-1.1 and QM-1.2	No	Yes	No
Year 1 construction (Section 3-10)						
Angophora robur	Yes – loss of 42 trees (23% total loss) at five in-situ sites (Ar-3.2, Ar-3.5, Ar-3.10, Ar-3.10a and Ar-3.11)	No	No	Yes	Yes	No
Arthraxon hispidus	No	Yes – but not project related	No	No	N/A	No
Cyperus aquatilis	N/A – no individuals identified	No	No	No	N/A	No

Species	Thresholds (triggers for corrective actions)*				Impacts within approved project boundary.	Requires corrective actions (inadvertent construction impact)
	Any loss of retained in situ threatened plants .	Noxious and environmental weeds reported in areas adjacent to threatened plants Spread of noxious and environmental weeds into properties adjoining the project noted in monitoring activities	Breaches of erosion, sediment and water quality controls recorded. Loss of ecological condition recorded from plant health monitoring particularly from altered water quality.	Exclusion zone fencing is damaged or found to be ineffective.		
Endiandra muelleri subsp. bracteata	No	Yes – but not project related	No	No	Yes	No
Grevillea quadricauda	Yes – loss of 14 shrubs and 6 seedlings (74% total loss) in-situ (Gq-3.1). 18 plants were translocated prior to impact.	No	No	No	Yes	No
Lindsaea incisa	Yes – loss of 0.95% cover / m^2 (13% total loss) from Site Li-3.1. 15 clumps translocated from this site prior to impact.	No	No	No	Yes	No
Macadamia tetraphylla	No	No	No	No	N/A	No
Maundia triglochinoides	Yes – loss of 12.1% cover /m^2 from two sites (Mt-7.1, Mt-7.2 and Mt-7.3)	No	Yes - M-3.2, Mt-7.1 and Mt-7.2	No	No – Site Mt-7.2 was indirectly impacted outside the project boundary	Yes
Melaleuca irbyana	No	No	No	No	Yes	No
Oberonia complanata	No – All 29 plants were salvaged and translocated to nursery and recipient site of which 19 died. Site Oc-8.1 no longer monitored. Approximately 35 plant clumps were translocated from clearing boundary in Section 10.	N/A	No	No	Yes	No
Oberonia titania	No	No	No	No	Yes	No
Persicaria elatior	Yes – loss of two sites (Pe-4.2 and Pe-5.2). Part of the soil seed bank was translocated from Pe-4.2, but not Pe-5.2.	No	No	No	Yes	No
Prostanthera cineolifera	Yes– loss of 43 adult and juvenile plants at in-situ Site Pc-	No	No	No	Yes	No

Species	Thresholds (triggers for corrective actions)*				Impacts within approved project boundary.	Requires corrective actions (inadvertent construction impact)
	Any loss of retained in situ threatened plants .	Noxious and environmental weeds reported in areas adjacent to threatened plants Spread of noxious and environmental weeds into properties adjoining the project noted in monitoring activities	Breaches of erosion, sediment and water quality controls recorded. Loss of ecological condition recorded from plant health monitoring particularly from altered water quality.	Exclusion zone fencing is damaged or found to be ineffective.		
	6.2. The soil seedbank was translocated from Pc-6.2.					
Rotala tripartita	No	No	No	No	Yes	No
*refer to Table 6-1 of the Threatened Flora Management Plan (Roads and Maritime, 2013)						

5. Correction actions and recommendations

5.1 Adaptive management

The TFMP outlines an adaptive and responsive management approach, whereby the results of the monitoring program provide input into the design and refinement of mitigation measures and ongoing monitoring. If the monitoring results have indicated a substantial decline in the health and number of threatened plants at in-situ sites, adaptive management measures can be implemented.

5.2 Recommendations

Construction activities exceeding the performance thresholds were noted at some locations that are inconsistent with the TFMP and therefore have triggered the need for corrective actions. Some corrective actions are time bound and require immediate implementation that are not achievable prior to reporting and permanent loss of threatened flora may result. Part of the monitoring program has been already slightly modified to improve the measure of change at threatened flora sites, as well as increasing and replacing the number of plot locations as required.

Table B-1 in Appendix B provides a detailed overview of all net changes following detailed design which shows an overall reduction in direct impacts to threatened flora populations. Any impact increases have been contained within the approved project boundary as well as mitigation measures to translocate individuals where feasible. Investigation and future monitoring into impacted flora populations outside the approved project boundary is continuing of which none are project-related.

To supplement the prescribed corrective actions, in line with TFMP, the results of this report have identified (at a worst case) reasons for the loss of threatened flora and existing threats. It is recommended that in-situ sites with triggered corrective actions be investigated on the ground by the contractor, particularly sites with ongoing impacts such as any breaches in erosion or sediment control. A site-specific corrective action would be appropriate to improve the effectiveness of mitigation measures on a case by case basis. Based on the 2016/2017 monitoring findings, the following recommendations and Roads and Maritime responses are presented in Table 5-1

Table 5-1 Recommendations following the 2016/2017 of non-rainforest threatened flora monitoring and Roads and Maritime responses

Recommendation No.	Recommendation	Roads and Maritime response
1	Continue future monitoring as per TFMP and replace sites (if necessary) as part of adaptive monitoring program, particularly at partially impacted sites to measure change in health and recovery of threatened flora populations such as *M. triglochinoides* at sites Mt-1.1, Mt-7.2 and Mt-7.3.	Adopted. Monitoring to continue with focus on recording recovery of plants impacted by sediment.
2	Contractors to comply and regularly review the TFMP and CEMP in order to implement the time bound corrective actions.	Adopted
3	Review and maintain exclusion boundaries and/or protections, particularly at *A. robur* sites where damage has occurred.	Adopted. Exclusion boundaries have been reviewed and updated including area around Angophora.robur sites.
4	Contractor to investigate sites with threshold triggers as a case by case process (refer to Table 4-2), especially indirect sediment laden runoff at M. triglochinoides sites occurring outside the project boundary (Mt-1.1, Mt-7.2 and Mt-7.3) as well as indirect sediment laden runoff at Sites Et-2.3 and Elt-1.5 and inside the project boundary.	Adopted. Erosion and sediment control has been repaired, reviewed and upgraded where required.

Recommendation No.	Recommendation	Roads and Maritime response
5	Suppress and control weeds where appropriate at sites, particularly at weed increases for *A. hispidus* and *E. muelleri* subsp. *bracteata.*	Adopted
6	Continue to maintain, repair, investigate areas of erosion and sediment controls, particularly during heavy flood events.	Adopted
7	Although an ecological burn may benefit the Quassia population, this should be considered after completion of the monitoring program to keep site treatment/conditions consistent.	Adopted
8	Any offsets will need to capture revised impacts which may change for certain species over the duration of the monitoring program. The need for additional offsets would be determined following the outcomes of future monitoring.	Adopted

6. References

ECOS Environmental Pty Ltd (2019) Woolgoolga to Ballina Threatened Flora Translocation Project (Sections 1-11) Annual Monitoring Report (2017-2018). Prepared for Pacific Complete.

Jacobs, (2014). Woolgoolga to Ballina Pacific Highway Upgrades, NSW Roads and Maritime Services, Threatened Flora Pre-construction Surveys, Rev02

Landmark, (2017). Threatened Species Management: Spring 2016 Monitoring of Threatened Flora during Construction in Sections 1 and 2. Woolgoolga to Ballina Pacific Highway Upgrade. Landmark Ecological Services Pty Ltd, Suffolk Park.

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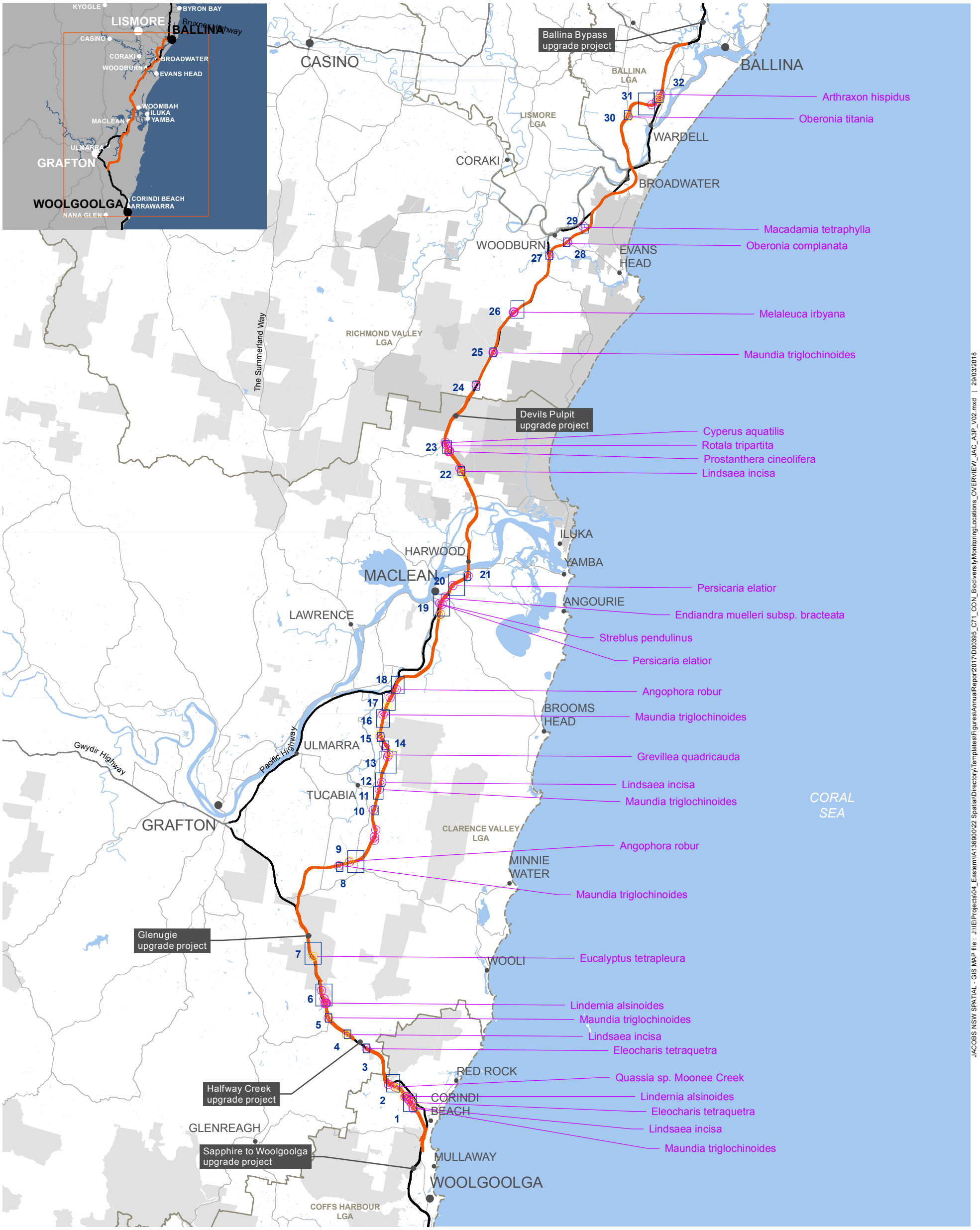
Poore MED, (1955) The use of phytosociological methods in ecological investigations: 1. The Braun-Blanquet system. Journal of Ecology 43 (1): 226-244.

Roads and Maritime Services, (2013). Woolgoolga to Ballina Pacific Highway Upgrade: Threatened Flora Management Plan. Version 3. Roads and Maritime Services, NSW.

