Botanical Assessment of Proposed Access Roads from Catalina to the Beach

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STATEMENT OF LIMITATIONS

Scope of Services

This report ("the report") has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Eleanor Bennett ("the Author"). In some circumstances a range of factors such as time, budget, access and/or site disturbance constraints may have limited the scope of services.

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In preparing the report, the Author has relied upon data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise stated in the report, the Author has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. The Author will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to the Author.

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SUMMARY

Bennett Environmental Consulting Pty Ltd undertook a Level 2 botanical survey of two proposed access roads from the new development at Catalina through remnant bushland to the beach. Some sections of the proposed roads were common, namely the eastern end where it commences at the edge of the housing development and the western end where there is a car park proposed. It is proposed to make a hard surface road with a car park close to the beach where it bifurcates the southern survey area was through remnant bushland and the northern section was along a current off road track.

Four different vegetation units recorded from the survey area. These were:

1. Open Heath of *Melaleuca cardiophylla* over Very Open Grassland dominated by **Ehrharta longiflora* over Herbland dominated by **Raphanus raphanistrum, *Crassula glomerata* and **Petrorhagia dubia* over Sedgeland dominated by *Lomandra maritima* and *Desmocladus flexuosus*;
2. Tall Open Scrub of *Acacia rostellifera* and *Spyridium globulosum* over Low Shrubland of *Melaleuca systena* over Open Grassland dominated by **Ehrharta longiflora* over Open Herbland dominated by **Lysimachia arvensis* over Very Open Sedgeland *of Lomandra maritima* and *Desmocladus flexuosus*;
3. Shrubland of *Acacia rostellifera* over Low Shrubland dominated by *Rhagodia baccata* subsp. *dioica* and *Scaevola crassifolia* over Very Open Grassland dominated by **Ehrharta longiflora* over Open Herbland dominated by *Acanthocarpus preissii*, **Crassula glomerata* and **Trachyandra divaricata* over Sedgeland of *Lepidosperma gladiatum*; and
4. Low Open Shrubland of *Olearia axillaris, Scaevola crassifolia, *Pelargonium capitatum* and *Rhagodia baccata* subsp. *dioica* over Grassland dominated by *Spinifex longifolius* over Very Open Herbland dominated by **Trachyandra divaricata.*

The vegetation condition varied between very good and good except along the track where it was degraded. Weeds were common throughout the remnant bushland but were very dense only along the edges of the track.

A total of 31 vascular plant families, 58 genera and 68 taxa were recorded during the survey, of which 26 taxa were weeds. None of the species were threatened or priority species and none of the weeds were listed as Declared Pants.

Recommendations were made on the construction of the tracks, the hard stand near the beach, rehabilitation due to site works associated with this construction and closure and rehabilitation of other off road tracks through the area. It is important that endemic species relevant to each vegetation unit be planted, in particular *Spinifex longifolius* and *Spinifex hirsutus* in preference to Marram Grass close to the strand line and in the foredunes.

1. INTRODUCTION

1.1 Background

Bennett Environmental Consulting Pty Ltd was commissioned by Coterra Environment to undertake a Level 2 assessment of two alternate routes proposed for a hard surfaced road from the new extension of the Catalina housing development to the beach. The development at Catalina commenced in 2012 and a new section is currently being prepared for additional housing.

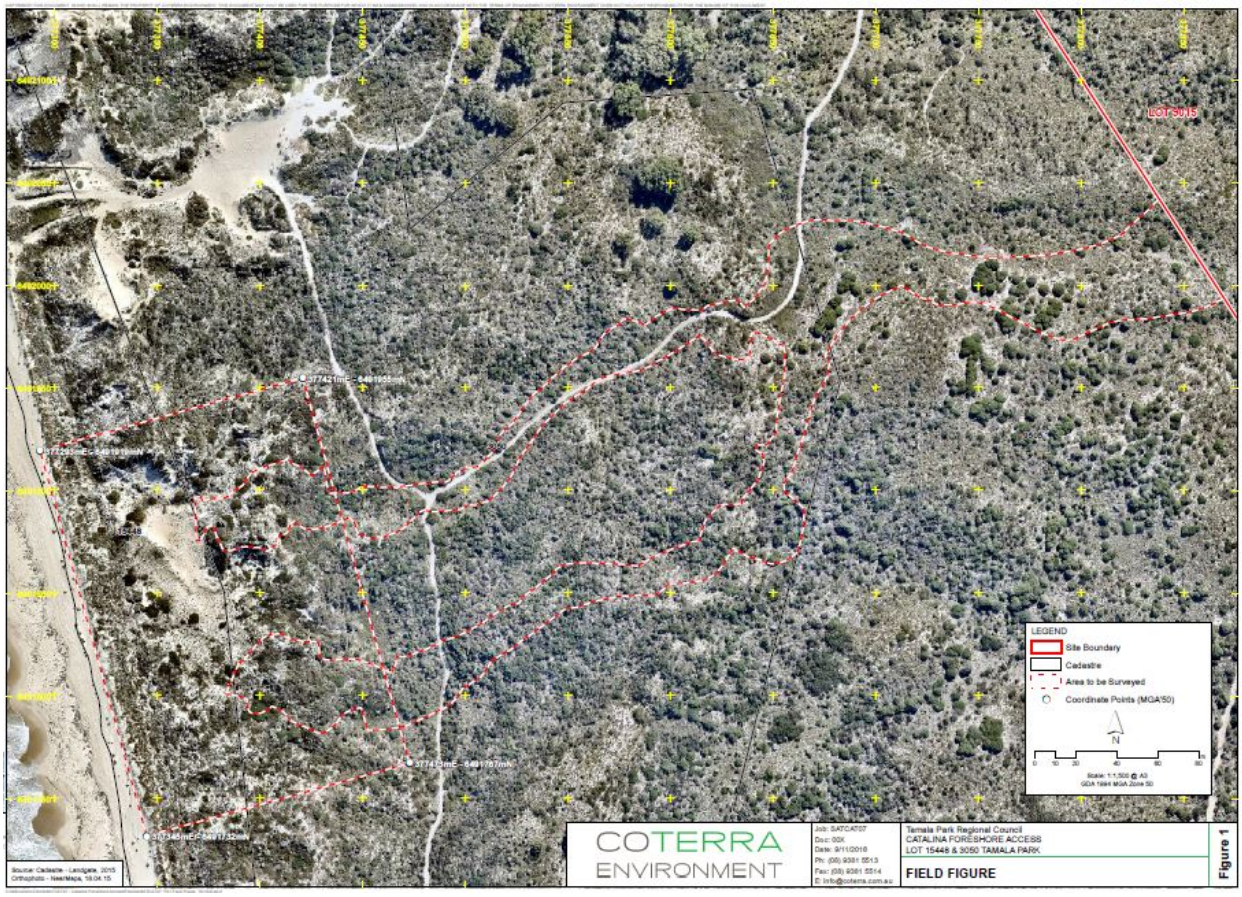

Diagram 1. Study area outlined in red/white lines. The white area indicates current tracks and the red line at the top right hand corner is where the current expansion will terminate.

Both of the tracks in Diagram 1 end in a rectangular area where it is proposed to construct a car park.

