



ML1124/ML7064 Glass Sand Mine Rehabilitation Monitoring 2022

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Glossary of Terms

Acronym	Description
cm	Centimetres
EA	Environmental Approval
EMP	Environmental Management Plan
km	Kilometres
m	Metres
ML	Mining Lease
SIS	Sorenson's Index of Similarity
sp.	Species (singular)
spp.	Species (plural)
sub sp.	Sub species

1 Introduction

The Sibelco Silica Sand Mine Glass Mining Leases (ML) 1124 and 7064 is situated approximately 4 km north-east of the township of Dunwich on North Stradbroke Island, Southeast Queensland. Both leases have been mined and rehabilitated progressively since 1975. Between 2018 and 2021, Sibelco has undertaken rehabilitation in the remaining disturbed areas to progress towards relinquishment in the coming years. To achieve this, the rehabilitation must meet condition F2-1(a) of the Environmental Authority (EA) EPML00349813. This is evaluated using monitoring methods detailed in Section 5.2 of *Rehabilitation of Disturbed Areas at ML1124, ML1132 and ML7064 North Stradbroke Island* (UNIMIN, 2009), hereafter referred to as the Glass Environmental Management Plan (EMP).

To meet the requirements stipulated above, Ausecology Pty Ltd ("Ausecology") was engaged by Sibelco to conduct monitoring at reference sites, and rehabilitation monitoring sites. The primary objective of this monitoring is to assess the progress and quality of the rehabilitation when compared to remnant vegetation at reference sites. Ausecology conducted the scheduled monitoring between 15th and 16th July 2022.

This report details a summary of the methodology used to conduct these activities and presents results for each rehabilitation area when compared to the requirements under the EA.

2 Methodology

This section details the revegetation completion criteria, the survey sites, data collection and analysis, and limitations of the work.

2.1 Revegetation completion criteria

The Glass EMP specifies conditions that must be reached in the establishment of rehabilitated flora. For rehabilitated areas, two categories of criteria are to be met (as presented in Table 2-1), including:

- Species type and diversity
- Species percent comparison

Table 2-1 Revegetation completion criteria reproduced from the Glass

Rehabilitation Parameter	Rehabilitation Objectives	Possible Indicators	Nature of completion criteria	Description
Sustainable Land Use	Establish specified self-sustaining natural vegetation or habitat	Species type and diversity	The index of similarity has increased for 3 consecutive years after the value has reached 50%	A site is deemed compliant if, when compared to a reference site, it has recorded increasing Sorenson's Index of Similarity (SIS) values over 0.5 (50%) for four consecutive years (i.e., the first monitoring event where 0.5 is met, then 3 consecutive years after this year).
Sustainable Land Use	Establish specified self-sustaining natural vegetation or habitat	Species percent comparison	Species comprising more than 15% of the reference areas, the difference in percentage between reference and rehabilitation areas is within $\pm 20\%$.	The 20% difference refers to the percentage abundance of the species. For example, for a species comprising 20% of the reference area, this species must be present at a proportion between 16% and 20% of the rehabilitated area.

2.2 Methodology

2.2.1 Survey sites

A total of six rehabilitation sites were monitored including previously monitored sites G1, G2, and G3 and newly established monitoring sites in 2022 at G4, G5, and G6. Table 2-2 provides a summary of the rehabilitation sites and the monitoring history for each. All rehabilitation plots were in areas mapped as RE 12.2.10 on the Qld Regulated Vegetation Management preclearance mapping. Areas of RE 12.2.10 were dominated by *Eucalyptus planchoniana*, the key diagnostic canopy species for RE 12.2.10. Three reference sites of RE 12.2.10 were also monitored in 2022 and were compared against the monitoring results of Glass rehabilitation sites. Due to variation within regional ecosystem types, it is more appropriate to compare a rehabilitation site to a suite of reference sites to evaluate the success of the rehabilitation (Gravina et al., 2011). Therefore, rather than averaging reference site data, each rehabilitation site was compared to each reference site independently.

Table 2-2 Summary of rehabilitation sites and monitoring history

Site	Rehabilitation Establishment Year	Year(s) Monitored			
		2019	2020	2021	2022
G1	2018	✓	✓	✓	✓
G2	2019		✓	✓	✓
G3	2020			✓	✓
G4	2021				✓
G5	2021				✓
G6	2021				✓

2.2.2 Survey methodology

At each monitoring site a 50 m tape was laid out (Figure 2-1). Within a 50 m by 2 m area (1 m either side of the tape) a stem count for each species was recorded. It should be noted, some species are extremely difficult to determine how many individuals are present due to being multi-stemmed or rhizomatous with subterranean stem junctions. Therefore, for species of the sedge and rush families (Cyperaceae, Restionaceae, Hemerocallidaceae, Juncaceae), grass family (Poaceae), and the *Lomandra* (mat-rushes), *Cassytha* (dodder laurels), *Austromyrtus* (midyim) and *Xanthorrhoea* (grass-trees) genera, the foliage projective cover (FPC) of the individual species was recorded within the 50 m by 2 m area (1 m either side of the tape) instead of a stem count.

Additional flora species were noted within a 10 m by 50 m plot to contribute to the species list. A 10 m by 50 m plot is considered a standard plot type for measuring the species richness of a site where diversity is highest in the lower strata (Eyre et al., 2015; Neldner et al., 2020).

Start and end points of the 50 m transect was geolocated using a Trimble Geoplotter 7 for G1, G2, and G3. Newly established monitoring sites in 2022 (i.e. G4, G5, G6) were geolocated using a Bad Elf GNSS surveyor and were corrected to approximately 1 m accuracy. Photos were taken from the start and end points along the transect tape at each site. Each site was demarcated with a star picket at the start and end of the transect to allow for repeated surveys.

Quaternary assessments as per Neldner et al. (2020) were performed at each site, to justify the selection of reference sites and the comparison of rehabilitation sites to reference sites representing a certain RE.

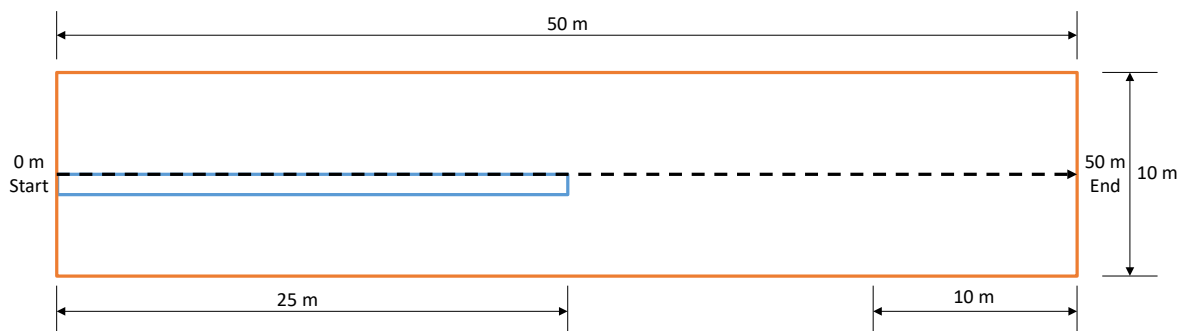


Figure 2-1 Monitoring plot layout

2.3 Analysis

Data analysis was performed as per Section 5.2 of the Glass EMP and included two components: (1) Index of Similarity, and (2) Species Percent Comparison.

