



Technical Appendix C1

Flora and Vegetation

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GORGON DEVELOPMENT ON BARROW ISLAND

TECHNICAL REPORT

FLORA AND VEGETATION

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Summary

A total of 68 families, 180 genera and 406 vascular plant taxa have been recorded on Barrow Island (Attachment A). The total of 406 vascular plant species, subspecies and varieties constitutes approximately 23 per cent of the flora recorded for the Pilbara region. Fourteen vascular plant species have been introduced to the Island, the majority of which have been recorded in the vicinity of previously disturbed sites.

No Declared Rare Flora species, as listed under subsection (2) of Section 23F of the Western Australian *Wildlife Conservation Act 1950* and as listed by the Department of Conservation and Land Management (2003a, 2004a), have been found on Barrow Island. Two Priority species have been collected on Barrow Island: *Helichrysum oligochaetum* (Priority 1) and *Corchorus interstans* ms (Priority 3).

The Priority 1 species *Helichrysum oligochaetum* is known to occur on Barrow Island and was searched for during post cyclonic rain surveys (April and May 2004) to check for potential presence on the proposed development site. *Corchorus interstans* ms (Priority 3) was recorded within the proposed gas processing plant site and the proposed North White's Beach pipeline. *Corchorus interstans* ms is widely distributed on parts of the Island and the mainland and 'has also been observed to regenerate successfully on rehabilitated sites' (Astron Environmental 2002).

No vegetation communities listed under The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* have been recorded or are known to occur on Barrow Island. No threatened ecological community as listed by CALM's Threatened Ecological Database (2003c) has been recorded or is known to occur on Barrow Island.

Barrow Island's vegetation has been previously classified by Buckley (1983) into eight major vegetation units. They were subsequently divided into 34 vegetation types based on major landforms, soil types and species composition by Mattiske (1993b). In recent, more detailed mapping of the vegetation on the proposed development area and associated infrastructure corridors, 83 vegetation communities (Attachment B and Attachment C) were defined and mapped within the proposed gas processing facility and wider study area and the proposed pipeline routes.

Flora and vegetation communities, especially those of particular significance located within the proposed development area, are discussed in this technical appendix to the ERMP for the Gorgon Gas Development.

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1 Introduction

Barrow Island is approximately 70 km off the coast of Western Australia and falls within the Fortescue Botanical District, which itself is a component of the Eremaean Botanical Province (Beard 1980). Climate, landforms and soils determine the distribution of vegetation and plant communities within the Fortescue Botanical District (Beard 1975, Beard 1990).

Barrow Island consists primarily of an undulating limestone plateau (Beard 1975). The southern end of the island is low lying and sandy with Quaternary beach sands and sandy bays. The central part of the island consists of many small limestone ridges and slopes. The northern and eastern sides of the island consist of low cliffs with intervening sandy flats and bays. The western side of the island is more exposed and consists of deeper drainage valleys within the limestone plateau and sandy beaches and narrow near-coastal dune systems.

This report details the findings of a series of vegetation surveys of the proposed gas processing facility and surrounding areas on the eastern side of the island (Figure 2-1) and of three proposed pipeline routes, which extend to the western and northern boundaries of Barrow Island (Figure 3-1 to 5-2), as detailed below:

- the proposed CO₂ reinjection pipeline deviates north from the proposed feed gas pipeline and runs north to Cape Dupuy (Figure 3-1 to 3-6) *this option has since been dropped from Development plan,*
- the proposed feed gas pipeline route runs from a northerly point on the proposed CO₂ reinjection line north-west to North White's Beach (Figure 5-1 and 5-2).
- an alternative feed gas pipeline route runs from the east side of the island close to the 'Terminal Tanks', west to Flacourt Bay (Figure 4-1 to 4-4) ,

The methodology for the above surveys is detailed in Section 2.2. The findings of a preliminary vegetation survey of the proposed pipeline corridor on the mainland on Mardie Station are also discussed in this report.

This appendix is a stand alone document as per EPA Guidance No. 51. A summary of the report is included in the ERMP document.

2 Methods

2.1 Historical Data

A series of vegetation and flora studies have been undertaken on Barrow Island since the 1960's (Butler (1970), Buckley (1983), West Australian Petroleum Pty Ltd (1988), Mattiske and Associates (1993a, 1993b) and Astron (2002)).

Many available species lists from the series of studies undertaken on Barrow Island (Attachment F) were merged and the names checked against those currently accepted by the Western Australian Herbarium using the MAX database and the Department of Conservation and Land Management's (2003b, 2004b) FloraBase and in consultation with other experienced botanists working on the island including Vicki Long, Arthur Weston and Libby Mattiske. Peer review of the species lists for the technical report were

undertaken by Vicki Long and review of the technical report was undertaken by Arthur Weston as per EPA Guidance No. 51.

The amalgamated list, including historical synonyms was used by the team to assist in facilitating plant identifications and to identify gaps in existing collections.

While undertaking a review of the amalgamated species list for the island, substantial changes in identifications and in taxonomic nomenclature were noted.

2.2 Field Program

The initial botanical surveys conducted for the proposed Gorgon development areas were undertaken by botanists with significant survey experience, as per EPA Guidance No. 51. The botanical team consisted of a team of eight botanists with vast collective botanical survey experience. Members of the team have been coordinating and participating in botanical surveys in excess of 5 years for most individuals and more than 10 and 30 years botanical survey experience for others. The botanical team contained individuals with significant botanical experience, including significant experience in the Pilbara region. Members of the original survey team were used for all subsequent botanical surveys for the project.

2.2.1 Proposed Gas Processing Facility Site

The wider study area for this study is located on the eastern side of the island, approximately halfway between the northern and southern ends of the island (Figure 2-1). It covers a rectangular area of approximately 1683 ha and is bound on the eastern side by the island's coast. The proposed gas processing facility falls within the eastern side of this area and covers approximately 134 ha.

The field program was designed in consultation with CALM to ensure consistency with other regional studies and databases.

Plots were selected to represent undisturbed vegetation within the proposed development area and surrounding areas. Areas of previous disturbance, for example by seismic lines or clearing, were avoided. The plots were selected on the basis on aerial photography, GIS information and field observations.

In September and October 2003, fifty six 50 m x 50 m plots, each divided into 10 m x 10 m quadrats were established within the proposed gas processing facility site and wider study area. Gaps in representation of vegetation communities within the wider study area were identified through preliminary analysis and a further fifteen plots were established in the area in January 2004. This resulted in a total of seventy two plots.

The data collected in the January 2004 survey were collected in an identical manner to the September and October 2003 surveys, by members of the original field team to ensure continuity in the datasets.

Physical limitations precluded establishing 50 m x 50 m square plots in some communities. In small or linear communities (e.g. coastal, dunes, creeks), the plots consisted of abutting and continuous 10 m x 10 m quadrats within the community boundary, with as many quadrats as possible (up to 25).

The establishment of 10 m x 10 m quadrats allowed comparison with previously established 20 m x 20 m plots on the island (Mattiske 1993b) and with data collected by Trudgen (1989).

Two post-cyclonic rain surveys of the proposed development area were undertaken in April and May 2004, approximately six to eight weeks after Cyclone Monty passed over Barrow Island. Two post-cyclonic rain surveys were undertaken in accordance with EPA Guidance No. 51, in order to complement the initial survey which was undertaken after a long dry period. The first post-cyclonic rain survey focussed primarily on collection of annual grass species and the second on general annual species that may have germinated as a result of the recent rains. The 50 m x 50 m vegetation plots established within the proposed gas processing facility were reassessed as part of the post-cyclonic rain surveys.

In each 10 m x 10 m quadrat the percentage foliage cover was recorded, instead of numbers of individuals, due to difficulties in accurately counting *Triodia* hummocks.

Flora of interest that occurred outside the recording sites was noted during the field surveys.

2.2.2 Proposed Pipeline Routes

A continuous transect, at least twice the width of the proposed pipeline easement, was surveyed for the three proposed pipeline routes:

- the feed gas pipeline from Flacourt Bay to the gas processing facility,
- the alternate feed gas pipeline from North White's Beach to the proposed gas processing facility and,
- the proposed CO₂ reinjection pipeline from the proposed gas processing facility to Cape Dupuy.

The entire length of each of the proposed pipeline routes (Figure 3-1 to Figure 5-2) was surveyed on foot, with either a new site recorded with every change in vegetation or notes taken with reference to the recurrence of a previously observed community.

Percentage foliage cover and height range of each species were recorded and photographs and GPS locations were taken at the Northwest corner at each site.

2.3 Plant Identifications

All plant specimens were processed (pressed and dried) on site and then returned to Perth for identification.

Plant specimens were identified by experienced botanists and all specimens were compared with plant collections at the Western Australian Herbarium. Some plant identifications required further specialist input. *Corchorus* specimens were sent to Dr David Halford at the Queensland Herbarium for identification. *Acacia* specimens were confirmed by Dr Bruce Maslin of the Western Australian Herbarium and specimens of *Chenopodiaceae* were identified by Dr Paul Wilson of the Western Australian Herbarium.

Liaison with the Western Australian Herbarium was undertaken as per EPA Guidance No. 51 and specimens collected as part of the surveys on Barrow Island will be

submitted for mounting, and will be included in the Western Australian Herbarium and Karratha regional herbarium collections.

2.4 Data Analyses

The data were loaded into a proprietary SQL-compliant database. All taxon names were corrected against the names in the most recent CALM census.

Basic statistics of the percentage cover observations were calculated using the SYSTAT statistical software package. These included means, ranges and medians. Histograms of each taxon were prepared in order to check statistical distributions of the taxa. Box and whisker plots were produced for each taxon in order to identify any outliers in the data set. These outliers were then rechecked for validity against the field sheets, and corrected as necessary.

PATN software was used to analyse both the data recorded in the vegetation plots within the proposed gas processing facility plant area and a merged data set which included previous survey data. Initial data analyses were undertaken on presence/absence, percentage live foliage cover and total percentage foliage cover, by plot and by individual quadrat.

Hierarchical clustering was undertaken using two principal association measures, Bray and Curtis and Cosine (or Ochiai). Hierarchical fusion clustering was undertaken using a number of strategies. Nearest Neighbour, Furthest Neighbour, Flexible WPGMA (weighted pair group arithmetic averaging), Flexible UPGMA (unweighted pair group arithmetic averaging) using $\beta = -0.1$, UPGMC (unweighted pair group centroid) and WPGMC (weighted pair group centroid) were evaluated.

Dendrograms were produced for each combination of association measure and clustering strategy. A TWINSPAN run was undertaken using the plot data. All of the clustering was undertaken on both plots and quadrats (Q mode). Some R mode clustering was investigated on taxa.

Outputs were then compared and interpreted in relation to other data, notes and aerial photographs.