The survey area is included in the conservation area known as Tamala Park and managed by the Western Australian Planning Commission. The narrow coastal section is included in Bush Forever Site Number 322 – Burns Beach Bushland (Government of Western Australia, 2000). The Tamala Park Regional Council (2016) was formed in 2006 specifically to implement the urban development of the Tamala Park Project, marketed as Catalina As part of environmental offsets, the Tamala Park Regional Council transferred 91 hectares of land, adjoining the foreshore reserve, to the Western Australian Planning Commission to form part of the future Coastal reserve from Burns Beach to Mindarie. This offset includes the study area.

1.2 Scope of Works

The requirements for this project were to:

i. Undertake a Level 2 vegetation survey (Environmental Protection Authority and Department of Parks and Wildlife, 2015) of the proposed roads and the car parking area as indicated in Diagram 2; and

ii. Search for threatened or priority flora within the proposed development areas.

2. BACKGROUND INFORMATION

2.1 Geology and Landform

The site is included in the Quindalup unit which consists of calcareous sands occurring as beach ridges and parabolic dunes. A detailed description of the soils and landforms was undertaken for the coastal area Mindarie to Quinns Rocks (Ecoscape Australia Pty. Ltd, 2004). A typical transect from west to east through the dune system included fore dunes gradually rising to higher primary and secondary dunes further away from the coast.

Although the current study area was not included in this detailed dune analysis some soil units can be inferred. Diagram 2 is a section of this study showing Mindarie which is just north of the survey area and the dune system recorded there.

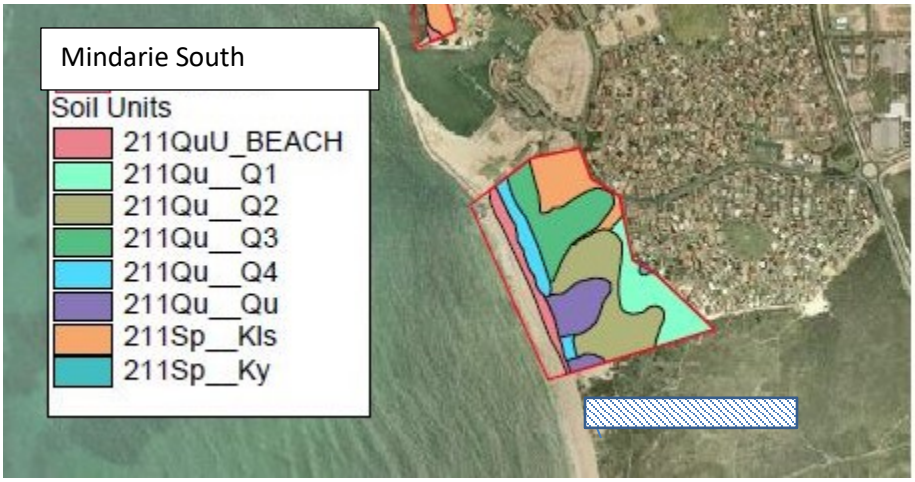

Diagram 2. Soils and Landforms described for Mindarie South including the cross hatched current study area.

From Diagram 2 it can be inferred that the current study area includes following the soil units: which are described as:

211QuU_Beach = Beach;
211Qu_Qu = Presently unstable sand;
211Qu_Q4 = the youngest Quindalup phase of irregular dunes with slopes up to 20%, consisting of loose pale brown sand with no soil profile development;
211Qu_Q2 = the second Quindalup phase consisting of a complex pattern of dunes with moderate relief. These sands have organic staining to a depth of about 20cm, passing into pale brown sand with some cementation below 1m;
211Qu_Q1 = the oldest Quindalup phase of dunes or remnants with low relief, consisting of calcareous soils with organic staining to 30cm, overlying pale brown sand with definite cementation below 1m.

2.2 Vegetation

The Interim Biogeographical Regionalisation for Australia (IBRA) (Thackway and Cresswell, 1995) recognizes 85 bioregions. The IBRA is used as the common unit to compare biological and biophysical attributes. Bioregions represent a landscape-based approach to classifying the land surface and each region is defined by a set of major environmental influences, which shape the occurrence of flora and fauna and their interaction with the physical environment. The site occurs in the Swan Coastal Plain, which has been subdivided into the northern section and the southern section. The study area is located in the southern section, abbreviated SWA2 (Mitchell, Williams and Desmond, 2002).

Prior to the above classification Beard (1981) classified the vegetation of Western Australia. Western Australia was divided into three main Botanical Provinces, Southwest, Eremaean and Northern. The

survey area occurs in the Southwest Botanical Province Beard (1990). Beard (1981) described the vegetation of the site as Coastal Heath and Thicket.

Heddle *et al.* (1980) described the vegetation complexes of the Darling System at a scale of 1:250 000. There was found to be a distinct pattern of plant distribution linked to landforms, soils and climate. The most obvious trend was associated with increasing aridity from west to east on the Darling Plateau. The vegetation changes observed were a decrease in height and percentage cover of the tallest stratum and a distinct change in floristics. The site occurs within the Quindalup Vegetation Complex which is restricted to the coastal dunes. The Quindalup Complex consists of two alliances - the strand and fore dune alliance and the mobile and stable dune alliance. The vegetation differs in the species composition from one area to another because of differences in the dune environment due to edaphic and topographical factors and shelter from salt laden winds.

Bush Forever (Government of Western Australia, 2000) states that 48% of the Quindalup Complex remained vegetated within the Swan Coastal Plain in 2000. The area proposed for protection is 20%.

2.3 Threatened Ecological Communities

An ecological community is a naturally occurring biological assemblage that occurs in a particular type of habitat. A Threatened Ecological Community is one which falls into one of the following categories, presumed totally destroyed, critically endangered, endangered or vulnerable (Department of Parks and Wildlife, 2016b).

A restricted ecological community which does not meet the criteria for a Threatened Ecological Community is added to the Priority Ecological Community List. Priorities 1, 2, and 3 are adequately known but are not currently believed to be threatened. Those that have recently been removed from the threatened list are listed as Priority 4. Conservation dependent ecological communities are placed in Priority 5.

The Department of Parks and Wildlife (2016b) lists Threatened and Priority Ecological Communities recorded for Western Australia but none were listed as occurring in the study area.

2.4 Significant Flora

Prior to undertaking the field work a search was undertaken of NatureMap (Department of Parks and Wildlife, 2016d) for a 5 km buffer from the centre at 115° 42' 26" E, 31° 42' 06"S. This search resulted in the species listed in Table 2.

Table 1. Code and description of Threatened and Priority Flora (Government Gazette of WA (2015) with the threatened species split into their IUCN (2015) categories

Code	Declared Rare and Priority Flora Categories
T	T (Threatened) -Extant Taxa. Taxa, which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection. This category is further subdivided: CE: Flora that are considered likely to become extinct or rare, as critically endangered flora. E: Flora that are considered likely to become extinct or rare, as endangered flora. V: Flora that are considered likely to become extinct or rare, as vulnerable flora.
X	DRF (Declared Rare Flora) -Presumed Extinct Taxa. Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently.
1	Priority One -Poorly Known Taxa. Taxa, which are known from one or a few (generally <5) populations, which are under threat.
2	Priority Two -Poorly Known Taxa. Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat.
3	Priority Three -Poorly Known Taxa. Taxa, which are known from several populations, at least some of which are not believed to be under immediate threat.
4	Priority Four -Rare Taxa. Taxa which are considered to have been adequately surveyed and which whilst being rare, are not currently threatened by any identifiable factors.

