FLORA AND VEGETATION OF BEATONS CREEK

FINAL

27 February 2020

PREPARED FOR

NOVO RESOURCES CORP

PREPARED BY

Woodgis
ENVIRONMENTAL ASSESSMENT & MANAGEMENT

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Document STATUS

Document Number:	Final
Circulation Date:	27/02/2020
Documents Superseded:	Draft A 29/11/2019

Other Related Documents:

Woodgis (2019) *2019 Calotropis Procera Management Plan - Beatons Creek, Nullagine*, unpublished report by Woodgis Environmental Assessment and Management for Novo Resources Corp.

RECOMMENDED REFERENCE

The recommended reference for this document is:

Woodgis (2020) *Flora and Vegetation Survey of the Beatons Creek,* unpublished report by Woodgis Environmental Assessment and Management for Novo Resources Corp.

ACKNOWLEDGEMENTS

Woodgis wishes to acknowledge the input of the following in contributing to this document:

[redacted] Environmental Manager Novo Resources Corp
Senior Environmental Advisor Novo Resources Corp

ACRONYMS AND ABBREVIATIONS

The following acronyms are used in this report for succinctness:

BAM Act	(WA) Biosecurity and Agriculture Management Act 2007
CAR	Comprehensive, Adequate and Representative (reserve system)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DBCA	(WA) Department of Biodiversity, Conservation and Attractions
EPA	(WA) Environmental Protection Authority
EPBC	(Commonwealth) Environment Protection and Biodiversity Conservation (Act)
IBRA	Interim Biogeographic Regionalisation for Australia
PEC	Priority Ecological Community
subsp.	subspecies
TEC	Threatened Ecological Community
WA	Western Australia/n

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EXECUTIVE SUMMARY

This report establishes baseline values for flora and vegetation over 1,532 hectares of the Beatons Creek area, adjacent to the Nullagine townsite in the Shire of East Pilbara. The Area of Interest is not in, or contiguous with, any conservation estate or DBCA managed lands.

A total of 8 vegetation types were defined in terms of the presence/absence of perennial species, and 25 vegetation subtypes identified on the basis of differences in cover/dominance of species and/or distinct landscape/landform position. The vegetation units strongly reflect the landform patterns, and land systems, which were floristically distinct.

State-wide vegetation mapping (system-associations), Pilbara-wide vegetation mapping (land systems) and Pilbara-wide vegetation classification (site types) indicate the vegetation types are extensive in the region, with the exception of the site type 'SSCG: Stony plain spinifex grassland with chenopod shrubs'. This site type corresponds to the 'Stony saline plains of the Mosquito Land System', which are listed as a Priority 3(iii) Priority Ecological Community (PEC) by DBCA (2019). The PEC covers approximately 46,000 ha to the east of Nullagine and is generally in good condition. In the Area of Interest, the PEC occupies 75.2 hectares, which was almost entirely occupied the Day Dawn Mine operations and is generally degraded to completely degraded with very low native plant cover.

Surface water is associated with:

- *Eucalyptus camaldulensis* woodlands along the Nullagine, which are potentially a groundwater dependent ecosystem;
- Beaton Creek Gorge (to the south and east of the Area of Interest), which is the most likely refugia for taxa with preferences for low temperature fluctuations, seclusion from fire, permanent moisture etc; and
- the Nullagine Water Reserve Dam.

The Area of Interest includes substantial areas of degradation, including 215 hectares of partial and complete clearing, 97 hectares dominated by weeds and 13 hectares of flooding.

A total of 14 weeds were confirmed, of which 4 species should be treated as natives as they likely predate European settlement. One weed, *Calotropis procera,* was a Declared Pest and was comprehensively mapped. The Department of Primary Industries and Regional Development does not require reporting or management, but encourages land managers to undertake control. Given the degraded state of the vegetation in the vicinity of the Nullagine townsite, it is likely that not all weed species and not all locations of weeds were recorded and there is also a high probability of additional weeds becoming established over time.

The Area of Interest does not support high species diversity, it is not located in an area listed for high species and ecosystem diversity, and the vegetation formations (site types) present typically support low to moderate diversity.