2.5 Vegetation Mapping

2.5.1 Proposed Gas Processing Facility Development and Wider Study Areas

Vegetation within the proposed gas processing facility development and wider study areas (Figure 2-1) was mapped from detailed observations, aerial photograph interpretation and data from the detailed recording sites.

Vegetation along the proposed pipeline options was mapped from detailed site observations, aerial photograph interpretation and plant specimen collections. Plots were not established along the proposed pipeline routes and therefore statistical and cluster analyses of the proposed pipeline routes were not undertaken for this area of the study.

Barrow Island was classified into eight major vegetation units by Buckley (1983). These were subsequently refined and mapped as 34 vegetation types, based on major landforms, soil type and species composition, by Matiske and Associates (1993b) (Figure 6-1 to

Figure 6-2). The Mattiske mapping units were based on vegetation components, as follows:

- M Marine — 1 vegetation type
- T Tidal — 2 vegetation types
- C Coastal Complex and Dunes Systems — 7 vegetations types
- D Drainage lines and creeks — 3 vegetation types
- F Flats — 7 vegetation types,
- L Limestone Ridges and Slopes — 10 vegetation types,
- S Clay Pans — 2 vegetation types,
- V Valley Slopes and Escarpment Slopes — 2 vegetation types.

Trudgen's (2002) adaptation of Aplin's (1979) modification of Specht's (1970) vegetation classification system was used in order to allow cover of species with less than two per cent cover to be considered. This system allows for the 'low cover of many strata in the vegetation of more arid areas' (Trudgen 2002). Species with greater than 0.5 percent cover were included in vegetation descriptions for this study.

Vegetation communities were mapped in accordance with EPA Guidance No. 51. Vegetation communities for the proposed gas processing facility and wider study area were described on the basis of the relationships between plots in the cluster analysis, tables of alive and dead species, covers and original field plot community descriptions, and Trudgen's (2002) vegetation classification system. The term 'tall' is substituted for 'high' in vegetation descriptions in this report.

2.6 Limitations

The initial surveys followed a significant period without substantial rains and consequently, the full floral diversity, of annual species in particular, would have been underestimated. Further surveys undertaken after cyclonic rain improved the representation of ephemeral flora. However it is assumed that additional species would be found after several 'good' seasons.

Although plots were established extensively within the proposed gas processing facility area and the wider surrounding study area, it was not logistically possible to establish plots for analysis of vegetation over the whole island. For this reason, analysis was undertaken using data from vegetation plots established in the current survey and that from plots established previously on the island to assist in the assessment of representation of vegetation on the island. Some temporal variation in vegetation would be introduced by using data from different years. This may reduce the accuracy of our assessment of representation of vegetation communities on the island.

3 Flora

3.1 Barrow Island

The Eremaean nature of the flora on Barrow Island is demonstrated by the dominance of families such as Poaceae (grasses), Chenopodiaceae (chenopods), Papilionaceae (peas), Malvaceae and Asteraceae (daisies). The dominant flora, namely *Triodia* and *Acacia*, are typically Eremaean (Mattiske 1997).

The Department of Conservation and Land Management (2004a, 2004b) currently has 1733 records of flora taxa for the Pilbara region, which covers about 178 017 km².

The flora of Barrow Island is typical of the arid Pilbara region but has floral affinities with the Cape Range area on the mainland (Trudgen 1989; Mattiske Consulting 1997), particularly in coastal areas, and with the Pilbara and Kimberley regions for other flora (Table 3-2).

Trudgen (1989) based the similarities between the vegetation of Cape Range and Barrow Island on the dominance of *Melaleuca* with *Triodia* hummock grasses and the presence of selected species such as *Acanthocarpus verticillatus*, *Lechenaultia divaricata*, *Olearia* sp. and *Scaevola crassifolia*. The *Lechenaultia* sp. highlighted by Trudgen (1989) may correspond to an unidentified *Lechenaultia* sp. on Barrow Island (Attachment F).

These floral linkages reflect the diversity of the environments on Barrow Island, as well as the past linkages to the mainland.

A total of 68 families, 180 genera and 406 vascular plant taxa have been recorded on Barrow Island (Attachment A). The flora includes 250 perennial species, 75 annual species and 81 species which are considered to be annual or perennial species (Attachment A and Attachment F). The Barrow Island flora constitutes approximately 23 per cent of the flora records for the Pilbara region. Fourteen vascular plant taxa have been introduced to the island, the majority of which have been recorded in the vicinity of previously disturbed sites.

Table 3-1 (below) summarises the number of vascular plant taxa recorded from the various studies that have been undertaken on Barrow Island, as shown in full in Attachment F.

Table 3-1 – Number of Vascular Plant Taxa on Barrow Island

Data Source	No. of Vascular Plant Taxa
Barrow Island records	201
Western Australian Herbarium ^	199
Karratha Herbarium ^	124
Buckley and Butler ^(Buckley 1980)	215
Lewis and Grierson ^(1989)	56
M.E. Trudgen (1989)	69
Mattiske & Associates (1993a)	76
Mattiske & Associates (1993b)	166
Astron Environmental (2002, 2004)	213
RPS Bowman Bishaw Gorham (2003, 2004)	164
Pilbara Region – CALM Florabase (2004b)	1733
Current Barrow Island Flora Tally	406

Note: ^ Many voucher plant specimens were not relocated – totals are an overestimate of potential numbers.

It is estimated that at least 90 per cent of the total vascular plant flora of the island has been documented through these studies. Approximately 20 to 30 per cent of the species on the island would occur only after cyclonic rain or as ephemerals after fires.

Table 3-2 summarises the geographical spread of species recorded on Barrow Island. The table is expanded further in Attachment A.

Table 3-2 – Geographical Affinities of Species and Taxa Recorded on Barrow Island with Other Parts of the Region

Regional Distribution	Number of Species/Taxa
Potentially restricted to Barrow Island (section 3.2)	17
Kimberley	122
Pilbara	193
Cape Range and southern districts	50
Widespread (multiple botanical districts)	115

The flora of Barrow Island is regionally significant because there are species or taxa that:

- appear to be restricted to the island
- represent the southern limit of plants of the Kimberley region
- represent the western limit of plants of the Pilbara region
- represent the northern limit of the plants of Cape Range and southwards.

3.1.1 Rare and Priority Flora

No protected plant taxa listed under Section 179 of the EPBC Act and no Declared Rare Flora species, listed under subsection (2) of Section 23F of the *Wildlife Conservation Act* or listed by CALM (2004a) were located during surveys on Barrow Island.

Two Priority Flora species have been collected on Barrow Island:

- *Helichrysum oligochaetum* (Priority One), and
- *Corchorus interstans* ms (Priority Three).

Helichrysum oligochaetum was recorded on the flats south of the proposed gas processing facility and north of the current ChevronTexaco camp (Mattiske & Associates 1993b). This species is only known from six records at the Western Australian Herbarium and was not found within the proposed gas processing facility footprint or proposed pipeline routes during the initial or post cyclonic rain surveys.

Corchorus interstans ms is represented by only four collections in the Western Australian Herbarium but is widespread on Barrow Island and known to extend into the Pilbara region. It was recorded in 18 of the 24 vegetation communities defined in the wider study area, in eight of the nine communities located within the proposed gas processing facility area, along the Flacourt Bay feedgas pipeline route and on the proposed CO₂ reinjection line (Attachment G and Attachment H). The Herbarium collection will be supplemented by collections from the current study.

Specimens collected on the proposed pipeline routes which were potentially *Corchorus interstans* ms were recently identified as *Corchorus congener*, *Corchorus ?congener*, *Corchorus maccottii* and *Corchorus* sp. Further collection of *Corchorus* specimens along the proposed pipeline routes would be required to confirm the identification of the *Corchorus* sp. collections and to determine the potential distribution of *Corchorus interstans* ms along these routes.

3.1.2 Restricted Flora

The plant species listed in Table 3-3 are considered to have restricted distributions. They either have a limited distribution on Barrow Island or occur as range extensions from other botanical regions in Western Australia.

Table 3-3 – Restricted Flora on Barrow Island and their Presence in the Gorgon Development Areas

Taxa	Regional Range and Barrow Island Occurrence	Present in Proposed Gorgon Development Area
<i>Acacia conleana</i>	Appears to extend from Barrow Island to the Kimberley region. Restricted to one small population on the island.	This species was not located in the proposed development areas.
<i>Acacia inaequilatera</i> (dwarf form)	This variant is restricted to the south-west corner of the island and differs from the mainland variant.	This variant was not located in the proposed development areas.

Taxa	Regional Range and Barrow Island Occurrence	Present in Proposed Gorgon Development Area
<i>Acacia synchronicia</i>	Is very restricted on Barrow Island but appears to be widespread in mainland areas.	This species was not located in the proposed development areas, but occurs to the north and northeast of the existing airstrip.
<i>Cassytha capillaris</i>	This creeper extends from Barrow Island to the Kimberley and Pilbara regions.	This species was not located in the proposed development areas.
<i>Cullen patens</i> (formerly known as <i>Psoralea patens</i>)	Extends from Barrow Island to the Pilbara and southern areas. This species is relatively restricted on the island.	This species was not located in the proposed development areas.
<i>Dichanthium sericeum</i> subsp. <i>humilius</i>	This subspecies extends from Barrow Island to the Kimberley and Pilbara regions.	This subspecies was recorded within the proposed gas processing facility area in recent post-cyclonic rain surveys.
<i>Dysphania kalpari</i>	This species is widespread on the mainland, but its distribution on Barrow Island is unknown.	This species was not located in the proposed development areas.
<i>Erythrina vespertilio</i>	This species is restricted on the island to five main populations and localised scattered trees. Although this species is considered to be relatively widespread in the State, on Barrow Island it is very restricted. The main areas were initially defined and mapped as vegetation community F4 (Mattiske and Associates, 1993b).	The species was recently mapped within vegetation community F4a along the proposed CO ₂ reinjection pipeline.
<i>Eucalyptus xerothermica</i> ms	This species is restricted to localised patches, three main small populations and a few scattered trees on the island. This species is widespread in the Pilbara region.	This species was not located in the proposed development areas.
<i>Euphorbia</i> sp. A	This species requires further taxonomic investigations.	This species was not located in the proposed development areas.
<i>Ficus opposita</i> var. <i>aculeata</i> (formerly recorded as <i>Ficus opposita</i> var. <i>micrantha</i>)	This species is known from only one location in the south-west section of the island and from three recent collections on the island. This species extends in distribution to the Pilbara and Kimberly regions.	This species was not located in the current proposed development areas.
<i>Gossypium australe</i>	This species extends from Barrow Island to the Kimberley and Pilbara regions.	This species was not located in the proposed development areas.
<i>Grevillea pyramidalis</i> subsp. <i>leucadendron</i>	Scattered populations of this subspecies occur in the middle of the island, near the central east coast and in the northwest of the island.	This subspecies was recorded in communities L6b, L6c and L6d on the proposed North White's Beach pipeline route and in community L6a, south-east of the proposed camp area.