Table 1 presents the definitions of Declared Rare and the four Priority Flora ratings under the Wildlife Conservation Act (1950) as extracted from Government Gazette of WA (2015).

Table 2. Threatened and Priority Flora Species List recorded in the selected area with W.A. Government Gazette Threatened Flora code and categories and Priority Flora code and categories listed by the Department of Parks and Wildlife (2016a). Description extracted from FloraBase (Western Australian Herbarium, 2016)

Taxon	Code	Description
Threatened Flora		
Eucalyptus argutifolia	V	(Mallee), 1.5-4 m high, bark smooth. Fl. white, Mar to Apr. Shallow soils over limestone. Slopes or gullies of limestone ridges, outcrops.
Marianthus paralius	CE	Almost prostrate, eventually scandent, woody shrub. Fl. red, Sep to Nov. White sand over limestone. Low coastal cliffs.
Priority Flora		
Acacia benthamii	P2	Shrub, ca 1 m high. Fl. yellow, Aug to Sep. Sand. Typically on limestone breakaways.
Fabronia hampeana	P2	Moss commonly on *Macrozamia riedlei* trunks.
Lecania turicensis var. *turicensis*	P2	Lichen
Tetraria sp. Chandala (G.J. Keighery 17055)	P2	No description provided.
Conostylis bracteata	P3	Rhizomatous, tufted or shortly proliferous perennial, grass-like or herb, 0.2-0.45 m high. Fl. yellow, Aug to Sep. Sand, limestone. Consolidated sand dunes.
Hibbertia spicata subsp. *leptotheca*	P3	Erect or spreading shrub, 0.2-0.5 m high. Fl. yellow, Jul to Oct. Sand. Near-coastal limestone ridges, outcrops & cliffs.
Jacksonia gracillima	P3	No description provided.
Pimelea calcicola	P3	Erect to spreading shrub, 0.2-1 m high. Fl. pink, Sep to Nov. Sand. Coastal limestone ridges.
Sarcozona bicarinata	P3	Shrub, ca 0.1 m high. Fl. white, Aug. White sand.
Jacksonia sericea	P4	Low spreading shrub, to 0.6 m high. Fl. orange, usually Dec or Jan to Feb. Calcareous & sandy soils.

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3. METHOD

The site was surveyed using the method set out in the Environmental Protection Authority and Department of Parks and Wildlife (2016). The two proposed roads were walked to ensure a record was made of each vegetation unit, their associated species and any additional species (opportunistic species) recorded outside of the quadrat but within the same vegetation unit. Where a vegetation unit was recorded a temporary 10m x 10m quadrat was set up using a compass and oriented due N,S,E,W. Quadrats were placed to record the variation in the vegetation and associated species. The location of the quadrats is shown in Appendix D Map 1. All species, including weeds were recorded. The vegetation, flora, Threatened and Priority Flora surveys were conducted concurrently. For each quadrat, the following were recorded in the field:

- GPS reading (WGS84, equivalent to Geocentric Datum of Australia 1994 (GDA94)) at NW corner;
- Digital photograph taken at the NW corner;
- Soil type;
- Presence, size and type of any outcropping rocks;
- Topography – eg. ridge, upper slope, middle slope, lower slope, drainage line, minor creek, major creek, wetland;
- Vegetation condition using the scale of Keighery (1994) outlined in Table 5;
- Presence of any Threatened or Priority Flora or other significant flora;
- Additional information including dieback, age since fire, predators, erosion, weeds, grazing, tracks etc.; and
- All species were listed together with their percentage cover within the quadrat and average height.

The area outside of each quadrat was also surveyed to record additional (opportunistic) species for that vegetation unit.

The vegetation units recorded at the site are described using the vegetation classification in Bush Forever (from Government of Western Australia, 2000) as described in Table 3 and the vegetation condition (from Keighery, 1994) as in Table. 4.

Table 3. Vegetation Classification (from Government of Western Australia, 2000)

LIFE FORM / HEIGHT CLASS	Canopy Cover			
	DENSE 70 % - 100%	MID DENSE 30% - 70%	SPARSE 10% - 30%	VERY SPARSE 2% - 10%
Trees over 30 m Trees 10 – 30 m Trees under 10m	Tall Closed Forest Closed Forest Low Closed Forest	Tall Open Forest Open Forest Low Open Forest	Tall Woodland Woodland Low Woodland	Tall Open Woodland Open Woodland Low Open Woodland
Tree Mallee	Closed Tree Mallee	Tree Mallee	Open Tree Mallee	Very Open Tree Mallee
Shrub Mallee	Closed Shrub Mallee	Shrub Mallee	Open Shrub Mallee	Very Open Shrub Mallee
Shrubs over 2 m Shrubs 1 – 2 m Shrubs under 1m	Closed Tall Scrub Closed Heath Closed Low Heath	Tall Open Scrub Open Heath Open Low Heath	Tall Shrubland Shrubland Low Shrubland	Tall Open Shrubland Open Shrubland Low Open Shrubland
Grasses	Closed Grassland	Grassland	Open Grassland	Very Open Grassland
Herbs	Closed Herbland	Herbland	Open Herbland	Very Open Herbland
Sedges	Closed Sedgeland	Sedgeland	Open Sedgeland	Very Open Sedgeland

Table 4. Explanation of Vegetation Condition Rating (Keighery, 1994)

Rating	Description	Explanation
1	Pristine	Pristine or nearly so, no obvious signs of disturbance.
2	Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
3	Very Good	Vegetation structure altered, obvious signs of disturbance.
4	Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it.
5	Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management.
6	Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species.

4. RESULTS

A botanical survey was undertaken on 17th November 2016 when transects were walked within the proposed roads. Prior to undertaking the field work an overlay on an aerial photograph of the track options was provided on the aerial of the site together with the easting and northing. To ensure the transects walked and the quadrats established were within the proposed development areas, way points were entered into the GPS to be used in the field. This enabled walking from one of the way points to the next ensuring that the transects walked were within the proposed area of disturbance.

By referring to Diagram 1 it can be seen that there is one road nominated from the current development site for a distance before it bifurcates, resulting in two possible road alignments which remain separated but both lead to the same larger area proposed as a car park

A total of four quadrats were surveyed. The locations of these are mapped in Appendix D Map 1, and a full description for each quadrat is provided in Appendix B.

4.1 Vegetation

There were four different vegetation units recorded from the survey area. These were:

1. Open Heath of *Melaleuca cardiophylla* over Very Open Grassland dominated by **Ehrharta longiflora* over Herbland dominated by **Raphanus raphanistrum, *Crassula glomerata* and **Petrorhagia dubia* over Sedgeland dominated by *Lomandra maritima* and *Desmocladus flexuosus.* This was represented by quadrat caq1;
2. Tall Open Scrub of *Acacia rostellifera* and *Spyridium globulosum* over Low Shrubland of *Melaleuca systena* over Open Grassland dominated by **Ehrharta longiflora* over Open Herbland dominated by **Lysimachia arvensis* over Very Open Sedgeland *of Lomandra maritima* and *Desmocladus flexuosus.* This was represented by quadrat caq2;
3. Shrubland of *Acacia rostellifera* over Low Shrubland dominated by *Rhagodia baccata* subsp. *dioica* and *Scaevola crassifolia* over Very Open Grassland dominated by **Ehrharta longiflora* over Open Herbland dominated by *Acanthocarpus preissii, *Crassula glomerata* and **Trachyandra divaricata* over Sedgeland of *Lepidosperma gladiatum.* This was represented by quadrat caq3; and
4. Low Open Shrubland of *Olearia axillaris, Scaevola crassifolia, *Pelargonium capitatum* and *Rhagodia baccata* subsp. *dioica* over Grassland dominated by *Spinifex longifolius* over Very Open Herbland dominated by **Trachyandra divaricata*. This was represented by quadrat caq4.