Appendix A. Threatened Flora Monitoring Sites (Figures)



Legend

- The project (10-11-2017)
- Existing Pacific Highway
- Monitoring location - Control
- Monitoring location - Impact
- Location of figure A-1 to A-32 map extents
- Local Government boundary
- State Forest
- NPWS Reserve

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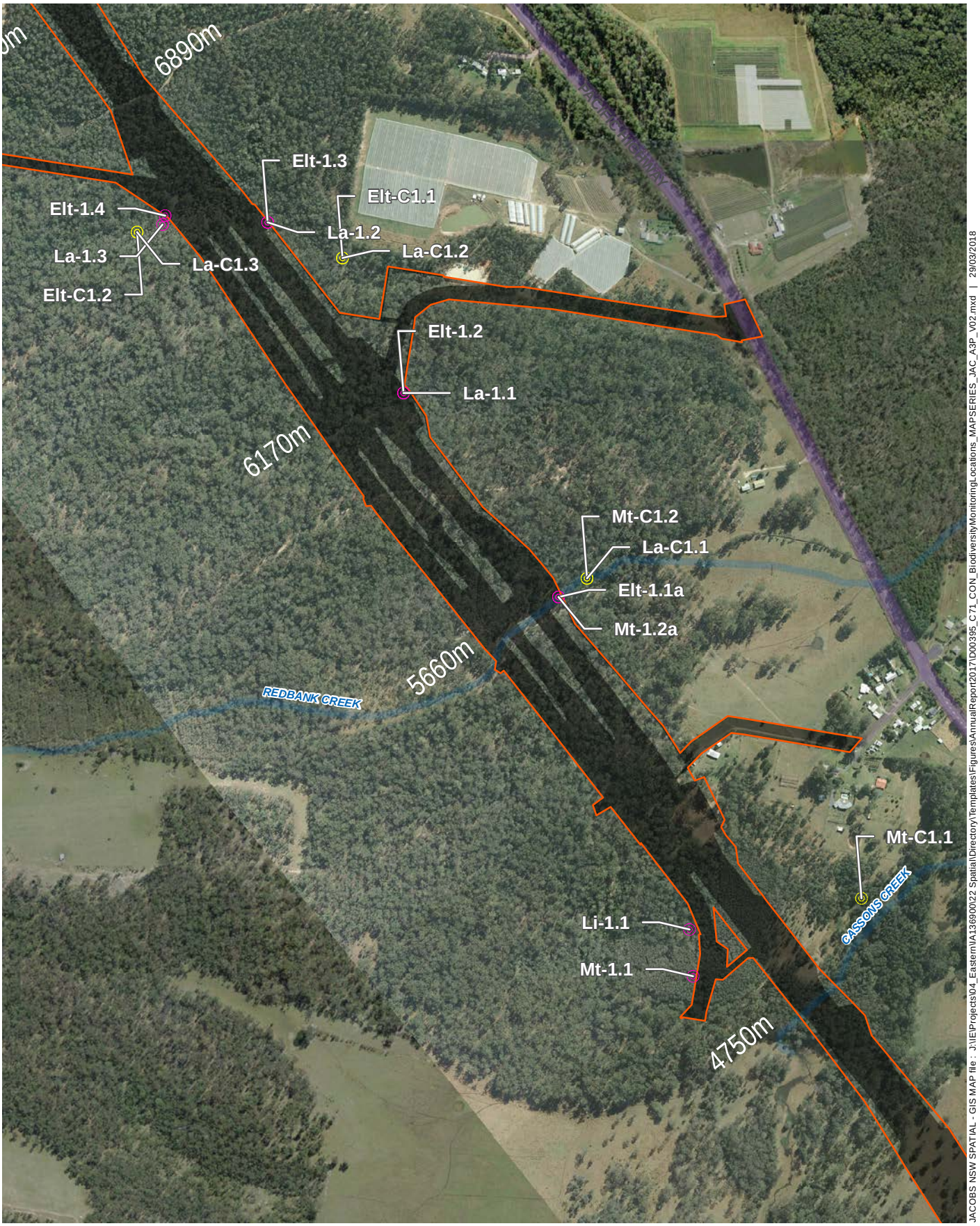
Figure A | Overview of threatened flora locations

Data sources

Jacobs 2017
Pacific Complete 2017
LPI 2010, 2018



Legend

- Monitoring location - Control (Jacobs 2018)
- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)
- Road corridor (LPI 2018)
- Waterway (LPI 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

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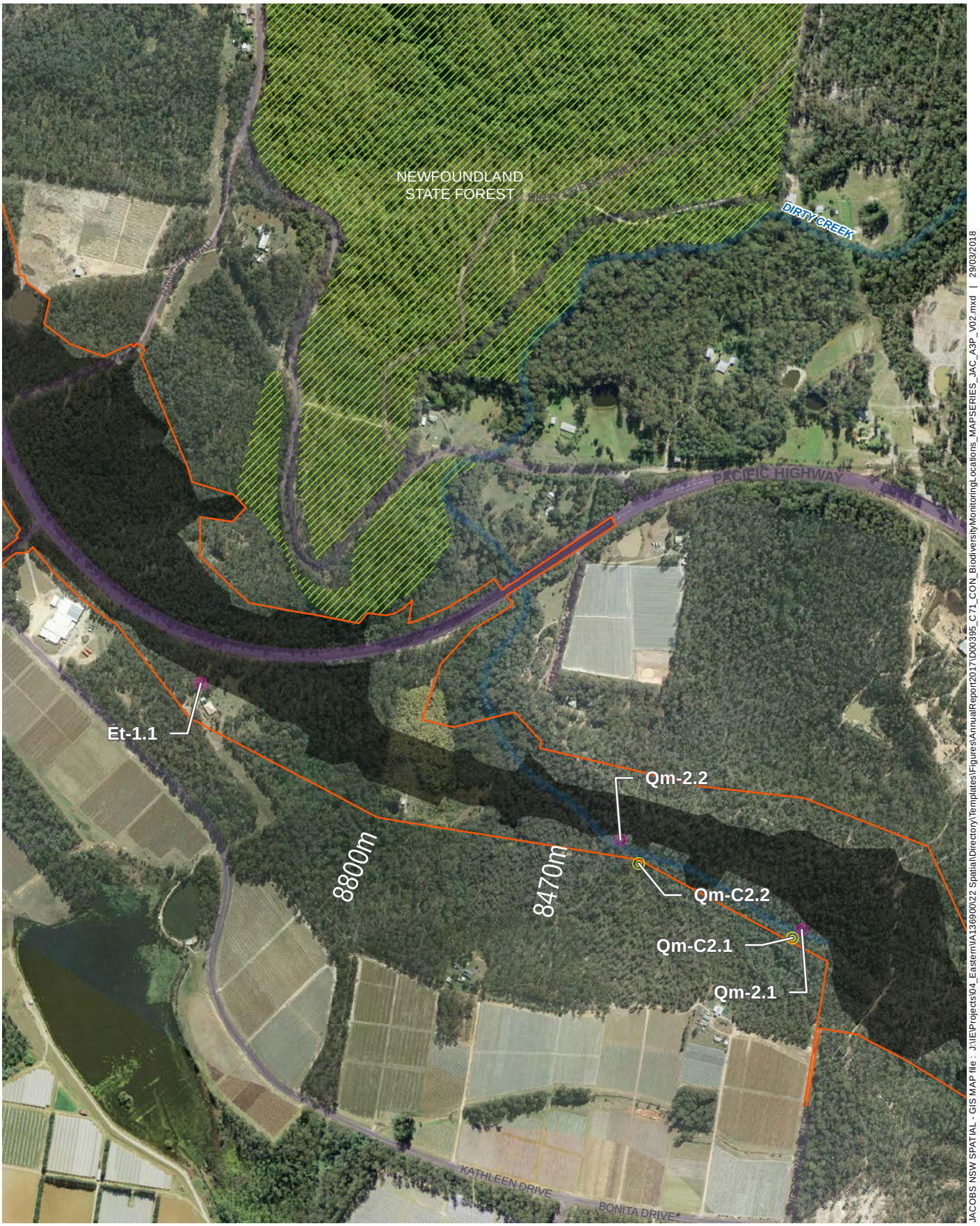
Figure A-1 | Threatened flora monitoring locations



Legend

- Monitoring location - Control (Jacobs 2018)
- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)
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- Waterway (LPI 2018)
- State Forest (LPI 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

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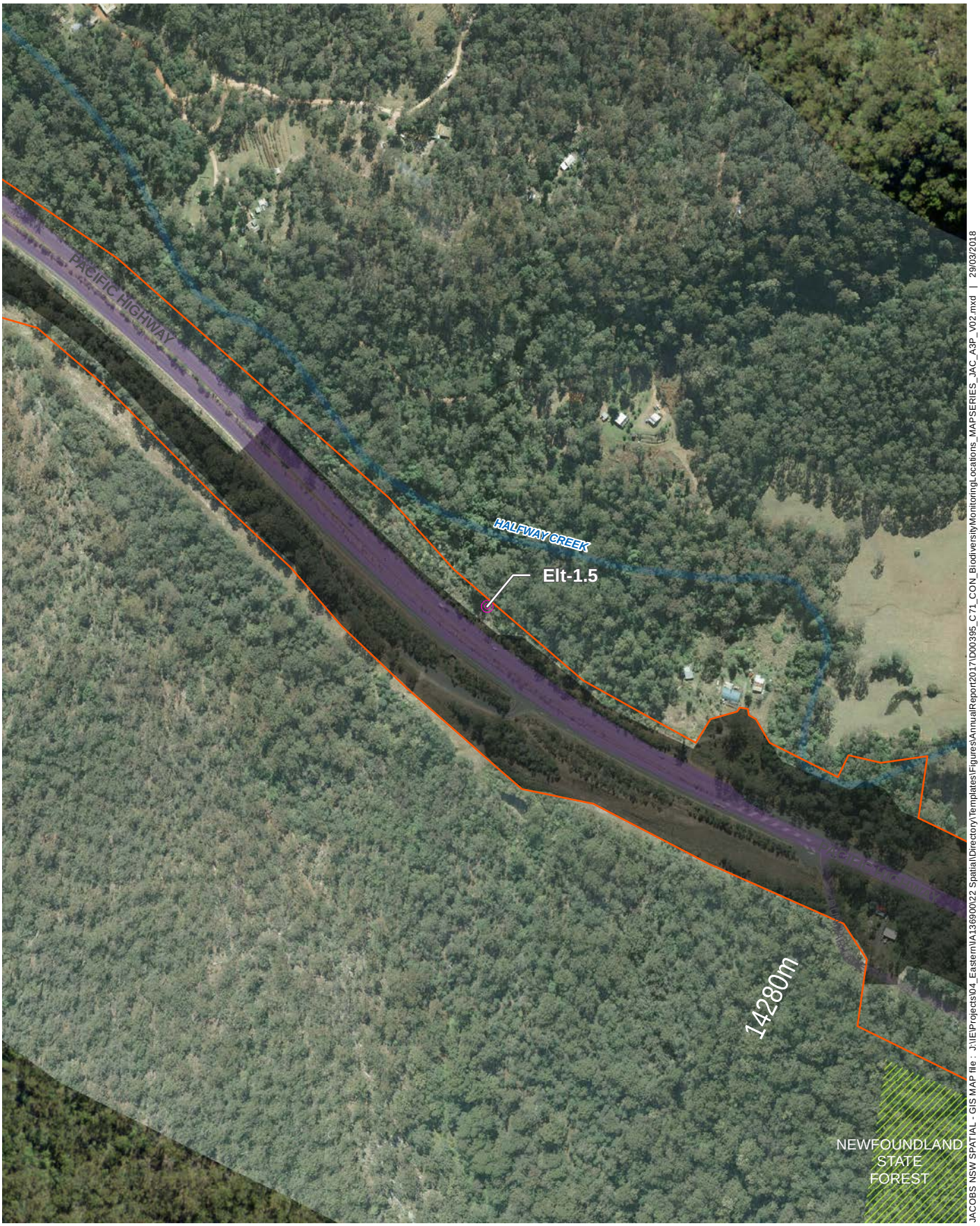
Figure A-2 | Threatened flora monitoring locations



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Legend

- Monitoring location - Impact (Jacobs 2018)
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- Clearing boundary (PC 2018)
- Road corridor (LPI 2018)
- Waterway (LPI 2018)
- State Forest (LPI 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