Taxa	Regional Range and Barrow Island Occurrence	Present in Proposed Gorgon Development Area
<i>Hakea lorea</i> subsp. <i>lorea</i>	This subspecies was previously located in scattered populations in the central part of the island and is recognised as being widespread in the Pilbara region. It is now known to occur in a range of vegetation community types on the island.	This subspecies occurs in several communities associated with a range of site conditions from valleys (V1m and V3b) to drainage systems (D1a) and limestone slopes and ridges (L3i, L5a and L6a) within the proposed development area.
<i>Halosarcia indica</i> subsp. <i>julacea</i>	This subspecies extends from Barrow Island to the Kimberley. Restricted to tidal flood areas of the island.	This subspecies was not located in the proposed development area.
<i>Hibiscus sturtii</i> var. <i>platychlams</i>	This variety extends from Barrow Island to the Pilbara region. Located on edges of red sandy areas and in gullies on western and northern edges of the island.	This variety was not located in the proposed development area.
<i>Hybanthus aurantiacus</i>	This species extends from Barrow Island to the Kimberley and Pilbara regions. Previously located on a disturbed site on northern section of the island.	This species was located in communities L3a, L5a and V1m in the proposed gas processing facility footprint and wider study area and within plot 15 under the proposed footprint. This species is a relatively short-lived plant, which occurs after favourable seasonal rains.
<i>Isotropis atropurpurea</i>	This species extends from Barrow Island to the Kimberley and Pilbara. Localised occurrence on the island.	This species was not located in the proposed development area.
<i>Mallotus dispersus</i> (formerly recorded as <i>Mallotus didmochryseus</i>)	This species is restricted on Barrow Island and extends to the Kimberley.	This species was not located in the proposed development area.
<i>Santalum murrayanum</i>	Restricted to one valley on the island. This species extends from Barrow Island southwards.	This species was not located in the proposed development area.
<i>Sporobolus mitchellii</i>	This species, although restricted in occurrence on Barrow Island, is widespread on the mainland. It has only been recorded in the south-west of the island.	This species was not located in the proposed development area.
<i>Stemodia glabella</i>	This species is relatively widespread on the mainland, but its distribution on Barrow Island is unknown. It extends from Barrow Island to the Kimberley and Pilbara regions.	This species was not located in the proposed development areas. Further investigations are required to clarify the taxonomy of the <i>Stemodia</i> species on the island.
<i>Whiteochloa airoides</i>	This species extends from Barrow Island to the Kimberley and Pilbara regions. This species has been recorded on the western coastal area and inland. It appears that this grass may be grazed in some areas and therefore may be more widespread following favourable seasonal conditions for establishment and growth.	This species was located on the proposed feed gas pipeline area.

An additional 17 taxa are potentially restricted to Barrow Island and require further attention in order to confirm their classification, distribution and conservation status (Attachment A). This group includes variants of *Acacia bivenosa* and *Corchorus* sp. and the following:

- *Abutilon* sp. (VL-2706-09)
- *Calandrinia* aff. *remota*
- *Euphorbia* aff. *drummondii* (Boodie Island)
- *Ficus brachypoda* (hairy variant – ex *Ficus platypoda* var. *lachnocaula*)
- *Heliotropium* sp. (VL-2104-19)
- *Isolepis* sp.
- *Lechenaultia* sp. (VL-BW103-13)
- *Marsilea* ?*hirsuta*
- *Ptilotus obovatus* (adherent prostrate from on island)
- *Scaevola* sp. (VL-2104-26)
- *Sida* sp. (VL-2709-14).

Species that tend to be restricted to creek beds and gullies on Barrow Island are of conservation significance, due to the historical loss of this habitat through anthropogenic disturbance. The taxa associated with these habitats include *Abutilon otocarpum*, *Dysphania kalpari*, *Euphorbia* sp. A, *Gossypium australe* and *Hibiscus sturtii* var. *platychlamyis*.

3.1.3 Introduced Species

Fourteen plant species have been introduced to Barrow Island (Table 3-4).

Table 3-4 – Introduced Species Previously Recorded on Barrow Island

FAMILY	GENUS AND SPECIES
AMARANTHACEAE	<i>Aerva javanica</i> (Kapok bush)
ASTERACEAE	<i>Arctotheca calendula</i> (Cape weed)
	<i>Conyza sumatrensis</i> (Tall fleabane)
	<i>Pseudognaphalium luteoalbum</i> (Jersey cudweed)
	<i>Sonchus oleraceus</i> (Milk thistle)
CYPERACEAE	<i>Isolepis marginata</i> (Coarse club-rush)
MALVACEAE	<i>Malvastrum americanum</i> (Spiked Malvastrum)
MYRTACEAE	<i>Eucalyptus gomphocephala</i> (native to SW EA – planted)
PASSIFLORACEAE	<i>Passiflora foetida</i> var. <i>hispida</i> (Wild passionfruit)
POACEAE	<i>Cenchrus ciliaris</i> (Buffel grass)
	<i>Cynodon dactylon</i> (Couch grass)
	<i>Setaria verticillata</i> (Whorled pigeon grass)
POLYGONACEAE	<i>Emex australis</i> (Doublegee)
SOLANACEAE	<i>Solanum nigrum</i> (Blackberry nightshade)

Astron Environmental (2002) notes that *Malvastrum americanum* was rated by CALM in 1999 as being 'moderate' in its potential to invade and endure, and that the weed has become naturalised on the Pilbara mainland.

3.2 Proposed Development Areas

3.2.1 Species of Conservation Significance in Proposed Development Areas

The occurrence of restricted species within the proposed development areas is detailed at Table 3-3 above. The significant species recorded within the proposed development areas are further described below:

Species restricted to specific areas on the island

Erythrina vespertilio occurs within vegetation community F4a on the proposed CO₂ reinjection pipeline (Figure 3-1) and an isolated tree of this species was located near the proposed North White's Beach pipeline.

Grevillea pyramidalis subsp. *leucadendron* occurs within community L6a near the proposed camp site (Figure 2-1) and communities L6b, L6c and L6d along the proposed North White's Beach pipeline (Figure 5-1, Figure 5-2). Scattered populations have been recorded in the centre of Barrow Island (Mattiske and Associates 1993b).

Hakea lorea subsp. *lorea* occurs in several communities associated with a range of site conditions from valleys (V1m and V3b) to drainage systems (D1a) and limestone slopes and ridges (L3i, L5a and L6a) within the proposed gas processing facility area, the proposed feed gas pipeline corridor and the proposed CO₂ reinjection pipeline corridor. Prior to this study it was recorded by Mattiske (1993b) as occurring only in scattered populations in the middle of the island, but has since been recorded in a variety of communities.

Melaleuca cardiophylla occurs in vegetation communities D1a, F8a, L3h, L7a, L7b, V1d, V1k and V1m, of which communities D1a, F8a, V1d, V1k and V1m occur within the proposed gas processing facility footprint (Figure 2-1). This species was recorded within approximately 1583ha of vegetation type L7 (Mattiske and Associates 1993b). This species is now known to be widely distributed on the island, but remains significant due to its ecological function as fauna habitat.

Dichanthium sericeum subsp. *humilius* is an annual grass that was recorded in two locations within the proposed gas processing facility area during the post cyclonic rain surveys. Mattiske and Associates (1993b) also found the species amongst the chenopod fringes of Barrow Island. This subspecies extends from Barrow Island to the Kimberley and Pilbara regions and is expected to be widely distributed on the island, but distribution on the island is unknown.

Hybanthus aurantiacus occurs in vegetation community V1m within the proposed gas processing facility area and in communities L3a, L5a and V1m in the wider study area. This species extends from Barrow Island to the Kimberley and Pilbara regions and is also located on a disturbed site in the northern part of Barrow Island. It is a relatively short-lived species which occurs after favourable seasonal rains. Although some populations will be affected by the proposed gas processing facility, the majority of the populations will not be affected.

Whiteochloa airoides grows on the proposed feedgas pipeline route. This species extends from Barrow Island to the Kimberley and Pilbara regions and has been recorded on the western coastal area and in the centre of the island. It appears that this grass is heavily grazed and therefore is likely to be more widespread following favourable seasonal conditions for establishment and growth.

Several different forms of *Acacia bivenosa* were recorded in the survey of the proposed gas processing facility and wider study areas. Two forms of *Acacia bivenosa* were apparent in the collections — a ‘normal’ variant and an ‘elongate phyllode variant’ (Bruce Maslin, Western Australian Herbarium, personal communication). Further assessment of these forms and other *Acacia* species on Barrow Island is anticipated in the future to determine whether they are genetic variants.

Table 3-5 summarises the number of vascular plant taxa and families recorded within the proposed development areas. Attachment G and Attachment H show the taxa recorded in plots within the proposed gas processing facility.

Table 3-5 – Numbers of Plant Taxa and Families Recorded within Proposed Gorgon Development Areas

Proposed Development Area	No. Taxa	No. Families	Dominant Families
Proposed gas processing facility wider study area	115	38	Poaceae (13 taxa), Asteraceae (11 taxa), Tiliaceae (10 taxa), Mimosaceae (6 taxa), Euphorbiaceae (7 taxa) and Papilionaceae (6 taxa)
Proposed gas processing facility footprint (species recorded in six vegetation plots within footprint)	48	26	Euphorbiaceae (7 taxa), Poaceae (5 taxa), Asteraceae (3 taxa), Papilionaceae (4 taxa)
Proposed CO ₂ reinjection pipeline	68	30	Poaceae (9 taxa), Asteraceae (4 taxa), Mimosaceae (4 taxa) and Papilionaceae (5 taxa)
Proposed feed gas pipeline	60	27	Poaceae (12 taxa), Asteraceae (5 taxa) and Papilionaceae (4 taxa)
Proposed North White’s Beach pipeline	67	27	Chenopodiaceae (9 taxa), Poaceae (9 taxa) and Asteraceae (7 taxa)

Table 3-6 shows the numbers of annual and perennial species recorded within vegetation plots in the proposed gas processing facility area, before and after the post-cyclonic rain surveys.

Thirteen additional species were recorded in the proposed gas processing facility and wider study areas. Eleven additional species were recorded on the proposed feed gas pipeline area, 16 additional species were recorded on the proposed CO₂ reinjection pipeline area and 11 additional species were recorded on the proposed North White’s Beach pipeline as a result of post-cyclonic rain surveys.