The vegetation units are mapped in Appendix D, Map 2. The vegetation changed from the east (quadrat caq1), then further west to quadrat caq2, then quadrat caq3 and near the beach to quadrat caq4. This change was gradual with an overlap of some species. Just above the strand line there was an area up to 5m wide where Marram Grass (**Ammophila arenaria*) was established in amongst the endemic grass *Spinifex longifolius*. The Marram Grass plants were all relatively young so it was uncertain if they had been planted or if rhizomes had come down on the current from Mindarie. Marram Grass has been used a lot to stabilize dunes but it is a weed which has the ability to change the ecosystem of the dunes it invades.

4.2 Vegetation Condition

Bushland has been historically subject to ongoing degradation and is especially susceptible to disturbances arising as a result of indirect impacts from surrounding developments and human activity. Degradation is caused by a wide range of factors, including isolation, edge effects, weed invasion, plant diseases, changes in fire frequency, landscape fragmentation, increased predation on native fauna by feral animals, decrease in species richness and general modification of ecological function. These issues affect the biodiversity rating and ecological viability of areas of remnant vegetation and should be assessed in line with conservation values.

Vegetation condition was rated according to the vegetation condition scale used in Keighery (1994). Table 4 provides the vegetation condition rating and Table 5 the vegetation condition of each of the quadrats.

Table 5. Vegetation Condition Recorded from the quadrats surveyed

Vegetation Condition	Quadrat Number
Very good	caq3
Very good to good	caq1, caq4
Good	caq2
Good to degraded	Some sections in the area of caq4
Degraded	Track through part of northern route

It can be seen from Table 5 that most of the vegetation was in good or better condition. The only area which was degraded was the along the off road vehicle track. The vegetation condition is mapped in Appendix D Map 3.

4.3 Taxa

A total of 31 vascular plant families, 58 genera and 68 taxa were recorded during the survey. All species observed are listed under vascular plant families in Appendix A.

4.4 Significant Taxa

No threatened or priority species were located during the survey.

4.5 Weeds

A total of 26 weeds were recorded from the survey area. All have been determined as weeds by the Western Australian Herbarium (2016) and Department of Parks and Wildlife (2016c). There are several ratings allocated to each weed in the Invasive Plant Prioritisation but only three have been selected to include in this report. These are ecological impacts, invasiveness and current distribution which are shown in Table 8 for each of the non-endemic species recorded. .Thirteen of the weeds recorded have a high ecological impact on the natural vegetation.

Weeds that are, or may, become, a problem to agriculture or the environment can be formally classified as Declared Plants under the *Agriculture and Related Resources Protection Act, 1976* (Department of Agriculture and Food, 2016). The Department of Agriculture and Food Western Australia and the Agriculture Protection Board maintain a list of Declared Plants for Western Australia. None of the weeds listed in Table 6 are Declared Plants.

Table 6. Weeds Recorded From the Site

Species	Common Name	Ecological Impacts	Invasiveness	Current Distribution
		Ecological impact L = low impact species M = medium impact species H=high impact species U = unknown impact	Rate of dispersal R=rapid M=moderate S=slow U=unknown	L = limited (localised) M = moderate H = high E = extensive (widespread) U =unknown
**Ammophila arenaria*	Marram Grass	U	S	L
**Avena barbata*	Bearded Grass	H	R	E
**Briza maxima*	Blowfly Grass	U	R	E
**Bromus diandrus*	Great Brome	H	R	E
**Crassula glomerata*	Stonecrop	U	R	E
**Cuscuta epithymum*	Lesser Dodder	M	M	E
**Ehrharta calycina*	Perennial Veldt Grass	H	R	E
**Ehrharta longiflora*	Annual Veldt Grass	H	R	E
**Euphorbia terracina*	Geraldton Carnation Weed	H	R	H
**Heliophila pusilla*	Heliophila	H	M	H
**Hordeum leporinum*	Barley Grass	H	U	E
**Lactuca serriola*	Prickly Lettuce	H	R	H
**Lagurus ovatus*	Hare's Tail Grass	H	R	E
**Lolium loliaceum*	Stiff Rye Grass	H	R	E
**Lysimachia arvensis*	Pimpernel	U	R	E
**Oenothera glazioviana*	Evening Primrose	L	M	H
**Pelargonium capitatum*	Rose Pelargonium	H	R	E
**Petrorhagia dubia*	Velvet Pink	M	R	E
**Raphanus raphanistrum*	Wild Radish	U	M	M
**Romulea rosea*	Guildford Grass	U	R	E
**Silene gallica*	French Catchfly	L	M	E
**Sonchus oleraceus*	Common Sowthistle	U	R	E
**Tetragona decumbens*	Sea Spinach	H	R	E
**Trachyandra divaricata*	Dune Onion Weed	M	R	H
**Urospermum picroides*	False Hawkbit	M	R	M
**Vulpia myuros*	Rat's Tail Fescue	H	R	H

Thirteen of the weeds listed above are recorded as having a high impact on the environment. The most common weeds listed as having a high impact throughout the site were **Avena barbata, *Ehrharta longiflora, *Euphorbia terracina, *Lagurus ovatus* and **Pelargonium capitatum.*

4.6 Rehabilitation

With the planned development of an access road rehabilitation and weed control will need to be undertaken. It is essential that all species used in rehabilitation are endemic to the particular vegetation unit. Appendix C lists all endemic species together with the quadrat they were recorded. By referring back to Section 4.1 the vegetation unit associated with each quadrat can be determined.

Four species were recorded from all vegetation units; *Acacia cyclops, Acanthocarpus preissii, * Olearia axillaris* and *Spyridium globulosum.* Seed collection should commence immediately and seedlings established before any site works are undertaken. Cuttings especially of *Spinifex longifolius* and *Spinifex hirsutus* should be undertaken in the sections of the car park area proposed for disturbance. The manual prepared by the Department of Planning (2011) provides excellent examples of how to propagate species. For example "the rooted cuttings of grasses (e.g. *Spinifex hirsutus* and *Spinifex longifolius*) that grow on the seaward slope of foredunes have given good results. The roots used for cuttings must be healthy and either yellowish or white in colour and the transplant site should be well moistened". Successes have been achieved by the methods they outline and *Spinifex* plants must be used along the strand line and foredune in preference to Marram Grass.

Marram Grass has been used a lot to stabilize dunes as it is adapted to sand accretion with the burial promoting leaf elongation and the development of rhizomes from the axillary buds Florabase (Western Australian Herbarium, 2016) includes a comprehensive description about this species its general biology, notes and general control. In the notes section the following information is provided. "It traps sand and builds dunes at rates much greater than that of the native species, thus out competing the native species. It interferes with the natural dynamics of the dune systems. It out-competes native vegetation and interferes with the natural dynamics of dune systems, including changing topography, adversely affecting long term development of coastal barriers, inhibits transgressive dune development, increases steepness of slopes and restricts movement of sand from beach to interior dunes. Also disrupts structure and reduces diversity of dunal arthropod communities. Harbours symbiotic nitrogen-fixing bacteria within stems and rhizomes that may contribute to its proliferation on nutrient-poor sand. Seed set, viablility and survival is low, however viablity of buds remains high following submergence in seawater, giving the potential for long-distance vegetative dispersal to other beaches."