The 241 native taxa recorded, which was estimated to represent 91% of species present, included:

- 1 priority taxa that appears to occur in relatively small distinct patches around Nullagine (*Ptilotus wilsonii* P1);
- 4 priority taxa that are locally widespread/abundant (*Acacia aphanoclada* P1, *Acacia cyperophylla* var. *omearana* P1, *Atriplex spinulosa* P1 and *Solanum* sp. Mosquito Creek P1);
- 4 locally endemic taxa (*Acacia aphanoclada* P1, *Acacia cyperophylla* var. *omearana* P1, *Atriplex spinulosa* P1 and *Solanum* sp. Mosquito Creek P1);
- 7 taxa that appear to be near the limits of their recorded distributions, and an additional 3 taxa appear disjunct from other records;
- 5 relictual taxa that are all widespread in both the Pilbara and Kimberley; and
- no plant taxa with distinctive features or unusual forms.

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1 INTRODUCTION

1.1 Objectives and Scope

This report examines the flora and vegetation in the area being considered for the Beatons Creek Project and a potential associated haul road, and presents:

- description/s and map/s of vegetation onsite;
- an assessment of the regional significance of the vegetation;
- a flora inventory;
- an assessment of the regional significance of the flora; and
- description/s and map/s of conservation significant flora.

The dataset from the Beatons Creek Haul Road Area was integrated with the contiguous Beatons Creek Project Area, that was previously surveyed by MMWC (2015), with:

- a floristic classification including quadrats from both surveys; and
- a comprehensive priority flora and weed census undertaken in the Haul Road and the Approvals Envelope within the Project Area.

1.2 Area of Interest

The Beatons Creek Area of Interest (Figure 1), which covers approximately 1,532 hectares adjacent to the Nullagine townsite in the Shire of East Pilbara, consisted of:

- the 356 hectare Haul Road Area survey by Woodgis in 2018/2019; and
- the 1,172 hectare Project Area previously surveyed by MMWC (2015).

The 994 hectare Priority Flora and Weed Census Area consisted of the Haul Road Area combined with the 718 hectare Approvals Envelope (Figure 1).

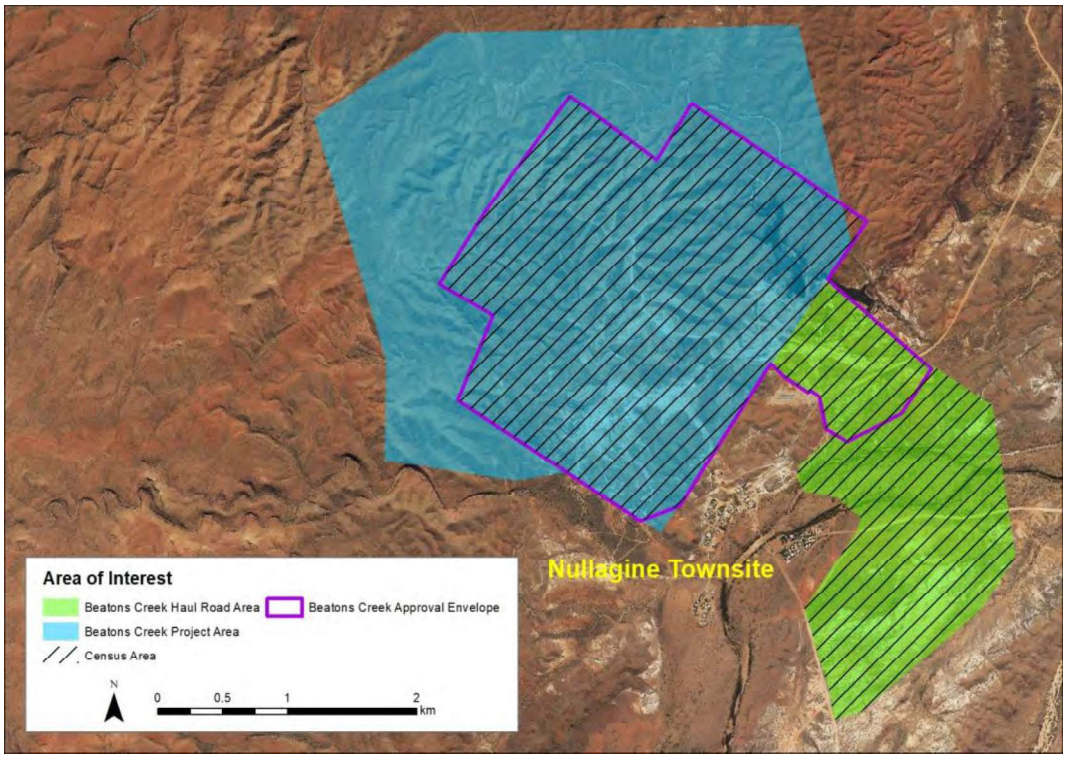

Figure 1: Surveys within Area of Interest

1.3 Regional Vegetation

The Area of Interest, as shown in Figure 2, is located in the Chichester subregion of the Pilbara Interim Biogeographic Regionalisation for Australia (IBRA) region.