2.3.1 Species composition

Sorenson's Index of Similarity (SIS) was employed to compare the species richness of rehabilitation sites to reference sites as measured in a 10 m by 50 m plot. It was calculated for each rehabilitation site in comparison to a corresponding reference site using the formula:

$$SIS = \frac{2c}{a + b}$$

Where:

a = species richness of the rehabilitation site

b = species richness of the reference site

c = number of species found at the rehabilitation site and the reference site

The result of this index is a value between 0 and 1, where 0 is completely different and 1 is identical.

2.3.2 Species abundance

To identify if certain flora species are too sparse or over abundant within rehabilitated areas compared to the reference sites, the percent contribution of dominant species (i.e. those that contribute over 15% of stems to a reference site) are compared with each corresponding rehabilitation site.

The species abundance methodology is stated in Section 5.2 of the Glass EMP, and although it compares the percent contribution of species dominant in the reference sites to their percent contribution in rehabilitation sites, it does not indicate which species are dominant in the rehabilitation. Therefore, the analysis was also performed in reverse by identifying species contributing more than 15% to the stem density of rehabilitation sites and comparing that to the percent contribution of those species to each of the reference sites.

3 Results

This section presents the results of the 2022 field survey followed by an analysis of the Index of Similarity and species percent contributions of rehabilitation when compared to reference sites.

3.1 Site descriptions

3.1.1 Rehabilitation sites

As of July 2022, there are six rehabilitation sites within the Glass Mine including G1, G2, G3, G4, G5, and G6. The species composition of all six sites is most similar to regional ecosystem (RE) 12.2.10 which is described by the Queensland Herbarium (2018) as: “Mallee *Eucalyptus planchoniana* +/- *Corymbia gummifera*, *E. racemosa* subsp. *racemosa*, *Banksia aemula* woodland on dunes and sand plans, especially southern sand mass islands. Usually deeply leached soils”.

Rehabilitation site G1 is located within an area rehabilitated in 2018 and was monitored for the fourth consecutive year (Appendix A; Figure 3-1). Tree species include *Eucalyptus planchoniana*, *E. racemosa*, *Corymbia gummifera* and *Banksia aemula* ranging from 1 m to 4 m in height. The shrub layers are sparse with *Ricinocarpos pinifolius* the most abundant tall shrub species whilst *Acacia ulicifolia* is the most abundant low shrub species. The ground layer is sparse and dominated by *Caustis recurvata*, *Eriachne pallescens* and *Eragrostis* spp. Non-native species include, *Megathyrsus maximus** and *Praxelis clematidea**. New growth of plants was observed, and flowering and fruiting was also evident within the G1 site (Figure 3-2).

The 2019 rehabilitation is represented by site G2 which was monitored for the third consecutive year (Figure 3-3). Tree density remains sparse and is dominated by *Eucalyptus planchoniana* and *Banksia aemula* with a maximum tree height of 2.6 m. The tall shrub layer is yet to form, however there is a moderate density of species which will develop a tall shrub layer in the future, these include *Leptospermum polygalifolium*, *L. trinervium* and *Ricinocarpos pinifolius*. The low shrub layer is dense with *Ochrosperma lineare*, *Acacia ulicifolia* and *Woolisia pungens* – the most abundant low shrub species. The ground layer is sparse and consists of native and exotic grasses and forbs with *Imperata cylindrica*, *Caustis recurvata*, *Praxelis clematidea** observed as the most abundant. Other non-native species include, *Andropogon virginicus** and *Paspalum urvillei**. Flowering and fruiting of tree species were also observed on this site (Figure 3-4).

Site G3 was rehabilitated to RE 12.2.10 in 2020 and was first monitored in 2021. The landform at G3 includes a flat bench top which slopes down towards the west into a valley before flattening out into an ephemeral water body (Figure 3-6). The survey area is located along the southern face of the valley running along contour at the lower half of the slope (Figure 3-5). The tree layer is sparse and low with a maximum height of 1.1 m. Dominant species including, *Eucalyptus planchoniana* and *Banksia aemula* with *Angophora leiocarpa*, *Corymbia gummifera* and *Eucalyptus racemosa* also present. Defined shrub layers are yet to separate, however tall shrub species include, *Leptospermum polygalifolium*, *L. semibaccatum* and *L. trinervium*, whereas *Acacia ulicifolia*, *Hibbertia linearis* and *Ochrosperma linearis* dominate the low shrub layer. The ground layer is dominated by bare ground however, a high native grass and forb species richness was observed, including, *Laxmannia gracilis*, *Pteridium esculentum*, *Cymbopogon refractus* and *Eriachne pallescens*. Regeneration of non-native species included, *Cynodon dactylon**, *Eleusine indica** and *Melinis repens**. The gully erosion feature caused by water draining towards the ephemeral water to the west of the 2020 rehabilitation area (as noted in the 2020 report) persists directly downslope of the G3 survey site.

Sites G4, G5, and G6 were rehabilitation to RE 12.2.10 in 2021 and were first monitored in 2022. The landform at G4 includes a gently undulating sand slope surrounded by remnant woodland. The landform at G5 and G6 are both located on flatter sand substrate. The tree layer at all new Glass rehabilitation sites is very sparse and low and includes *Corymbia gummifera*, *Allocasuarina littoralis*, *Eucalyptus planchoniana*, *Acacia concurrens*, and *Banksia aemula*. Defined shrub layers are yet to separate, however tall shrub species were absent except for

Acacia suaveolens where some scattered individuals were approximately 1.5 m in height. Most shrub species were very low with the most dominant in abundance/density of low shrubs included: *Ochrosperma lineare*, *Acacia ulicifolia*, *Hibbertia linearis*, *Laxmannia gracilis*, *Bossiaea heterophylla*, *Dillwynia retorta*, *Monotoca* sp. (Fraser Island P.Baxter 777). Flowering and fruiting of *Acacia ulicifolia* and *Acacia suaveolens* was observed at each of the newly established sites.