The above information exemplifies why *Spinifex longifolius* and *Spinifex hirsutus* root cuttings should be propagated and used in preference to Marram Grass.

Coastal Planning and Management Manual (Department of Planning, (2011) provides a lot of information including weeds and their management and the selection of species for rehabilitation. In addition it outlines the different methods that can be used in rehabilitation including, direct seeding, use of nursery grown seedlings, seeds and required treatments to break dormancy, cuttings, division, layering as well as the different methods used for planting out. Planting and direct seeding must be undertaken with the onset of the winter rains.

4.7 Management of the Tamala Park Region

Several committees have been established that deal with the management of the coastal area from Mindarie to Burns Beach. These include:

1. The Tamala Park Regional Council (TPRC) is a local government group formed in 2006 specifically to implement the urban development of the Tamala Park Project (marketed as Catalina) with representatives from Town of Cambridge, City of Joondalup, City of Perth, City of Stirling, Town of Victoria Park, City of Vincent and City of Wanneroo. They manage the development of the Tamala Park Local Structure Plan covering residential density and associated requirements.

2. The Community Advisory Committee (set up in 2008 with representatives from the City of Wanneroo and City of Joondalup) was formed to produce a plan for the long term environmental management of the area between Burns Beach and Mindarie. This committee developed the Tamala Conservation Park plan, and includes members from a wide cross section of State and Local Government Agencies and community organisations. One of the many initiatives suggested by the committee is "that funding for comprehensive weed mapping and flora and fauna surveys be provided as a matter of priority for interim management of the area" – which is endorsed by author of tis current survey.
3. In March 2012 a Tamala Conservation Park was proposed and an establishment plan prepared (Western Australian Planning Commission, 2012). The area under consideration is outlined below in Diagram 3 and it can be seen that it includes the current survey area. This was proposed to be managed by the Department of Environment and Conservation (now Department of Parks and Wildlife). The Establishment Plan did not include a timetable for creation of the Conservation Park as it is understand that part of the land covered remains in private ownership. The Tamala Conservation Park has three broad zones of usage, conservation and protection, natural environmental use and recreational use (Western Australian Planning Commission, 2012). With conservation and protection the primary management concern is to ensure no further disturbance to the bushland ensuring that public access is restricted and only via walk paths. Access to the beach has been poorly managed with off road vehicle tracks crossing the bushland.

Diagram 3. Area outlined in red proposed as Tamala Conservation Park.

5. DISCUSSION

The proposed access roads were through remnant bushland with a section of the northern alternative route along an existing off road track. Four different vegetation units were recorded from the survey area. These were:

1 Open Heath of *Melaleuca cardiophylla* over Very Open Grassland dominated by **Ehrharta longiflora* over Herbland dominated by **Raphanus raphanistrum, *Crassula glomerata* and **Petrorhagia dubia* over Sedgeland dominated by *Lomandra maritima* and *Desmocladus flexuosus*;
2 Tall Open Scrub of *Acacia rostellifera* and *Spyridium globulosum* over Low Shrubland of *Melaleuca systena* over Open Grassland dominated by **Ehrharta longiflora* over Open Herbland dominated by **Lysimachia arvensis* over Very Open Sedgeland *of Lomandra maritima* and *Desmocladus flexuosus*;
3 Shrubland of *Acacia rostellifera* over Low Shrubland dominated by *Rhagodia baccata* subsp. *dioica* and *Scaevola crassifolia* over Very Open Grassland dominated by **Ehrharta longiflora* over Open Herbland dominated by *Acanthocarpus preissii, *Crassula glomerata* and **Trachyandra divaricata* over Sedgeland of *Lepidosperma gladiatum*; and
4. Low Open Shrubland of *Olearia axillaris, Scaevola crassifolia, *Pelargonium capitatum* and *Rhagodia baccata* subsp. *dioica* over Grassland dominated by *Spinifex longifolius* over Very Open Herbland dominated by **Trachyandra divaricata.*

The vegetation condition varied between very good and good except along the track where it was degraded. Weeds were common throughout the remnant bushland but were very dense along the edges of the track.

A total of 31 vascular plant families, 58 genera and 68 taxa were recorded during the survey, of which 26 taxa were weeds. None of the species were threatened or priority species and none of the weeds were listed as Declared Pants.

Marram grass (**Ammophila arenaria*) was established in amongst *Spinifex longifolius* plants above the strand. The Marram plants were all relatively young so it was uncertain if they had been planted or if they had established from rhizomes which had come down on the current from Mindarie.

Photograph of Marram Grass established above the strand line.

It is important that native species in particular *Spinifex longifolius* and *Spinifex hirsutus* be planted in preference to Marram Grass close to the strand line and in the foredunes.

It is suggested that the northern route be the one selected as some sections of this route are already degraded. The car park area should be fenced off to ensure off road drivers do not continue across the dunes and onto the beach. A fenced off sand track path should be constructed down to the beach from the car park.

The sides of the selected road must be stabilised as both routes traverse steep sided dunes, although this is not such a concern on the northern route as a track has already cut through a section of the area. In some sections the sand may need to have a wall constructed otherwise erosion will cause the sides to collapse and cover the road which could make it impassable. The environment must be conserved. This includes the dune system as well as the vegetation. People must be discouraged from walking through the dunes as this will most likely result in the destruction of some area.

The Community Advisory Committee (set up in 2008 with representatives from the City of Wanneroo and City of Joondalup) recommended that there be fenced, hard stand access from Long Beach Promenade through the reserve to the beach but with no hard stand access through to the beach. Public access to the beach must be managed to protect the environmental values of the area.

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APPENDIX A

Species List

LEGEND

ABBREVIATION	DESCRIPTION
subsp.	subspecies
var.	variety
*	weed

Vascular Plant Family	Taxon
Aizoaceae	
	Carpobrotus virescens
	**Tetragonia decumbens*
Asparagaceae	
	Acanthocarpus preissii
	Lomandra maritima
	Thysanotus arenarius
Asphodelaceae	
	**Trachyandra divaricata*
Asteraceae	
	**Lactuca serriola*
	Olearia axillaris
	Ozothamnus cordatus
	Senecio pinnatifolius var. *latilobus*
	**Sonchus oleraceus*
	**Urospermum picroides*
Brassicaceae	
	**Heliophila pusilla*
	**Raphanus raphanistrum*
Caryophyllaceae	
	**Petrorhagia dubia*
	**Silene gallica*
Chenopodiaceae	
	Rhagodia baccata subsp. *baccata*
	Rhagodia baccata subsp. *dioica*
	Threlkeldia diffusa
Convolvulaceae	
	**Cuscuta epithymum*
Crassulaceae	
	Crassula colorata
	**Crassula glomerata*
Cyperaceae	
	Isolepis marginata
	Lepidosperma calcicola
	Lepidosperma gladiatum
Ericaceae	
	Leucopogon parviflorus
Euphorbiaceae	
	**Euphorbia terracina*
Fabaceae	
	Acacia cyclops
	Acacia rostellifera
	Acacia saligna
	Gompholobium capitatum
	Hardenbergia comptoniana
	Kennedia prostrata

