Woolgoolga to Ballina Pacific Highway upgrade

Operational Monitoring of In-situ Threatened Flora Species (non-rainforest)

Annual Report 2021

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In-situ Threatened Flora (non-rainforest flora)

Annual Monitoring Report 2021

Final Report

6 July 2022

Transport for NSW

Woolgoolga to Ballina Pacific Highway Upgrade

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Contents

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 *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 threatened plant species during construction and three years operation.

The in-situ threatened 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 sites for each threatened species identified in the TFMP. This occurred in 2014. Impact and control sites were monitored in the first year of construction in 2017 from two monitoring events for Sections 1 to 2 and four quarterly monitoring events (Q1-Q4) for Sections 3 to 10 of the W2B upgrade (Jacobs 2018). Operational monitoring in Section 1-2 (2018) was completed in two (biannual) events in autumn and spring and transitioned to annual spring monitoring in 2019. For Section 1 and 2 the third and final operational monitoring event was completed in spring 2020 and for Section 3-10, the first year of operational monitoring was completed in spring 2020. The current report describes the results of the second year of operational monitoring for Sections 3-10 completed in 2021. Operational monitoring is conducted annually in spring.

The report provides discussion on avoiding and minimising impacts to threatened plant species 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 threatened flora monitoring program is specific to 20 threatened plant species, these are listed in **Table 1-1** along with their status and relevant project section.

Table 1-1 Threatened flora species targeted in the construction monitoring

Species	Common Name	Status		Project section for monitoring in 2021
		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	3, 6, 7
Eleocharis tetraquetra	Square-stemmed Spike-rush	-	E	3
Endiandra muelleri subsp. *bracteata*	Green-leaved Rose Walnut	-	E	4
Eucalyptus tetrapleura	Square-fruited Ironbark	V	V	Not monitored in 2021 (species only in section 2)
Grevillea quadricauda	Four-tailed Grevillea	V	V	3

Species	Common Name	Status		Project section for monitoring in 2021
		EPBC Act	BC Act	
Lindernia alsinoides	-	-	E	3
Lindsaea incisa	Slender Screw Fern	-	E	3, 6
Macadamia tetraphylla	Rough-shelled Bush Nut	V	V	7, 8
Maundia triglochinoides	-	-	V	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
Prostanthera cineolifera	Singleton Mint Bush	V	V	6
Quassia sp. Moonee Creek	Moonee Quassia	E	E	3
Rotala tripartita	-	-	E	6
V=vulnerable, E=endangered				

1.2 Detailed design outcomes

A small number of the in-situ sites established during the pre-construction phase of the project, were inadvertently placed in areas that were subject to approved clearing associated from the detailed design. These sites, which were removed during Year 1 construction activities, were documented in the 2017 annual report (Jacobs 2018) and will be excluded from future annual reports. Details of the program reset are provided in **Appendix B**. Following review of the detailed design and comparison with concept design the total number of remaining in-situ populations being monitored were reset across the whole project. Monitoring plots partially impacted in 2017 were continually monitored to examine any change post impact or from future direct or indirect impacts. Where possible, additional plots were established to monitor remaining populations adjacent to pre-existing impacted sites.

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 events be undertaken once annually during the operational phase of the project. This report details the Year 2 operational monitoring for Sections 3-10 and was conducted in late spring during October-November 2021, with dates described in the report.

2.1.2 Climatic conditions

Given the length of the project study area spanning over 160 km, localised climatic conditions and rainfall vary across this extent and it is important to identify these conditions in interpreting the data and trends in natural variation of plants and changes in their health, abundance and occurrence. This is particularly important for threatened flora that grow in wetland and riparian habitats and depend on rainfall.

Total annual rainfall for 2021 ranged from 1327.4 mm at Grafton Research Station (Sections 3-5), and 1748.1 mm at New Italy (Sections 6-10).

Each localised site received varied amounts of annual rainfall preceding the 2021 surveys, particularly compared with previous monitoring years, primarily March experienced the greatest monthly rainfall during 2021 at Grafton which received 328.8 mm and New Italy which received 419.8 mm. The lowest amounts of annual rainfall in 2021 in comparison to historical rainfall data occurred during the months of January and June to September for Grafton and January, May, June and August for New Italy. Monthly rainfall trends were variable across the whole region though generally below average rainfall preceding the 2021 monitoring event (refer **Figure 2-1** and **Figure 2-2**). Overall, the annual rainfall for 2020 and 2021 has been higher than the proceeding drought years of 2018 and 2019 and the highest totals since the baseline work in 2014 and the three years construction 2017-2019., with the exception of the 2018 flood event in the northern portion of the project (Section 7-10) (refer **Figure 2-3**).

Overall mean maximum and minimum temperatures were above average during majority of summer, autumn and spring months, and below average for majority of winter in 2021.

A summary of all monitoring events, survey timing and local weather conditions is presented in **Table 2-1**.

Monthly rainfall data and monthly historical average from Grafton is presented in **Figure 2-1**, monthly rainfall data and monthly historical average from New Italy is presented in **Figure 2-2**, and annual and historical rainfall data from Grafton and New Italy is presented in **Figure 2-3**.

Table 2-1 Survey timing and rainfall total for proceeding months from monitoring program

Season	Monitoring period 2021 (survey dates)		Total mean rainfall three months preceding survey (mm)*	
	Section 3-5	Section 6-10	Grafton	Woodburn
Spring	Annual (18-21 Oct)	Annual (5-9 Nov)	25.1	58.4

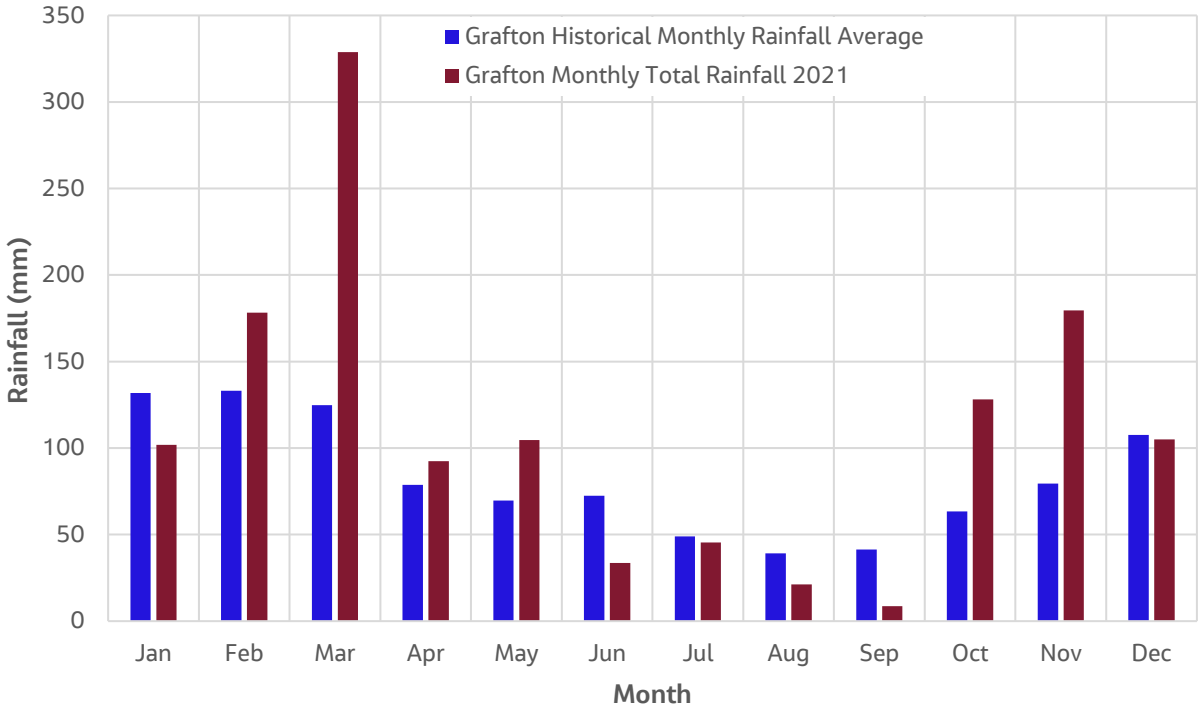

Figure 2-1 Monthly rainfall data and monthly historical average from Grafton Research Station (058077) for 2021

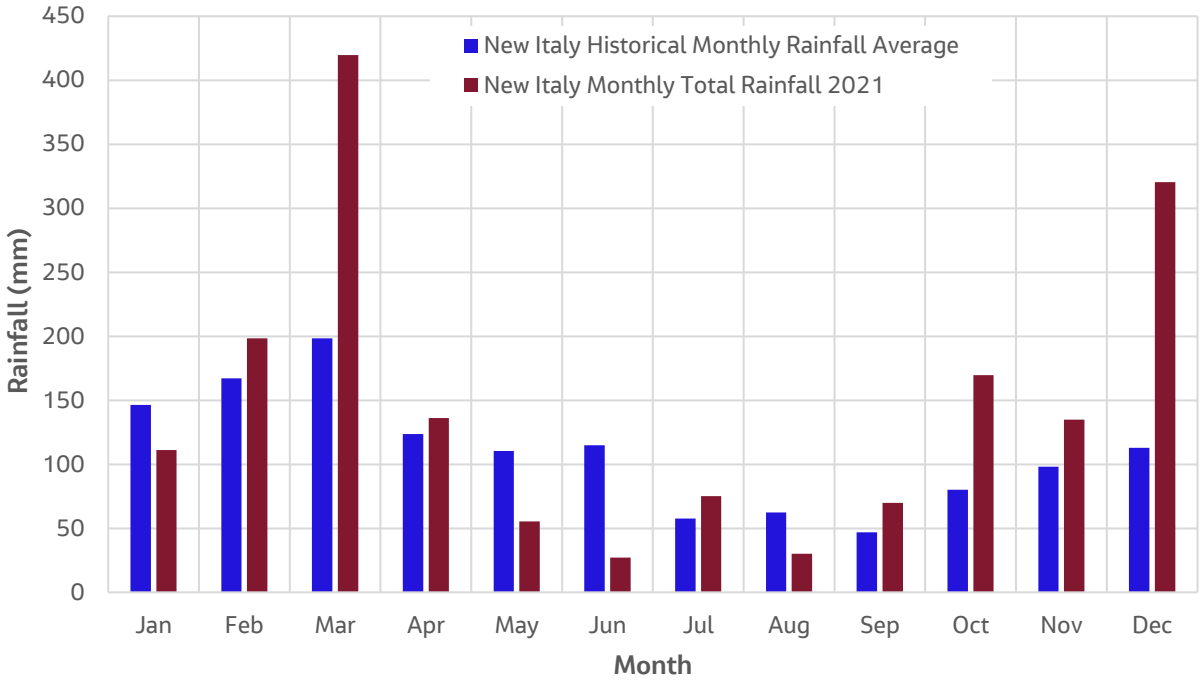

Figure 2-2 Monthly rainfall data and monthly historical average from New Italy (058097) for 2021