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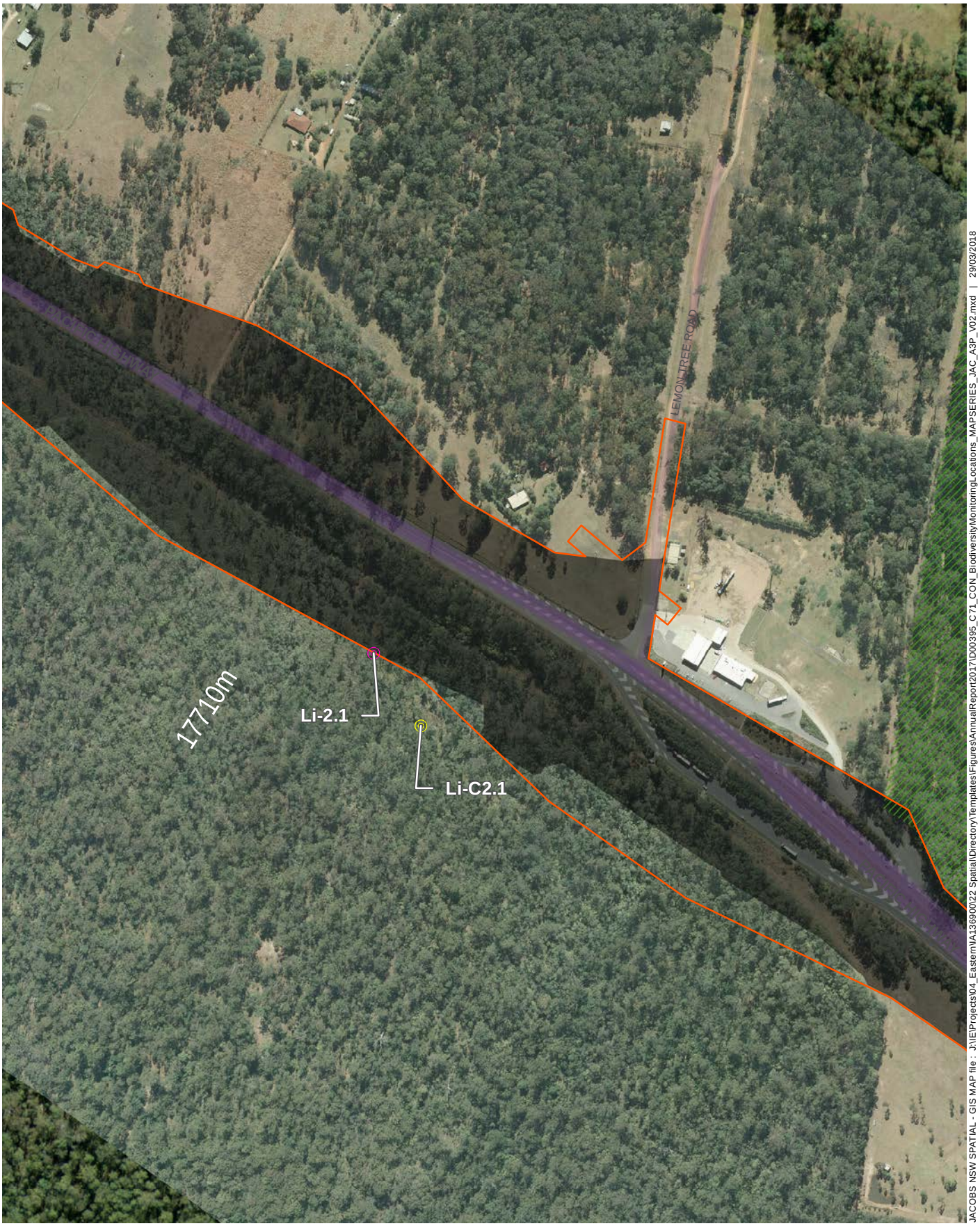
Figure A-3 | Threatened flora monitoring locations



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Legend

- Monitoring location - Control (Jacobs 2018)
- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)
- Road corridor (LPI 2018)
- NPWS Reserve (LPI 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

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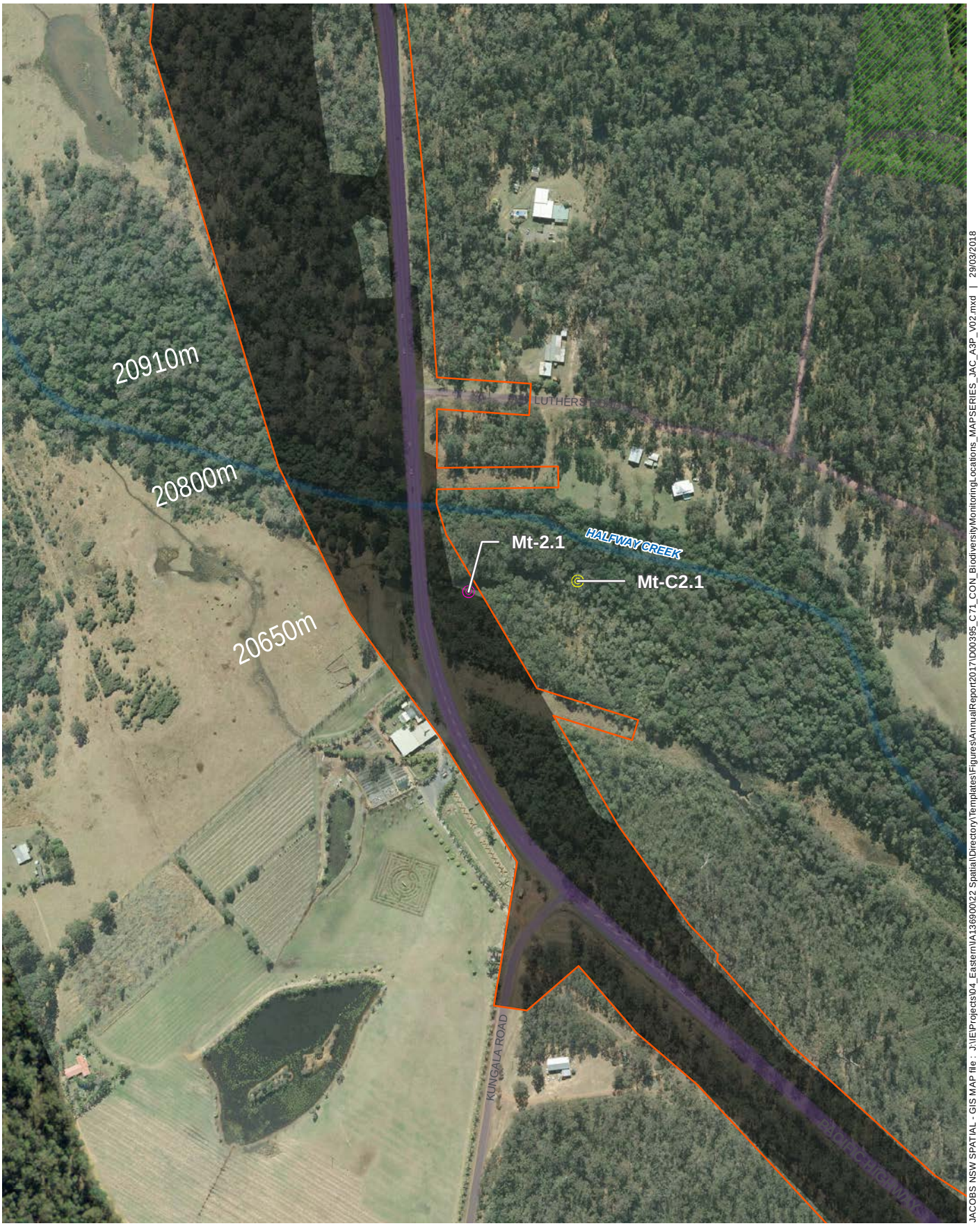
Figure A-4 | Threatened flora monitoring locations



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Legend

- Monitoring location - Control (Jacobs 2018)
- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
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- NPWS Reserve (LPI 2018)

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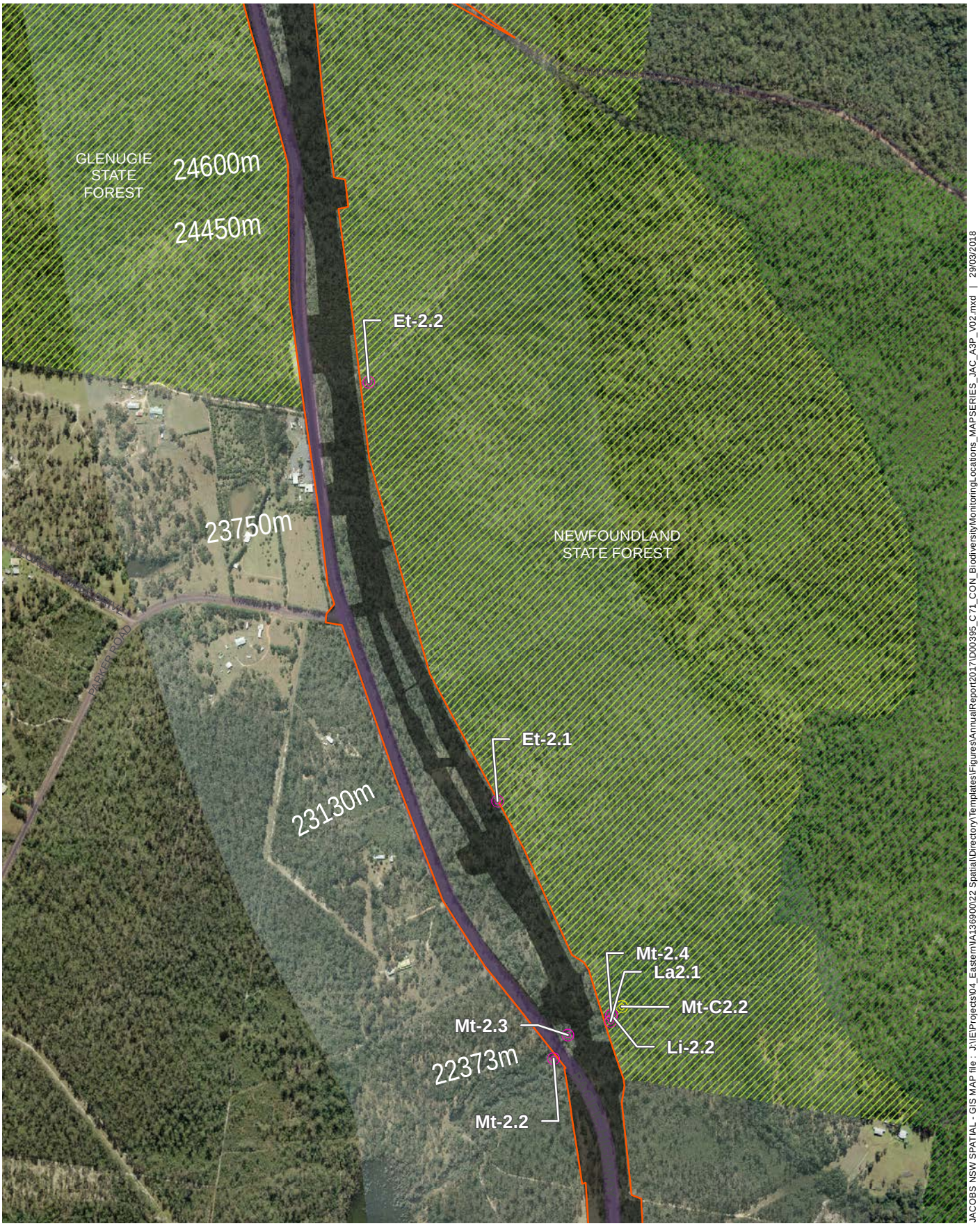
Figure A-5 | Threatened flora monitoring locations



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Legend

- Monitoring location - Control (Jacobs 2018)
- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)
- Road corridor (LPI 2018)
- State Forest (LPI 2018)
- NPWS Reserve (LPI 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

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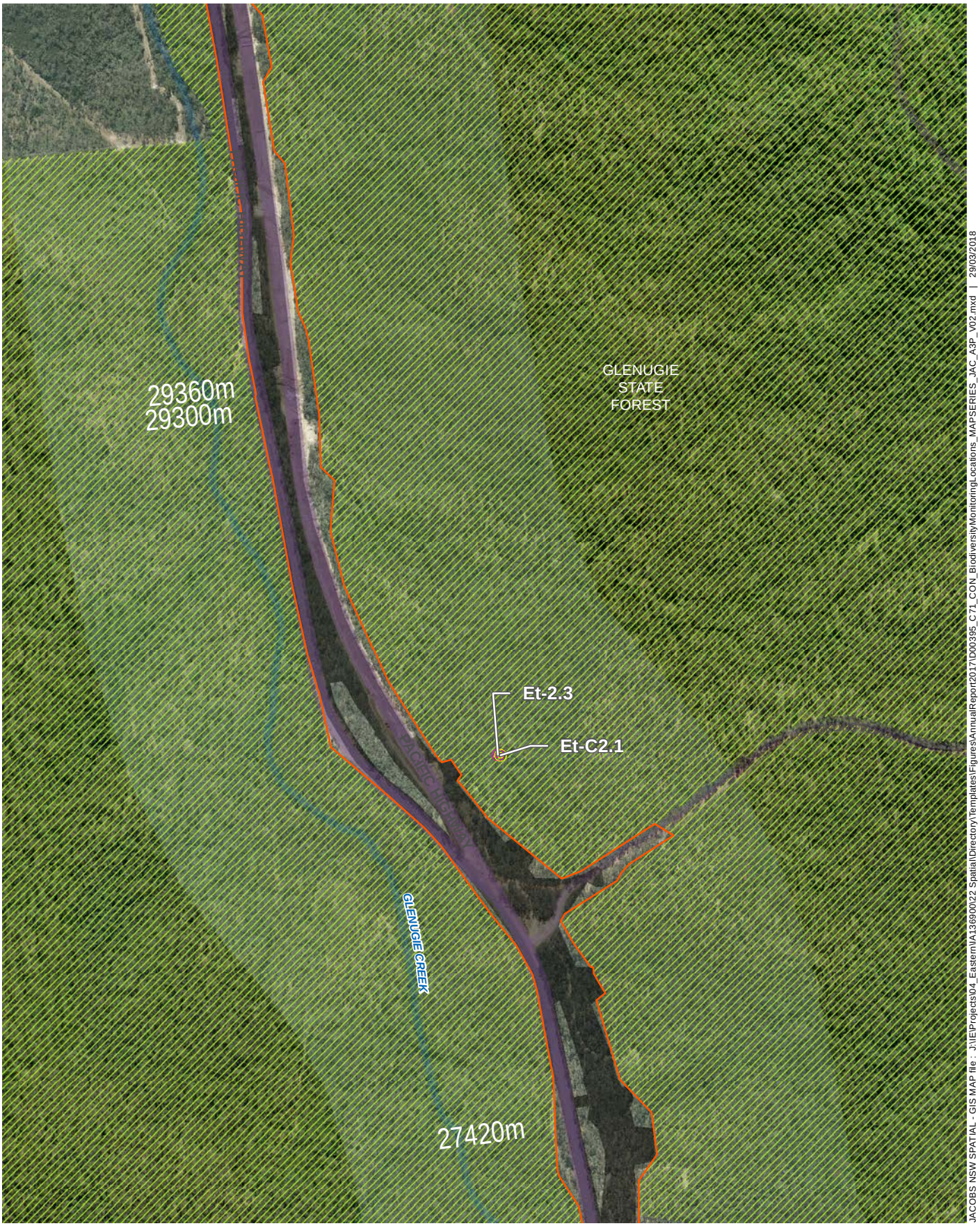
Figure A-6 | Threatened flora monitoring locations