Vascular Plant Family	Taxon
Geraniaceae	
	**Pelargonium capitatum*
Goodeniaceae	
	Scaevola crassifolia
	Scaevola globulifera
Haemodoraceae	
	Conostylis aculeata subsp. *cygnorum*
	Conostylis candicans
Hemerocallidaceae	
	Dianella revoluta var. *divaricata*
Iridaceae	
	**Romulea rosea*
Lamiaceae	
	Hemiandra pungens
Lauraceae	
	Cassytha flava
Myrtaceae	
	Melaleuca cardiophylla
	Melaleuca systena
Onagraceae	
	**Oenothera glazioviana*
Phyllanthaceae	
	Phyllanthus calycinus
Poaceae	
	**Ammophila arenaria*
	Austrostipa flavescens
	**Avena barbata*
	**Briza maxima*
	**Bromus diandrus*
	**Ehrharta calycina*
	**Ehrharta longiflora*
	**Hordeum leporinum*
	**Lagurus ovatus*
	**Lolium loliaceum*
	Paspalum vaginatum
	Poa porphyroclados
	Spinifex hirsutus
	Spinifex longifolius
	**Vulpia myuros*
Polygalaceae	
	Comesperma integerrimum
Primulaceae	
	**Lysimachia arvensis*
Ranunculaceae	
	Clematis linearifolia
Restionaceae	
	Desmocladus flexuosus

Vascular Plant Family	Taxon
Rhamnaceae	
	Spyridium globulosum
Rubiaceae	
	Opercularia vaginata
Santalaceae	
	Exocarpos sparteus

APPENDIX B

Quadrat Data

LEGEND

ABBREVIATION	DESCRIPTION
subsp.	subspecies
var.	variety
*	weed

QUADRAT caq1

GPS (WGS84): 377775E; 6492000N
Location: Most eastern section of the proposed road
Topography: Upper slope to crest of sand dune
Soil: Grey sand
Litter: Branches 10%; Leaves 20%
Vegetation Description: Open Heath of *Melaleuca cardiophylla* over Very Open Grassland dominated by **Ehrharta longiflora* over Herbland dominated by **Raphanus raphanistrum*, **Crassula glomerata* and **Petrorhagia dubia* over Sedgeland dominated by *Lomandra maritima* and *Desmocladus flexuosus*
Vegetation Condition: Good to very good
Notes: Numerous weeds

SPECIES	HEIGHT (cm)	% COVER
Acacia cyclops	70	1
Acanthocarpus preissii	30	2
Austrostipa flavescens	90	1
**Avena barbata*	90	5
**Bromus diandrus*	60	<1
Conostylis aculeata subsp. *cygnorum*	50	12
**Crassula glomerata*	5	15

SPECIES	HEIGHT (cm)	% COVER
Desmocladus flexuosus	50	10
Dianella revoluta subsp. *divaricata*	70	1
**Ehrharta calycina*	90	2
**Ehrharta longiflora*	80	20
**Euphorbia terracina*	70	5
Hardenbergia comptoniana	twiner	<1
**Lagurus ovatus*	30	2
Leucopogon parviflorus	60	1
**Lolium loliaceum*	70	<1
Lomandra maritima	60	50
**Lysimachia arvensis*	20	5
Melaleuca cardiophylla	200	50
**Petrorhagia dubia*	60	15
Phyllanthus calycinus	50	2
**Raphanus raphanistrum*	90	20
Rhagodia baccata subsp. *baccata*	50	2
**Silene gallica*	60	10
**Sonchus oleraceus*	50	1
Spyridium globulosum	200	5
**Urospermum picroides*	60	3
Acacia rostellifera	opportunistic	
Acacia saligna	opportunistic	
Clematis linearifolia	opportunistic	
Comesperma integerrimum	opportunistic	
Exocarpus sparteus	opportunistic	
Gompholobium capitatum	opportunistic	
**Hordeum leporinum*	opportunistic	
Isolepis marginata	opportunistic	
Kennedia prostrata	opportunistic	
Lepidosperma calcicola	opportunistic	
Melaleuca systena	opportunistic	
Olearia axillaris	opportunistic	
**Pelargonium capitatum*	opportunistic	
Thysanotus arenarius	opportunistic	

QUADRAT caq2

GPS (WGS84): 377550E; 6491850E
Location: **S**outhern proposed track
Topography: Middle slope
Soil: Grey sand
Litter: Branches 5%; Leaves 25%
Vegetation Description:. Tall Open Scrub of *Acacia rostellifera* and *Spyridium globulosum* over Low Shrubland of *Melaleuca systena* over Open Grassland dominated by **Ehrharta longiflora* over Open Herbland dominated by **Lysimachia arvensis* over Very Open Sedgeland *of Lomandra maritima* and *Desmocladus flexuosus*
Vegetation Condition: Good
Notes: Very occasional *Xanthorrhoea preissii* recorded opportunistically

SPECIES	HEIGHT (cm)	% COVER
Acacia rostellifera	300	15
Austrostipa flavescens	90	2
**Briza maxima*	50	5
Clematis linearifolia	twiner	2
Conostylis aculeata subsp. *cygnorum*	30	1
**Crassula glomerata*	10	5
Desmocladus flexuosus	40	5
Dianella revoluta subsp. *divaricata*	70	1

SPECIES	HEIGHT (cm)	% COVER
**Ehrharta calycina*	80	5
**Ehrharta longiflora*	60	10
**Euphorbia terracina*	60	5
Gompholobium capitatum	30	<1
**Lagurus ovatus*	50	<1
Lepidosperma calcicola	50	1
**Lolium loliaceum*	90	<1
Lomandra maritima	50	5
**Lysimachia arvensis*	30	15
Melaleuca systena	80	10
Opercularia vaginata	40	<1
Poa porphyroclados	70	1
**Romulea rosea*	40	<1
**Sonchus oleraceus*	60	<1
Spyridium globulosum	250	40
Acanthocarpus preissii	opportunistic	
**Bromus diandrus*	opportunistic	
Cassytha flava	opportunistic	
Comesperma integerrimum	opportunistic	
Conostylis candicans	opportunistic	
Hardenbergia comptoniana	opportunistic	
Leucopogon parviflorus	opportunistic	
Olearia axillaris	opportunistic	
**Pelargonium capitatum*	opportunistic	
Rhagodia baccata subsp. *baccata*	opportunistic	
Scaevola globulifera	opportunistic	
**Trachyandra divaricata*	opportunistic	

QUADRAT caq3

GPS (WGS84): 377425E; 6491800N
Location: Last tall dune before beach
Topography: Upper slope to crest
Soil: Pale grey sand
Litter: Leaves 20%
Vegetation Description:. Shrubland of *Acacia rostellifera* over Low Shrubland dominated by *Rhagodia baccata* subsp. *dioica* and *Scaevola crassifolia* over Very Open Grassland dominated by **Ehrharta longiflora* over Open Herbland dominated by *Acanthocarpus preissii*, **Crassula glomerata* and **Trachyandra divaricata* over Sedgeland of *Lepidosperma gladiatum*
Vegetation Condition: Very Good
Notes: Valleys between the dunes had dense cover (>75%) of *Lepidosperma gladiatum*