Figure 3-1 Stratification of G1 site rehabilitated in 2018



Figure 3-2 Example of dieback/stressed *Imperata cylindrica* grasses at G1 site



Figure 3-3 G2 site representing 2019 rehabilitation



Figure 3-4 *Banksia aemula* dieback at G2 site



Figure 3-5 G3 site representing 2020 rehabilitation



Figure 3-6 Increased cover of understorey species on the western slope of G3 site



Figure 3-7 G4 site representing 2020 rehabilitation



Figure 3-8 Looking towards the G5 site with a moderately dense cover of introduced non-native Megathyrsus maximus



Figure 3-9 G5 site showing a mix of native shrub and understorey species as well as scattered patches of Megathyrsus maximus



Figure 3-10 Looking towards the G6 site demonstrating current moderately dense cover of shrubs and understorey, with a few taller Acacia suaveolens shrubs

3.1.2 Reference sites

As the target RE for the rehabilitation was RE 12.2.10, three reference sites were monitored to cover the different canopy species composition and community structure of the RE 12.2.10 surrounding the rehabilitation (Table 3-1; Appendix A). No disturbance or substantial differences to the reference vegetation communities were observed in 2022 when compared to the previous monitoring event in 2021.

The reference site - P7, is a woodland co-dominated by *Eucalyptus planchoniana* and *E. racemosa* with scattered *Corymbia gummifera* to 14 m. REF2 reference site is considered more open than P7 and is dominated by a 10 m canopy of mallee *Eucalyptus planchoniana* and *Banksia aemula* with scattered *Eucalyptus racemosa* and *Corymbia gummifera*. REF1 reference site has a similar community structure to REF2 but is co-dominated by *Eucalyptus planchoniana* and *Corymbia gummifera* however, *Eucalyptus racemosa* is absent. A commonality between all reference sites is a low tree layer of *Banksia aemula* at varying densities.

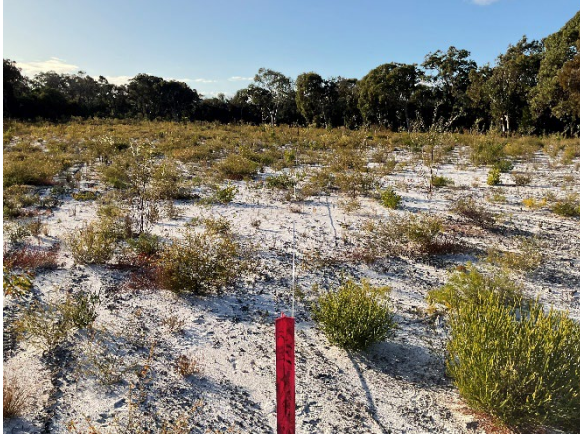
All three reference sites had a tall shrub layer, comprised of *Leptospermum trinervium*, *Ricinocarpos pinifolius* and *Monotoca* sp. (Fraser Island P.Baxter 777), which was mid-dense at P7 and REF1, but very sparse at REF2. *Xanthorrhoea johnsonii* can be considered a tall shrub in mature undisturbed form, however at all three sites was present in a trunkless form in the ground layer. At site P7, *Leptospermum polygalifolium* and *Baeckea frutescens* formed a tall shrub layer over the latter half of the transect.

Each reference site contained a diverse low shrub layer often dominated by the following shrub species: *Ochrosperma linearis*, *Homoranthus virgatus*, *Styphelia leptospermoides*, *Boronia rosmarinifolia*, *Acacia ulicifolia* and *Dillwynia retorta*. Common ground cover species included, *Caustis recurvata*, *Coleocarya gracilis* and *Platysace ericoides*.

Table 3-1 Description of rehabilitation and reference sites sampled during the 2022 monitoring event

Site	Description	Transect Start	Transect End
Rehabilitation Sites			
G1	Tree layer beginning to form with <i>Eucalyptus planchoniana</i> , <i>Corymbia gummifera</i> and <i>E. racemosa</i> reaching up to 4 m in height. Heath understorey dominated by tall and low shrub species. Rehabilitation established in 2018.		
G2	Shrubland of <i>Eucalyptus planchoniana</i> , <i>Corymbia gummifera</i> , <i>Banksia aemula</i> and <i>E. racemosa</i> to a height of 2.6 m. Diverse tall and low shrub species dominated by <i>Ochrosperma lineare</i> , <i>Acacia ulicifolia</i> and <i>Aotus lanigera</i> . Rehabilitation established in 2019.		

Site	Description	Transect Start	Transect End
G3	Very sparse dwarf shrubland with tree species at a maximum 1.1 m. <i>Eucalyptus planchoniana</i> is the dominant tree, with <i>Corymbia gummifera</i> and <i>Angophora leiocarpa</i> subdominant. Diverse shrub species dominated by <i>Acacia ulicifolia</i> , <i>Hibbertia linearis</i> and <i>Ochrosperma lineare</i> .		
G4	Dwarf shrubland dominated by mixed species including, <i>Acacia ulicifolia</i> , <i>Ochrosperma lineare</i> , <i>Laxmannia gracilis</i> , <i>Hibbertia linearis</i> , <i>Bossiaea heterophylla</i> , <i>Woollisia pungens</i> , <i>Dillwynia retorta</i> , and <i>Monotoca</i> sp. (Fraser Island P.Baxter 777). Tree species recorded included, <i>Acacia concurrens</i> , <i>Allocasuarina littoralis</i> , <i>Banksia aemula</i> and <i>Eucalyptus planchoniana</i> , however, abundance/density was noted as very low.		

Site	Description	Transect Start	Transect End
G5	Dwarf shrubland dominated by mixed species including, <i>Acacia ulicifolia</i> , <i>Ochrosperma lineare</i> , <i>Laxmannia gracilis</i> , <i>Hibbertia linearis</i> , <i>Bossiaea heterophylla</i> , <i>Woollsia pungens</i> , <i>Dillwynia retorta</i> , <i>Acacia concurrens</i> , <i>Persoonia virgata</i> and <i>Monotoca</i> sp. (Fraser Island P.Baxter 777). Tree species recorded included, <i>Acacia concurrens</i> , <i>Allocasuarina littoralis</i> , <i>Banksia aemula</i> and <i>Eucalyptus planchoniana</i> , however, abundance/density was noted as very low.		
G6	Dwarf shrubland dominated by mixed species including, <i>Acacia ulicifolia</i> , <i>Ochrosperma lineare</i> , <i>Laxmannia gracilis</i> , <i>Hibbertia linearis</i> , <i>Bossiaea heterophylla</i> , <i>Woollsia pungens</i> , <i>Aotus lanigera</i> , and <i>Acacia suaveolens</i> . Tree species recorded include, <i>Allocasuarina littoralis</i> , <i>Banksia aemula</i> , <i>Corymbia gummifera</i> , and <i>Eucalyptus planchoniana</i> , however abundance/density was noted as reasonably low.		

Site	Description	Transect Start	Transect End
Reference Sites			
P7	Woodland to 14 m of <i>E. planchoniana</i> and <i>Eucalyptus racemosa</i> , with <i>Corymbia gummifera</i> and a subcanopy of <i>Banksia aemula</i> to 8 m and a dense ground layer of native tall and low shrubs.		
REF1	Low open forest of mallee <i>Eucalyptus planchoniana</i> and <i>Corymbia gummifera</i> to 10 m with a <i>Banksia aemula</i> subcanopy to 6 m. Absence of recent fire likely resulting in a particularly high cover of tall shrubs species.		