Table 3-6 – Annual and Perennial Species Recorded in Plots within the Proposed Development Area Before and After Post-cyclonic Rains

Annual/Perennial	Plot 1		Plot 2		Plot 3		Plot 15		Plot 46		Plot 47	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
A	0	3	1	3	0	0	0	1	0	3	0	2
P	5	7	10	11	13	14	12	16	9	9	9	10
A/P	1	4	1	8	1	2	0	3	0	0	0	0
total	6	14	12	22	14	16	12	18	9	12	9	12
Increase # species after rain	-	8	-	10	-	2	-	6	-	3	-	3
% species increase	-	133.3	-	83.3	-	87.5	-	50	-	33.3	-	33.3

Note: Pre = number of annuals/perennials in initial plot surveys (September/October/ December 2003),

Post = number of annuals/perennials in post rain surveys (April/May 2004)

New Records for Barrow Island

Nine new records or confirmed identities for Barrow Island were added to the list of vascular plant species as a result of the post-cyclonic rain surveys on the island.

These new records and confirmations are described in the following.

Tephrosia clementii has not previously been recorded for Barrow Island and was found in limestone community F5d (Figure 3-1) on the proposed CO₂ pipeline route. This species differs from *Tephrosia rosea* var. *clementii*, which was previously recorded on Barrow Island. The Western Australian Herbarium's current MAX database lists four varieties of *Tephrosia rosea*: var. *clementii*, var. *glabrior*, var. *rosea* and var. *venulosa*. Both *Tephrosia clementii* and *Tephrosia rosea* var. *clementii* names are current.

The recent collections of *Tephrosia clementii* were very small and herbaceous. Only five collections of the species are lodged at the Western Australian Herbarium. The limited collections and knowledge of the distribution of this species suggests that listing by CALM as a Priority species may be considered. Further survey work will be required to determine the distribution of this species on the island.

The Southern Pilbara — Carnarvon Coastal form of *Eriachne flaccida* (Trudgen 2002), was collected from the clay pan community S1a on the proposed CO₂ reinjection pipeline and confirms the identity of the previous collection from the same area. Trudgen (2002) noted that the *Eriachne* specimen from Barrow Island differs from the inland Pilbara material for *Eriachne flaccida* in seven ways. However, it is the same as R. Buckley's collection of the species from Barrow Island and a few coastal specimens from the Carnarvon area.

An unidentified *Isolepis* sp. was found within the proposed gas processing facility footprint after the post-cyclonic rains, in the south-west corner of the proposed footprint, and at two locations outside the proposed footprint. The Barrow Island

specimens do not match any known *Isolepis* specimen held in the Western Australian Herbarium (Cate Tauss (pers. comm.)), apart from a specimen recently collected in Perth. There is potential for the species to be a new native species, or a cosmopolitan species of Asian origin. Further investigation of this species is required to resolve its taxonomic and biogeographical affinities.

Tribulus hirsutus was recorded within community F8a in the wider study area (Figure 2-1) and Community F5c on the proposed CO₂ reinjection pipeline. It appears to be a new record for the island. The species has a distribution that extends from the Pilbara to parts of the Kimberley.

Corchorus congener was added to the species list for the island after recent identifications of *Corchorus* specimens by David Halford of the Queensland Herbarium. This species has been recorded near Exmouth but had not been previously recorded on Barrow Island.

Corchorus congener was found within the proposed gas processing facility footprint. Specimens tentatively identified as *Corchorus congener* were also located within the wider study area surrounding the proposed gas processing facility footprint (Figure 2-1) and on the proposed North White's Beach pipeline route. Further survey and collections would be required to determine the distribution of this species on the island.

The other taxa added to the Barrow Island flora list after the recent post-cyclonic rain surveys include *Evolvulus alsinoides* var. *villosicalyx*, *Ptilotus fusiformis* var. *fusiformis* and introduced species *Setaria verticillata*. None of these three records appear to be significant range extensions. However, the collection of a new introduced species (*Setaria verticillata*) near the proposed North White's Beach pipeline corridor warrants further investigation.

Little is known about the non-vascular plant species in the Pilbara region. Fruiting bodies of an unidentified fungus were observed on a termite mound on the proposed CO₂ reinjection pipeline route (Plate 1). No non-vascular plant species were observed within the proposed development area during post-cyclonic rain surveys.

3.2.2 Proposed Gas Processing Facility

Forty eight taxa, from 26 families were recorded from six plots within the proposed facility footprint, after post-cyclonic rain surveys. These totals probably underestimate the number of species within the gas processing facility footprint and represent less than half of the taxa in the area.

No introduced species were recorded in the proposed gas processing facility or the wider study area.

3.2.3 Proposed Pipeline Corridors

Each of the three pipeline routes yielded more than 60 plant taxa (Table 3-5). One introduced species, *Setaria verticillata*, was recorded outside the proposed North White's Beach pipeline in the post-cyclonic rain surveys.

The flora values in these pipeline areas will be assessed further as part of the finalisation of the alignment of the pipelines.

3.2.4 Proposed Mainland Pipeline Corridor

A preliminary flora and vegetation survey of the proposed mainland pipeline route, adjacent to the existing Apache pipeline on Mardie Station south of Karratha, was undertaken in May 2003. Preliminary vegetation assessment of this area, which has coastal mangrove and samphire communities, salt pans and inland terrestrial vegetation communities, is shown in section 4.2.3 of this report and in Appendix J and Chapter 11 of the main report. Further collections and identifications are required to complete a species list for the proposed mainland pipeline survey area.

4 Vegetation

Generally, the vegetation of the near-coastal environments are relatively consistent within the Pilbara region. The typical pattern of vegetation comprises mangroves in tidal areas, *Spinifex longifolius* assemblages on the foredunes, halophytic communities on the saline flats, stunted vegetation on the near-coastal rocky headlands, and hummock grasslands of *Triodia* on the inland areas. The grass species and emergent shrubs and trees in these hummock grasslands reflect local patterns in landforms, soils and moisture availability.

4.1 Vegetation Types of Barrow Island

The 34 vegetation types mapped by Mattiske and Associates (1993b) were further refined to create 83 mapping units after surveys of the proposed development areas (Figures 1-1 to 1-4). The mapping codes for the vegetation communities were linked to previous mapping studies by Mattiske and Associates (1993a) and Astron Environmental (2002).

Additional vegetation communities that were delineated and mapped within and near the proposed development area were the rocky headlands (mapping unit R) and disturbed areas (Dist). Disturbed areas include roads, areas of recent disturbance, seismic lines and areas of historical disturbance where partial regrowth of vegetation had occurred, well pad areas and areas of disturbance around the Terminal Tanks and the old airport (Figure 2-1).

The ground-truthing and high resolution aerial photography used in the current survey facilitated the clarification of some vegetation types and hence there are some discrepancies between the various maps. For example it facilitated the definition of the new vegetation type (F8) on the flats near the proposed gas processing facility footprint.

4.2 Proposed Development Area

4.2.1 Proposed Gas Processing Facility

Figure 2-1 shows the distribution of vegetation communities in the vicinity of the proposed gas processing facility footprint (including proposed plant, camp area and adjoining road).

Table 4-1 shows the areas of the 11 vegetation communities, areas of disturbance and unvegetated rocks which will potentially be impacted by the proposed gas processing facility.

Table 4-1 – Vegetation Communities and Areas Potentially Impacted by the Proposed Gas Processing Facility Footprint

Vegetation Community	Area (ha)
C2a	0.20
C2b	0.002
C5a	0.58
D1a	0.09
Disturbed Areas	0.66
F8a	47.86
L3a	1.34
L3f	6.24
L3i	28.06
L7b	2.20
Rocks (unvegetated)	0.50
V1d	3.15
V1k	10.70
V1m	31.77

The dominant communities within the proposed gas processing facility area as shown in the table above are V1m, F8a and L3i. Community V1m consists of *Melaleuca* and *Acacia* heath over mixed *Triodia* hummock grassland on limestone slopes and ridges. Community F8a consists of *Acacia bivenosa* shrubland over mixed *Triodia* hummock grassland on flats and valley floors. Community L3i consists of *Acacia bivenosa* shrubland over mixed *Triodia* hummock grassland on limestone slopes, small rises and flats.

Vegetation within a wider study area surrounding the proposed gas processing facility footprint was mapped to provide context and guidance for the location of the proposed gas processing facility footprint. The wider study area totals approximately 1483 ha (Figure 2-1). Of this, approximately 64ha has been previously cleared or disturbed for roads, terminal tanks and oil remediation areas. A further 40 ha has been disturbed within the wider study area by the removal of drainage soil material for road works and well sites.

The wider study area contains 26 vegetation communities. Substantial areas of communities such as F8a (*Acacia bivenosa* and *Triodia wiseana* ‘flats’) occur in the east, with ten undulating limestone slope and ridge communities and eight valley slope communities with minor drainage lines in the west. Small pockets of the limestone community (L6a), dominated by *Grevillea pyramidalis* subsp. *?leucadendron* and *Triodia angusta*, are located in the south-east of the wider study area (Figure 2-1).

Several major drainage gullies occur within the wider study area and flow towards the east coast of the island. Some of these drainage gullies have been disturbed as a result of ‘borrowing’ of soil material. The east coast of the island forms the eastern edge of the

wider study area and supports four coastal dune vegetation communities and one coastal limestone cliff vegetation community (Figure 2-1).

Data Analyses

Dendrograms (Figure 7-1 to 7-3) were used as a means of checking groupings and the resulting vegetation communities for the proposed gas processing facility and for a comparison of this area with the remainder of Barrow Island.

The results for some of the more distinct vegetation communities reflected sharp boundaries in site conditions, whilst other less-distinct vegetation communities were related and reflected only subtle differences in species composition. In general, there was a reliance on experience of the ecologists in delineating the less-distinctive communities.

In delineating the groups the following trends were observed:

- Although plots established in dune areas were located both on top of dunes and in swales between the dunes, and aerial photography showed the two areas as differing in appearance, several of these plots were linked closely in the output of the analysis. It appears that the composition and percentage cover of species in these differing parts of the dune system were sufficiently similar to allow the grouping of the plots into the same vegetation community.
- Although plot 47 was not linked closely in the dendrogram with the other plots containing *Melaleuca cardiophylla*, it was grouped within *Melaleuca* community V1m as a result of the presence of this dominant species and certain other species, and its topographical position in the landscape.
- Although the *Melaleuca* plots were linked closely in the dendrograms, the plots were divided into upper slope, valley and flats communities.
- Plot 12 was not linked closely to other dune plots as it was a transect that traversed several different coastal communities adjacent to a major creek line.

4.2.2 Proposed Pipeline Corridors

Proposed CO₂ Reinjection Pipeline

The corridor surveyed for the proposed CO₂ reinjection pipeline extends from near the proposed gas processing facility footprint almost to Cape Dupuy at the northern end of the island, and has an approximate width of 60m (Figure 3-1 to 3-6). Of the 70 ha mapped within the pipeline survey area, approximately half of that would be expected to be impacted by the proposed pipeline. Forty three vegetation communities were mapped within the proposed corridor survey area, approximately six hectares of which has been previously disturbed or cleared for roads.