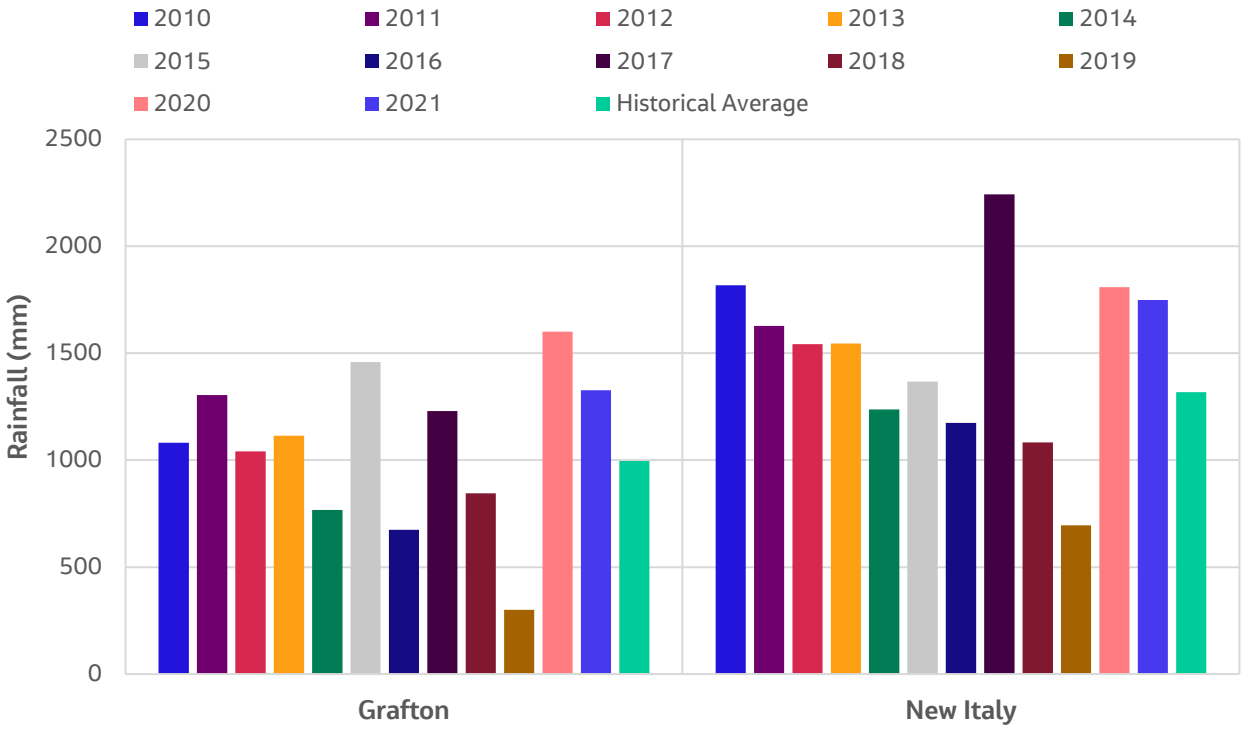

Figure 2-3 Annual and historical rainfall data from the Grafton (058077) and New Italy (058097) weather stations (missing annual data was complemented with data from nearby stations)

2.2 Monitoring sites

The pre-construction baseline surveys undertaken by Jacobs in 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 plot location. All sites monitored for pre-construction were established during the development of the project concept design. A total of 49 sites are monitored in Section 3-10 of the project (comprising 38 impact and 11 control sites). Site locations are illustrated in **Appendix A**. Refer to the Construction Monitoring of In-situ Threatened Flora (non-rainforest flora) Annual Report 2017 for a description of replaced, removed, or added sites from 2017 (also tabled in Appendix B).

2.2.1 Decommissioned monitoring sites

A total of 25 sites have been removed from the monitoring program due to continued access restrictions at 10 sites, loss of 10 sites impacted within the detailed design construction footprint and other reasons for five other sites. Some sites have been replaced or duplicated where possible and are referenced in the annual report 2017 (Jacobs). The list of sites removed is shown in **Table 2-2**.

Table 2-2 Sites removed from monitoring program

Site	Chainage	Reason/status	Site	Chainage	Reason/status
Elt-1.1	5700	Impact	Ar-3.10	66500	Impact
Elt-1.2	6200	Impact	Ar-3.11	67700	Impact
Elt-C1.1	6400	No access	Pe-4.2	80600	Impact
Elt-C1.2	6400	No access	Pe-5.1	83400	Impact
Elt-1.4	6700	No access	Emb-4.2	80700	Inadvertent impact
La-1.1	6200	Impact	Sp-4.1	80700	Not listed as threatened
La-C1.1	6400	No access	Sp-8.1	134900	Not listed as threatened
La-C1.2	6400	No access	Pc-6.2	101700	Impact
La-1.3	6700	No access	Pc-6.2a	101700	Monitored in translocation program
La-C1.3	6400	No access	Pc-C6.1	101700	Replaced with in-situ site
Mt-C1.1	4900	No access	Oc-8.1	132200	Impact
Mt-1.2	5700	Impact	Pa-9.1	144400	*Calanthe triplicata* - not listed as threatened
Mt-3.3	64300	No access	Ah-10.5	157600	Impact

2.3 Sampling methods

2.3.1 Targeted surveys and species detection

The long-term monitoring program (pre, during and post construction) is designed to ensure that different plant life stages and climatic conditions are targeted over multiple monitoring events and years. Surveys focus on monitoring the health and condition of known individuals as well as investigating plant recruitment. Detection of cryptic threatened flora was reliant on suitable climatic and seasonal conditions, particularly for *Cyperus aquatilis* and *Rotala tripartita*. Climate variability also has an effect on *Lindernia alsinoides, Lindsaea incisa* and *Maundia triglochinoides,* which rely on moist conditions. *Persicaria elatior* and *Arthraxon hispidus* have an annual life cycle and were only detectable at certain times of the year. *Persicaria elatior* would generally show signs of natural dieback in late autumn with few plants remaining in winter and seedlings would appear in late spring, depending on rainfall conditions and seed presence from the previous year. *Arthraxon hispidus* would dieback in winter and seedlings would appear in spring and begin to set seed in late autumn. *Cyperus aquatilis* and *Rotala tripartita* are also short-lived annuals and rely on wet summer periods.

While rainfall conditions have improved since the 2018/19 drought period, it is evident that some annual species had not returned to the monitoring plots. The drier environmental conditions in 2018/19 impacted some of these species, particularly *Persicaria elatior*, which were absent from many sites, including both impact and control sites post 2019, and absent from the 2021 monitoring events. However, this is consistent with the absence of plants in November 2020 (Year 1 operational monitoring).

2.3.2 Sampling technique

A 20 m x 20 m plot with a central 20 m transect was used at each site following the same techniques carried out in previous years and in line with the TFMP. 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 were 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 their cover 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.

A quantitative measure of a subject plant's abundance and distribution within a plot was used for groundcover plants (and annuals) that are difficult to count and/or grow in large clusters. This method was adopted for *C. aquatilis* and *R. tripartita*. *L. alsinoides, L. incisa* and *M. triglochinoides.*

The technique involved the measurement of an area of occupancy (AoO) of subject plant's distribution within the plot and a series of 1x1 metre quadrats randomly placed within the AoO to either estimate percentage ground cover or count number of stems. Any plots with continual low abundances of individuals were directly counted. A measure of percentage cover was only used for *M. triglochinoides*. For *A. hispidus, C. aquatilis, R. tripartita*. *L. alsinoides and L. incisa,* stems (where present) and were directly counted within specified patches or mean number of stems determined in 1 x 1m quadrats for larger occurrences.

To account for consistent temporal changes in site abundance and occupancy (i.e. increase/decline), a standard method of recording cover/abundance was applied across the entire plot for each monitoring event. This was calculated by multiplying the mean percentage ground cover, or mean number of stems, by the division of the AoO over the plot size, i.e. ((AoO / 400m^2) x mean cover or stem count).

The remaining species of 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 (Braun Blanquet, 1928; Poore 1955), refer **Table 2-3**.

Table 2-3 Cover abundance score used for measuring weeds

Score	Description
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 to in-situ threatened flora. The 2021 data is now relevant to the operational phase of the project and has been compared with baseline and construction data to evaluate any impacts and determine effectiveness of the management measures used. This is assessed in the context of the performance measures identified in the plan (refer to **Table 4-2** and **Table 4-3**).

Specific goals for mitigating impacts using performance thresholds and corrective actions during the operational phase for in-situ threatened plants are outlined in **Table 2-4** summarised from the TFMP.

Table 2-4 Mitigation measures and corrective actions for threatened flora during operation

Performance goals	Proposed mitigation measure	Monitoring/timing frequency	Trigger for corrective actions	Corrective actions
Zero mortality of retained in-situ threatened plant populations during construction and for three consecutive monitoring periods post-construction. Post the above period 80 per cent survival of tree, shrub, and herbaceous perennials after three years.	Clearly identify in-situ populations and exclusion zones. Implementation of weed management measures throughout operational period.	Threatened plant health monitoring and weed monitoring to occur as per Sections 8. Monitoring to occur annually of in-situ monitoring sites and control sites. Monitoring will occur for a minimum of three years post-construction (subject to achieving three consecutive monitoring periods as per MCoA D8 (k).	Any mortality of in-situ threatened plants for the first three consecutive monitoring periods post construction. Post the above timeframe more than a 20 per cent decline for an in-situ threatened plant population over one monitoring event from the baseline (depending on species specific seasonal fluctuations).	Commence assessment of potential reasons for mortality, including natural events such as drought and fire within one month of trigger being identified. Review weed maintenance schedule within one month of trigger being identified. Identify potential threats, implement corrective actions, and modify monitoring as necessary. Offset any additional threatened plant impacts that have occurred as a result of the Project.

Performance goals	Proposed mitigation measure	Monitoring/timing frequency	Trigger for corrective actions	Corrective actions
At least 90 per cent of the plants planted as part of the revegetated areas have survived after the first year and 80 per cent after three consecutive monitoring events.	Regular maintenance activities such as watering, mulching, weed control and supplementary plantings as required as per the landscape design.	For the first twelve months monitoring will be monthly. It will then go to every 6 months for two years. Monitoring will occur in Spring/Summer to evaluate the success of revegetation against performance objectives.	Monitoring and maintenance activities not being undertaken. More than 10 per cent of plants have died after year one, and more than 20% have died after three consecutive monitoring events.	Within one month of the trigger review and update maintenance methods as required. Identify any other potential threats and implement corrective actions as required. Any failed areas to be reseeded within 6 weeks of trigger. Ongoing monitoring and maintenance undertaken until plant health and/or ecological condition of habitat has been maintained at 80% survival after three consecutive monitoring events.
Less than five per cent weed cover at retained in-situ threatened flora sites (end of monitoring program).	Implementation of weed management measures throughout operational period.	Threatened plant health monitoring and weed monitoring to occur as per Sections 8. Weeds will be monitored in proximity to in-situ flora populations annually. Monitoring will occur for a minimum of three years post-construction (subject to achieving three consecutive monitoring periods as per MCoA D8 (k)).	Weed cover increases by 10% from the baseline cover in areas surrounding in-situ populations. More than 30% weed coverage in revegetation areas.	Review weed maintenance program within one month of trigger being identified and update as required.

3. Results and discussion

3.1 Operational Year 2 monitoring (Sections 3-10)

3.1.1 Sandstone Rough-barked Apple (*Angophora robur*)

All thirteen *Angophora robur* sites (in-situ and control) (chainage:44600-67700) were visited between 18-20 October 2021.