Site	Description	Transect Start	Transect End
REF2	Low open forest of mallee <i>Eucalyptus planchoniana</i> with <i>Banksia aemula</i> and scattered <i>Eucalyptus racemosa</i> and <i>Corymbia gummifera</i> to 10 m. A subcanopy of <i>Banksia aemula</i> present to 6 m.		

3.2 Species composition

Table 3-2 compares the SIS values for rehabilitation sites and reference sites recorded from 2019 to 2022. The table demonstrates that no sites currently meet the compliance criteria, though the SIS values have remained ≥ 0.5 for most sites during this time. SIS values for G1 increased for all three reference sites between 2019 and 2020, then decreased in subsequent years. In 2021, G2 decreased in SIS value when compared to sites P7 and Ref1, however both sites have maintained and increased their SIS value in 2022. Sites G3, G4, and G5 are new sites that have not been monitored before 2022 and therefore cannot be compared to previous years. In 2022, site G4 recorded SIS values >0.5 when compared to all three reference sites, while G5 and G6 each had SIS values >0.5 when compared to two reference sites.

Table 3-2 Year-on-year comparison of Sorenson's Index of Similarity (SIS) recorded at rehabilitation sites (compliant = green; not compliant = orange).

Site	Rehabilitation Establishment Year	SIS Per Monitoring Year											
		P7				Ref1				Ref2			
		2019	2020	2021	2022	2019	2020	2021	2022	2019	2020	2021	2022
G1	2018	0.55	0.71	0.55	0.53	0.47	0.69	0.54	0.53	0.48	0.67	0.55	0.53
G2	2019		0.75	0.59	0.59		0.64	0.51	0.54		0.63	0.55	0.54
G3	2020			0.55	0.51			0.53	0.50			0.49	0.45
G4	2021				0.59				0.50				0.56
G5	2021				0.53				0.44				0.54
G6	2021				0.58				0.52				0.49

3.3 Species abundance

3.3.1 Stem counts

Total stem counts were conducted within 2 m by 50 m plots. The three reference sites recorded an average of 264.7 stems and ranged from 108 stems at Ref1 to 382 stems at Ref2 (Table 3-3). Stem density was higher on the rehabilitation sites which recorded an average of 340.8 stems and ranged from 62 stems at G1 to 760 at G2.

Table 3-4 provides a summary of dominant species (i.e. species making up $>15\%$ of the total stem count at a site) within reference and rehabilitation sites, including stem counts and the proportion of the total for each species per site. There were three species regarded as dominant across the three reference sites: *Boronia rosmarinifolia*, *Styphelia leptospermoides*, and *Woollisia pungens*. In comparison, six species were recorded as dominant across the six rehabilitation sites including *Acacia ulicifolia*, *Dianella caerulea*, *Laxmannia gracilis*, *Ochrosperma lineare*, *Ricinocarpos pinifolius*, and *Woollisia pungens*.

The heath shrub *Woollisia pungens* was a dominant species at two of the three reference sites (P7 and Ref2) and made up 14% of all stems at site Ref1. Average abundance of the species within the reference sites was 23%. In comparison, *Woollisia pungens* was only recorded as dominant at one of the rehabilitation sites (G2) at 36 stems which equals 19% of all stems recorded on G2.

Both *Boronia rosmarinifolia* at 18% and *Styphelia leptospermoides* at 16% were dominant at Ref1 however were not recorded as dominant in any of the other reference or rehabilitation sites.

Acacia ulicifolia was recorded in dominant abundance at three rehabilitation sites, and the average abundance across all rehabilitation sites was 18%. In comparison, the average abundance of the species in the reference sites was 2%.

Ochrosperma lineare was a dominant species occurring in high abundance at four of the six rehabilitation sites with an average of 175 stems and 34% of the total stem count across the rehabilitation sites. At site G4, the species was recorded with 504 stems, making up 66% of the total stems recorded at that site. The species also occurred on each of the three reference sites, although not at a dominant density with a mean of 22.7 stems and 8% of the total stem count.

Site G1 recorded the lowest total stem count of all the monitored sites, with 62 total stems recorded for four species. *Dianella caerulea* and *Ricinocarpos pinifolius* collectively made up 53% of all stems recorded at the site. By comparison, *R. pinifolius* was recorded in low densities at all other sites, while *D. caerulea* was not recorded at any other site.

3.3.2 Foliage projective cover

The presence of herbaceous species and *Austromyrtus* (midyim) and *Xanthorrhoea* (grass-trees) genera was recorded as foliage cover in lieu of stem counts. The percentage cover of each species per site and mean cover for reference and rehabilitation sites is presented in Table 3-5. Only one species, *Xanthorrhoea johnsonii*, was recorded as dominant within the reference sites at Ref1 (Table 3-5). *X. johnsonii* was present at all reference sites, with an average cover of 13%. By comparison, average cover of the species across the rehabilitation sites was just 1% (Table 3-5).

Within the rehabilitation sites, one species, *Sporobolus virginicus*, was recorded as dominant at G5 with 25% cover, however it was not recorded at any other site (Table 3-5).

Table 3-3 Total and mean stem counts for reference and rehabilitation sites in 2022.

	Reference sites			Rehabilitation sites					
	P7	Ref1	Ref2	G1	G2	G3	G4	G5	G6
Total stem count	382	108	304	62	187	89	760	273	674
Mean stem count	264.7			340.8					

Table 3-4 Stem count (n) and proportion of site total (%) for dominant species (i.e. >15%) at reference and rehabilitation sites in 2022 with dominant species and sites highlighted blue

Species	Reference								Rehabilitation													
	P7		Ref1		Ref2		Mean		G1		G2		G3		G4		G5		G6		Mean	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
<i>Acacia ulicifolia</i>	21	5%	0	0%	1	0%	7.3	2%	21	34%	36	19%	25	28%	63	8%	16	6%	88	13%	41.5	18%
<i>Boronia rosmarinifolia</i>	12	3%	19	18%	10	3%	13.7	8%	1	2%	0	0%	0	0%	3	0%	0	0%	1	0%	0.8	0.4%
<i>Dianella caerulea</i>	0	0%	0	0%	0	0%	0	0%	22	35%	0	0%	0	0%	0	0%	0	0%	0	0%	3.7	6%
<i>Laxmannia gracilis</i>	0	0%	0	0%	0	0%	0	0%	0	0%	9	5%	14	16%	58	8%	33	12%	66	10%	30	8%
<i>Ochrosperma lineare</i>	43	11%	9	8%	16	5%	22.7	8%	0	0%	55	29%	10	11%	504	66%	119	44%	362	54%	175	34%
<i>Ricinocarpos pinifolius</i>	25	7%	3	3%	1	0%	9.7	3%	11	79%	23	12%	9	10%	1	0%	0	0%	2	0%	7.7	17%
<i>Styphelia leptospermoides</i>	14	4%	17	16%	20	7%	17	9%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
<i>Woolfsia pungens</i>	85	22%	15	14%	97	32%	65.7	23%	0	0%	36	19%	0	0%	18	2%	28	10%	14	2%	16	6%