Vegetation along the corridor consists predominantly of 13 'flats' communities, located more commonly in the north of the island, with 11 valley slopes communities and 11 undulating limestone slopes and ridge communities in the southerly extent of the corridor (Figure 3-1 to 3-6). Of the 'flats' communities recorded along this corridor, one community (F4a) is dominated by *Erthyria vespertilio*, *Triodia wiseana* and *Triodia angusta*. Approximately 0.3 ha of this community is expected to be impacted by the proposed pipeline corridor.

Six drainage communities occur intermittently along this route, of which 1.5 ha of major drainage is likely to be impacted by the proposed corridor. One coastal community was recorded at the northern end of the proposed pipeline corridor. A clay pan community (S1a) was also recorded in this corridor, 0.3 ha of which is likely to be impacted by the proposed corridor.

Proposed Feed Gas Pipeline

The proposed feed gas pipeline corridor extends from near the proposed gas processing facility footprint to Flacourt Bay, on the west coast of the island (Figure 4-1 to 4-4). The area surveyed for this pipeline was approximately 50 m wide. It includes 23 vegetation communities over an area of about 44 ha, of which approximately 22 ha is expected to be impacted by the proposed corridor. Approximately 3.5 ha of this area has been previously disturbed or cleared for roads.

For much of the corridor length, vegetation consists predominantly of seven undulating limestone slope and ridge communities and seven valley slope communities.

The proposed corridor intersects two major and two minor drainage vegetation communities and additional minor drainage lines within the limestone and valley slope communities. Approximately 0.5 ha of major drainage lines are expected to be impacted by the proposed corridor. The undulating limestone communities toward the western end of the proposed corridor drop away steeply to Flacourt Bay, which supports five coastal vegetation communities; C1d, C2e, C5b, C5c and C4e, which are restricted to the small erodible beach dunes and limestone flats (Figure 4-1 to 4-4).

Proposed North White's Beach Pipeline

The proposed North White's Beach pipeline corridor is located in the north of the island. It extends west from the proposed CO₂ reinjection pipeline to the northern end of White's Beach on the west coast of the island (Figure 5-1 to 5-2). The area surveyed for this pipeline is approximately 50 m wide and includes 20 vegetation communities over an area of about 20 ha, of which approximately 10 ha is likely to be impacted by the proposed pipeline. Of this area, less than 0.03 ha has previously been disturbed.

The proposed North White's Beach pipeline corridor contains two valley slope vegetation communities and seven undulating limestone vegetation communities, of which three are dominated by *Grevillea pyramidalis* subsp. *?leucadendron* over *Triodia epactia* or *Triodia wiseana*. A total of about 3ha of communities containing *Grevillea pyramidalis* subsp. *?leucadendron* is likely to be impacted by the proposed pipeline. Several of the valley slope and limestone vegetation communities contain minor drainage lines.

The vegetation opens out into two 'flats' communities near the west coast, separated in parts by a small area of limestone vegetation community (L3c) containing scattered herbs and grasses, of which approximately 0.1 ha is likely to be impacted by the proposed pipeline. A third 'flats' community is located further east on the proposed corridor.

The proposed North White's Beach pipeline corridor supports eight coastal vegetation communities, including elevated dunes, swales and flats (Figure 5-1 and 5-2).

4.2.3 Proposed Mainland Pipeline Corridors

The proposed mainland pipeline route is adjacent to an existing Apache pipeline on Mardie Station, south of Karratha. Preliminary vegetation mapping of the proposed pipeline route showed intertidal vegetation in this area, including mangroves consisting of *Avicennia marina* subsp. *?eucalyptifolia*, *Bruguiera exaristata* and *Rhizophora stylosa*, areas of samphires consisting of a low shrubland of *Halosarcia halocnemoides* subsp. *tenuis*, *Halosarcia indica* and *Suaeda arbusculooides* and unvegetated tidal flats (Plate 69, Plate 70 and Plate 71).

Preliminary assessment of the inland vegetation along the proposed mainland pipeline route includes communities consisting of the following:

- A Grassland of *Triodia epactia* and *?Cenchrus* sp. with *Eragrostis dielsii* and *Eragrostis falcata* with occasionally emergent *Acacia farnesiana*, *Acacia trachycarpa*, *Lawrencia viridigrisea* and *Neobassia astrocarpa* shrubs on raised red earth mounds (Plate 72).
- A Low Open Shrubland including *Acacia* sp. over grassland with *Dicanthium sericeum* subsp. *humilius*, *Eriachne flaccida*, *Aristida holathera* var *holathera* and *Eriachne benthamii* over a Very Open Herbland including *Rhynchosia minima* and *Neptunia dimorphantha* on red earth flats (Plate 73).
- An Open Shrubland to Tall Open Shrubland of *Acacia trachycarpa*, *Acacia ancistrocarpa*, *Acacia elachantha*, *Acacia victoriae* and *Acacia xiphophylla* over a Grassland of *Triodia epactia* and *?Cenchrus* sp. over mixed herb species on red sandy flats (Plate 74). This community was recorded at the eastern end of the proposed mainland pipeline route, near the existing compressor station.

Confirmation of the identification of the *?Cenchrus* sp. specimen and other specimens collected in the preliminary survey is likely to indicate the significant presence of introduced species *Cenchrus ciliaris* along this proposed route; Arthur Weston (pers.comm) notes that it is almost certainly this species. Detailed vegetation mapping and Declared Rare and Priority Flora searches should be undertaken prior to finalisation of the route.

4.3 Vegetation Representation on Barrow Island

4.3.1 Dendrogram Outputs

In reviewing the dendrograms the initial letter and first number code were consistent among recent and historical vegetation studies on the island, however, an additional letter was added for the vegetation communities defined for the proposed gas processing facility site as the studies were then undertaken at a more detailed sampling level. Therefore C2 and L3 (Mattiske 1993b) can be compared with C2a and L3a to L3i respectively.

The dendrogram for the sites on the proposed gas processing facility reflected some key groupings (Figure 7-1 to 7-3). For example, the coastal communities C1a, C2a and C5a were delineated in the first of the groupings.

The dendrogram for the sites on the proposed gas processing facility area and the wider island reflects the complexity of the vegetation on Barrow Island. As for the proposed gas processing facility site, some of the groupings reflect overlap with similar vegetation community types, whilst others were grouped with apparently dissimilar community types. In general, although the samples were based on different survey times, some

general trends were consistent, for example, the valley (V) and drainage (D) types overlapped in some of the groupings, and the coastal (C) and flat (F) types overlapped or merged due to the species' composition, reflecting similar underlying soil types.

The results for the D2 and V1 communities in Figure 6-1 reflect the concentrated effort of Trudgen in 1989 (sites prefixed by MET) on the vegetation in the valleys and gullies.

4.3.2 Representation of Vegetation Communities

In reviewing the representation of the vegetation communities on the island it is important to recognise the different data sets used. To address the differences between the data sets, the various mappings undertaken to date were related through the vegetation mapping codes in Attachment C. The use of related mapping codes also allowed linkage of similar vegetation descriptions from work undertaken by Astron Environmental (2002) and vegetation descriptions for the current study. Codes for similar units mapped by Astron Environmental in 2002 units were given a prefix 'A' (Attachment C).

4.3.3 Representation of Significant Vegetation Communities

The vegetation communities on the proposed development area were assessed by comparison of the 2003/2004 studies with previous findings on the vegetation of the island (Mattiske and Associates 1993b). The communities and representation are summarised in Attachment C and discussed in the following.

4.4 Significant Vegetation Types

Criterion 2 of the 'Guidelines for applying criteria to assess the level of threat to ecological communities' (Environment Australia 2004) uses a total of 1000 ha as an indicative threshold for identifying terrestrial vegetation communities with small distributions as 'very restricted'.

Based on the combined areas of the vegetation types as defined by Mattiske (1993b) only eight vegetation types defined for Barrow Island cover more than 1000 ha (D2, F1, F5, L1, L3, L7, L9 and V1), with the remaining 26 vegetation types covering less than 1000 ha (M1, T1, T2, C1, C2, C3, C4, C5, C6, C7, D1, D3, F2, F3, F4, F6, F7, L2, L4, L5, L6, L8, L10, S1, S2 and V2). All of the vegetation communities mapped recently in the proposed development area, including F8 and V3, which were not defined and mapped prior to the current survey, cover less than 1000 ha. These communities are well represented on the island and the 1000 ha guideline has not been adopted in the current assessment.

In assessing the representation of vegetation types and vegetation communities, the scale of definition is critical in applying criteria defined by others. At this point, the vegetation mapping by Mattiske and Associates (1993b) as the vegetation type scale, the regional mapping by Beard (1975) and the extensive botanical experience by various authors (Astron, Trudgen and Mattiske) provide a wider context in which to assess the significance of the vegetation on Barrow Island. Therefore, the representation and significance of the vegetation communities in the proposed development area have been assessed against the broader vegetation types that have been defined for Barrow Island.

Comparisons were also made with previous studies on the seismic lines and drainage areas (Mattiske and Associates 1993a; Mattiske Consulting 1997; Trudgen 1989). The significance of these relationships with the environment has been used in the interpretation of representation.

Previous broad-scale mapping on the island undertaken by Mattiske and Associates (1993b) used prefixes to categorise the vegetation assemblages. For example, limestone outcropping ridge and slope community descriptions are grouped as 'L', valley systems as 'V', drainage areas as 'D', coastal communities as 'C' and communities on the extensive sandy flats as 'F'. Astron Environmental (2002) further expanded this coding system to define communities within the broader units, for example C1a. This methodology has been employed for the current study to enable linkage to previous studies.

The representation of the vegetation types within those defined and mapped previously by Mattiske and Associates (1993b), and for the recently mapped proposed development, are reviewed below.

- **'Marine' community (M1 vegetation type)** occurs within localised pockets (covering approximately 24.67 ha) on the fringes of the more protected southern and eastern coastlines (Mattiske and Associates 1993b). On current knowledge of regional communities, this vegetation type is well represented on the mainland. This type was not recorded in the proposed development area.
- **'Tidal' communities (T vegetation types)** occur in very localised pockets (covering approximately 16.6 ha) on the tidal areas scattered around the island (Mattiske and Associates 1993b). These vegetation types have similarities with halophytic communities on the mainland, although further regional comparisons are required. These types were not recorded within the proposed development area.
- **'Coastal' communities (C vegetation types)** occur in very localised pockets (covering approximately 1536.8 ha) on the island. Some have similarities with mainland coastal communities, whilst others appear to differ from those on the mainland. Further regional studies and comparisons with coastal areas in the Pilbara and Cape Range areas are required. Based on recent vegetation community mapping (Figure 2-1 to 5-2) and estimates of vegetation types (Mattiske and Associates 1993b), 0.5 per cent of the combined 'C' types on the island occur within the proposed development area.
- **'Drainage and creekline' communities (D vegetation types)** occur in linear patterns (covering approximately 1137.56 ha) along the floors of broader valley systems. These communities have been widely disturbed by historical activities on Barrow Island and this significance has been highlighted by Trudgen (1989). Based on recent vegetation community mapping (Figure 2-1 to 5-2) and estimates of vegetation types (Mattiske and Associates 1993b), 0.6 per cent of the combined 'D' types on the island may occur within the proposed development area.
- **'Flats' communities (F vegetation types)** occur on broad sandy flats, largely located on the northern, eastern and southern fringes (covering approximately 72.1 ha) of the island. Based on recent vegetation community mapping (Figure 2-1 to 5-2) and estimates of vegetation types (Mattiske and Associates 1993b), 1.8 per cent of the combined 'F' types on the island occur within the proposed development area.
- **'Limestone' communities (L vegetation types)** occur on the shallow limestone ridges and slopes located mainly on the central part of the island (covering

approximately 9444.1 ha). Based on recent vegetation community mapping (Figure 2-1 to 5-2) and estimates of vegetation types (Mattiske and Associates 1993b), 0.9 per cent of the combined 'L' types on the island occur within the proposed development area.