The data from the Year 2 operation monitoring of *A. robur* has remained relatively stable with some minor declines in the number of plants across several sites however recruitment was also reported in most plots. The most notable changes in tree abundance from the 2021 surveys was at site Ar-3.10a with a recorded total of 16 new plants which has significantly increased from having recorded no plants in 2020. Likewise, the most notable changes in seedling abundance from the 2021 surveys were at sites Ar-C3.1, Ar-C3.2, Ar-3.3, Ar-3.9 and Ar-3.10a. The highest increase in seedling abundance was recorded at Ar-3.10a with a total of 10 new seedlings which has significantly increased from having recorded no seedlings in 2020 (refer to **Figure 3-1**). Recent under scrubbing by private landholder has impacted ArC3.1 by removing all native small trees and shrubs from the site, (including the plot and juvenile Angophora robur) and has resulted in a significantly lower mid-storey cover of native plants. Mature trees remain in good condition. This impact is not project related and affects the control plot.

As noted from previous monitoring general plant dieback continues to be evident (since Year 1 construction monitoring) at sites Ar-3.4 and Ar-3.7 and may be associated with the drought and heat stress and / or caused by the epidemic infection of the root-rot fungus Cinnamon Fungus (*Phytophthora cinnamomi*), but this would need to be confirmed. This dieback pre-dates the highway construction. Around 50% of the trees in these two plots have new shoots and showing recovery in 2021. Evidence of controlled groundcover fire was noted (occurring around 2 months prior to the monitoring) at sites Ar-3.3 and Ar-3.4, this is associated with landholders and is not project related. These fires caused minor impacts to 3 small trees at Ar-3.3 and 1 small tree at Ar-3.4, each of which were resprouting during the 2021 monitoring event. In addition to this, trees at sites Ar-3.1 and Ar-3.8 appear to have had been impacted by storm damage and all trees have bare branches consistent with form of tree growth for this species at all sites.

No baseline data exists for sites Ar-3.10a and Ar-3.11a that were established in 2017. These sites were surveyed in 2021 and *A.robur* were found to be in excellent condition. This was particularly evident at site Ar-3.10a due to an overall increase in tree and seedling abundance, whereas site Ar-3.11a has remained consistent with the results recorded in 2020 in terms of tree and seedling abundance.

A summary of all in-situ and control *A. robur* sites is presented in **Figure 3-1**.

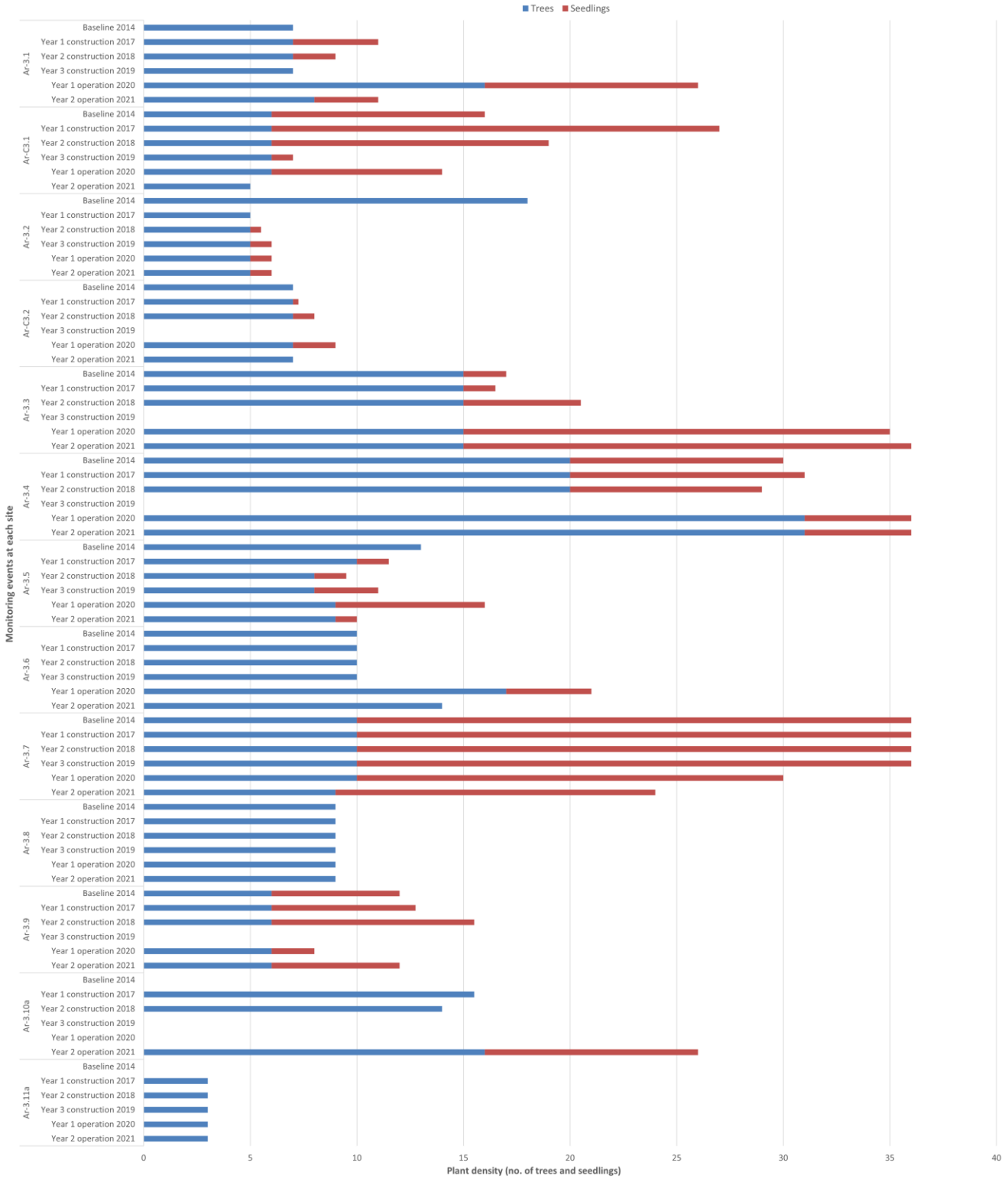

Figure 3-1 Number of *A. robur* trees and seedlings observed over eleven monitoring events (2014 [n=1], mean results for 2017 [n=4], mean results for 2018 [n=2], 2019 [n=1], 2020 [n=2] and 2021 [n=1] at eleven in-situ sites and two control sites).

3.1.2 Hairy-joint Grass (*Arthraxon hispidus*)

All six *Arthraxon hispidus* in-situ sites (chainage:129300-157900) and two control sites (chainage:157200-157500) were surveyed on 5 November 2021. This considers the removal of Ah-10.5 from the monitoring program as it was located within the detailed design boundary.

A. hispidus was detected at four sites (Ah-8.1, Ah-10.1, Ah-10.2 and Ah-C10.2) and absent from four sites (Ah-10.3, Ah-10.4, Ah-10.6 and Ah-C10.1) from the 2021 surveys. The most notable increase in average number of stems per square metre for *A.hispidus* was demonstrated at site Ah-10.2. Additionally, plants observed in Ah-10.1 and Ah-C10.2 also indicated a slight increase in average number of stems per square metre for *A.hispidus* in comparison to data recorded in previous monitoring events. Plants at site Ah-10.1 were up to 10 cm in height and all in good condition which is consistent with the data from 2020. Furthermore, plants observed at site Ah-10.2 were up to 35 cm in height and all in good to excellent condition and site Ah-C10.2 were up to 45cm in height and all in good condition. No flowers or buds were observed at each of these three sites.

A. hispidus is an annual species that naturally dies back each year and the abundance of plants observed at the sites surveyed as part of this monitoring program have fluctuated considerably since baseline surveys (refer **Figure 3-2**). The soil moisture for all sites was recorded as very wet with some sites demonstrating standing surface water which has likely promoted this species to re-establish especially with regards to site Ah-10.2 which has noticeably spiked to 7.35 (mean no. of stems/m^2) in 2021, a result that is closely aligned with that of Year 2 construction in 2018 of 8.13 (mean no. of stems/m^2). These observations in 2021 are considered primarily the result of above average rainfall and wet conditions experienced in some preceding months leading up to the 2021 surveys (refer **Figure 2-2**) compared to the drought conditions in 2019/20. However, the absence of *A.hispidus* at the remaining four sites have been reported as having dense weed invasion since baseline monitoring which has likely been the result of minimal to no plants recorded at most of these sites especially over the last two monitoring events in Year 3 construction 2019 and Year 1 operation 2020.

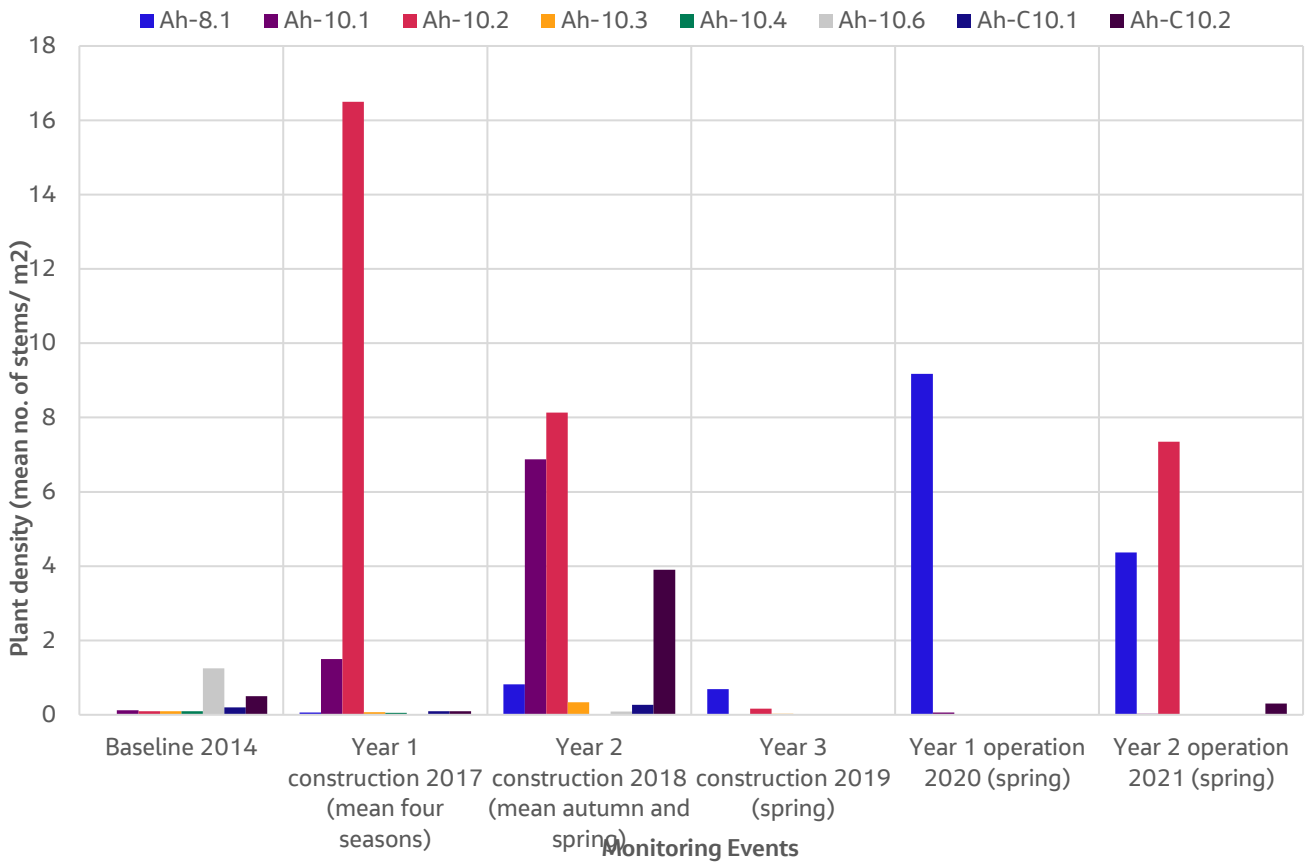

Figure 3-2 Density (mean no. of stems / m^2) of *Arthraxon hispidus* in each plot observed over ten monitoring events at six in-situ sites and two control sites