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- Monitoring location - Control (Jacobs 2018)
- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)
- Road corridor (LPI 2018)
- Waterway (LPI 2018)
- State Forest (LPI 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

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Figure A-7 | Threatened flora monitoring locations

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- Monitoring location - Impact (Jacobs 2018)
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Figure A-8 | Threatened flora monitoring locations

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- Waterway (LPI 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

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Figure A-9 | Threatened flora monitoring locations

Figure A-10 | Threatened flora monitoring locations

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Legend

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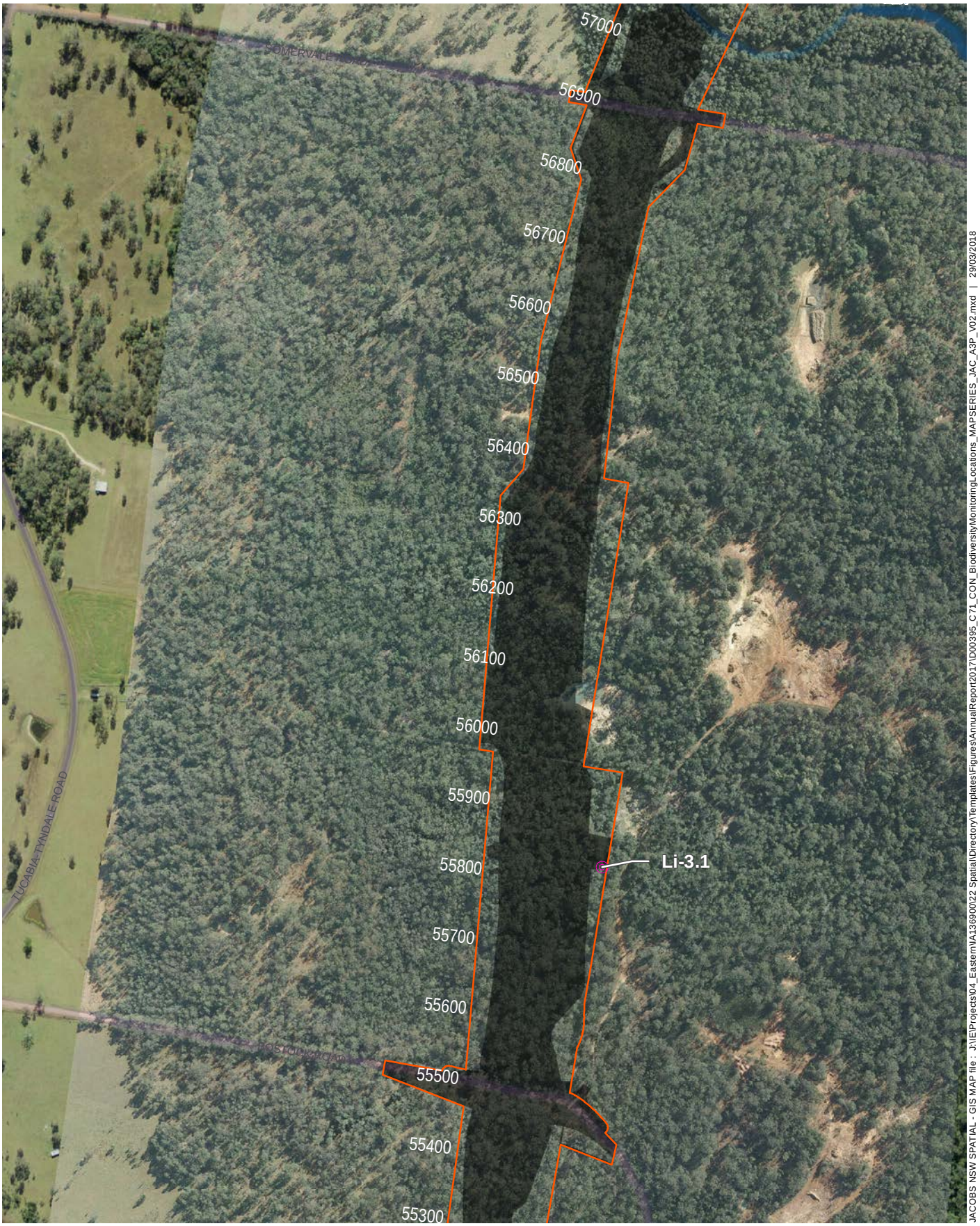
Figure A-11 | Threatened flora monitoring locations



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- Monitoring location - Impact (Jacobs 2018)
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Figure A-12 | Threatened flora monitoring locations

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Legend

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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

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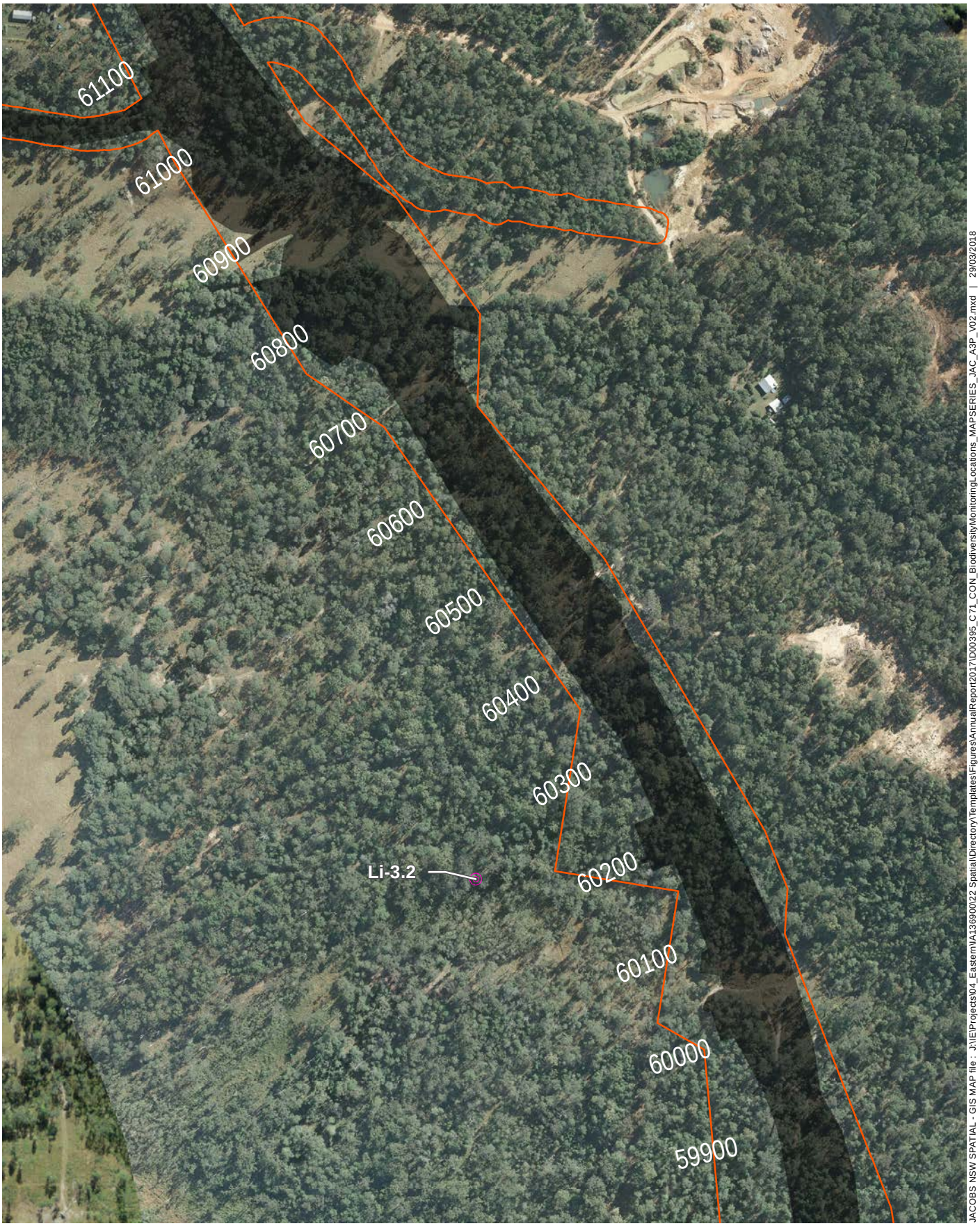
Figure A-13 | Threatened flora monitoring locations



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Legend

- Monitoring location - Impact (Jacobs 2018)
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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

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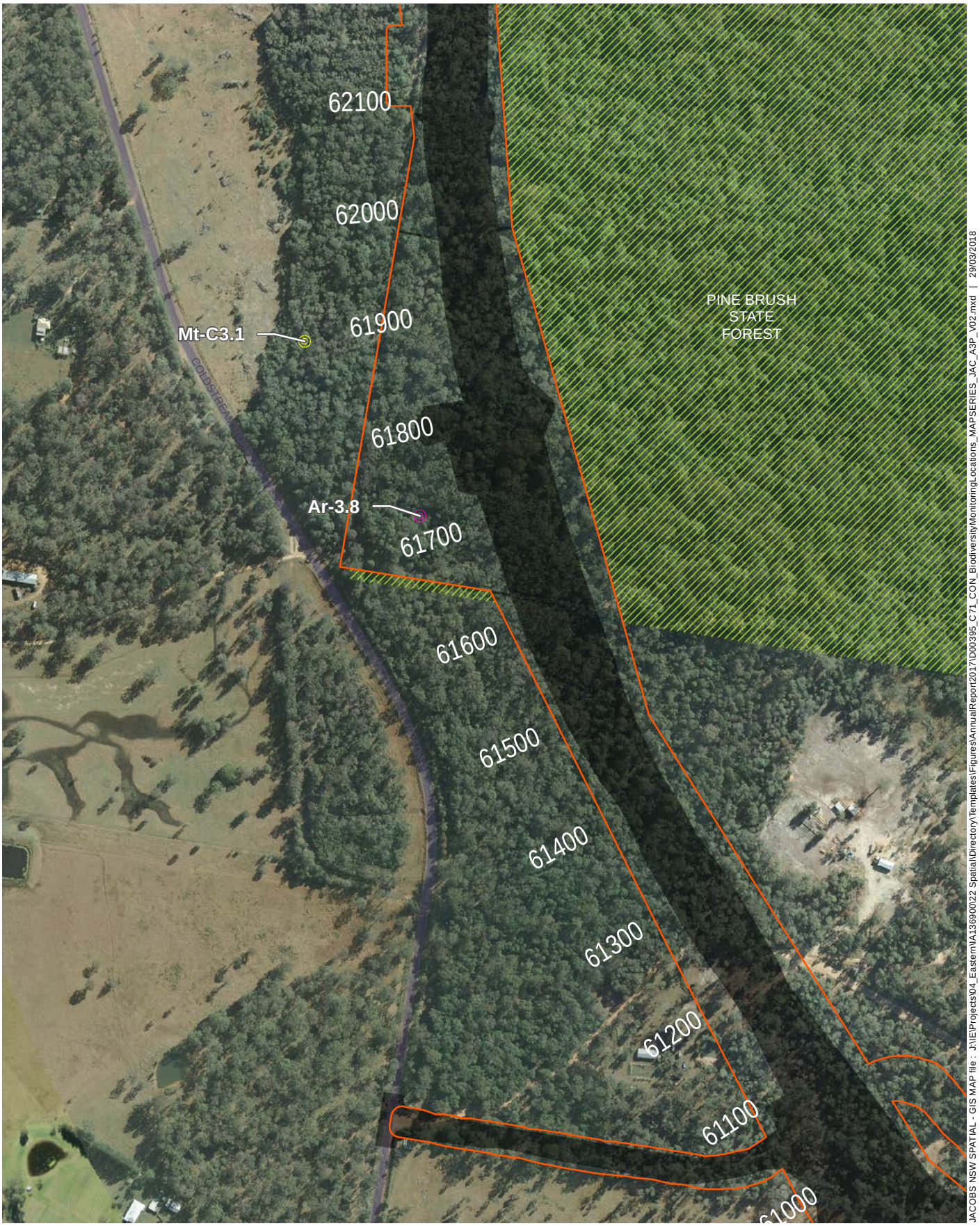
Figure A-14 | Threatened flora monitoring locations