- **'Clay Pan' communities (S1 and S2 vegetation types)** occur on the localised clay pans located on flow lines and flats on the island (covering approximately 193.2 ha). Similar clay pan communities have been recorded by Trudgen and Mattiske in the Pilbara region and are generally associated with significant shifts in the local floristic composition of the communities. Based on recent vegetation community mapping (Figure 2-1 to 5-2) and estimates of vegetation types (Mattiske and Associates 1993b), 0.3 per cent of the combined 'S' types on the island occur within the proposed development area.
- **'Valley slopes and escarpment slopes' communities (vegetation types V1 and V2)** occur on the various slopes of the narrow and broad valley systems. Based on recent vegetation community mapping (Figure 2-1 to 5-2) and estimates of vegetation types (Mattiske and Associates 1993b), 1.2 per cent of the combined 'V' types on the island occur within the proposed development area.

Although several halophytic communities occur south of the proposed North White's Beach pipeline route and will not be impacted by the current proposal, it is important to highlight their presence in the event that a change of pipeline route is considered. Halophytic communities have been identified as one of the restricted communities on the island and should be avoided by proposed developments.

4.4.1 Significant Vegetation Communities

Communities with Restricted Distribution or Threatened or Restricted Species

Beyond the extent of representation of a vegetation community, flora and vegetation may be significant for a variety of reasons, including the presence of rare, threatened or geographically-restricted species or restricted distribution of the community. While there are recognised limitations with respect to representation of vegetation on Barrow Island, the vegetation communities located within the proposed development considered to be of particular significance (Figure 8-1 to 8-4) include the following:

- *Erythrina vespertilio* has a restricted distribution on Barrow Island, and consequently vegetation community F4a, which was recorded on the proposed CO₂ reinjection pipeline in the current survey, is considered to be locally significant. Of this community, 0.6 ha may be impacted by the proposed development. 127.6 ha within five main populations of the broader F4 unit have been mapped previously on Barrow Island (Mattiske and Associates 1993) (Plate 20).
- *Grevillea pyramidalis* subsp. *leucadendron* has a patchy and restricted distribution on Barrow Island, and consequently vegetation communities L6a, L6b, L6c and L6d which contain the species *Grevillea pyramidalis* subsp. *leucadendron* are considered to be locally significant. Two small areas of community L6a are located south of the proposed gas processing facility, in the south-east part of the wider study area (Plate 49).

The proposed campsite, to the south of the proposed gas processing facility, was relocated during the design stage to avoid community L6a. Of communities L6b, L6c

and L6d, 1.2 ha, 1.5 ha and 0.19 ha respectively are likely to be impacted by the North White's Beach pipeline route (Figure 5-1 to 5-4).

Major Drainage Areas

The proposed feed gas pipeline and proposed CO₂ reinjection pipeline cross several areas of major drainage line which are restricted in distribution as a result of historical 'borrowing' of soil material. Approximately 0.5 ha and 1.5 ha of these communities are likely to be impacted by the proposed feed gas pipeline and proposed CO₂ reinjection lines, respectively (Figure 3-1 to 4-4). A drainage area of 0.092 ha may be affected by the proposed camp site (Plate 10 to 19).

Otherwise Significant Vegetation Communities

Previously mapped vegetation type L7 as defined by Mattiske and Associates (1993b) contains *Melaleuca cardiophylla*, which is significant for supporting the restricted and endemic White-winged fairy-wren (*Malurus leucopterus edouardi*) which is listed as Vulnerable under the Western Australian Wildlife Conservation Act and the EPBC Act. In recent mapping of the wider study area the species was recorded in vegetation communities D1a, F8a, L3h, L7a, L7b, V1d, V1k and V1m, of which five communities; D1a, F8a, V1d, V1k and V1m, totalling 93.57 ha were mapped beneath the proposed gas processing facility footprint (Figure 2-1). A total of 1583.84 ha of vegetation type L7 has been previously mapped for the island (Mattiske and Associates 1993b).

Communities Requiring Further Investigation

A range of communities within the proposed development area are either patchy or very restricted in area and require further investigation to clarify their significance. These communities include:

- A range of coastal communities defined and mapped at the western end of the proposed feed gas pipeline, including communities C1d, C2e, C5b, C5c and C4e, which are restricted to the near-coastal areas. Total areas of 0.13 ha, 0.19 ha, 0.22 ha, 0.07 ha and 0.38 ha respectively, would be affected by the proposed pipeline route. (Plate 2, Plate 7, Plate 8). Only one other small area with strong affinities with these communities has been found.
- The clay pan community S1a (Plate 55) recorded on the proposed CO₂ reinjection pipeline. Of this community, 0.3 ha may be impacted by the proposed pipeline. Community S1a relates to broader scale mapping unit S1 (Mattiske and Associates 1993b) which is represented by 192.3 ha on Barrow Island. This community is significant as it supports a combination of grasses that are restricted to the northern clay pans.
- Limestone community L3c is located on the proposed North White's Beach pipeline (Figure 5-1 and 5-2). Of this community, 0.1 ha is likely to be impacted by the proposed pipeline. This community is very restricted and requires further investigation to determine its wider distribution on the island.
- Communities which contain species that germinated after recent post-cyclonic rains and appear to be restricted. Such communities include limestone communities F5d and F5e on the proposed CO₂ reinjection pipeline. One of these communities is known and another presumed to contain *Tephrosia clementii*, which appears to be

restricted on the island. These limestone communities appear to be restricted in distribution and further work is required to determine their extent.

- Vegetation communities in the proposed CO₂ reinjection well sites areas on Barrow Island and the proposed pipeline corridor on the mainland, the significance of which is to be assessed when the locations have been confirmed.

4.5 Vegetation Condition

Most of the vegetation in the proposed development area is in excellent-to-pristine condition, with little apparent disturbance. Exceptions are along main tracks and seismic lines that run across the proposed gas processing facility site and wider study areas and, to a lesser degree, along the proposed pipeline routes.

Vegetation has regenerated to varying degrees on the seismic lines. Table 4-2 shows the areas of vegetation communities within the proposed gas processing facility and wider study area (Figure 2-1) affected by seismic line disturbance.

Table 4-2 – Areas of Vegetation Communities Affected by Seismic Lines and Roads within the Proposed Gas Processing Facility Footprint and Wider Study Area

Vegetation Community	Area of Pre 1994 Seismic lines (ha)	Area of 1994 Seismic lines (ha)	Area of roads (ha)	Total area (ha)
C1a	0.05	0.11	0.01	0.18
C2a	0.56	0.56	0.26	1.38
C2b	0.24	0.41	0.43	1.08
C2c	0.00	0.01	0.00	0.01
C5a	0.04	0.16	0.49	0.68
D1a	0.87	0.98	3.75	5.60
D1a dist	0.05	0.14	31.43	31.62
Dist	0.23	0.56	27.49	28.28
F8a	1.87	2.58	2.85	7.30
L3a	0.16	0.20	0.20	0.56
L3f	0.58	0.57	0.75	1.90
L3h	0.18	0.29	0.31	0.78
L3i	0.99	1.96	1.20	4.15
L4a	1.53	2.18	1.52	5.23
L5a	0.37	0.28	0.37	1.02
L6a	0.01	0.04	0.02	0.07
L7a	0.02	0.06	0.05	0.12
L7b	1.32	2.30	2.22	5.84
L9a	0.08	0.11	0.08	0.28
R	0.00	0.04	0.55	0.59

Vegetation Community	Area of Pre 1994 Seismic lines (ha)	Area of 1994 Seismic lines (ha)	Area of roads (ha)	Total area (ha)
V1a	0.41	0.84	0.51	1.76
V1c	0.01	0.29	0.11	0.40
V1d	0.05	0.10	0.15	0.31
V1k	0.77	1.57	1.77	4.12
V1m	1.68	2.67	2.55	6.89
V1n	0.13	0.17	0.33	0.64
V3a	0.66	0.47	0.73	1.87
V3b	0.48	1.00	0.59	2.07
Total	13.34	20.65	80.72	114.14

5 Discussion and Conclusions

The majority of vegetation communities mapped within the proposed development areas extend well beyond the proposed development area and the areas of the communities are larger outside the proposed corridors and gas processing facility than within these areas.

Some work has been undertaken in accurately determining the extent of significant vegetation communities in the vicinity of the proposed development areas, however the extent of these communities over the island requires further clarification. Consideration should be given to, where possible, avoiding those communities identified as being of particular significance within the proposed development areas.

The F4a *Erythrina vespertilio* community, F5d and F5e *Scaevola cunninghamii* limestone communities, the L6b, L6c and L6d *Grevillea pyramidalis* communities, S1a Clay pan community and L3c Limestone communities mapped within the proposed development area appear to be restricted in distribution on the island. Five coastal vegetation communities recorded at the western end of the proposed feed gas pipeline at Flacourt Bay (C1d, C2e, C5b, C4e and C5c) appear to be restricted to the near coastal areas at Flacourt Bay. Community C2e occurs just outside the proposed pipeline corridor and any changes to the proposed pipeline routes should take into account these five coastal communities.

The *Grevillea pyramidalis* subsp. *?leucadendron* communities on the proposed North White's beach pipeline corridor appear to extend well beyond the expected area of impact, however the distribution of these communities over the island appears to be limited.

Limited searching in the vicinity of community L3c on the proposed North White's Beach pipeline route were recently undertaken, however limited knowledge of the extent the community shows that it appears to be locally restricted at this stage. Limited searches have been undertaken on the west coast of the island to find other occurrences of community C5c. This community appears at this stage to be locally restricted.

The species composition of the clay pan communities in the south west of the island differed significantly from the S1a clay pan community on the proposed CO₂ reinjection

pipeline. Further investigation is required to determine whether other clay pan areas mapped previously by Matiske and Associates (1993) differ significantly from the S1a community on the proposed pipeline route.