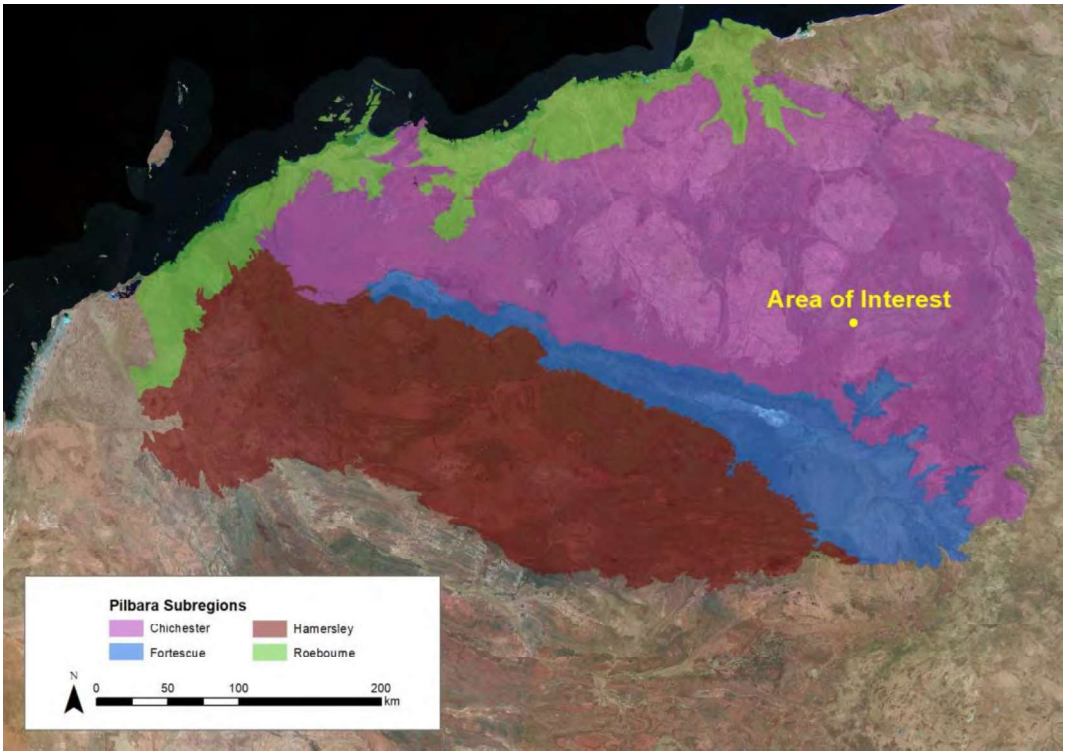

Figure 2: Biogeographic Context of Area of Interest

The 17,808,657 hectare Pilbara biogeographic region is a transition zone between the tropical north and semi-arid desert.

The 8,374,327 hectare Chichester biogeographic subregion was broadly characterised by DPaW (2002) as comprising undulating Archaean granite and basalt plains that include significant areas of basaltic ranges, with plains supporting a shrub steppe characterised by *Acacia inaequilatera* over *Triodia pungens* hummock grasslands, and *Eucalyptus leucophloia* tree steppes occurring on ranges. *Acacia aneura* communities occur in valleys and short bunch grasslands occur on alluvial plains (Van Vreeswyk, Payne, Leighton, & Hennig, 2004). Soils are primarily hard alkaline red soils on plains and pediments, and shallow and skeletal soils on the ranges (Van Vreeswyk, Payne, Leighton, & Hennig, 2004).

The Chichester biogeographic subregion contains 13 vegetation systems (combinations of vegetation and landscape types where a series of plant communities recur in a pattern related to topographic, pedological and/or geological features), which in the Pilbara were based on the physiographic subdivisions of Beard (1975).

The Chichester biogeographic subregion contains 48 vegetation associations, which are the largest identifiable units with a consistent dominant species or group of species, and were originally mapped in the Pilbara at a scale of 1:1,000,000 by Beard (1975).

Vegetation system associations (an intersection of vegetation systems with associations) are the finest scale of mapping used in the Comprehensive, Adequate and Representative (CAR) reserve system analysis for Western Australia (Government of Western Australia, 2017). There are 76 Vegetation system associations in the Chichester subregion.

The Area of Interest is located on the boundary of two system-associations, as shown in Figure 3.