Competition with other plants continues to be a threat to *A.hispidus* and the wetter conditions in 2021 has cause increase in cover of some weeds. This is primarily by exotic species such as *Ageratum houstonianum*, *Paspalum dialatatum*, *Commelina benghalensis, Senecio madagascariensis, Verbena littoralis* and *Ambrosia artemisiifolia* forming dense groundcover (refer **Photograph 3.1 and 3.2**). This is particularly evident at sites Ah-8.1, Ah-10.3, Ah-10.4, Ah-10.6 and Ah-C10.1, where it appears *A.hispidus* plants are being out-competed. Similarly, this is also happening at Ah-C10.1 with the native grass *Leersia hexandra*. *A.hispidus* appears to prefer small clearings and disturbed sites that have been slashed or grazed and this is a consequence of strong competition with native and exotic greases and weeds which share this favoured moist low-lying habitat. This problem may be exacerbated by the removal of cattle from these properties, which have been previously managed through grazing. Cattle removal has occurred in some locations during the construction period. **Table 3-1** shows the change in weed cover and number of weed species for all sites over all monitoring periods. This impact is not project related.

Table 3-1 Comparison of weed abundance ground cover and species richness) at *Arthraxon hispidus* monitoring plots (pre-construction, construction, and operational periods)

Site	Mean weed ground cover (%) / weed richness (No. spp.)							Change (%) in mean weed ground cover (baseline vs construction) / baseline vs operation (+/-)	Difference in no. of weed species (cons / oper (+/-)	Detailed design impact
	Pre-construction	Construction Year 1	Construction Year 2	Construction Year 3	Construction mean	Operation Year 1	Operation Year 2			
Ah-8.1	100/1	67.5/8	82.5/8	100/8	83.3	80/5	100/6	-16.7 / -10.0	+7 / +4	**No**
Ah-10.1	100/2	99/10	100/10	100/11	99.7	100/10	80/4	-0.3 / -10.0	+4 / +8	**No**
Ah-C10.1	20/1	31.5/4	15/4	0/4	15.5	19/3	0/0	-4.5 / -9.5	+3 / -1	**No**
Ah-10.2	85/3	75/3	57.5/10	80/10	70.8	100/3	90/6	-14.2 / +5.0	+7 / +1.5	**No**
Ah-C10.2	20/3	35/8	40/8	95/8	56.7	100/8	60/4	+36.7 / +60.0	+5 / +3	**No**
Ah-10.3	65/3	82.5/11	77.5/11	80/11	80	75/5	5/1	+15 / -60.0	+8 / +0	**No**
Ah-10.4	75/6	64/9	65/5	65/9	64.7	65/5	50/1	-10.3 / -17.5	+3 / -3	**No**
Ah-10.6	65/2	96/9	100/9	100/9	98.7	100/5	100/3	+33.7 / +35.0	+7 / +1	**No**

Photograph 3.1: Plot Ah10.4 Exotic species (*Paspalum)* dominating the plot and outcompeting *Arthraxon hispidus*.

Photograph 3.2: *Arthraxon hispidus* continuing to grow in spaces amongst Paspalum (Ah-10.4). This situation was observed at a number of impact and control sites.

3.1.3 Water Nutgrass (*Cyperus aquatilis*)

No *Cyperus aquatilis* individuals were recorded from the monitoring plot during the spring 2021 survey, and this is consistent with previous years. This species is best detected during summer and autumn where climatic conditions are most suitable. It is possible the drought conditions in 2018/19 had resulted in loss of plants at this site, and despite good rainfall in 2020 and 2021, the species has not recovered at this location.

Although individuals have not been detected since the baseline surveys, and its absence from the site is not considered to be related to the project, but rather a change in conditions associated with surface hydrology and weed abundance, which occurred prior to and during construction.

3.1.4 Green-leaved Rose Walnut (*Endiandra muelleri* subsp. *bracteata*)

Site Emb-4.2 consisted of one mature *Endiandra muelleri* subsp. *bracteata* shrub, which was inadvertently removed by a construction contractor in January 2019. The contractor was required to implement a Remediation Plan to address corrective actions. Site Emb-4.2 has now been removed from the monitoring program.

Emb-4.1 (chainage: 81700) was inspected on 20 October 2021. The single individual *E. muelleri* subsp. *bracteata* at site Emb-4.1 remains in good health and has improved in the last 12 months (refer **Photographs 3-3 and 3-4**). Insect activity and browsing on leaves in 2021 was minimal and consisted of only 1% of the leaves present. Leaf insect damage has been noted since the start of the program but hasn't caused detrimental harm to plant, however this has diminished significantly in 2021. New shoots were observed at the top of *E. muelleri* subsp. *bracteata* in 2021.

The *E. muelleri* shrub was observed in 2018 being smothered by Dutchmen's Pipe (*Aristolochia elegans*) climber weed, however weed works have been undertaken and flagging has been re-established around the shrub and this weed was absent in 2021. The amount of sunlight entering this site has increased from vegetation clearing during construction to the south (inside the project boundary) and dieback of Flooded Gum (*Eucalyptus grandis*) tree canopy, suspected to be caused by irregular roosting of Flying Foxes. The increased sunlight to the

groundcover has been the cause of increases in weed cover which has increased to 40% in 2021 and an increase of 30% since the baseline. The cover of weeds is not currently having a detrimental impact on the health of the plant at this location.

Photograph 3-3: E. muelleri subsp. bracteata at in-situ site Emb-4.1 showing insect browsing on older leaves

Photograph 3-4: New growth on E.muelleri subsp bracteata.

3.1.5 Four-tailed Grevillea (*Grevillea quadricauda*)

Both in-situ site Gq-3.1 (chainage:59300) and control site Gq-C3.1 (chainage:59500) were surveyed on 19 October 2021.

In-situ site Gq-3.1 sits on the edge of the forest, and much of the plot remains exposed to increased sunlight from clearing for the project, this continues in 2021. This has resulted in good recruitment of new individuals in 2021. Site Gq-3.1 had ten adult *G. quadricauda* plants and eight juvenile plants in 2021, which is an improvement in contrast to the results from 2020. Observations of plant recruitment, seed dispersal and seedling mortality have varied over the years of monitoring. There were 24 seedlings counted in autumn 2018, 21 seedlings in November 2018, 20 in October 2019, 7 in November 2020 and 8 in October 2021. These results reflect that some recruits from this period have now been counted as adult plants and there are now 10 adult plants recorded at site Gq-3.1 in 2021 compared with 6 at the start of construction in 2017. Plants 1 and 2 have new shoots and seeds, plant 7 is setting seeds and has 50% new shoots. Moreover, while plant 7 and 8 have some minor yellowing of a few leaves. No dieback was observed in 2021. The old track along the road edge is continuing to become overgrown with Broad-leaved Paspalum (*Paspalum mandiocanum*) and native shrubs and Monterey Pine (*Pinus radiata*) have continued to increase the mid-storey and canopy cover on site.

Shrub abundance at Gq-C3.1 remained at 15 individuals in 2021, however an increase in 2 seedlings was observed in 2021 in comparison to the results from 2020. Plant height ranged from 30 cm to 1.8 m with occurrence of new buds and shoots. Overall plants were assessed as being in excellent condition with new shoots and seeds observed on a number of plants.

A summary of *G. quadricauda* plant numbers at monitoring sites is presented in **Figure 3-3**.

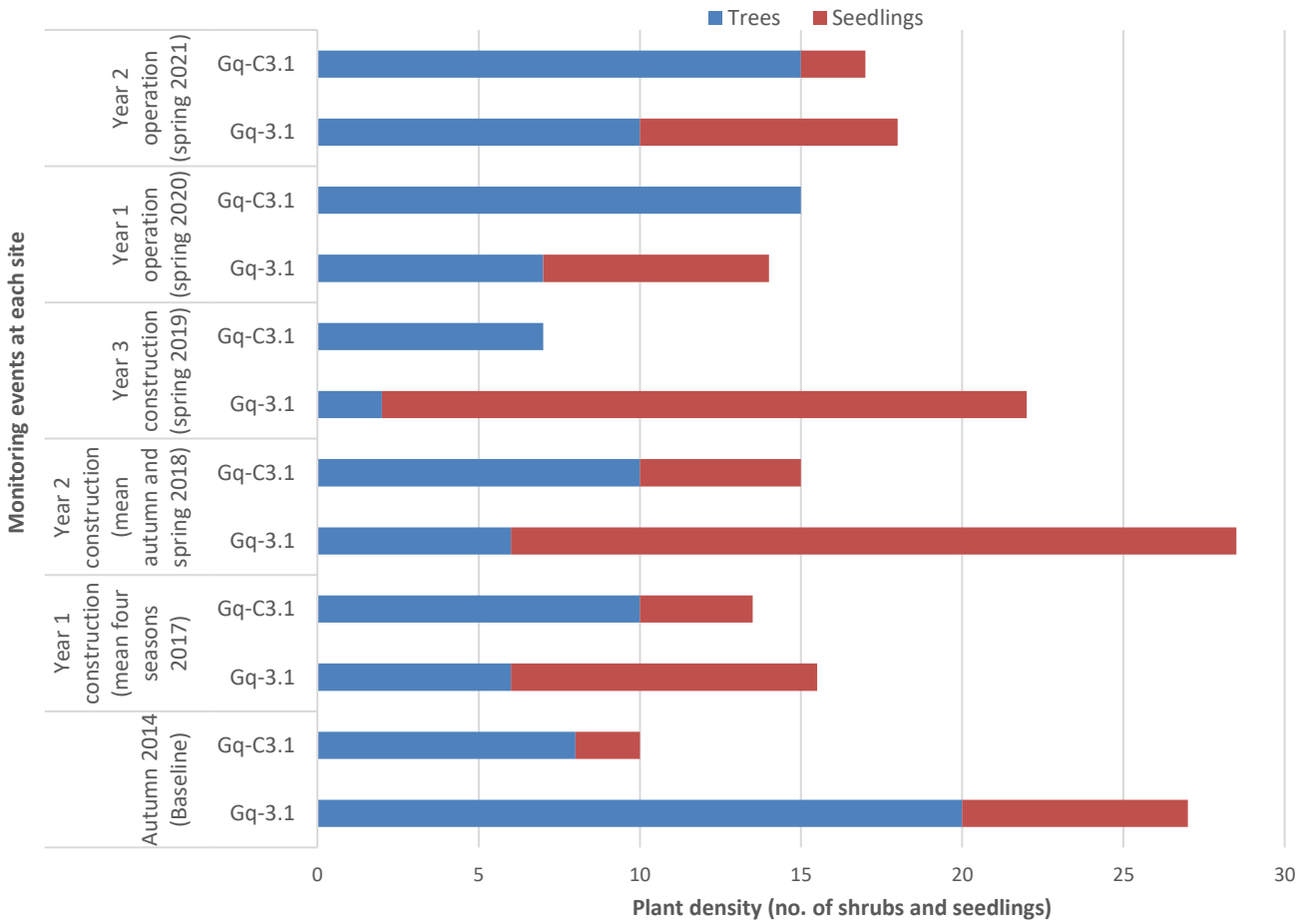

Figure 3-3 Number of *G. quadricauda* shrubs and seedlings observed over ten monitoring events (2014 [n=1], mean results for 2017 [n=4], mean results for 2018 [n=2], 2019 [n=1], 2020 [n=1] and 2021 [n=1] at in-situ and control site).