SPECIES	HEIGHT (cm)	% COVER
Acacia rostellifera	150	15
Acanthocarpus preissii	30	5
**Bromus diandrus*	80	1
**Crassula glomerata*	5	10
**Ehrharta longiflora*	70	5
Hardenbergia comptoniana	twiner	<1
**Lactuca serriola*	10	<1

SPECIES	HEIGHT (cm)	% COVER
Lepidosperma gladiatum	120	40
Olearia axillaris	70	1
**Pelargonium capitatum*	50	1
Rhagodia baccata subsp. *dioica*	100	5
Scaevola crassifolia	80	5
Senecio pinnatifolius var. *latilobus*	40	1
**Sonchus oleraceus*	70	2
**Trachyandra divaricata*	60	5
Carpobrotus virescens	opportunistic	
Cassytha flava	opportunistic	
Clematis linearifolia	opportunistic	
**Cuscuta epithymum*	opportunistic	
**Heliophila pusilla*	opportunistic	
Hemiandra pungens	opportunistic	
**Lagurus ovatus*	opportunistic	
Melaleuca systena	opportunistic	
Ozothamnus cordatus	opportunistic	
Poa porphyroclados	opportunistic	
Scaevola globulifera	opportunistic	
Spyridium globulosum	opportunistic	
**Tetragona decumbens*	opportunistic	
Threlkeldia diffusa	opportunistic	
Thysanotus arenarius	opportunistic	

QUADRAT caq4

GPS (WGS84): 377325E; 6491875N
Location: Just back from the beach
Topography: Fore dune
Soil: Pale grey/white sand
Litter: Leaves 5%
Vegetation Description:. Low Open Shrubland of *Olearia axillaris, Scaevola crassifolia, *Pelargonium capitatum* and *Rhagodia baccata* subsp. *dioica* over Grassland dominated by *Spinifex longifolius* over Very Open Herbland dominated by **Trachyandra divaricata*
Vegetation Condition: Good to very good
Notes: Just before the drop down to the water there was a belt about 5m wide where young Marram grass (**Ammophila arenaria)* was dominant and growing between the plants of *Spinifex longifolius.* Many of the plants recorded a dense infestation of the native parasitic twiner *Cassytha flava* If the infestation is very heavy it has the capacity to kill plants

SPECIES	HEIGHT (cm)	% COVER
Acanthocarpus preissii	50	2
**Avena barbata*	100	5
Cassytha flava	twiner	30
**Crassula glomerata*	10	2
Olearia axillaris	100	3
Ozothamnus cordatus	40	<1

SPECIES	HEIGHT (cm)	% COVER
**Pelargonium capitatum*	50	5
Rhagodia baccata subsp. *dioica*	50	2
Scaevola crassifolia	50	5
**Sonchus oleraceus*	70	1
Spinifex longifolius	80	40
**Tetragona decumbens*	30	1
**Trachyandra divaricata*	60	15
**Vulpia myuros*	15	2
Acacia cyclops	opportunistic	
**Ammophila arenaria*	opportunistic	
Carpobrotus virescens	opportunistic	
Crassula colorata	opportunistic	
**Oenothera glazioviana*	opportunistic	
Paspalum vaginatum	opportunistic	
Spinifex hirsutus	opportunistic	
Spyridium globulosum	opportunistic	
Threlkeldia diffusa	opportunistic	

APPENDIX C

Endemic species recorded from each quadrat (introduced species removed)

LEGEND

ABBREVIATION	DESCRIPTION
subsp.	subspecies
var.	variety
*	weed
+	species recorded

ENDEMIC SPECIES	QUADRAT NUMBER			
	caq1	caq2	caq3	caq4
Acacia cyclops	+	+	+	+
Acacia rostellifera	+	+	+	
Acacia saligna	+			
Acanthocarpus preissii	+	+	+	+
Ammophila arenaria				+
Austrostipa flavescens	+	+		
Carpobrotus virescens			+	+
Cassytha flava		+	+	+
Clematis linearifolia	+	+	+	
Comesperma integerrimum	+	+		
Conostylis aculeata subsp. *cygnorum*	+	+		
Conostylis candicans		+		
**Crassula glomerata*	+	+	+	+
Desmocladus flexuosus	+	+		
Dianella revoluta subsp. *divaricata*	+	+		
Exocarpus sparteus	+			
Gompholobium capitatum	+	+		
Hardenbergia comptoniana	+	+	+	
Hemiandra pungens			+	
Isolepis marginata	+			
Kennedia prostrata	+			
Lepidosperma calcicola	+	+		
Lepidosperma gladiatum			+	
Leucopogon parviflorus	+	+		
Lomandra maritima	+	+		
Melaleuca cardiophylla	+			
Melaleuca systena	+	+	+	
Olearia axillaris	+	+	+	+
Opercularia vaginata		+		
Ozothamnus cordatus			+	+
Paspalum vaginatum				+
Phyllanthus calycinus	+			
Poa porphyroclados		+	+	
Rhagodia baccata subsp. *baccata*	+	+		
Rhagodia baccata subsp. *dioica*			+	+
Scaevola crassifolia			+	+
Scaevola globulifera		+	+	
Senecio pinnatifolius var. *latilobus*			+	
Spinifex hirsutus				+
Spinifex longifolius				+

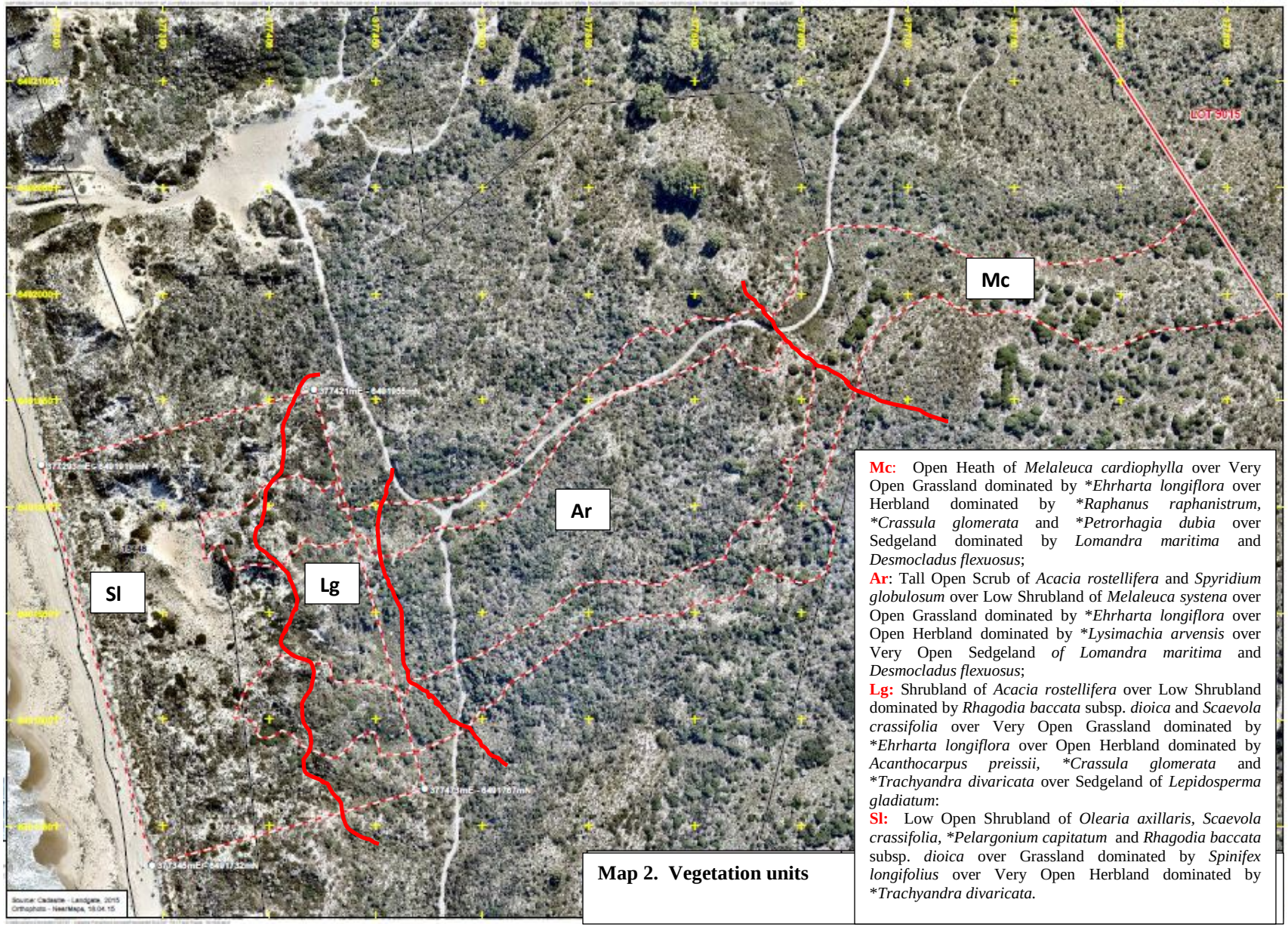
ENDEMIC SPECIES	QUADRAT NUMBER			
	caq1	**caq2**	**caq3**	**caq4**
Spyridium globulosum	+	+	+	+
Threlkeldia diffusa			+	
Thysanotus arenarius	+		+	