Impacts on major drainage lines in the vicinity of the proposed development should be minimised, given the historical disturbance of major drainage communities on the island.

Neither of the two Priority species recorded on Barrow Island (*Corchorus interstans* ms or *Helichrysum oligochaetum*) are restricted to the island. *Helichrysum oligochaetum* has not been observed or recorded in surveys of the proposed development areas. Although the proposed development on Barrow Island may impact some of the populations of *Corchorus interstans* ms, this species is widely represented outside the proposed development areas. *Corchorus interstans* ms is abundant in a wide range of environments and is not threatened by the proposed development.

A number of species, though not listed as Rare or Priority, appear to be restricted in distribution on the island and consideration should be given to avoiding these species where possible within the proposed development areas. Of the 23 species considered to be restricted in distribution or poorly known on the island prior to recent post cyclonic rain surveys, 6 species were recorded in recent surveys of the proposed development areas;

Dichanthium sericnem subsp. *humilius*, *Erythrina vespertilio*, *Grevillea pyramidalis* subsp. *?leucadendron*, *Hakea lorea* subsp. *lorea*, *Hybanthus aurantiacus* and *Whiteochloa airoides*.

Dichanthium sericnem subsp. *humilius* was located within the proposed gas processing facility area in recent post cyclonic rain surveys and knowledge of this species on the island is limited.

Grevillea pyramidalis subsp. *?leucadendron* occurs in communities L6a, L6b, L6c and L6d, of which three communities were recorded on the proposed North White's Beach pipeline route. *Erythrina vespertilio* was recorded within community F4a on the proposed CO₂ reinjection pipeline corridor.

Hakea lorea subsp. *lorea* was recorded in a variety of vegetation communities within the proposed development areas in the current survey, and appears to be more widespread than previously considered.

Hybanthus aurantiacus was recorded within the proposed gas processing facility area and in the wider study area. Although some populations are likely to be affected by the proposed gas processing facility, most populations of this species are not likely to be affected.

Whiteochloa airoides was recorded on the proposed feed gas pipeline corridor and has been found further inland in previous surveys. Further investigation of this species is required to determine its distribution on the island.

Species recorded during recent post cyclonic surveys of the proposed development areas that require further investigation to clarify their distribution on the island include *Tephrosia clementii*, *Eriachne flaccida* (Southern Pilbara — Carnarvon Coastal Form), *Isolepis* sp. , *Tribulus hirsutus* and *Corchorus congener*.

Eriachne flaccida (Southern Pilbara – Carnarvon Coastal Form) may be restricted to the clay pan community on the proposed CO₂ reinjection pipeline. Further investigation of other clay pan areas on the island are required to clarify the distribution of community S1a on the island.

Due to the limited number of specimens of *Tephrosia clementii* in the Western Australian Herbarium and limited knowledge of its wider distribution, the conservation significance of this species may be revised by CALM.

Seventeen species requiring further identification are potentially restricted on Barrow Island and further studies are required to determine whether these species are restricted to Barrow Island. Of these 17 species, *Isolepis* sp. and *Acacia bivenosa* (elongate phyllode variant) were recorded within the proposed development areas. The *Isolepis* specimen does not appear to match any known *Isolepis* specimen held in the Western Australian Herbarium, apart from a specimen recently collected in Perth. Further collections of *Isolepis* sp. are necessary to enable positive identification.

Two forms of *Acacia bivenosa* occur in the proposed development areas, a ‘normal’ variant and an ‘elongate phyllode’ variant. Further studies of *Acacia bivenosa* and variants of it on the island are required to clarify the taxonomic status of this species.

The collection of a new introduced species; *Setaria verticillata* on the island, near the proposed North White’s Beach pipeline corridor warrants further investigation.

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	C1a	Open Grassland of <i>Spinifex longifolius</i> with low scattered <i>Atriplex isatidea</i> , <i>Myoporum montanum</i> , <i>Euphorbia myrtilloides</i> and <i>Salsola tragus</i> shrubs and herbs on seaward face of white sandy fore dunes.
	C1d	Low Open Shrubland of <i>Scaevola cunninghamii</i> , <i>Corchorus</i> sp. and <i>Heliotropium glanduliferum</i> over Very Open Grassland of <i>Spinifex longifolius</i> over scattered <i>Cynanchum floribundum</i> creeper on lower slopes at the base of primary sand dunes.
	C1e	Grassland of <i>Spinifex longifolius</i> over Low Open Shrubland of <i>Threlkeldia diffusa</i> with scattered <i>Rhagodia preissii</i> subsp. <i>obovata</i> and <i>Frankenia pauciflora</i> var. <i>pauciflora</i> on ridges and back slopes of white sandy fore dunes.
	C2a	Shrubland to Tall Shrubland of <i>Acacia coriacea</i> over Low Open Shrubland to Open Shrubland of <i>Acacia bivenosa</i> with low scattered <i>Olearia dampieri</i> subsp. <i>dampieri</i> shrubs over Open Hummock Grassland to Grassland of <i>Triodia angusta</i> on dune swales, slopes and ridges.
	C2b	Open Shrubland of <i>Acacia coriacea</i> over Low Open Shrubland of <i>Acacia bivenosa</i> and <i>Pentalepis trichodesmoides</i> with scattered <i>Acanthocarpus verticillatus</i> over Hummock Grassland of <i>Triodia angusta</i> and <i>Triodia wiseana</i> on red/brown sandy flats.
	C2c	Shrubland to Tall Shrubland of <i>Acacia coriacea</i> over Low Open Shrubland to Open Shrubland of <i>Acacia bivenosa</i> with low scattered <i>Olearia dampieri</i> subsp. <i>dampieri</i> shrubs over Open Hummock Grassland to Grassland of <i>Triodia angusta</i> on dune slopes and ridges.
	C2d	Low Open Shrubland of <i>Acacia coriacea</i> and <i>Myoporum montanum</i> over Grassland to Hummock Grassland of <i>Spinifex longifolius</i> with patches of <i>Triodia epactia</i> in swales between dunes.
	C2e	Low Open Shrubland of <i>Myoporum montanum</i> with <i>Corchorus</i> sp. over Grassland to Hummock Grassland of <i>Spinifex longifolius</i> with <i>Triodia angusta</i> over scattered <i>Cynanchum floribundum</i> creeper on crest of primary dunes.
	C2f	Open Shrubland of <i>Acacia coriacea</i> over Low Open Shrubland of <i>Olearia dampieri</i> subsp. <i>dampieri</i> and <i>Acacia bivenosa</i> with occasional <i>Stylobasium spathulatum</i> over Hummock Grassland of <i>Triodia epactia</i> on sandy dune ridges (over scattered <i>Heliotropium glanduliferum</i> and <i>Diplopeltis eriocarpa</i> on back of red/brown sandy flats and dunes).
	C2g	Shrubland of <i>Acacia coriacea</i> over Low Shrubland to Shrubland of <i>Olearia dampieri</i> subsp. <i>dampieri</i> , <i>Stylobasium spathulatum</i> and <i>Acacia bivenosa</i> over Hummock Grassland of <i>Triodia epactia</i> over low scattered <i>Threlkeldia diffusa</i> herbs in swales between dunes.
	C2h	Low Shrubland of <i>Acacia coriacea</i> with <i>Rhagodia preissii</i> subsp. <i>obovata</i> over Very Open Hermland of <i>Threlkeldia diffusa</i> over Grassland to Hummock Grassland of <i>Triodia epactia</i> and <i>Spinifex longifolius</i> on secondary dune slopes and ridges.
	C3a	Open Heath of <i>Acacia bivenosa</i> over Low Open Shrubland of <i>Olearia dampieri</i> subsp. <i>dampieri</i> with low scattered <i>Myoporum montanum</i> and <i>Enchylaena tomentosa</i> var. <i>tomentosa</i> shrubs over Open Hummock Grassland of <i>Triodia epactia</i> on red/brown sandy flats behind dunes.
	C4e	Open Shrubland of <i>Trichodesma zeylanicum</i> over Low Open Shrubland of <i>Corchorus</i> sp., <i>Olearia dampieri</i> subsp. <i>dampieri</i> , <i>Scaevola cunninghamii</i> and <i>Whiteochloa airoides</i> over Open Hummock Grassland of <i>Triodia angusta</i> over <i>Cynanchum floribundum</i> scattered creepers on upper slope to mid slopes of sandy dunes.
	C5a	Low scattered <i>Frankenia pauciflora</i> var. <i>pauciflora</i> shrubs with scattered <i>Oldenlandia crouchiana</i> herbs and <i>Cyperus cunninghamii</i> subsp. <i>cunninghamii</i> sedges on coastal limestone cliffs and in major drainage lines in coastal areas.
	C5b	Low scattered <i>Pentalepis trichodesmoides</i> , <i>Olearia dampieri</i> subsp. <i>dampieri</i> , <i>Corchorus</i> sp. and <i>Tephrosia rosea</i> shrubs over Hummock Grassland of <i>Triodia angusta</i> over scattered <i>Cynanchum floribundum</i> creepers on limestone ridges and flats (plateaus).
	C5c	Very Open Hummock Grassland of <i>Triodia angusta</i> over low scattered <i>Scaevola cunninghamii</i> , <i>Corchorus</i> sp., <i>Frankenia pauciflora</i> var. <i>pauciflora</i> and <i>Heliotropium glanduliferum</i> scattered herbs and shrubs on lower slopes on limestone.
	C5d	Low Open Shrubland of <i>Myoporum montanum</i> over Very Open Grassland of <i>Spinifex longifolius</i> with scattered Hummocks of <i>Triodia epactia</i> over Low Open Shrubland of <i>Frankenia pauciflora</i> var. <i>pauciflora</i> with scattered <i>Heliotropium glanduliferum</i> on flat sandy swales with occasional limestone outcropping behind primary dunes.
	D1a	Scattered tall <i>Acacia coriacea</i> shrubs over Low Shrubland to Shrubland of <i>Stylobasium spathulatum</i> and <i>Acacia bivenosa</i> over Very Open Hermland of <i>Acanthocarpus verticillatus</i> over Closed Hummock Grassland of <i>Triodia angusta</i> with scattered <i>Triodia wiseana</i> on valley floors and deep gullies. This unit contains occasional <i>Hakea lorea</i> subsp. <i>lorea</i> . Unit also contains areas of scoured drainage channel in areas of heavy seasonal flow.
	D1c	Low Open Shrubland of <i>Pentalepis trichodesmoides</i> over Closed Hummock Grassland of <i>Triodia angusta</i> with <i>Triodia epactia</i> at edges in major drainage lines.
	D1d	Low Open Shrubland of <i>Pentalepis trichodesmoides</i> over Hummock Grassland of <i>Triodia epactia</i> with patchy <i>Triodia angusta</i> and <i>Triodia wiseana</i> on lower slopes and broad drainage flats.
	D1e	Open Shrubland of <i>Stylobasium spathulatum</i> , <i>Pentalepis trichodesmoides</i> with <i>Trichodesma zeylanicum</i> over Closed Hummock Grassland of <i>Triodia angusta</i> and <i>Triodia wiseana</i> over Low Open Shrubland of <i>Acacia bivenosa</i> and <i>Acacia gregorii</i> in some locations on lower slopes, drainage flats and wide drainage lines.
	D1f	Open Shrubland of <i>Acacia pyrifolia</i> over Low Open Shrubland of <i>Stylobasium spathulatum</i> with patchy <i>Petalostylis labicheoides</i> over Hummock Grassland to Closed Hummock Grassland of <i>Triodia angusta</i> with patchy <i>Triodia wiseana</i> in major drainage lines. This unit contains occasional <i>Hakea lorea</i> subsp. <i>lorea</i> .
	D1g	Closed Hummock Grassland of <i>Triodia angusta</i> and <i>Triodia wiseana</i> over low scattered <i>Tephrosia rosea</i> and <i>Indigofera monophylla</i> shrubs in wide drainage lines.
	D2c	Scattered tall <i>Trichodesma zeylanicum</i> shrubs over Hummock Grassland of <i>Triodia angusta</i> with <i>Triodia wiseana</i> over Low Open Shrubland of <i>Tephrosia rosea</i> in disturbed drainage lines.
	D2d	Low Open Shrubland of <i>Pentalepis trichodesmoides</i> over Closed Hummock Grassland of <i>Triodia epactia</i> and <i>Triodia wiseana</i> over Low Shrubland of <i>Acacia gregorii</i> in minor creek and drainage lines.
	D2f	Open Shrubland of <i>Acacia pyrifolia</i> over Low Open Shrubland of <i>Stylobasium spathulatum</i> with patchy <i>Petalostylis labicheoides</i> , <i>Acacia gregorii</i> and <i>Acacia bivenosa</i> over Hummock Grassland to Closed Hummock Grassland of <i>Triodia angusta</i> with patchy <i>Triodia wiseana</i> in minor drainage lines. This unit contains occasional <i>Hakea lorea</i> subsp. <i>lorea</i> .