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Legend

- Monitoring location - Control (Jacobs 2018)
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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

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Figure A-15 | Threatened flora monitoring locations

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Legend

- Monitoring location - Impact (Jacobs 2018)
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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

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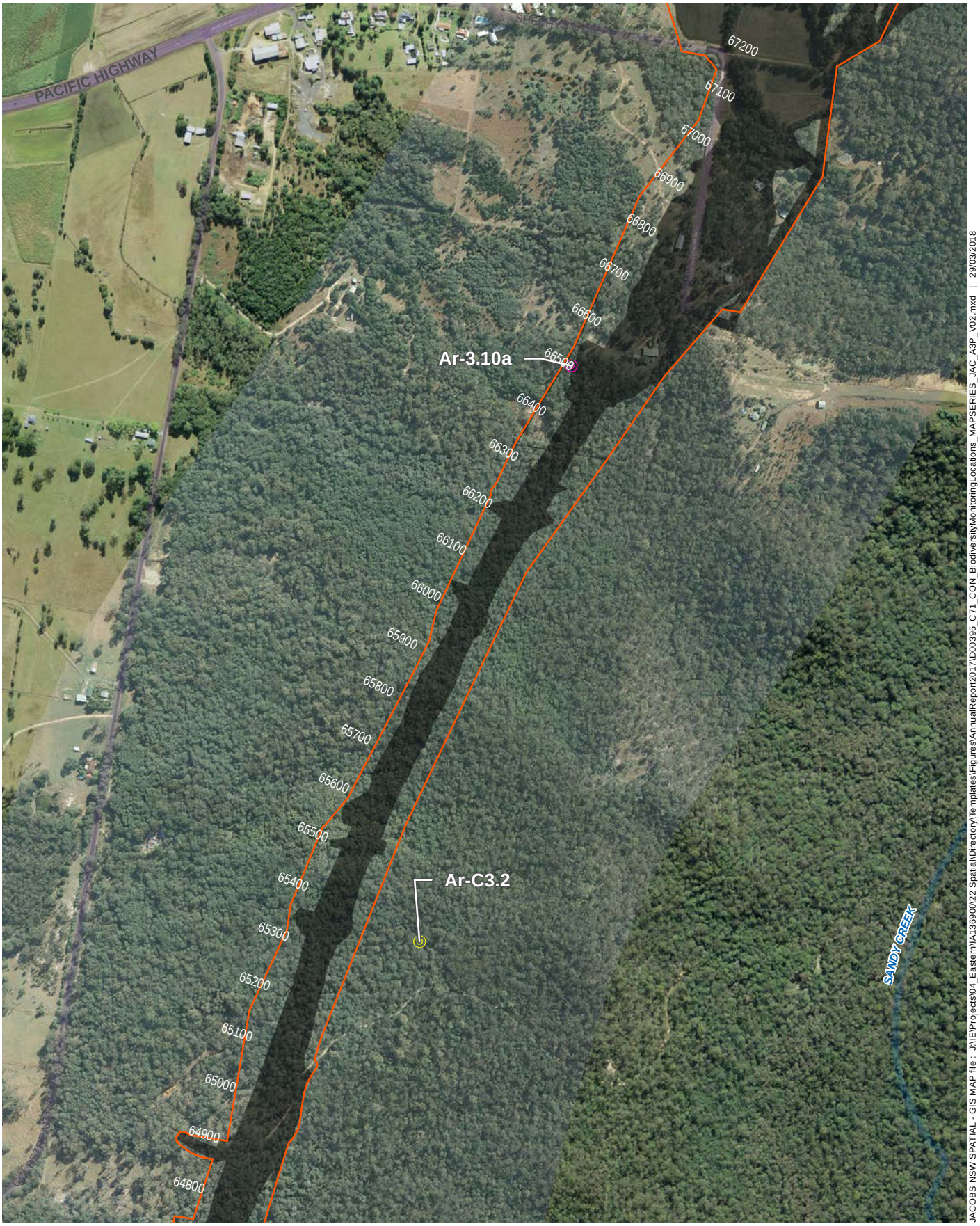
Figure A-16 | Threatened flora monitoring locations



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Legend

- Monitoring location - Control (Jacobs 2018)
- Monitoring location - Impact (Jacobs 2018)
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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

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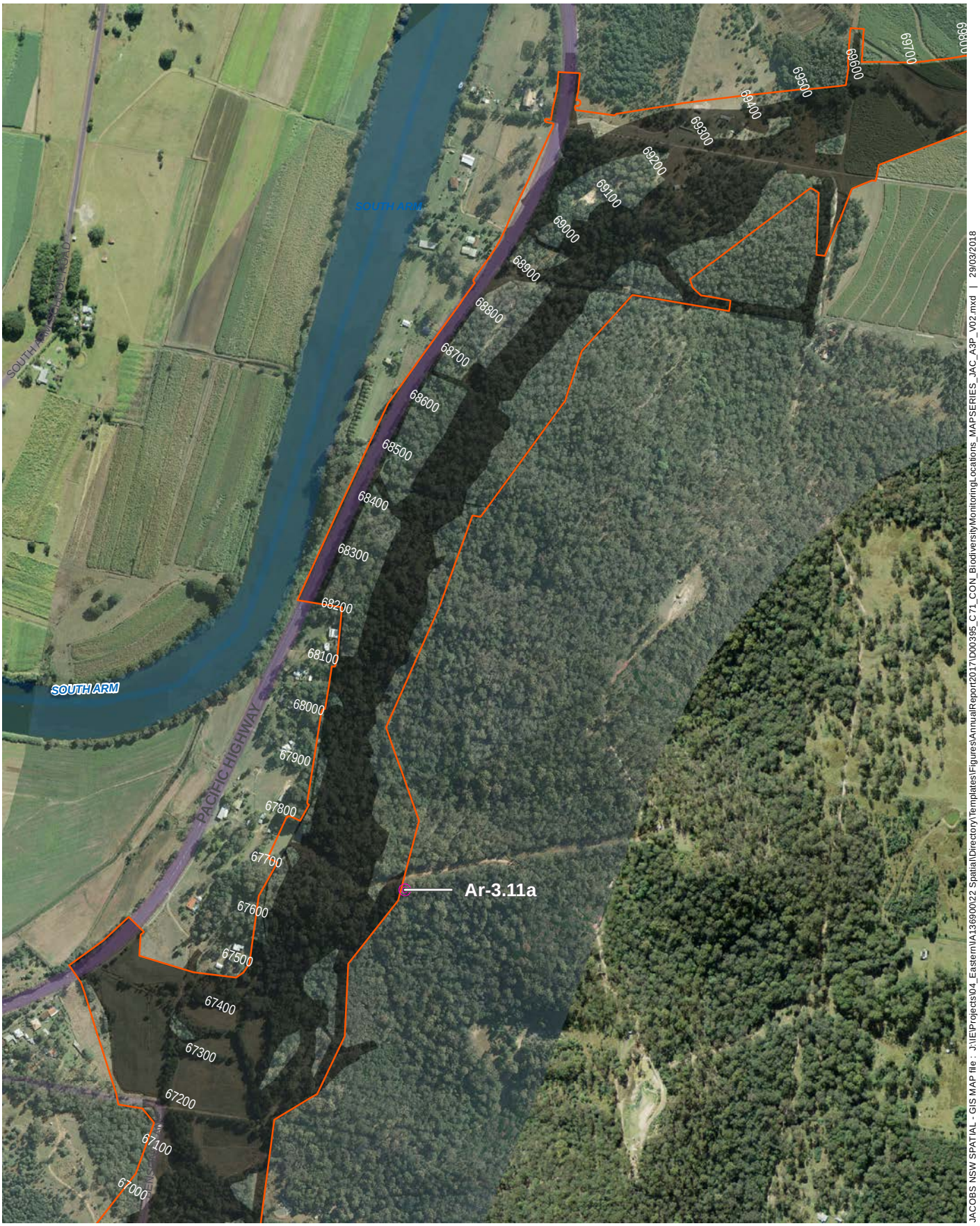
Figure A-17 | Threatened flora monitoring locations



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Legend

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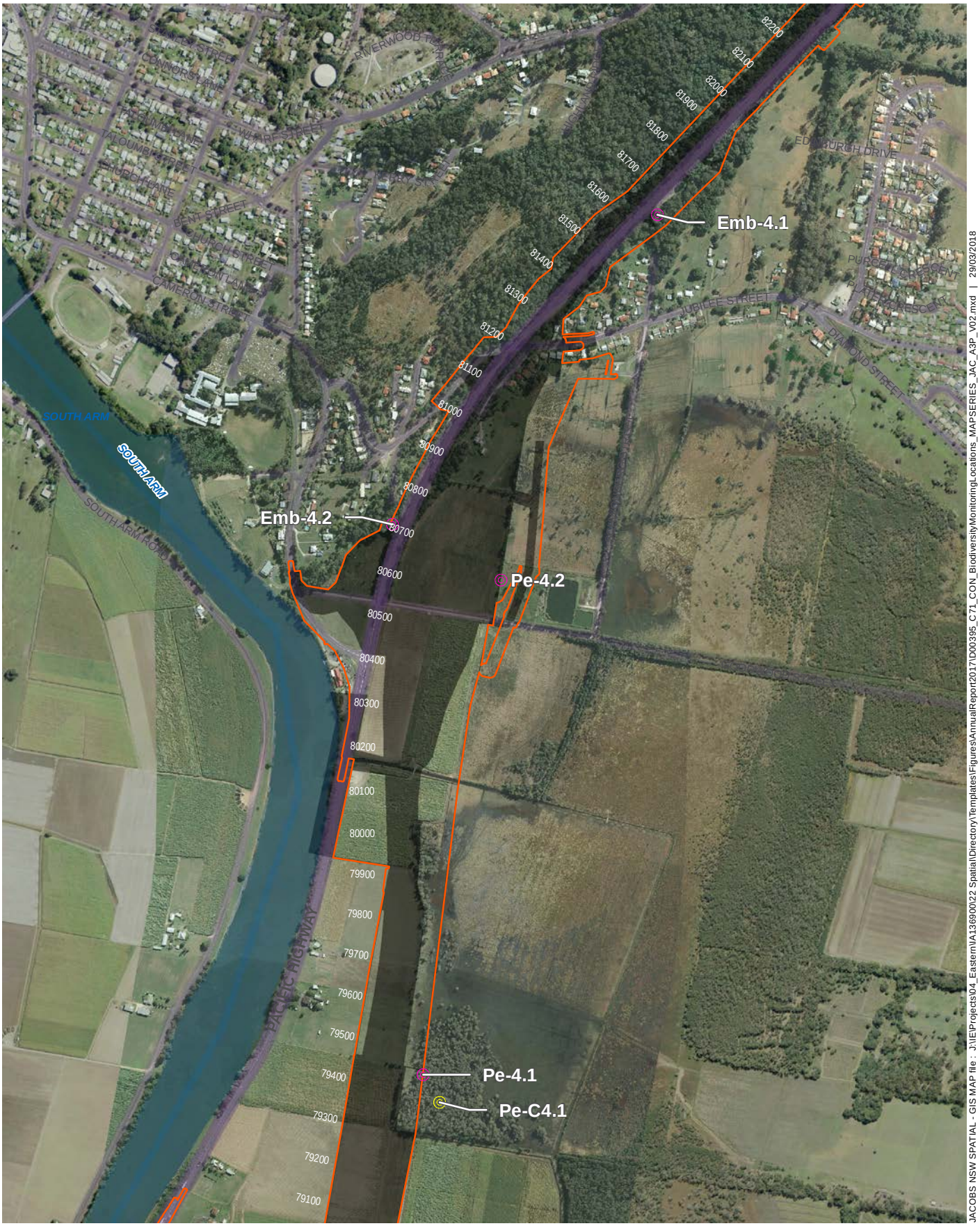
Figure A-18 | Threatened flora monitoring locations