3.1.6 Slender Screw Fern (*Lindsaea incisa*)

Year 2 operational monitoring was conducted on 19 and 20 October 2021 for in-situ sites Li-3.1, Li-3.2, (chainage:55800-60200), Li-6.1, Li-6.2 and, control site Li-C6.1 (chainage:98600-99300).

In-situ site Li-3.1 has exhibited a large increase in area of occupancy over the plot during the last three monitoring events. In 2021 the area occupied was 33 m^2 compared with 0.5 m^2 in 2019 (drought year) and 19.3 m^2 in 2020. This site was directly impacted by the approved detailed design work prior to autumn 2018 survey with the construction of a man-made drainage line in the middle of the site, which resulted in some loss of ferns. The decrease in areas of occupancy to just 0.5 m^2 observed during 2019 surveys is possibly a result of a combination of this impact plus the drought conditions. Since this impact, there has been strong recovery of plants observed in the last two spring monitoring events in 2020 (construction) and 2021 (operation) and there are no further construction impacts occurring at the site. The plants in Li-3.1 were in good health and a range of ages and sizes of plants suggested reproduction and stages of maternity.

In-situ site Li-3.2 has also substantially increased across all sites in area of occupancy of *L. incisa* from 10 m^2 in 2019 (drought year), to 113 m^2 in 2020 and 190 m^2 in 2021. *L. incisa* ferns were in excellent health during Year 2 operation.

Mororo State Forest had experienced a very hot fire in November 2019 which was also a drought year, subsequently no plants were observed at monitoring locations Li-6.1 and Li-6.2 within the State Forest in Section 6 during the 2020 survey and again in 2021 despite good post-fire recovery here. Prior to this no plants were recorded in 2019 prior to the fire, during a drought phase and the environmental conditions at these sites are thought to have led to the decline rather than clearing for the project. Indeed, these observations are expected to be a result of lower-than-average rainfall and infrequent rainfall events in the region across 2018-2019, including the hot fire in late 2019. This species is likely to be sensitive to the very low rainfall trends and these observations are unlikely to be a project-related impact. The understorey was very dense in 2021 which offered very little opportunity for plants to establish at Li-6.1. Furthermore, Li-6.2 was still recovering from the 2019 fire and was experiencing low light on the forest floor.

In contrast however, plants at the control plot to the south (Li-C6.1) had recovered following the fire. No plants were recorded at the plot in 2018 and 2019, although an area of 30 m^2 of the plot contained young plants that were recorded in November 2020, 12 months after fire. It is unsure why plants have re-appeared at the control plot compared with the two nearby impact plots, this is probably a result of dense post-fire recovery of competing shrubs. During the 2021 monitoring event, Li-C6.1 demonstrated a decline in plant density with a result of 0.01 (mean cover % / m^2) in comparison to 1.08 (mean cover % / m^2) recorded in 2020.

Summary of mean percent cover for all *L. incisa* sites is presented in **Figure 3-4**.

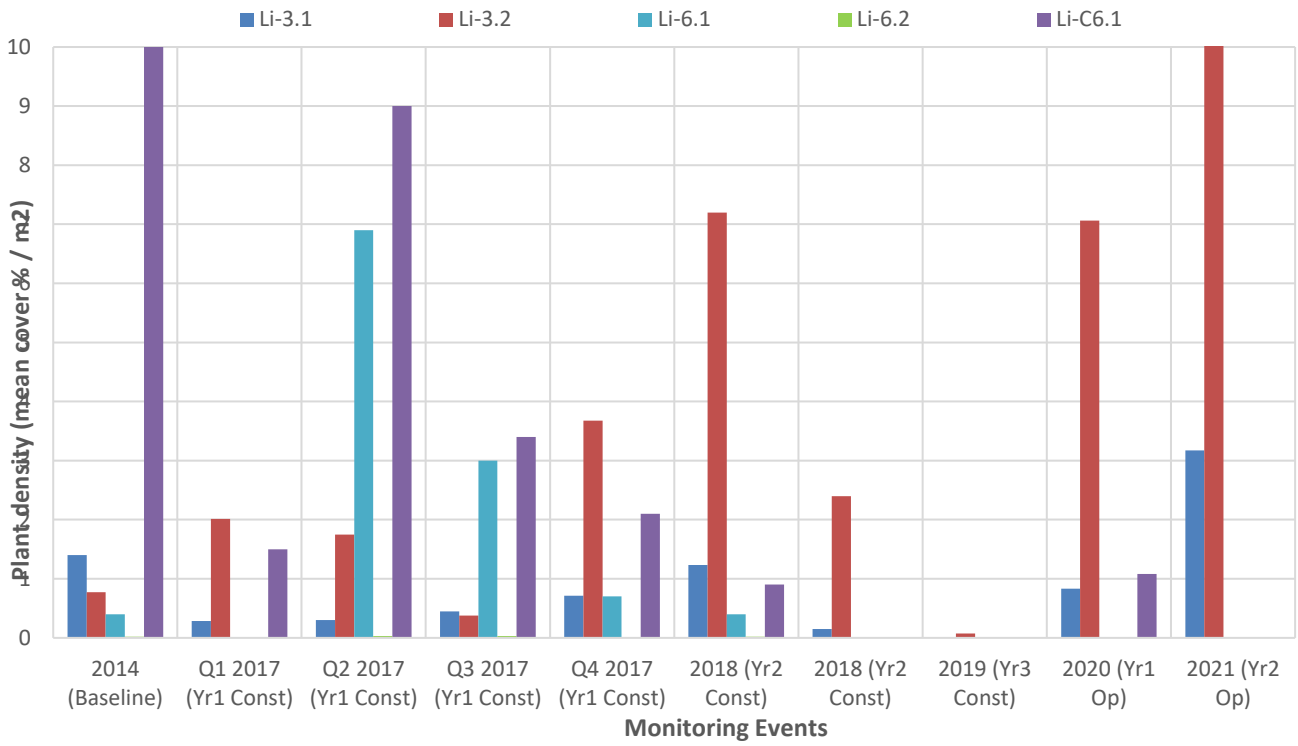

Figure 3-4 Density (mean no. of stems / m^2) of *Lindsaea incisa* observed over ten monitoring events at four in-situ sites and one control site.

3.1.7 Rough-shelled Bush Nut (*Macadamia tetraphylla*)

There has been no notable change in health of the single *Macadamia tetraphylla* tree or change in weed cover over the first two years of operational monitoring (2020/21) at Site Mac-8.1 (chainage: 134700). As per monitoring in 2019 and 2020, the tree was not flowering or fruiting at the time of the survey and there was no evidence of old fruit around base of tree. Weed cover remains high with 70% mean cover in the plot and a total of 13 weed species remain, the most abundant of which include *Senecio madagascariensis*, *Cenchrus clandestinus*, *Bromus catharticus*, *Cirsium vulgare* and *Bidens pilosa*.

3.1.8 *Maundia triglochinoides*

Monitoring was conducted on 18 and 19 October 2021 for in-situ sites Mt-3.1, Mt-3.2 and control site Mt-C3.1, and on 21 October 2021 for in-situ sites Mt-7.1, Mt-7.2 and Mt-7.3.

Changes in mean cover and area of occupancy of *M. triglochinoides* occurred at all impact and control sites compared with the first year of operation (2020), and these annual fluctuations are likely associated with changing hydroperiods of ponds and creeks where the species is found. Additionally, above average annual rainfall conditions were experienced in 2021 mostly in February and March and in some months preceding the survey. For species such as Maundia, these rapid high rainfall events may dislodge plants and account for changes in areas of occupancy at monitoring sites. The depth of water will change the micro-habitat conditions for the species, which prefers shallow ponded environments and edges of pools and dams.

For example, no plants were found at the control site Mt-C3.1 during 2020 surveys. Control site Mt-C3.1 had a large decrease in cover of *M. triglochinoides* from 150 m^2 area of occupancy in 2018 to 0.5 m^2 in 2019 and plants appeared absent in 2020. The species was observed around 50 metres from the plot persisting in a ponded section of the creek. As above-ground plant parts of have dieback, presumably *M. triglochinoides* continue to exist only as tubers in the soil until sufficient water returns. Plants were again present at site Mt-C3.1 in the 2021 survey with three new individuals identified in the plot and a mean percentage cover of 0.22. Plants

were found to be flowering in deep sections of the plot and the site has recovered from the drought period in 2018/19 period. Overall plants were in good health ranging from 25-30 cm in height.

Seven plants were observed at in-situ site Mt-3.1 during the 2021 monitoring event which has increased by 3 plants since 2020. However, the mean percentage cover has slightly decreased in 2021 to 0.25 from 0.27 in 2020. It was also noted that the Coldstream River was in good condition with abundant macrophytes occurring during the 2021 survey.

In contrast, plants at the in-situ site Mt-3.2 exhibited the highest decrease across all sites in mean percent cover from covering 1.38 in 2020 to 0.40 in 2021. During the 2020 surveys, the soil moisture at Mt-3.2 was recorded as dry and the waterway as stagnant, whereas during the 2021 surveys the soil moisture at Mt-3.2 was recorded as moist with the waterway experiencing recent flow, this may have dislodged some plants from deeper sections of the stream.

The cover of *M. triglochinoides* at the in-situ site Mt-7.1 decreased from 12 % to 4.5 % percent cover from 2019 to 2020 (associated with drought and fire period), however has increased up to 38 % of the plot by 2021 due to pond filling and large increase in area of available habitat, good post-fire recovery. This is related to a large hot fire which passed through the habitat in November 2019 and plant abundance declined for next 12months. There was evidence of plants at the edge of the pond being burnt. Two years post fire, many new recruits were observed in 2021 with plants having expanded into the new shallow water showing good recovery. Around 10% of the plants present still display burnt tips indicating stress during drought and fire but have survived. No weeds were present in the pond, with *M. triglochinoides* dominating the plot along with the presence of *Philydrum lanuginosum* (refer **Photograph 3-7**).

The recovery of the *M. triglochinoides* population at in-situ site Mt-7.2 from inadvertent indirect impacts during Year 1 construction in 2017 is evident. The area of occupancy was 13 m^2 in 2018, and increased to 29 m^2 in 2019 and 2020, and has increased significantly in 2021 to 104 m^2 which reflects the increased rainfall and flushing of the stream (refer **Photograph 3-6**).