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	F4a	Low Open Woodland of <i>Erythrina vespertilio</i> over Low Open Shrubland of <i>Pentalepis trichodesmoides</i> over Hummock Grassland of <i>Triodia wiseana</i> and <i>Triodia angusta</i> with occasionally emergent <i>Ficus brachypoda</i> on flats with shallow red/brown sands and emergent limestone.
	F5a	Low Open Shrubland of <i>Stylobasium spathulatum</i> with scattered <i>Pentalepis trichodesmoides</i> and <i>Senna glutinosa</i> over Hummock Grassland of <i>Triodia angusta</i> with <i>Triodia epactia</i> over Low Open Shrubland of <i>Diplopeltis eriocarpa</i> on gentle low slopes and flats.
	F5b	Scattered low <i>Ficus brachypoda</i> trees over scattered low <i>Pentalepis trichodesmoides</i> , <i>Acacia bivenosa</i> , <i>Corchorus</i> sp., <i>Tephrosia rosea</i> and <i>Streptoglossa decurrens</i> shrubs over Closed Hummock Grassland of <i>Triodia epactia</i> with <i>Triodia angusta</i> on flats.
	F5c	Low Open Shrubland of <i>Pentalepis trichodesmoides</i> over mixed Hummock Grassland of <i>Triodia epactia</i> with occasional <i>Triodia angusta</i> over Low Open Shrubland of <i>Diplopeltis eriocarpa</i> and <i>Acacia gregorii</i> on limestone ridges, slopes and flats.
	F5d	Scattered low <i>Ficus brachypoda</i> trees over Low Open Shrubland of <i>Pentalepis trichodesmoides</i> over Closed Hummock Grassland of <i>Triodia angusta</i> over scattered low <i>Corchorus</i> sp., <i>Scaevola cunninghamii</i> and <i>Heliotropium glanduliferum</i> herbs and shrubs on upper slopes and mid slopes of small limestone rises.
	F5e	Scattered low <i>Ficus brachypoda</i> trees over low scattered <i>Pentalepis trichodesmoides</i> shrubs over Open Hummock Grassland of <i>Triodia angusta</i> with <i>Triodia epactia</i> over low scattered <i>Scaevola cunninghamii</i> , <i>Diplopeltis eriocarpa</i> and <i>Acacia bivenosa</i> shrubs on limestone flats and rises with shallow pale pink sands.
	F6a	Low Open Shrubland of <i>Acacia bivenosa</i> and <i>Stylobasium spathulatum</i> over Hummock Grassland of <i>Triodia epactia</i> on red/brown sandy flats.
	F6b	Scattered low <i>Ficus brachypoda</i> trees over Low Open Shrubland of <i>Pentalepis trichodesmoides</i> over Hummock Grassland of <i>Triodia epactia</i> with on sandy slopes and flats with occasional limestone outcropping.
	F6c	Tall Open Shrubland of <i>Acacia coriacea</i> over low scattered <i>Stylobasium spathulatum</i> shrubs over Open Hummock Grassland of <i>Triodia epactia</i> on light red/brown sandy flats.
	F6d	Open Shrubland of <i>Trichodesma zeylanicum</i> over low scattered <i>Pterocaulon sphacelatum</i> shrubs over Hummock Grassland of <i>Triodia epactia</i> on limestone flats with shallow sands.
	F7a	Low scattered <i>Pentalepis trichodesmoides</i> and <i>Trichodesma zeylanicum</i> shrubs over Hummock Grassland of <i>Triodia wiseana</i> over Low Open Shrubland of <i>Diplopeltis eriocarpa</i> and scattered <i>Acacia gregorii</i> on limestone slopes.
	F7b	Scattered low <i>Ficus brachypoda</i> trees over Low Open Shrubland of <i>Pentalepis trichodesmoides</i> over Closed Hummock Grassland of <i>Triodia wiseana</i> with patches of <i>Triodia angusta</i> on sandy flats.
	F7c	Open Shrubland of <i>Senna glutinosa</i> over Low Open Shrubland of <i>Pentalepis trichodesmoides</i> and <i>Tephrosia rosea</i> over Closed Hummock Grassland of <i>Triodia angusta</i> on red/brown sandy flats.
	F7d	Scattered <i>Hakea lorea</i> subsp. <i>lorea</i> shrubs over Low Scattered <i>Pentalepis trichodesmoides</i> and <i>Trichodesma zeylanicum</i> shrubs over Closed Hummock Grassland of <i>Triodia epactia</i> and <i>Triodia wiseana</i> on mid slopes and flats.
	F7e	Low Open Shrubland of <i>Pentalepis trichodesmoides</i> over low scattered <i>Corchorus</i> sp. and <i>Sarcostemma viminale</i> subsp. <i>australe</i> shrubs over Hummock Grassland of <i>Triodia wiseana</i> on red/brown sandy flats (with pockets of <i>Eriachne mucronata</i> on valley floors).
	F8a	Low Open Shrubland to Open Shrubland of <i>Acacia bivenosa</i> , with occasional scattered <i>Pentalepis trichodesmoides</i> , <i>Stylobasium spathulatum</i> and <i>Acanthocarpus verticillatus</i> shrubs over Hummock Grassland to Closed Hummock Grassland of <i>Triodia wiseana</i> with occasional <i>Triodia angusta</i> on flats and valley floors.
	F8b	Scattered tall <i>Hakea lorea</i> subsp. <i>lorea</i> shrubs over Low Open Shrubland of <i>Pentalepis trichodesmoides</i> over low scattered <i>Tephrosia rosea</i> shrubs over Hummock Grassland of <i>Triodia wiseana</i> on red/brown sandy flats.
	L1a	Scattered low <i>Ficus brachypoda</i> and <i>Pittosporum phylliraeoides</i> trees over low scattered <i>Stylobasium spathulatum</i> and <i>Petalostylis labicheoides</i> shrubs over Hummock Grassland of <i>Triodia wiseana</i> with occasional <i>Cymbopogon ambiguus</i> , <i>Tephrosia rosea</i> and <i>Triodia angusta</i> on limestone ridges and upper slopes.
	L1b	Scattered low <i>Ficus brachypoda</i> trees over low scattered <i>Pentalepis trichodesmoides</i> shrubs over Hummock Grassland of <i>Triodia wiseana</i> on limestone slopes and ridges.
	L1c	Scattered low <i>Ficus brachypoda</i> over Low Open Shrubland of <i>Acacia bivenosa</i> over Closed Hummock Grassland of <i>Triodia angusta</i> with <i>Triodia epactia</i> and occasional <i>Triodia wiseana</i> on limestone slopes and ridges.
	L1d	Hummock Grassland of <i>Triodia wiseana</i> over Low Open Shrubland of <i>Diplopeltis eriocarpa</i> and <i>Heliotropium glanduliferum</i> on limestone flats (plateau).
	L1e	Scattered low <i>Ficus brachypoda</i> and <i>Pittosporum phylliraeoides</i> trees (with <i>Mallotus nesophilus</i>) over Hummock Grassland of <i>Triodia wiseana</i> with patchy <i>Triodia angusta</i> over low scattered <i>Diplopeltis eriocarpa</i> shrubs on limestone slopes and flats.
	L1f	Scattered low <i>Ficus brachypoda</i> and <i>Pittosporum phylliraeoides</i> trees over Hummock Grassland of <i>Triodia wiseana</i> and patchy <i>Triodia angusta</i> on limestone slopes and ridges.
	L3a	Low Open Shrubland of <i>Stylobasium spathulatum</i> with <i>Petalostylis labicheoides</i> over Closed Hummock Grassland of <i>Triodia angusta</i> with patchy <i>Triodia wiseana</i> over Low Open Shrubland of <i>Acacia gregorii</i> on limestone slopes and ridges.
	L3b	Low scattered <i>Pentalepis trichodesmoides</i> shrubs over Hummock Grassland of <i>Triodia wiseana</i> with <i>Triodia epactia</i> over low scattered <i>Acacia gregorii</i> and <i>Diplopeltis eriocarpa</i> shrubs on limestone slopes and ridges.
	L3c	Low scattered <i>Diplopeltis eriocarpa</i> shrubs with scattered <i>Triodia epactia</i> , <i>Cymbopogon ambiguus</i> and <i>Cyperus cunninghamii</i> subsp. <i>cunninghamii</i> herbs and grasses on small exposed limestone flats.
	L3d	Low scattered <i>Stylobasium spathulatum</i> and <i>Petalostylis labicheoides</i> shrubs over Low Open Shrubland of <i>Diplopeltis eriocarpa</i> , <i>Acacia gregorii</i> and <i>Hannafordia quadrialvis</i> subsp. <i>recurva</i> over Hummock Grassland of <i>Triodia angusta</i> with <i>Triodia wiseana</i> on limestone ridges.

FIGURE 1-2
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