APPENDIX D

Maps

1. Location of quadrats
2. Vegetation units
3. Vegetation condition

Map 1. Location of quadrats



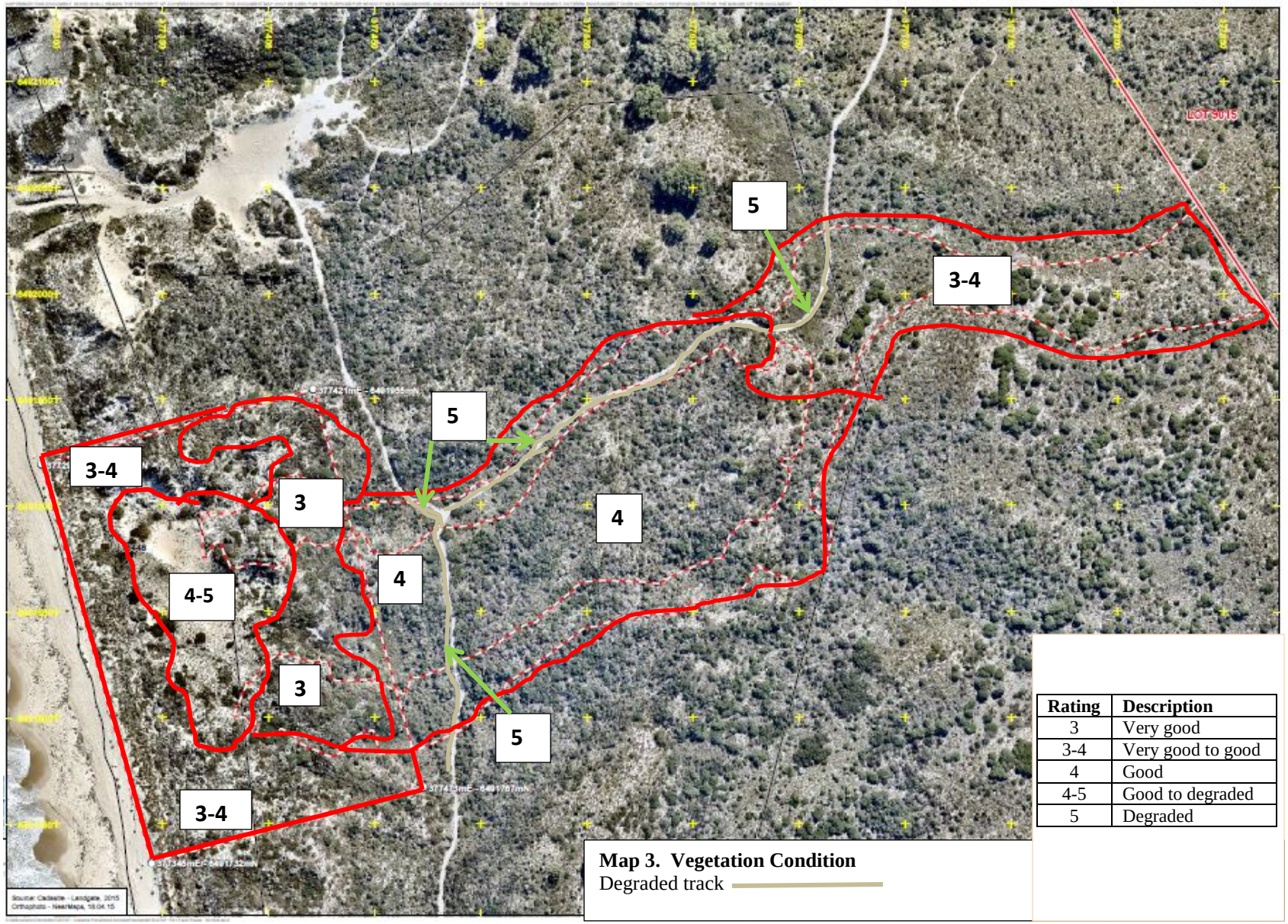
Mc: Open Heath of *Melaleuca cardiophylla* over Very Open Grassland dominated by **Ehrharta longiflora* over Herbland dominated by **Raphanus raphanistrum*, **Crassula glomerata* and **Petrorhagia dubia* over Sedgeland dominated by *Lomandra maritima* and *Desmocladus flexuosus*;

Ar: Tall Open Scrub of *Acacia rostellifera* and *Spyridium globulosum* over Low Shrubland of *Melaleuca systena* over Open Grassland dominated by **Ehrharta longiflora* over Open Herbland dominated by **Lysimachia arvensis* over Very Open Sedgeland *of Lomandra maritima* and *Desmocladus flexuosus*;

Lg: Shrubland of *Acacia rostellifera* over Low Shrubland dominated by *Rhagodia baccata* subsp. *dioica* and *Scaevola crassifolia* over Very Open Grassland dominated by **Ehrharta longiflora* over Open Herbland dominated by *Acanthocarpus preissii*, **Crassula glomerata* and **Trachyandra divaricata* over Sedgeland of *Lepidosperma gladiatum*:

Sl: Low Open Shrubland of *Olearia axillaris*, *Scaevola crassifolia*, **Pelargonium capitatum* and *Rhagodia baccata* subsp. *dioica* over Grassland dominated by *Spinifex longifolius* over Very Open Herbland dominated by **Trachyandra divaricata.*

Map 2. Vegetation units



Rating	Description
3	Very good
3-4	Very good to good
4	Good
4-5	Good to degraded
5	Degraded

Map 3. Vegetation Condition
Degraded track