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Legend

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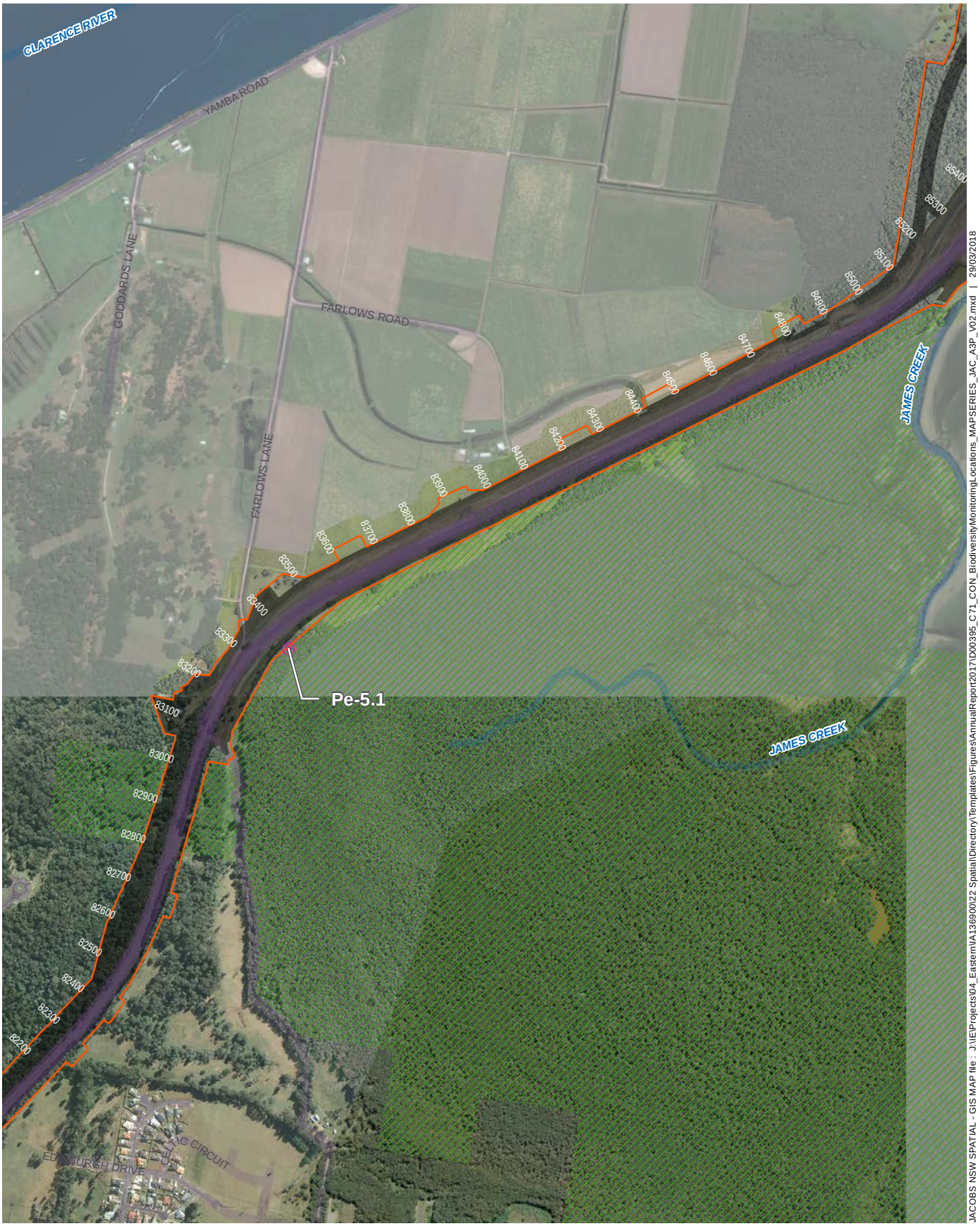
Figure A-19 | Threatened flora monitoring locations



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Legend

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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

N

1:12,500 @ A3

0 100 200m

Figure A-20 | Threatened flora monitoring locations

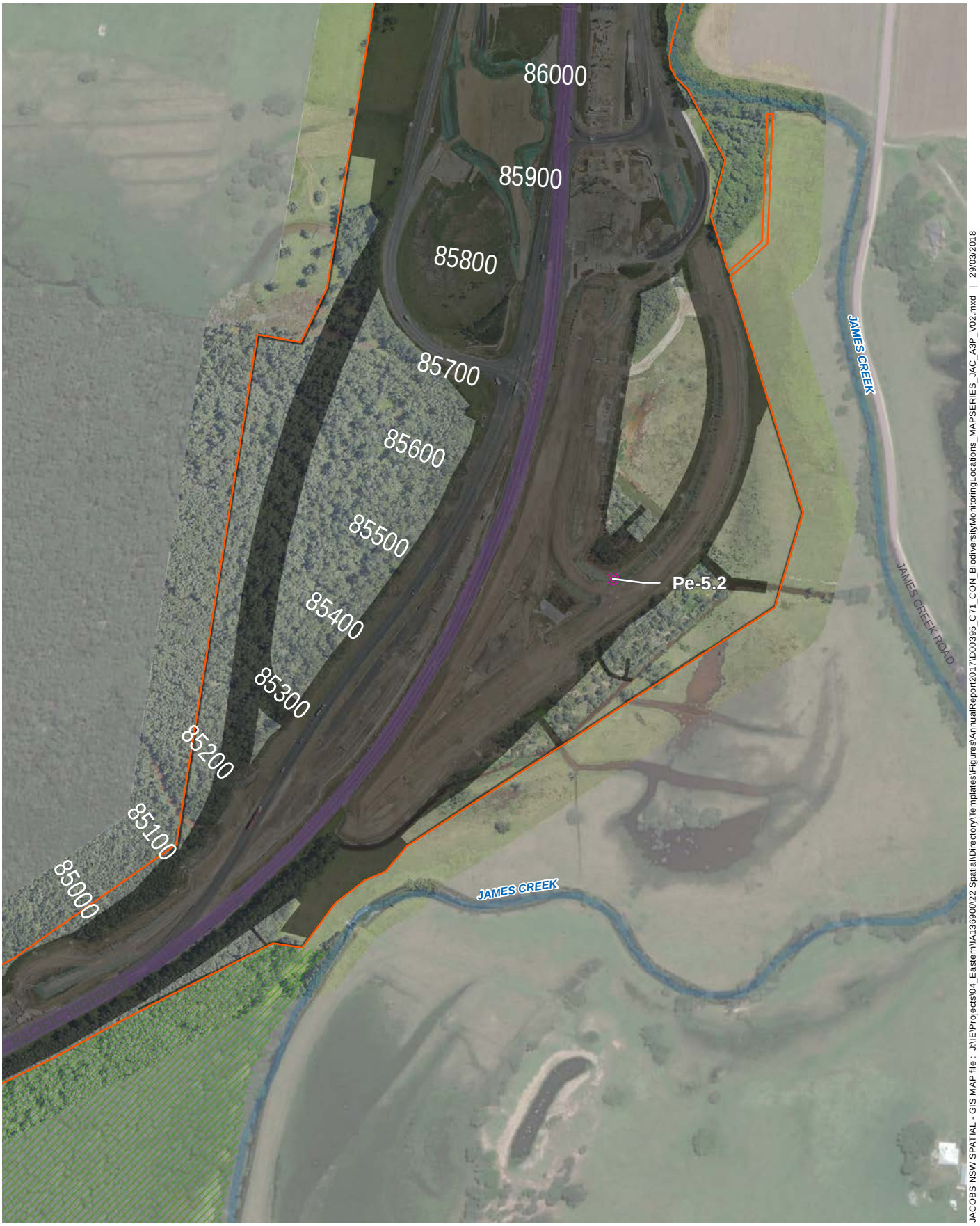
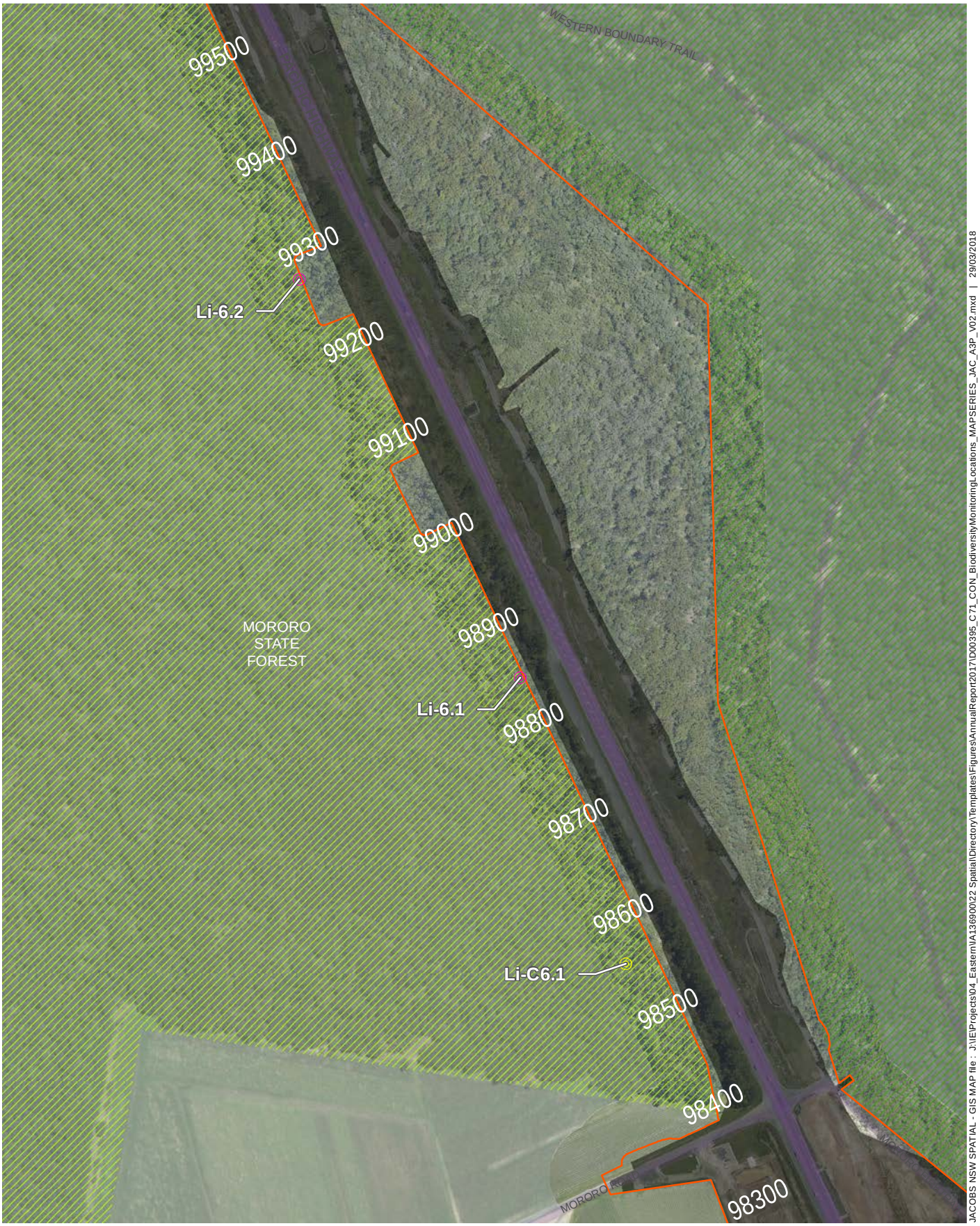


Figure A-21 | Threatened flora monitoring locations



JACOBS NSW SPATIAL - GIS MAP file : J:\IE\Projects\04_Eastern\A136900\22 Spatial\Directory\Templates\Figures\AnnualReport2017\D00395_C71_CON_BiodiversityMonitoringLocations_MAPSERIES_JAC_A3P_V02.mxd | 29/03/2018

Legend

- Monitoring location - Control (Jacobs 2018)
- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)
- Road corridor (LPI 2018)
- State Forest (LPI 2018)
- NPWS Reserve (LPI 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

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0 100 200m

Figure A-22 | Threatened flora monitoring locations

JACOBS NSW SPATIAL - GIS MAP file : J:\E\Projects\04_Eastern\A136900\22 Spatial\Directory\Templates\Figures\AnnualReport2017\D000395_C71_CON_BiodiversityMonitoringLocations_MAPSERIES_JAC_A3P_V02.mxd | 29/03/2018

Legend

- Monitoring location - Control (Jacobs 2018)
- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)
- Road corridor (LPI 2018)
- Waterway (LPI 2018)
- NPWS Reserve (LPI 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

N

1:7,000 @ A3

0 100 200m

Figure A-23 | Threatened flora monitoring locations

JACOBS NSW SPATIAL - GIS MAP file : J:\IE\Projects\04_Eastern\A136900\22 Spatial\Directory\Templates\Figures\AnnualReport2017\D00395_C71_CON_BiodiversityMonitoringLocations_MAPSERIES_JAC_A3P_V02.mxd | 29/03/2018