Table 3-5 Foliage projective cover (%) for dominant herbaceous species and *Austromyrtus* (midyim) and *Xanthorrhoea* (grass-trees) genera at reference and rehabilitation sites in 2022 with dominant species and sites highlighted blue

Species	Reference				Rehabilitation						
	P7	Ref1	Ref2	Mean	G1	G2	G3	G4	G5	G6	Mean
<i>Sporobolus virginicus</i>	0%	0%	0%	0%	0%	0%	0%	0%	25%	0%	4%
<i>Xanthorrhoea johnsonii</i>	2%	25%	11%	13%	2%	1%	1%	0%	0%	0%	1%

4 Summary of assessment against criteria

The objective of the monitoring survey in 2022 was to assess rehabilitation established between 2018 and 2021 on ML1124 and ML7064 against success criteria to fulfil condition F2-1(a) of the Environmental Authority EPML00349813 using methodology detailed in Section 5.2 of the Glass EMP. A summary of the two criteria and current progress towards meeting these as of 2022 is presented in Table 4-1.

Table 4-1 Summary of assessment against revegetation criteria in 2022 (compliant = green and ✓; partially compliant = purple and □; not compliant = orange and ✕)

Criteria	Rehabilitation Site and Establishment Year					
	G1 (2018)	G2 (2019)	G3 (2020)	G4 (2021)	G5 (2021)	G6 (2021)
Species type and diversity	✕	✕	✕	✕	✕	✕
Species dominance comparison	✕	□	✕	✕	✕	✕
Overall	✕	□	✕	✕	✕	✕

5 Discussion

5.1 Species composition

The criteria for species composition presented in Section 2.1 states each rehabilitation site must achieve a minimum SIS value of 0.5 and increase in value for the next three consecutive years.

Overall, the rehabilitation sites are not compliant with the revegetation criteria pertaining to species composition. Although many of the rehabilitation sites have partially met the criteria by recording SIS values ≥ 0.5 , none of the sites have recorded three consecutive increases in an SIS above 0.5.

The different species composition between rehabilitation and reference sites is likely due to a) the tube stock and seed mixes used for rehabilitation not including all reference site species, and b) the relatively early development stage of the rehabilitation which has a low, sparse canopy and understory cover compared to the reference sites and therefore encourages native and exotic grass and forb species richness and cover. As the structure of the rehabilitation communities develops and species naturally recruit from nearby areas, it is expected that the species composition of the rehabilitation sites will increase in similarity to the reference sites.

In 2022, rehabilitation site G2 recorded SIS values equal to and above the 2021 values when compared to reference sites P7 and Ref1. If G2 exceeds the previous SIS value with either reference site in the next two monitoring events, G2 will have satisfied the species composition criteria.

Neither rehabilitation sites G1 or G3 equalled or exceeded the SIS value recorded in 2021 and will therefore need to meet the 2022 SIS scores respectively in the subsequent monitoring event. The new monitoring sites (G4, G5, and G6) each recorded SIS values ≥ 0.5 when compared to two of the reference sites. Future monitoring will determine if these SIS values are maintained or increase, indicating progress towards meeting the criteria.

It should be noted, at G4, G5, and G6 several shrub and ground understorey species were observed to have been sun-bleached or early dieback. This is likely to have been caused by the excessive sun exposure since rehabilitation commenced in 2021. Tree sapling abundance and density for the same sites was observed as very low. Although no dieback of tree species was observed, it is likely tree species, such as, *Eucalyptus planchoniana* and *Corymbia gummifera* may have never been planted in higher densities at the time that G4, G5 and G6 sites were established. It is therefore recommended that infill planting of tree species that represent the target REs is undertaken to facilitate the early establishment of a canopy as well as provide some shade for those shrub and understorey species that have been exposed to excessive amounts of sunlight since 2021. In addition, the non-native weedy grass, *Megathyrsus maximus* was observed in moderately dense patches across most of G4 site. It is recommended that treatment of this weed should be undertaken to assist the succession of native plants.

5.2 Species abundance

The species abundance criteria presented in Section 2.1 compares the abundance of dominant species within the reference and rehabilitation vegetation communities. A species is considered dominant when it represents more than 15% of the total stem count. The criteria for species percent comparison states that for species that are dominant in reference sites, the same species must be within 20% of the reference percentage within the rehabilitation areas.

Rehabilitation site G2 is partially compliant, with one dominant reference species recorded at a dominant percentage at the site. All other rehabilitation sites are currently not compliant with regards to species abundance.

Average stem density for the reference sites decreased from 300.7 to 264.7 between 2021 and 2022 while the average stem density across the rehabilitation sites doubled from 164.7 to 340.8. Three additional rehabilitation sites (G4-G6) were monitored in 2022, and collectively made up 84% of the total stem count, which may in part explain the increased stem density. Greater stem densities are expected in the rehabilitation sites, and particularly the most recently established sites, due to the higher ground cover characteristic of areas following disturbance. As the vegetative communities advance in age, stem density is expected to decrease to resemble a structure more similar to the reference communities.

Three species were recorded in dominant stem densities across the three reference sites: *Boronia rosmarinifolia*, *Styphelia leptospermoides*, and *Woollisia pungens*, while one species - *Xanthorrhoea johnsonii* – was recorded with dominant foliage projective cover at a reference site.

Woollisia pungens was a dominant species at two of the three reference sites (P7 and Ref2), contributing more than 15% of the stems at these sites, and 14% of all stems at site Ref1. In comparison, *Woollisia pungens* was only detected as dominant at one of the rehabilitation sites, G2. The proportion of *W. pungens* at G2 has increased from 0% in 2020 to 19% in 2022, indicating the potential for successful recruitment within the rehabilitation sites. *Boronia rosmarinifolia* has also been recorded within the rehabilitation sites at low densities. As the rehabilitation sites remain sparse with a high proportion of bare ground, there is potential to increase the abundance of both species in the rehabilitation areas to a level of dominance. *Styphelia leptospermoides* has not been recorded at any rehabilitation sites yet.

Several species that were recorded as dominant in the rehabilitation sites are only found in lower densities at the reference sites. This is likely due to the affinity of species such as *Acacia ulicifolia* for recruiting in recently disturbed communities. As the structure of the rehabilitated communities continues to develop, the abundance of different species will fluctuate in line with available habitat (e.g. shade-tolerant species will become more dominant as the canopy grows and closes).