The mean percent cover of *M. triglochinoides* at in-situ site Mt-7.3 has changed temporally during the monitoring program. This site is directly within the corridor. The mean cover was at 80%in the baseline survey and remained similar at 86% during year 1 construction and 100 % in year 2. In year 3, works associated with bridge construction reduced the cover to 56% in 2019 and to 22% in 2020 with significant shading over the plots. In spring 2021 the site was showing evidence of good recovery, and plants have spread to the east and west of the bridge in areas not previously occupied, although absent below the bridge, which is expected. The cover is now at 50% (refer **Photograph 3-8**). These plants are located in the approved construction corridor.

Summary of mean percent cover for all *M. triglochinoides* sites is presented in **Figure 3-5**.

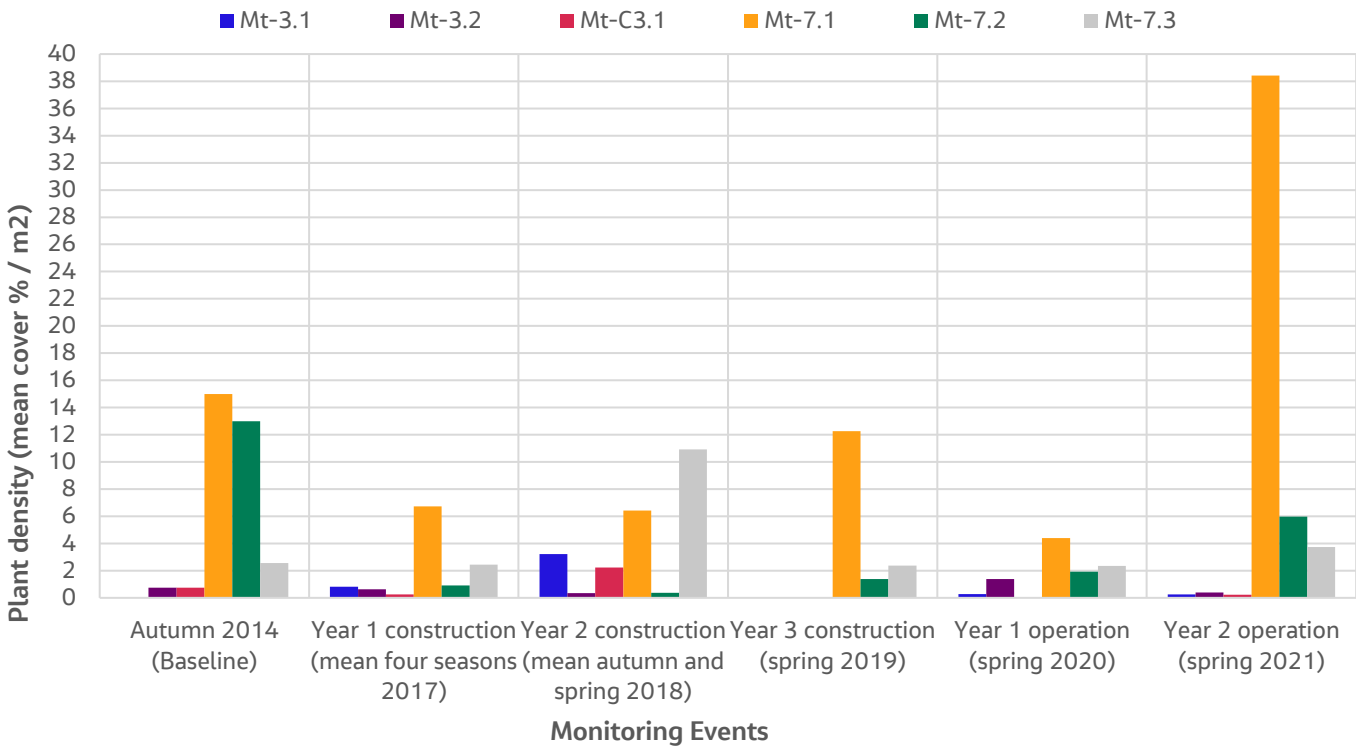

Figure 3-5 Density (mean cover % / m^2) of *Maundia triglochinoides* observed over ten monitoring events at five in-situ sites and one control site

Photograph 3-5: Pre-construction phase at in-situ site Mt-7.2 showing healthy population of M. triglochinoides (May 2014)

Photograph 3-6: Year 2 operational phase at in-situ site Mt-7.2 showing gradual recovery of M. triglochinoides core population (October 2021)

Photograph 3-7: Year 2 operational phase at in-situ site Mt-7.1 showing good recover following hot fire in November 2019 which burnt through Tabbimoble State Forest.

Photograph 3-8: Year 2 operational phase at in-situ site Mt-7.3 showing population adjacent to bridge in background

3.1.9 Swamp Tea-tree (*Melaleuca irbyana*)

The *Melaleuca irbyana* monitoring plots were surveyed on 20 and 21 October 2021. As reported in 2020 both impact and control plots had been severely burned from a large wildfire in November 2019. Very few trees were actually killed from the fire and the species continues to show good post-fire recovery evident by basal resprouting, coppice shoots and new germination of plants that had spread seed post-fire, demonstrating the species resilience to fire.

The abundance of *M. irbyana* at in-situ site Mi-7.1 (chainage: 120800) during the 2021 surveys confirmed 39 trees of which 27 were mature and 12 were resprouting in the easement. This site was observed as still recovering from fire with signs of dead trunks on older trees and new shoots sprouting from the base and burnt trunks (refer **Photograph 3-9**). Likewise, young trees in the easement were showing signs of regrowth from roots which had been previously slashed.

Similarly, the abundance of *M. irbyana* at in-situ site Mi-7.2 (chainage: 120900) during the 2021 surveys confirmed 33 trees of which 10 were mature and still recovering from fire, and 23 were immature located on the gas easement where these were previously slashed and have resprouted. These trees have increased in height now being up to 1 m taller in comparison to 2021. No signs of recruitment from seed were noted, however regeneration from fire is occurring (refer **Photograph 3-10**).

The abundance of *M. irbyana* at the control site Mi-C7.1 in 2021 confirmed 45 juveniles which could be seedlings, all being less than 10 cm in height. This species is known to have the ability to form root suckers and through root extension and interconnectivity form dense clumps of single clones. This is a common adaptive characteristic of wetland plants subject to very difficult conditions for survival, growth and sexual recruitment in which it was difficult to differentiate whether this species had seeded or sprouted from roots.

Photograph 3-9: Melaleuca irbyana in year 2 operational phase survey (October 2021) at in-situ site Mi-7.1 New growth after fire.

Photograph 3-10: Good post-fire recruitment of M. irbyana was noted in 2020 and 2021 impact and control plots demonstrating the species resilience to fire.

3.1.10 King of Fairies (*Oberonia titania*)

Both in-situ site Ot-10.1 and control site Ot-C10.1 (chainage:152300) were surveyed on 21 October 2021. As described in previous reports the in-situ site (Ot-10.1) occurs on the edge of the forest clearing adjacent to the highway. The plot is in an area close to the edge of the cleared project corridor (within 20 metres) and there is increased light and solar exposure, and conditions are drier than the internal forest where the control plot is located (Ot- C10.1).

The 2021 survey recorded the following observations within the in-situ site Ot-10.1:

- At Ot1 plants at 2 m have 1 small shoot, still alive, were growing on a Bangalow Palm. Individual plants that were noted in low condition in the November 2020 surveyed, were not able to be located in 2021 and likely had died. A plant approximately 15 m from forest edge has a new shoot and is in poor condition due to dieback, furthermore a lot of light was penetrating the host tree and no shade was evident from edge. Another plant observed in good condition is growing at 5 m height and is north facing alive with brown leaves and no presence of flowering.
- At Ot2 two clumps were present at 5 m above ground on the underside of trunk observed in excellent condition. An additional two clumps were present higher at 10 m above ground with brown leaves top side of trunk exposed and observed in good condition. Additionally, one clump was present at 7 m next to a stag. The underside of trunk displayed an old flower spike observed in good condition.

The 2021 survey recorded the following observations within the control site Ot-C10.1:

- At Ot1 four main clumps of numerous plants at 5 m above ground on a straight upright branch were observed and in excellent condition.
- At Ot2 two clumps of numerous plants at 7 m above ground were observed and in excellent condition.
- At Ot3 two clumps and two plants were observed and were in excellent condition.

There have been slight variations in *O. titania* plant numbers and plant condition status at the impact site. While it is difficult to quantify there appear around 7-10 less individuals than previous construction and operation surveys and some of the remaining plants appear in poor condition due to desiccation, with some plant leaves browning and others having dead plant material (refer **Photograph 3-11**). This impact may be related to the below average rainfall in proceeding months to the 2021 survey, however plants at the control site are located >100 m further east away from the forest edge and are in healthy condition, where no desiccation was noted, and this suggests that the edge effect along forest clearing has indirectly contributed to the noted impacts. Plants at the control site were in very healthy condition, and some were found with sprouting flower spike and setting seed.

Photograph 3-11: Oberonia titania on edge of forest clearing at in-situ site Ot-10.1 (facing west) showing desiccation, likely from greater exposure to increased sunlight ad dry conditions. Remaining shoot shown in circle. There as been no net loss at this stage

Photograph 3-12: Oberonia titania new plant located on same tree 5m from ground facing north away from forest edge is healthy

3.1.11 Tall Knotweed (*Persicaria elatior*)

Data was collected for *Persicaria elatior* on 20 October 2021 for in-situ sites Pe-4.1, Pe-4.2a and Pe-5.1, and control site Pe-C4.1.

P. elatior was not recorded at any of the impact and control sites during the October 2021 (Year 2 operational monitoring). And this is consistent with the absence of plants in November 2020 (Year 1 operational monitoring). The abundance of plants at all sites has been in a general trend of decline over the monitoring program and the drought conditions in 2018/19 had indirectly impacted species presence and abundance over this time, as well as grazing impacts at some sites. The highest number of plants recorded at each site was during baseline surveys. Further to this, all sites exhibited an increase in exotic species cover. The favourable wetter conditions in 2020 and 2021 have not seen more plants in the monitoring plots, however it is likely that the species occurs in adjacent areas outside the plots.

These changes are most likely directly related to the lower-than-average annual rainfall that the region had experienced in four of the last six years, as opposed to above average annual rainfall in the four years prior to baseline surveys (refer **Figure 2-3**). Particularly low rainfall in Year 3 construction monitoring (Grafton Research Station received 31 percent of the historical annual average in 2019 – refer **Figure 2-3**) resulted in the eventual drying out of standing water at all four monitoring sites. From the 2021 surveys, the in-situ sites Pe-4.1 was noted as having damp soil moisture and Pe-5.1 had 10 cm of surface water. In contrast, the soil moisture at the in-situ Pe-4.2a was recorded as dry.

These declines are considered not project related. Monitoring for the 2021 W2B Translocation Report (Benwell 2022) in Yaegl NR, near the in-situ plots has identified that the species is a fast growing annual, and not a perennial. If high waters recede during drought and there is no damp soil, then germination does not occur. This

is evident at the monitoring plots, where standing water was absent through 2019 and the soil dry, and the plants have not returned to these plots. Refer to **Figure 3-6** for a summary of results.