Legend

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- Clearing boundary (PC 2018)
- State Forest (LPI 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

N

1:5,000 @ A3

0 100 200m

Figure A-24 | Threatened flora monitoring locations

JACOBS NSW SPATIAL - GIS MAP file : J:\E\Projects\04_Eastern\A136900\22 Spatial\Directory\Templates\Figures\AnnualReport2017\D00395_C71_CON_BiodiversityMonitoringLocations_MAPSERIES_JAC_A3P_V02.mxd | 29/03/2018

Legend

- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)
- Road corridor (LPI 2018)
- State Forest (LPI 2018)
- NPWS Reserve (LPI 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

N

1:5,000 @ A3

0 100 200m

Figure A-25 | Threatened flora monitoring locations

JACOBS NSW SPATIAL - GIS MAP file : J:\IE\Projects\04_Eastern\A136900\22 Spatial\Directory\Templates\Figures\AnnualReport2017\D00395_C71_CON_BiodiversityMonitoringLocations_MAPSERIES_JAC_A3P_V02.mxd | 29/03/2018

Legend

- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)
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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

N

1:10,000 @ A3

0 100 200m

Figure A-26 | Threatened flora monitoring locations

JACOBS NSW SPATIAL - GIS MAP file : J:\IE\Projects\04_Eastern\A136900\22 Spatial\Directory\Templates\Figures\AnnualReport2017\D00395_C71_CON_BiodiversityMonitoringLocations_MAPSERIES_JAC_A3P_V02.mxd | 29/03/2018

Legend

- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)
- Road corridor (LPI 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

N

1:5,000 @ A3

0 100 200m

Figure A-27 | Threatened flora monitoring locations

JACOBS NSW SPATIAL - GIS MAP file : J:\IE\Projects\04_Eastern\A136900\22 Spatial\Directory\Templates\Figures\AnnualReport2017\D000395_C71_CON_BiodiversityMonitoringLocations_MAPSERIES_JAC_A3P_V02.mxd | 29/03/2018

Legend

- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)
- Road corridor (LPI 2018)

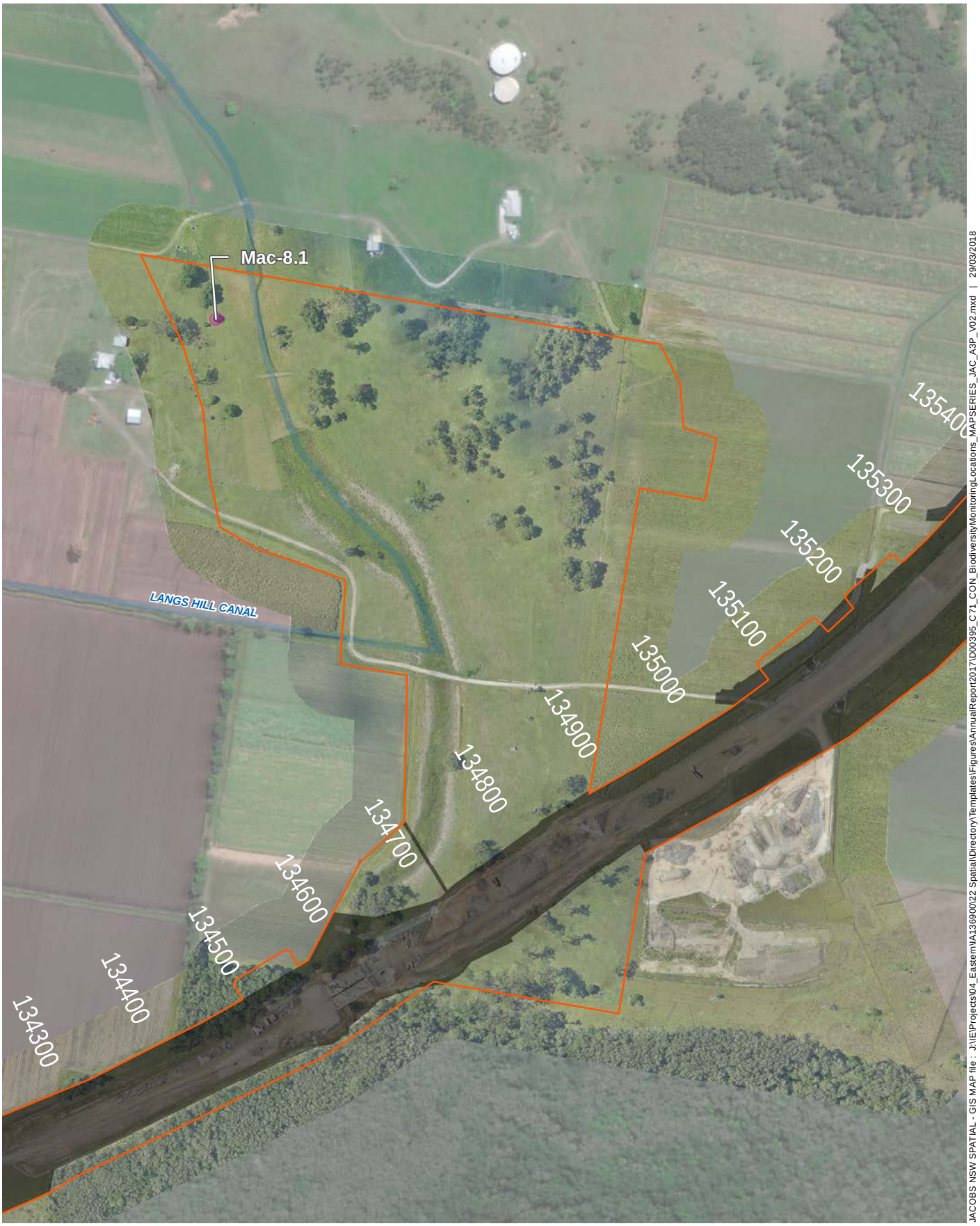
Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

N

1:5,000 @ A3

0 100 200m

Figure A-28 | Threatened flora monitoring locations



JACOBS NSW SPATIAL - GIS MAP file : J:\E\Projects\04_Eastern\A136900\22 Spatial\Directory\Templates\Figures\AnnualReport2017\D000395_C71_CON_BiodiversityMonitoringLocations_MAPSERIES_JAC_A3P_V02.mxd | 29/03/2018

Legend

- Monitoring location - Impact (Jacobs 2018)
- Draft project boundary (v12A, PC Dec 2017)
- Clearing boundary (PC 2018)
- Waterway (LPI 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

N

1:5,000 @ A3

0 100 200m

Figure A-29 | Threatened flora monitoring locations

JACOBS NSW SPATIAL - GIS MAP file : J:\IE\Projects\04_Eastern\A136900\22 Spatial\Directory\Templates\Figures\AnnualReport2017\D00395_C71_CON_BiodiversityMonitoringLocations_MAPSERIES_JAC_A3P_V02.mxd | 29/03/2018

Legend

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- Road corridor (LPI 2018)

Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

N

1:5,000 @ A3

0 100 200m

Figure A-30 | Threatened flora monitoring locations

JACOBS NSW SPATIAL - GIS MAP file : J:\E\Projects\04_Eastern\A136900\22 Spatial\Directory\Templates\Figures\AnnualReport2017\D00395_C71_CON_BiodiversityMonitoringLocations_MAPSERIES_JAC_A3P_V02.mxd | 29/03/2018

Legend

- Monitoring location - Impact (Jacobs 2018)
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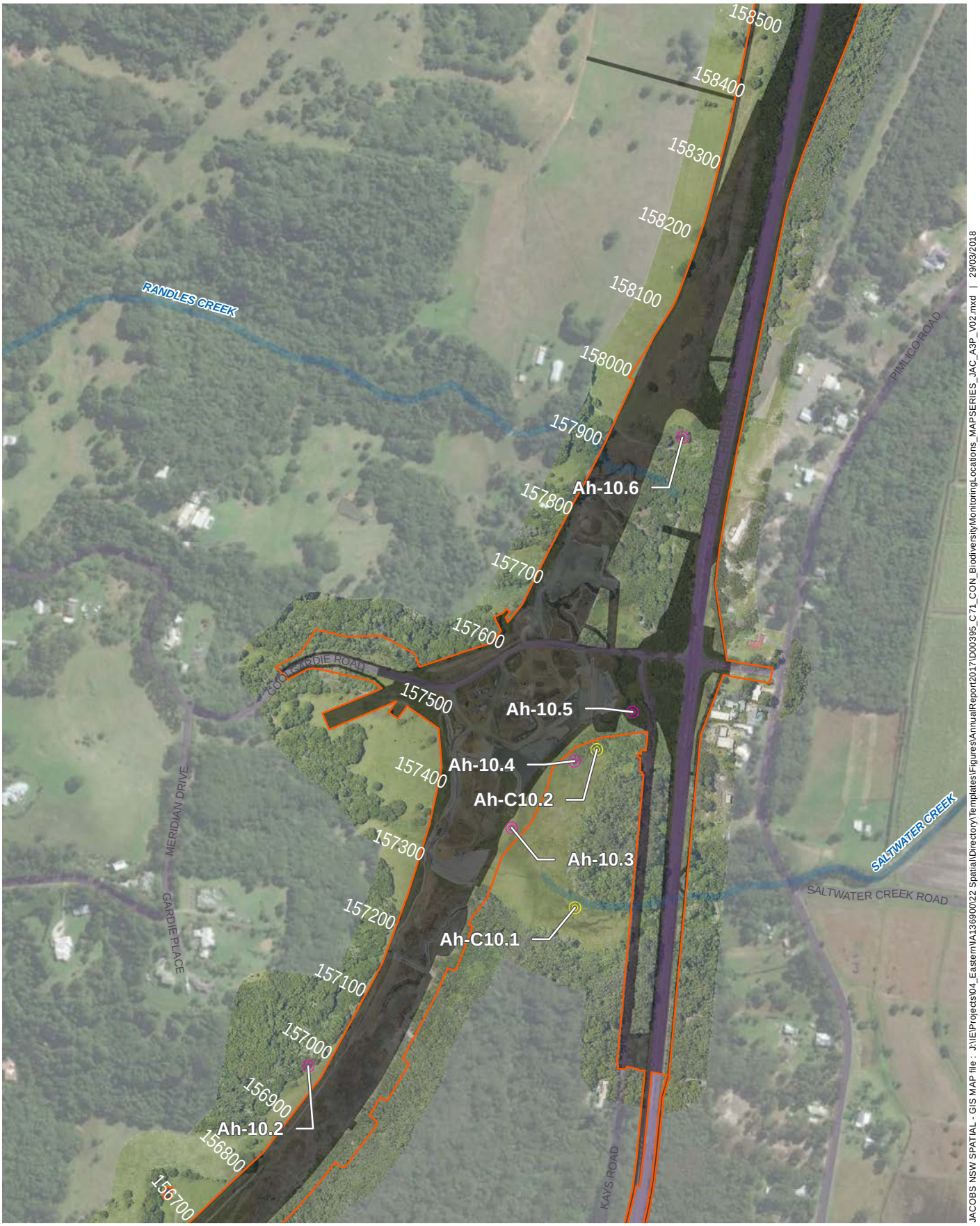
N

1:12,500 @ A3

0 100 200m

Figure A-31 | Threatened flora monitoring locations



JACOBS NSW SPATIAL - GIS MAP file : J:\IE\Projects\04_Eastern\A136900\22 Spatial\Directory\Templates\Figures\AnnualReport2017\D00395_C71_CON_BiodiversityMonitoringLocations_MAPSERIES_JAC_A3P_V02.mxd | 29/03/2018

Legend

- Monitoring location - Control (Jacobs 2018)
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Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Pacific Complete 2011, Nov 2017

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1:7,000 @ A3

0 100 200m

Figure A-32 | Threatened flora monitoring locations

Appendix B. Differences in EIS vs Current Clearing Boundary for Threatened Flora (Year 1 reset)