6 References

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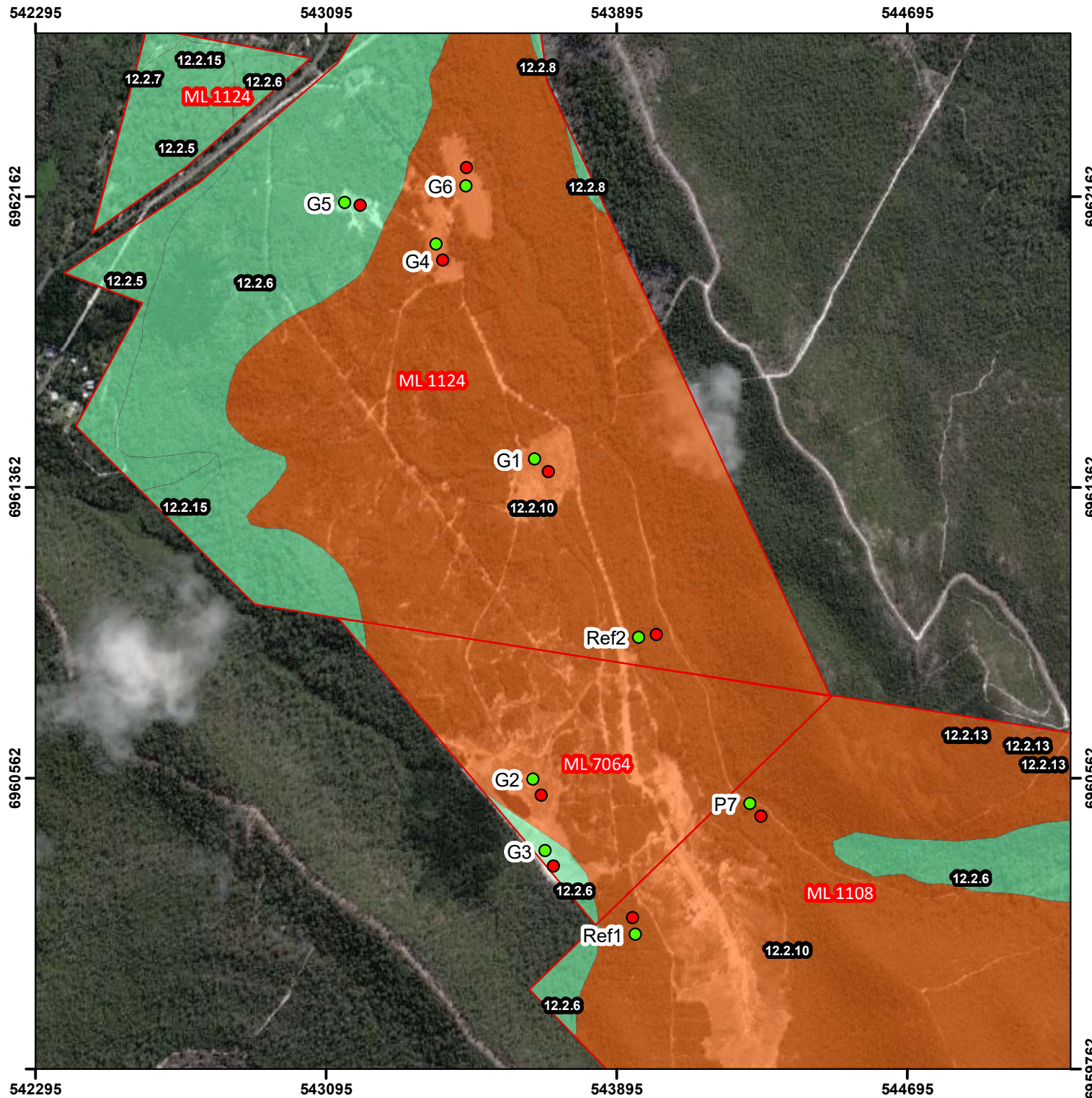
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Appendix A – Mapping



Appendix A:

Vegetation Monitoring Sites
Glass Mining Lease
North Stradbroke Island 2022



0 200 400 600 800
Meters

Scale: 1:8000

Coordinate System: GDA 1994 MGA Zone 56

Datum: GDA 1994

Legend

Mining Leases

Transect Position

- End
- Start

Pre-Clear Regional Ecosystems

- Pre-clearing area containing Of Concern RE
- Pre-clearing area that is a Least Concern RE

Data sources:
Mining Lease Boundaries
© State of Queensland (Department of Natural Resources and Mines) 2016

Document History:

Rev	Reason for Issue	Author	Reviewer	Approver	Date
A	Internal Draft	NC	AD	RR	21/07/2021
1	Issue for information	JS	RE	RR	06/08/2021
2	Issue for information	JS	AD	RR	21/07/2022

Appendix B – 2022 Species List

Scientific Name	Life Form	NC Act Status	P7	Ref1	Ref2	G1	G2	G3	G4	G5	G6
<i>Acacia concurrens</i>	Tree				✓			✓	✓	✓	
<i>Acacia suaveolens</i>	Shrub		✓		✓		✓	✓	✓	✓	✓
<i>Acacia ulicifolia</i>	Shrub		✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>Allocasuarina littoralis</i>	Tree					✓	✓	✓	✓	✓	✓
<i>Andropogon virginicus</i>	Grass	*					✓		✓	✓	
<i>Angophora leiocarpa</i>	Tree					✓		✓			
<i>Anthelepis paludosa</i>	Forb				✓						
<i>Aotus lanigera</i>	Shrub		✓	✓	✓		✓	✓	✓		✓
<i>Aristida jerichoensis</i>	Grass					✓					
<i>Austromyrtus dulcis</i>	Shrub		✓	✓	✓						
<i>Baeckea frutescens</i>	Shrub		✓								
<i>Baloskion pallens</i>	Forb		✓								
<i>Banksia aemula</i>	Tree		✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>Boronia rosmarinifolia</i>	Shrub		✓	✓	✓	✓			✓	✓	✓
<i>Boronia saffrolifera</i>	Shrub				✓						
<i>Bossiaea ensata</i>	Shrub										✓
<i>Bossiaea heterophylla</i>	Forb		✓		✓	✓	✓		✓	✓	✓
<i>Brachyloma scortechinii</i>	Shrub		✓	✓	✓	✓					
<i>Cassytha pubescens</i>	Forb		✓	✓	✓			✓			
<i>Caustis recurvata</i>	Forb		✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>Cenchrus</i> sp.	Grass									✓	
<i>Coleocarya gracilis</i>	Forb		✓	✓	✓	✓					
<i>Conospermum taxifolium</i>	Shrub		✓		✓					✓	
<i>Conyza bonariensis</i>	Shrub	*								✓	
<i>Corymbia gummifera</i>	Tree		✓	✓		✓	✓	✓	✓		✓
<i>Crotalaria incana</i>	Shrub	*								✓	