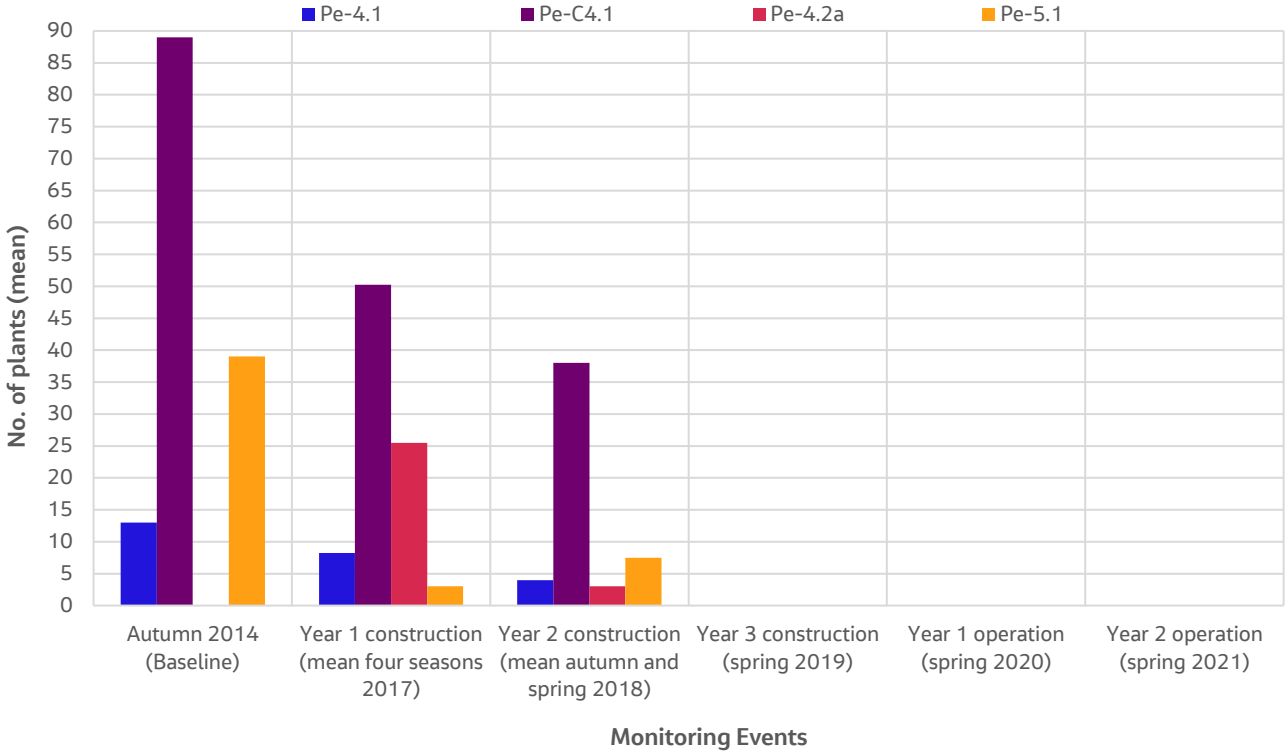

Figure 3-6 Mean number of *Persicaria elatior* plants over ten monitoring events (baseline and construction) at three in-situ sites and one control site. No baseline data exists for site Pe-4.2a as it was added in 2017.

3.1.12 Singleton Mintbush (*Prostanthera cineolifera*)

Both the in-situ (Pc-6.1) and control (Pc-C6.1a) (chainage: 101700) were surveyed on 21 October 2021. These sites were impacted by fire in November 2019. There has been very good recruitment of new plants evident across both plots in the spring 2021 monitoring. The number of established plants recorded in 2021 was at 141 individuals and includes 29 small seedlings (<20cm) spread across the whole plot at Site Pc-6.1. This has dramatically increased in comparison to the 2020 count of only 21 individuals recorded in total. The in-situ site demonstrated a healthy population of plants in a state of peak growth in 2021.

Similarly, the control site Pc-C6.1a exhibited an increase in plant numbers recorded at 23 plants and 4 juveniles in comparison to 14 plants recorded in 2020. Plants have also increased in height ranging from 10cm to 50cm in 2020 to now 10 cm to 2.1 m in 2021. The control site represented healthy plants in vigorous growth with the largest plants just finishing flowering and now going into seed.

Photograph 3-13. Prostanthera cineolifera impact site in 2021 showing recovery after fire

Photograph 3-13 new Prostanthera cineolifera individual sprouted after the 2019 fire

3.1.13 *Rotala tripartita*

Both *Rotala tripartita* in-situ sites Rt-6.1 and Rt-6.2 were surveyed on 21 October 2021. No plants were recorded at either site. The drainage line at in-situ site Rt-6.2 was much wetter in 2021 as opposed to 2020 and conditions appeared right as a short-lived annual may have disappeared during drought years and not returned. This species is an annual or short-lived perennial. Plants have not been recorded since April 2018, when the last of the small population were observed at Rt-6.2. It is understood that individuals of this population were removed in 2017 as part of the project translocation program (Benwell 2019). This population likely exists most of the time in the soil seedbank, only growing plant parts during periods of suitable rainfall. In contrast, the climatic conditions in 2021 at in-situ site Rt-6.1 were very damp and the water levels were >15 cm deep in the creek and suitable for the species, but no individuals were found. Though, much of the habitat has been colonised by the invasive exotic grass Setaria and only deeper water sections remain that are dominated by dense rushes (*Typha* spp) and sedges (*Carex* spp). There has been no evidence of inadvertent construction-related impacts at these sites.

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

4.1 Amendments to the program and assessing impacts

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 to 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.

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, which 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 Transport for NSW to establish new control sites to allow for additional data to be collected where sites were on private land with access restrictions.

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

Appendix B presents the final threatened flora impact for the project, 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 M-Class 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.

As noted in **Section 2.3.2**, the baseline methods for determining the abundance of threatened groundcover species were coarse and a percentage of mean cover over an area of occupancy for each relevant species was subsequently 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.

4.2 Discussion of observed impacts and threats to threatened flora

The final operational monitoring in Section 1-2 was complete in spring 2020. Monitoring for the second year of highway operation in Sections 3-10 occurred in spring 2021 and comprised a total of 49 sites (38 impact and 11 control sites)

No major changes or notable impacts were observed from the 2021 operational monitoring in Sections 3-10 and most sites experienced minor fluctuations and relatively stable results compared to previous years. For example, aquatic species reliant on persistent surface water such as *Maundia triglochinoides*, *Cyperus aquatilis* and *Rotala tripartita*, remained absent at some sites where water had completely dried up in 2018/19 and plants have not returned despite favourable wetter conditions. Similarly, the below average rainfall and sporadic rainfall occurrences during some months preceding the 2021 survey had resulted in an absence of *Persicaria elatior* (Sections 4-5) from the 2021 monitoring, these species typically occur in swampy sites, moist and riparian areas, and plants were absent from both impact and control sites. These changes are considered natural variation and in response to climatic conditions and not a result of construction or operational activities. In particular these annual or short-lived perennial species are impacted by drought conditions, and may not return to the monitoring plots, although are likely to occur in adjacent areas.

As noted from previous monitoring general plant dieback continues to be evident (since Year 1 construction monitoring) at sites Ar-3.4 and Ar-3.7 and may be associated with the drought and heat stress and / or caused by the epidemic infection of the root-rot fungus Cinnamon Fungus (*Phytophthora cinnamomi*), but this would need to be confirmed. This dieback pre-dates the highway construction. Around 50% of the trees in these two plots have new shoots and showing recovery in 2021. Evidence of controlled groundcover fire was noted (occurring around 2 months prior to the monitoring) at sites Ar-3.3 and Ar-3.4, this is associated with landholders and is not project related. These fires caused minor impacts to 3 small trees at Ar-3.3 and 1 small tree at Ar-3.4, each of which were resprouting during the 2021 monitoring event. In addition to this, trees at sites Ar-3.1 and Ar-3.8 appear to have had been impacted by storm damage and all trees have bare branches consistent with form of tree growth for this species at all sites.

Competition with other native and exotic plants continues to be a threat to *Arthraxon hispidus* and the wetter conditions in 2021 has caused increase in cover of some weeds. This is primarily by exotic species, but also includes the native rice grass (*Leersia hexandra*) forming dense groundcover. *A.hispidus* appears to prefer small clearings and disturbed sites that have been slashed or grazed and this is a consequence of strong competition with native and exotic grasses and weeds which share this favoured moist low-lying habitat. The species shows a dynamic habit of re-appearing in clearings and disturbed areas and is likely a life-cycle strategy due to competition. The continued presence at impact sites and disturbed roadside areas indicates there are no project related impacts occurring.

Cyperus aquatilis individuals continue to be absent from the monitoring plot in 2021 and this is consistent with previous years. This species is best detected during summer and autumn where climatic conditions are most suitable. Rainfall in the region has occurred in 2021 prior to monitoring, however the species had not reappeared following the 2018/19 drought years. This natural variation is not expected to be due to the project construction.

Changes in the abundance of Lindsaea incisa were noted only in the Mororo State Forest plots in Section 6, while impacts plots in Section 3 showed increases in area of occupancy in 2020 and 2021 compared with the drought years (2018/19). Mororo State Forest had experienced a very hot fire in November 2019 and in 2021 dense understorey and midstorey of native plants was observed in a state of recovery which offered very limited opportunity for Lindsaea incisa to establish, although new individuals were noted. In contrast however, plants at the control plot to the south (Li-C6.1) had recovered well following the fire. This natural variation is also considered to be a result of post-fire competition and not due to project construction or edge effects.

There have been slight variations in *O. titania* plant numbers and plant condition status at the impact site. While it is difficult to quantify there remains around 7-8 less individuals than previous construction and operation surveys and some of the remaining plants appear in poor condition due to desiccation. This impact is expected to be due to edge effects, however several plants have survived, and at least one new recruit was noted in 2021, indicating survival adjacent to the highway.

Rotala tripartita was not recorded at both in-situ sites Rt-6.1 and Rt-6.2 in 2021. The drainage line at in-situ site Rt-6.2 was much wetter in 2021 as opposed to 2020 and conditions appeared right as a short-lived annual may have disappeared during drought years and not returned. There has been no evidence of inadvertent construction-related impacts at these sites.

4.3 Measuring performance criteria

The TFMP provides indicative thresholds for measuring the performance of mitigation measures applied during the project construction. It is noted that some of the performance goals do not relate to the in-situ threatened flora species and monitoring program, such as plant translocation (examined in the translocation monitoring program) and dust monitoring. The relevant construction performance criteria and thresholds (refer to **Section 2.4**) that trigger corrective actions for this program is presented in **Table 4-1** 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 2021 monitoring period represents the second year of operational phase of the project (Year 2 for **Sections 3-11**). The relevant goals for mitigating impacts from operation of the project are addressed by the monitoring program as outlined in **Section 2.4**, include:

- Zero mortality of retained in-situ threatened plant populations during construction and for three consecutive monitoring periods post-construction.
- Post the above period 80 per cent survival of tree, shrub, and herbaceous perennials after three years
- Less than five per cent weed cover at retained in-situ threatened flora sites (end of monitoring program).

4.4 Effectiveness of mitigation measures implemented during construction

4.4.1 Method of mitigation and discussion of impacts

Where mitigation measures have been applied during construction, the effectiveness of these were previously 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.
- Monitor in-situ plants at established monitoring sites during construction.
- 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.