Common name	Scientific name	Location	Direct								Indirect within 10m								Indirect with 10 to 20m							
			EIS/SPIR boundary/impact (points)	EIS/SPIR boundary/impact + Additional finds & GIS consolidation (points)	Current boundary/impact + Additional finds & GIS consolidation (points)	**Net Change (points)**	EIS/SPIR boundary/impact approval (area)	EIS/SPIR boundary/impact + Additional finds & GIS consolidation (area)	Current boundary/impact + Additional finds & GIS consolidation (area)	**Net Change (area)**	EIS/SPIR boundary/impact (points)	EIS/SPIR boundary/impact + Additional finds & GIS consolidation (points)	Current boundary/impact + Additional finds & GIS consolidation (points)	**Net Change (points)**	EIS/SPIR boundary/impact approval (area)	EIS/SPIR boundary/impact + Additional finds & GIS consolidation (area)	Current boundary/impact + Additional finds & GIS consolidation (area)	**Net Change (area)**	EIS/SPIR boundary/impact (points)	EIS/SPIR boundary/impact + Additional finds & GIS consolidation (points)	Current boundary/impact + Additional finds & GIS consolidation (points)	**Net Change (points)**	EIS/SPIR boundary/impact approval (area)	EIS/SPIR boundary/impact + Additional finds & GIS consolidation (area)	Current boundary/impact + Additional finds & GIS consolidation (area)	**Net Change (area)**
Rough-barked Apple	Angophora robur	S3	6443	6443	5890	-553	87.895	89.115	77.521	-11.594	1146	1146	1463	317	20.691	21.137	25.863	4.726	1208	1208	1141	-67	19.572	21.056	23.570	2.514
		S4	108	108	34	-74	2.618	2.561	1.204	-1.357	3	3	35	32	0.462	0.550	1.147	0.597	8	8	34	26	0.425	0.480	0.986	0.506
		Total	6551	6551	5924	-627	90.513	91.676	78.725	-12.951	1149	1149	1498	349	21.153	21.687	27.010	5.323	1216	1216	1175	-41	19.997	21.536	24.556	3.020
Broad-leaved Apple	Angophora subvelutina	S1				0		0.290	0.291	0.001			1	1		0.050	0.051	0.001				0		0.054	0.054	0.000
		Total	0	0	0	0	0	0.290	0.291	0.001	0	0	1	1	0	0.050	0.051	0.001	0	0	0	0	0	0.054	0.054	0.000
White laceflower	Archidendron hendersonii	S10	1	3	4	1				0.000	4	8	1	-7				0.000	18	18	17	-1				0.000
		Total	1	3	4	1	0	0.000	0.000	0.000	4	8	1	-7	0	0.000	0.000	0.000	18	18	17	-1	0	0.000	0.000	0.000
Veiny Lace Flower	Archidendron muellerianum					0				0.000				0				0.000				0				0.000
			0	0	0	0	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000
	Artanema fimbriatum	S1		5	5	0				0.000				0				0.000				0				0.000
		Total	0	5	5	0	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000
Hairy-joint grass	Arthraxon hispidus	S1	2	2	2	0				0.000				0				0.000				0				0.000
		S3	1	1	1	0				0.000				0				0.000				0				0.000
		S8	38	38	16	-22	0.238	1.244	0.097	-1.147	2	2	17	15		0.020	0.115	0.095	8	8	20	12	0.038	0.038	0.101	0.062
		S10	347	347	376	29	1.232	0.256	1.575	1.320	47	47	52	5	0.697	0.697	0.861	0.164	53	53	35	-18	0.846	0.858	0.811	-0.046
		Total	388	388	395	7	1.47	1.500	1.672	0.172	49	49	69	20	0.697	0.717	0.976	0.259	61	61	55	-6	0.884	0.896	0.912	0.016
Stinking laurel	Cryptocarya foetida	S10	41	51		-51				0.000	1	1	6	5				0.000	6	7	3	-4				0.000
		Total	41	51	0	-51	0	0.000	0.000	0.000	1	1	6	5	0	0.000	0.000	0.000	6	7	3	-4	0	0.000	0.000	0.000
Water nutgrass	Cyperus aquatilis	S1	1	1	1	0	0.021	0.021	0.030	0.009				0		0.013	0.004	-0.009				0			0.000	0.000
		S2	6	6	6	0	0.003	0.003	0.003	0.000				0				0.000				0				0.000
		S6	113	121	111	-10				0.000				0				0.000			10	10				0.000
		S7	8	3	3	0				0.000	2	1		-1				0.000	1		1	1				0.000
		Total	128	131	121	-10	0.024	0.024	0.033	0.009	2	1	0	-1	0	0.013	0.004	-0.009	1	0	11	11	0	0.000	0.000	0.000
Davidson's Plum	Davidsonia jerseyana					0				0.000			1	1				0.000				0				0.000
			0	0	0	0	0	0.000	0.000	0.000	0	0	1	1	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000
Square-stemmed spike-rush	Eleocharis tetraquetra	S1	253	58	235	177	0.815	0.787	0.889	0.101	43	178	58	-120	0.118	0.135	0.144	0.009	48	44	11	-33	0.12	0.122	0.114	-0.007
		Total	253	58	235	177	0.815	0.787	0.889	0.101	43	178	58	-120	0.118	0.135	0.144	0.009	48	44	11	-33	0.12	0.122	0.114	-0.007
Green-leaved rose walnut	Endiandra muelleri ssp. bracteata	S4			1	1				0.000		1		-1				0.000	2	1	1	0				0.000
		S10	3	4	4	0				0.000	10	11	2	-9				0.000	3	4	10	6				0.000
		Total	3	4	5	1	0	0.000	0.000	0.000	10	12	2	-10	0	0.000	0.000	0.000	5	5	11	6	0	0.000	0.000	0.000
Square-fruited Ironbark	Eucalyptus tetrapleura	S2	822	868	823	-45	20.285	20.990	22.838	1.849	193	188	200	12	6.337	7.205	9.110	1.905	115	102	105	3	4.87	6.585	7.975	1.390
		S3				0				0.000				0		0.743		-0.743				0		0.720	4.178	3.458
		Total	822	868	823	-45	20.285	20.990	22.838	1.849	193	188	200	12	6.337	7.948	9.110	1.162	115	102	105	3	4.87	7.305	12.153	4.848
Four-tailed grevillea	Grevillea quadricauda	S3	3	3	5	2		0.020	0.020	0.000	35	35	34	-1	0.017	0.018	0.018	0.000	14	14	13	-1		0.003	0.003	0.000
		Total	3	3	5	2	0	0.020	0.020	0.000	35	35	34	-1	0.017	0.018	0.018	0.000	14	14	13	-1	0	0.003	0.003	0.000
Noah's false chickweed	Lindernia alsinoides	S1	1811	958	1035	77				0.000	18	72	17	-55				0.000	91	17	31	14				0.000
		S2				0				0.000				0				0.000	4	2		-2				0.000
		Total	1811	958	1035	77	0	0.000	0.000	0.000	18	72	17	-55	0	0.000	0.000	0.000	95	19	31	12	0	0.000	0.000	0.000
Slender screw fern	Lindsaea incisa	S1		1470	1470	0	0.013	0.013	0.013	0.000		250	250	0		0.001	0.001	0.000		330	330	0	0.003	0.003	0.003	0.000
		S2		409	409	0		0.024	0.024	0.000		1	1	0		0.003	0.003	0.000		2	2	0		0.004	0.003	0.000
		S3			1	1			0.005	0.005			2	2			0.007	0.007			1	1		0.001	0.003	0.002
		S6		11437	3409	-8028	0.37	0.370	0.281	-0.089		1501	3903	2402	0.058	0.058	0.137	0.078		3221	186	-3035	0.148	0.152	0.346	0.194
		Total	0	13316	5289	-8027	0.383	0.406	0.323	-0.084	0	1752	4156	2404	0.058	0.062	0.148	0.086	0	3553	519	-3034	0.151	0.159	0.355	0.196
Macadamia Nut	Macadamia integrifolia	S10				0				0.000			2	2				0.000			2	2				0.000
		Total	0	0	0	0	0	0.000	0.000	0.000	0	0	2	2	0	0.000	0.000	0.000	0	0	2	2	0	0.000	0.000	0.000
Rough-shelled Bush Nut	Macadamia tetraphylla	S5		3	2	-1				0.000			1	1				0.000			0	0				0.000
		S8			2	2				0.000	2	2		-2				0.000				0				0.000
		S10	10	10	10	0				0.000				0				0.000	3	3	11	8				0.000
		Total	10	13	14	1	0	0.000	0.000	0.000	2	2	1	-1	0	0.000	0.000	0.000	3	3	11	8	0	0.000	0.000	0.000
Maundia	Maundia triglochinoides	S1	5	4	6	2	0.075	0.103	0.117	0.014	5	1	1	0	0.038	0.044	0.042	-0.001		1	1	0		0.032	0.032	0.000
		S2	34	28	20	-8	0.075	0.069	0.052	-0.017	45	43	41	-2	0.072	0.082	0.058	-0.023	16	6	8	2	0.073	0.065	0.073	0.008
		S3	3	3	1	-2	0.016	0.050	0.020	-0.029			1	1		0.006	0.026	0.020	1	1	2	1		0.034	0.068	0.035
		S7	11	10	8	-2	0.023	0.023	0.018	-0.005	16	18	4	-14		0.008	0.003	-0.005	1	3	1	-2		0.018	0.002	-0.016
		Total	53	45	35	-10	0.189	0.245	0.207	-0.038	66	62	47	-15	0.11	0.140	0.130	-0.010	18	11	12	1	0.073	0.148	0.175	0.028
Weeping paperbark	Melaleuca irbyana	S7	1582	1582	1169	-413	2.761	2.761	2.714	-0.047	132	132	165	33	0.322	0.322	0.413	0.091	41	42	68	26	0.203	0.246	0.250	0.004
		Total	1582	1582	1169	-413	2.761	2.761	2.714	-0.047	132	132	165	33	0.322	0.322	0.413	0.091	41	42	68	26	0.203	0.246	0.250	0.004
Yellow-Flowered King of the Fairies	Oberonia complanata	S8	18	20	18	-2	0.033	0.033	0.038	0.005	1	2	8	6	0.013	0.013	0.011	-0.002	6	7	1	-6		0.003		-0.003
		Total	18	20	18	-2	0.033	0.033	0.038	0.005	1	2	8	6	0.013	0.013	0.011	-0.002	6	7	1	-6	0	0.003	0.000	-0.003
	Oberonia titania	S10				0				0.000				0				0.000		13	13	0				0.000
		Total	0	0	0	0	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000	0	13	13	0	0	0.000	0.000	0.000
	Olax angulata	S2		1	1	0				0.000				0				0.000				0				0.000
		Total	0	1	1	0	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000
Birdwing Butterfly Vine	Pararistolochia praevenosa	S10		40	50	10				0.000		10		-10				0.000		1	1	0				0.000
		Total	0	40	50	10	0	0.000	0.000	0.000	0	10	0	-10	0	0.000	0.000	0.000	0	1	1	0	0	0.000	0.000	0.000
Tall knotweed	Persicaria elatior	S4	53	53	49	-4	0.153	0.153	0.137	-0.016	3	8	108	100		0.042	0.521	0.479	1	3	64	61	0.006	0.006	0.436	0.430
		S5	23	23	97	74	0.047	0.057	0.154	0.097	25	25	30	5	0.069	0.077	0.060	-0.017	68	68	29	-39	0.084	0.098	0.057	-0.041
		Total	76	76	146	70	0.2	0.210	0.291	0.081	28	33	138	105	0.069	0.120	0.581	0.462	69	71	93	22	0.09	0.104	0.493	0.389
Singleton mint bush	Prostanthera cineolifera	S6	609	616	653	37	0.424	0.424	0.438	0.015	260	258	228	-30	0.188	0.188	0.177	-0.011	106	106	99	-7	0.229	0.229	0.204	-0.026
		Total	609	616	653	37	0.424	0.424	0.438	0.015	260	258	228	-30	0.188	0.188	0.177	-0.011	106	106	99	-7	0.229	0.229	0.204	-0.026
Moonee Quassia	Quassia sp. Moonee Creek	S1	73	133	73	-60	0.08	0.152	0.080	-0.073	137	173	137	-36	0.105	0.091	0.107	0.016	250	185	243	58	0.126	0.106	0.120	0.014
		Total	73	133	73	-60	0.08	0.152	0.080	-0.073	137	173	137	-36	0.105	0.091	0.107	0.016	250	185	243	58	0.126	0.106	0.120	0.014
	Rotala tripartia	S6			2	2				0.000				0				0.000	2	6		-6				0.000
		Total	0	0	2	2	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000	2	6	0	-6	0	0.000	0.000	0.000
	ROTAP Trichosanthes subvelutina	S10				0				0.000		1	1	0				0.000				0				0.000
		Total	0	0	0	0	0	0.000	0.000	0.000	0	1	1	0	0	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000
Siah's Backbone	Streblus pendulinus	S10	4	4	3	-1				0.000	1	1	4	3				0.000	2	2		-2				0.000
		S4				0				0.000			1	1				0.000	1	1	1	0				0.000
		S8				0				0.000				0				0.000		2	1	-1				0.000
		Total	4	4	3	-1	0	0.000	0.000	0.000	1	1	5	4	0	0.000	0.000	0.000	3	5	2	-3	0	0.000	0.000	0.000
Smooth-bark Rose Apple, Red Lilly Pilly	Syzygium hodgkinsoniae	S10	6	6	2	-4				0.000	4	4		-4				0.000		6	8	2				0.000
		Total	6	6	2	-4	0	0.000	0.000	0.000	4	4	0	-4	0	0.000	0.000	0.000	0	6	8	2	0	0.000	0.000	0.000