Scientific Name	Life Form	NC Act Status	P7	Ref1	Ref2	G1	G2	G3	G4	G5	G6
<i>Cymbopogon refractus</i>	Grass							✓		✓	
<i>Cynodon dactylon</i>	Grass	*						✓			
<i>Cyperus polystachyos</i>	Forb						✓			✓	
<i>Dianella caerulea</i>	Forb					✓					
<i>Dillwynia retorta</i>	Shrub		✓	✓	✓		✓		✓	✓	✓
<i>Dodonaea triquetra</i>	Shrub					✓	✓	✓	✓	✓	✓
<i>Elaeocarpus reticulatus</i>	Tree			✓							
<i>Eleusine indica</i>	Grass	*						✓			
<i>Emilia sonchifolia</i>	Forb	*					✓				
<i>Entolasia marginata</i>	Grass		✓	✓			✓	✓	✓		✓
<i>Epacris pulchella</i>	Shrub		✓		✓				✓		
<i>Eragrostis interrupta</i>	Grass					✓	✓	✓			
<i>Eragrostis parviflora</i>	Grass					✓					
<i>Eriachne pallescens</i>	Grass					✓	✓	✓	✓	✓	✓
<i>Eucalyptus planchoniana</i>	Tree		✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>Eucalyptus racemosa</i>	Tree		✓		✓	✓					
<i>Gompholobium virgatum</i>	Shrub					✓			✓		✓
<i>Hardenbergia violacea</i>	Forb					✓					
<i>Hibbertia acicularis</i>	Forb		✓								
<i>Hibbertia linearis</i>	Shrub		✓		✓	✓	✓	✓	✓	✓	✓
<i>Homoranthus virgatus</i>	Shrub		✓	✓	✓	✓	✓		✓	✓	✓
<i>Imperata cylindrica</i>	Grass								✓		
<i>Jacksonia stackhousei</i>	Shrub		✓		✓				✓	✓	✓
<i>Juncus</i> sp.	Forb					✓					
<i>Kennedia rubicunda</i>	Shrub								✓		✓
<i>Laxmannia gracilis</i>	Forb		✓			✓	✓	✓	✓	✓	✓

Scientific Name	Life Form	NC Act Status	P7	Ref1	Ref2	G1	G2	G3	G4	G5	G6
<i>Leptospermum polygalifolium</i>	Shrub		✓				✓	✓			
<i>Leptospermum semibaccatum</i>	Shrub				✓	✓					
<i>Leptospermum trinervium</i>	Shrub		✓	✓	✓		✓			✓	
<i>Leucopogon virgatus</i>	Shrub		✓								
<i>Lomandra elongata</i>	Forb			✓		✓					
<i>Lomandra laxa</i>	Grass		✓								
<i>Lomandra longifolia</i>	Forb			✓				✓			
<i>Lophostemon confertus</i>	Tree					✓					
<i>Megathyrsus maximus</i>	Grass	*				✓				✓	
<i>Melinis repens</i>	Grass	*							✓	✓	
<i>Monotoca scoparia</i>	Shrub		✓	✓	✓						
<i>Monotoca</i> sp. (Fraser Island P.Baxter 777)	Shrub		✓	✓	✓	✓				✓	✓
<i>Ochrosperma lineare</i>	Shrub		✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>Paspalum scrobiculatum</i>	Grass						✓				
<i>Paspalum urvillei</i>	Grass	*								✓	
<i>Patersonia sericea</i>	Forb		✓	✓		✓				✓	✓
<i>Persoonia stradbrokeensis</i>	Shrub									✓	✓
<i>Persoonia virgata</i>	Shrub		✓	✓	✓		✓	✓	✓	✓	✓
<i>Petrophile canescens</i>	Shrub					✓	✓	✓			
<i>Phyllota phyllicoides</i>	Shrub		✓	✓	✓						
<i>Pimelea linifolia</i>	Shrub		✓	✓	✓		✓	✓			
<i>Platysace ericoides</i>	Forb		✓	✓	✓						
<i>Praxelis clematidea</i>	Forb	*					✓			✓	
<i>Pseudanthus orientalis</i>	Shrub				✓	✓	✓				
<i>Pteridium esculentum</i>	Forb						✓	✓		✓	
<i>Ricinocarpus pinifolius</i>	Shrub		✓	✓	✓	✓	✓	✓	✓		✓

Scientific Name	Life Form	NC Act Status	P7	Ref1	Ref2	G1	G2	G3	G4	G5	G6
<i>Schizaea dichotoma</i>	Forb			✓							
<i>Sporobolus virginicus</i>	Grass							✓	✓	✓	
<i>Strangea linearis</i>	Shrub		✓	✓	✓	✓	✓	✓	✓		
<i>Styphelia deformis</i>	Shrub		✓		✓						
<i>Styphelia ericoides</i>	Shrub		✓	✓	✓	✓					
<i>Styphelia leptospermoides</i>	Shrub		✓	✓	✓						
<i>Styphelia viridis</i> subsp. <i>breviflora</i>	Shrub				✓						
<i>Utricularia lateriflora</i>	Forb						✓				
<i>Woollsia pungens</i>	Shrub		✓	✓	✓	✓	✓		✓	✓	✓
<i>Xanthorrhoea johnsonii</i>	Shrub		✓	✓	✓	✓	✓	✓			
<i>Zieria laxiflora</i>	Shrub		✓	✓	✓	✓	✓	✓	✓	✓	

NC Act Status - * exotic species

Appendix C – 2022 Stem Count & FPC Cover Data

			Reference Sites			Rehabilitation Sites					
Species	Life Form	NC Act Status	P7	Ref1	Ref2	G1	G2	G3	G4	G5	G6
Stem Count											
Acacia concurrens	Tree		0	0	0	0	0	1	0	8	0
Acacia suaveolens	Shrub		0	0	0	3	0	2	6	0	10
Acacia ulicifolia	Shrub		21	0	1	21	36	25	63	16	88
Allocasuarina littoralis	Tree		0	0	0	0	0	1	3	0	0
Aotus lanigera	Shrub		6	0	5	0	4	4	8	0	11
Baeckea frutescens	Shrub		30	0	0	0	0	0	0	0	0
Banksia aemula	Tree		21	0	19	0	0	0	0	0	0
Boronia rosmarinifolia	Shrub		12	19	10	1	0	0	3	0	1
Boronia saffrolifera	Shrub		0	0	3	0	0	0	0	0	0
Bossiaea ensata	Shrub		0	1	3	0	0	0	0	0	0
Bossiaea heterophylla	Forb		6	0	1	0	0	0	18	7	14
Brachyloma scortechinii	Shrub		12	0	3	0	0	0	0	0	0
Caustis recurvata	Forb		0	0	5	0	0	0	0	0	0
Conospermum taxifolium	Shrub		0	0	0	0	0	0	0	5	0
Crotalaria incana	Shrub	*	0	0	0	0	0	0	0	5	0
Dianella caerulea	Forb		0	0	0	22	0	0	0	0	0
Dillwynia retorta	Shrub		10	1	18	0	5	0	11	12	7
Dodonaea triquetra	Shrub		0	0	0	0	1	0	2	1	2
Entolasia marginata	Grass		0	0	0	0	0	0	0	0	1
Epacris pulchella	Shrub		9	0	8	0	0	0	0	0	0
Eucalyptus planchoniana	Tree		0	0	1	0	0	1	0	0	0
Eucalyptus racemosa	Tree		1	0	0	0	0	0	0	0	0
Gompholobium virgatum	Shrub		0	0	0	0	0	0	1	0	0
Hibbertia linearis	Shrub		1	0	9	0	0	4	47	10	55