Examples of impacts observed during construction within and outside the project boundary are described below, with reference to whether these are project-related and therefore an assessment of the effectiveness of the mitigation applied.

Table 4-1 Corrective actions applied during construction

Species	Impact and status	Corrective actions applied
Endiandra muelleri subsp. *bracteata*	As mentioned above, the single mature *Endiandra muelleri* subsp. *bracteata* shrub at site Emb-4.2 was inadvertently removed by a construction contractor in January 2019. This site was located within the approved clearing boundary; therefore, it is not an additional impact, however the plant was proposed to be retained for translocation. Pacific Complete have advised that the construction contractor (BGC Contracting) has developed and is implementing the Green-leaved Rose Walnut Rehabilitation Plan – W2B Section 4 Major Civil Works (Geolink 2019) to address corrective actions. The Rehabilitation Plan includes collaboration with local expert Dr Andrew Benwell (ECOS Environmental Pty Ltd) and contains four specific actions:	i. Targeted Green-leaved Rose Walnut Surveys - Identify additional occurrences of Green-leaved Rose Walnut in the Maclean area. ii. Collect and Propagate Seeds/ Cuttings - Collect and propagate at least 20 Green-leaved Rose Walnut seeds/ cuttings sourced from trees in the Maclean area or W2B Section 10. iii. Vegetation Regeneration and Green-leaved Rose Walnut Plantings (Management Zone 1) - Plant at least 10 propagated Green-leaved Rose Walnut trees as part of a vegetation regeneration area (Management Zone 1). iv. Vegetation Regeneration (Management Zone 2) - Manage weeds within Management Zone 2 around the retained in-situ Green-leaved Rose Walnut at approximate chainage 81700.
	Major increases in the abundance and number of weed species was noted in 2018 at sites Emb-4.1 and Emb-4.2 within the project boundary. Although sites had existing weeds, long-term monitoring results and site observation of construction works indicated notable weed problems exacerbated by the project.	Weed management actions were undertaken at site Emb-4.1 on 11 April 2019, with all actions completed. Ongoing weed maintenance is to continue as per BGC contract requirement. Surveys in spring 2019 confirmed that weed management actions had been effective in removing the weeds impacting this site.

Species	Impact and status	Corrective actions applied
Angophora robur	Suspected root-rot fungus at site Ar-3.7. Surveys in 2019 saw continued mortality of native plants *Xanthorrhoea* sp. and *B. oblongifolia*.	Pacific Complete engaged a consultant in 2018 to undertake sampling for *Phytophthora cinnamomi* along the entire project alignment, which found the fungus to be widespread. Management specification since the commencement of the project has included requirements for construction equipment wash downs before entering the project area. It is difficult to confirm if construction activities have contributed to the spread and prevalence of *Phytophthora cinnamomi*.
Maundia triglochinoides	Population of *Maundia triglochinoides* monitored at in-situ sites Mt-7.2 and Mt-7.3 was inadvertently impacted by the sediment run-off from the March 2017 storm event.	Not required. Continued monitoring in 2018-2020 has showed that the populations are slowly recovering from this flood event.

4.5 Thresholds triggering corrective actions during operation

The examples above describe where suitable corrective actions were applied to identified impacts during construction and identifies recovery or affected plants in-situ. All stages of the project are now in full operation, and the 2021 spring monitoring was the second event covering operation of **Sections 3-10**.

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 4-2**. **Table 4-2** summarises the results of the 2021 operational monitoring species and assesses any impacts against the triggers for corrective actions.

Table 4-2 Corrective actions relating to triggered performance thresholds during operation phase

Threshold triggers	Corrective actions
▪ Any loss of retained in-situ threatened plants for the first three consecutive monitoring periods post-construction.	▪ Commence assessment of potential reasons for mortality, including seasonal fluctuations, natural events such as drought and fire within one month of trigger being identified. ▪ Review weed maintenance schedule within one month of tigger being implemented ▪ Identify potential threats, implement corrective actions, and modify monitoring s necessary ▪ Offset any additional threatened plant impacts that have occurred as a result of the project.
▪ Weed cover increases by 10% from the baseline cover in areas surrounding in-situ populations ▪ More than 30% weed coverage in revegetation areas	▪ Review weed maintenance program within one month of trigger being identified and update as required.

Table 4-3 Assessment of thresholds triggering corrective actions for threatened flora during operational monitoring

Species	Thresholds (triggers for corrective actions)		Impacts within approved project boundary	Requires corrective actions (inadvertent construction impact
	Any loss of retained in-situ threatened plant populations for three consecutive monitoring periods post-construction	Less than five per cent weed cover at retained in-situ threatened flora sites (end of monitoring program)		
Year 2 operation (Section 3-11)				
Angophora robur	No loss of tree in second phase of operational monitoring. All impact and control sites have been either stable or increased plant numbers. No decline in health or abundance noted.	2021 is second year of monitoring. Weed cover varies, and there is a moderate proportion of Lantana and exotic grasses at some sites, that is consistent with the baseline.	No	**No**
Arthraxon hispidus	No apparent loss of plants in second phase of operational monitoring. All impact and control sites have been either stable or increased plant numbers. No decline in health or abundance noted.	Presence and abundance of weeds varies each year, although has always been above 5% during pre-construction and construction. There has been a reduction in cover from 2019 for some impact sites and increase for others. This is consistent with the control sites. Importantly there has been no declines in plant numbers.	No	**No**
Cyperus aquatilis	N/A – no individuals identified, and absent from site from pre-construction period.	2021 is second year of monitoring. Weed cover is currently low and consistent with baseline at this site.	No	**No**
Endiandra muelleri subsp. *bracteata*	There were no losses during Year 2 operation. Insect browsing has diminished in 2021 and overall plant health remains in good health with signs of improvement in the last 12 months.	2021 is second year of monitoring. Weed cover is currently low and reflects the weed control that was done in 2019.	No	**No**
Grevillea quadricauda	No apparent loss of plants in second phase of operational monitoring. Both the impact and control sites have increased plant numbers. No decline in health or abundance noted.	2021 is second year of monitoring. Weed cover is currently at around 10% but has decreased from 40% since initial construction phase, and this is not impacting plant health	No	**No**
Lindsaea incisa	Improved condition since drought years 2018/2019. No apparent loss of plants in second year of operational monitoring. All impact and control sites have been either stable or increased plant numbers. No decline in health or abundance noted.	2021 is second year of monitoring. Weed cover is currently low 5% and has been aided by bushfire in Mororo State Forest	No	**No**
Macadamia tetraphylla	No loss of tree in second year of operational monitoring. No decline in health or abundance noted.	2021 is second year of monitoring. Weed cover is consistent with baseline and reflects the grazed habitat the tree is located in.	No	**No**
Maundia triglochinoides	Declines noted in the drought years of 2018/2019 and all sites are now showing moderate recovery with increased rainfall and flushing of sediment.	2021 is second year of monitoring. Weed cover has declined from 2019 at all sites, and currently less than 5%.	No	**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 plant populations for three consecutive monitoring periods post-construction	Less than five per cent weed cover at retained in-situ threatened flora sites (end of monitoring program)		
Melaleuca irbyana	Some losses of mature plants due to a wildfire in November 2019, independent from highway operation. Good recovery through abundant germination and presence of new immature plants and new growth on mature trees. No long-term impacts	2021 is second year of monitoring. Weed cover is currently low post-fire, and lower than previous years.	No	**No**
Oberonia titania	The number of in-situ plants at the impact site and their condition in 2021 was similar to 2020, this remains at around 7-9 plants less than baseline, however there is evidence of recruitment. Desiccation / wilting of some remaining plants is still noted due to increased sunlight and edge effect. Plants at the control site were in very healthy condition, and some were found with sprouting flower spike and setting seed.	2021 is second year of monitoring. Weed cover is currently consistent with previous years, and no notable increase.	Impacts expected to be associated increased exposure to light along the cleared project edge. This was noted in 2020, and further monitoring is required.	**No, monitoring to continue**
Persicaria elatior	No further project related loss of plants in second phase of operational monitoring. All impact and control sites have showed decline or absence of plants related to changed hydrology and drought conditions. Plants have not returned to the monitoring plots, however this is not project related	2021 is second year of monitoring. Weed cover is currently low.	No	**No**
Prostanthera cineolifera	Some losses of mature plants occurred due to a wildfire in November 2019, independent from highway operation. There has been very good recovery evident from 2021 survey demonstrating significant increases in plant abundance and all in healthy condition.	2021 is second year of monitoring. Weed cover very low post-fire.	No	**No**
Rotala tripartita	No further project related loss of plants in second phase of operational monitoring. All impact and control sites have showed decline or absence of plants related to changed hydrology and drought conditions. Plants have not returned to the monitoring plots, however this is not project related	2021 is second year of monitoring. Weed cover low.	No	**No**

5. Correction actions and recommendations

5.1 Assessing mitigation performance

The current 2021 monitoring represents the second year of operational monitoring for in-situ threatened plants in Sections 3-10, and the third operational monitoring period is planned in spring 2022. There have been reported losses of plants that were also not located in 2020. These are associated with the drought conditions experienced during much of 2018/2019, and parts of 2020. The impact is largely associated with aquatic and semi-aquatic plant species where declines in surface water were also noted to occur and therefore habitat availability and condition was lower. While plants have not returned to the monitoring plots, the losses at this stage are not deemed to be project related.

The *Oberonia titania* site is a difficult one to monitor, as plants are small and some high in the canopy, making direct counts each year difficult to compare accurately. It is evident that slight variations in plant numbers and plant condition status have occurred in 2020 and 2021 compared to previous monitoring in 2018/19 and that plant health was lower for plants located within the in-situ site as opposed to the control site. This impact may be related to the increased sunlight and exposure on the cleared forest edge along the highway. Plants at the control site are located >100 m further east away from the forest edge and are in healthy condition, where no desiccation was noted, and this suggests that the edge effect along forest clearing has indirectly contributed to the noted impacts. There has been at least one new plant noted in 2021 which is sheltered from exposure, and this is a positive outcome. Further monitoring is required in 2022.

5.2 Recommendations

Operational corrective actions follow the same actions if thresholds are triggered for any loss of plants or increases in weeds. No notable impacts to threatened flora and/or sites have been reported in **Sections 3-10**, therefore no corrective actions are required for these sites.

As stated above, the operational monitoring in Sections 3-10 has identified plant mortality at only one site, associated with *Oberonia titania* at the in-situ population, compared with control population. This is inconsistent with the goals of the TFMP, which aim to achieve zero mortality and therefore has triggered the need for corrective actions. The current TFMP sets out prescribed corrective actions for all threatened flora species that have in part been addressed in this report by the assessment of site observations and reasons for impact. 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.

As this is the second year of operational monitoring in Sections 3-10 further monitoring in 2022 will be important to see if plants have recovered, particularly as more favourable wetter conditions prevail and vegetation along the edge would have increased in density. There are no recommendations at this stage, other than compare results for 2022 and assess at the end of Year 3. If further declines continue, this will be an opportunity to consider mitigation. The percentage of weeds at the site has not changed, and further weed control is not expected to mitigate the edge effect and is not recommended.

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Appendix A. Threatened Flora Monitoring Sites (Figures)

Appendix B. Differences in EIS vs Current Clearing Boundary for Threatened Flora (Year 2 reset)