Species	Life Form	NC Act Status	Reference Sites			Rehabilitation Sites					
			P7	Ref1	Ref2	G1	G2	G3	G4	G5	G6
<i>Homoranthus virgatus</i>	Shrub		11	0	0	1	2	2	4	2	9
<i>Jacksonia stackhousei</i>	Shrub		0	0	0	0	0	0	2	2	7
<i>Laxmannia gracilis</i>	Forb		0	0	0	0	9	14	58	33	66
<i>Leptospermum polygalifolium</i>	Shrub		16	0	0	0	1	1	0	2	0
<i>Leptospermum semibaccatum</i>	Shrub		0	0	17	0	0	0	0	0	0
<i>Leptospermum trinervium</i>	Shrub		2	15	2	0	3	0	0	4	0
<i>Leucopogon virgatus</i>	Shrub		0	0	1	0	0	0	0	0	0
<i>Lophostemon confertus</i>	Tree		0	0	0	0	0	1	0	0	0
<i>Monotoca scoparia</i>	Shrub		11	0	9	0	3	0	0	0	0
<i>Monotoca</i> sp. (Fraser Island P.Baxter 777)	Shrub		5	14	3	1	0	0	9	8	17
<i>Ochrosperma lineare</i>	Shrub		43	9	16	0	55	10	504	119	362
<i>Persoonia stradbokensis</i>	Shrub		0	0	0	0	0	0	0	1	2
<i>Persoonia virgata</i>	Shrub		8	0	8	0	7	5	2	7	6
<i>Petrophile canescens</i>	Shrub		0	0	0	1	1	2	0	0	0
<i>Phyllota phyllicoides</i>	Shrub		6	0	0	0	0	0	0	0	0
<i>Pimelea linifolia</i>	Shrub		1	0	2	0	0	0	0	0	0
<i>Pteridium esculentum</i>	Forb		0	0	0	0	0	0	0	2	0
<i>Ricinocarpus pinifolius</i>	Shrub		25	3	1	11	23	9	1	0	2
<i>Strangea linearis</i>	Shrub		11	14	32	0	1	1	0	0	0
<i>Styphelia ericoides</i>	Shrub		13	0	3	0	0	0	0	0	0
<i>Styphelia leptospermoides</i>	Shrub		14	17	20	0	0	0	0	0	0
<i>Styphelia viridis</i> subsp. <i>breviflora</i>	Shrub		0	0	5	0	0	0	0	0	0
<i>Woollsia pungens</i>	Shrub		85	15	97	0	36	0	18	28	14
<i>Zieria laxiflora</i>	Shrub		2	0	2	1	0	6	0	1	0

			Reference Sites			Rehabilitation Sites					
Species	Life Form	NC Act Status	P7	Ref1	Ref2	G1	G2	G3	G4	G5	G6
FPC (%)											
<i>Andropogon virginicus</i>	Grass	*	0%	0%	0%	0%	2%	0%	0%	0%	0%
<i>Anthelepis paludosa</i>	Forb		0%	0%	2%	0%	0%	0%	0%	0%	0%
<i>Aristida jerichoensis</i>	Grass		0%	0%	0%	1%	0%	0%	0%	0%	0%
<i>Brachyloma scortechinii</i>	Shrub		0%	0%	0%	0%	3%	0%	0%	0%	0%
<i>Cassytha pubescens</i>	Forb		0%	0%	1%	0%	0%	0%	0%	0%	0%
<i>Caustis recurvata</i>	Forb		3%	3%	0%	0%	3%	0%	0%	0%	2%
<i>Cenchrus</i> sp.	Grass		0%	0%	0%	0%	0%	0%	0%	1%	0%
<i>Coleocarya gracilis</i>	Forb		3%	0%	2%	0%	0%	0%	0%	0%	0%
<i>Conyza bonariensis</i>	Shrub	*	0%	0%	0%	0%	0%	0%	0%	1%	0%
<i>Cymbopogon refractus</i>	Grass		0%	0%	0%	0%	0%	0%	0%	1%	0%
<i>Cyperus polystachyos</i>	Forb		0%	0%	0%	0%	1%	0%	0%	0%	0%
<i>Emilia sonchifolia</i>	Forb	*	0%	0%	0%	0%	1%	0%	0%	0%	0%
<i>Entolasia marginata</i>	Grass		0%	0%	0%	0%	0%	0%	0%	0%	2%
<i>Eragrostis interrupta</i>	Grass		0%	0%	0%	0%	0%	1%	0%	0%	0%
<i>Eriachne pallescens</i>	Grass		0%	0%	0%	0%	5%	0%	0%	0%	2%
<i>Gahnia sieberiana</i>	Forb		0%	0%	0%	0%	1%	0%	0%	0%	0%
<i>Imperata cylindrica</i>	Grass		0%	0%	0%	0%	2%	0%	0%	0%	0%
<i>Kennedia rubicunda</i>	Shrub		0%	0%	0%	0%	0%	0%	1%	0%	1%
<i>Lomandra elongata</i>	Forb		0%	0%	0%	1%	0%	0%	0%	0%	0%
<i>Lomandra longifolia</i>	Forb		0%	1%	0%	1%	0%	2%	0%	0%	0%
<i>Melinis repens</i>	Grass	*	0%	0%	0%	0%	0%	0%	0%	1%	0%
<i>Paspalum scrobiculatum</i>	Grass		0%	0%	0%	0%	1%	0%	0%	0%	0%
<i>Paspalum urvillei</i>	Grass	*	0%	0%	0%	0%	2%	0%	0%	10%	0%
<i>Patersonia sericea</i>	Forb		1%	1%	0%	1%	0%	0%	0%	0%	1%

			Reference Sites			Rehabilitation Sites					
Species	Life Form	NC Act Status	P7	Ref1	Ref2	G1	G2	G3	G4	G5	G6
<i>Praxelis clematidea</i>	Forb	*	0%	0%	0%	0%	3%	0%	0%	1%	0%
<i>Pteridium esculentum</i>	Forb		0%	0%	0%	0%	0%	1%	0%	0%	0%
<i>Sporobolus virginicus</i>	Grass		0%	0%	0%	0%	0%	0%	0%	25%	0%
<i>Utricularia lateriflora</i>	Forb		0%	0%	0%	0%	1%	0%	0%	0%	0%
<i>Xanthorrhoea johnsonii</i>	Shrub		2%	25%	11%	2%	1%	1%	0%	0%	0%

NC Act Status - * exotic species