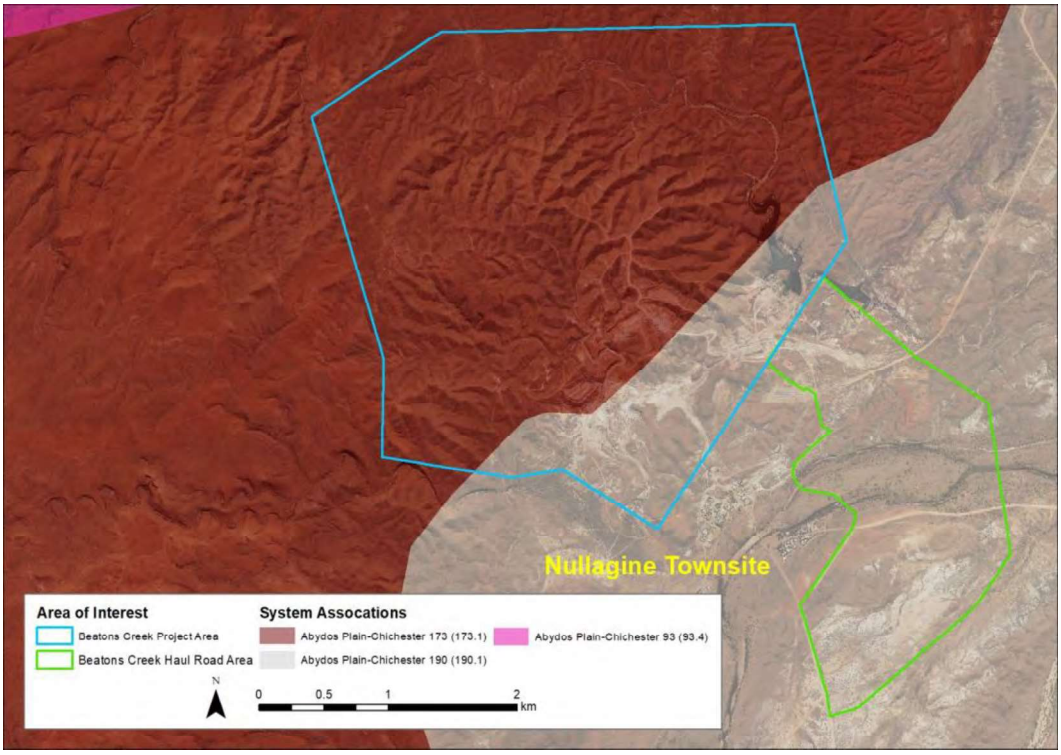

Figure 3: System-Associations in Area of Interest

The Project Area was predominately in system association 173.1, a mosaic of:

- high ridges with *Acacia pyrifolia, Senna* species Sparse Shrubland over *Triodia wiseana* Open Hummock Grassland; and
- lower rolling country with *Eucalyptus dichromophloia* Open Woodland over *Acacia pyrifolia, Acacia trachycarpa, Grevillea pyramidalis* Sparse Shrubland over *Triodia wiseana, Triodia pungens* Open Hummock Grassland and *Ptilotus exaltatus, Ptilotus clementii, Tephrosia* species open Forbland.

The Haul Road Area was predominately in system association 190.1, a mosaic of:

- stony hills with *Senna glutinosa* subsp*. charlesiana, Acacia tenuissima, Senna artemisioides subsp. x sturtii* Sparse Shrubland over *Triodia wiseana* Open Hummock Grassland;
- acacia shrub steppe with *Melaleuca species* Open Woodland over *Acacia bivenosa, Acacia trachycarpa* Sparse Shrubland over *Triodia wiseana, Triodia longiceps* Open Hummock Grassland; and
- flats and drainage areas as *Eucalyptus leucophloia, Eucalyptus* species Open Woodland over *Acacia tumida, Grevillea wickhamii, Gossypium robinsonii* Sparse Shrubland over *Triodia wiseana, Triodia longiceps, Triodia pungens* Open Hummock Grassland.

1.4 Land Systems

Land systems are areas with recurring patterns of topography, soils and vegetation that have been mapped across the Pilbara rangelands at a regional (publication) scale of 1:500,000 by the Western Australian Department of Agriculture. The 102 Pilbara land systems are documented in *An inventory and condition survey of the Pilbara region, Western Australia* (Van Vreeswyk, Payne, Leighton, & Hennig, 2004). Within land systems, component landforms, soils and vegetation were broadly identified, but not mapped.

The Area of Interest is located across three land systems, as shown in Figure 4.

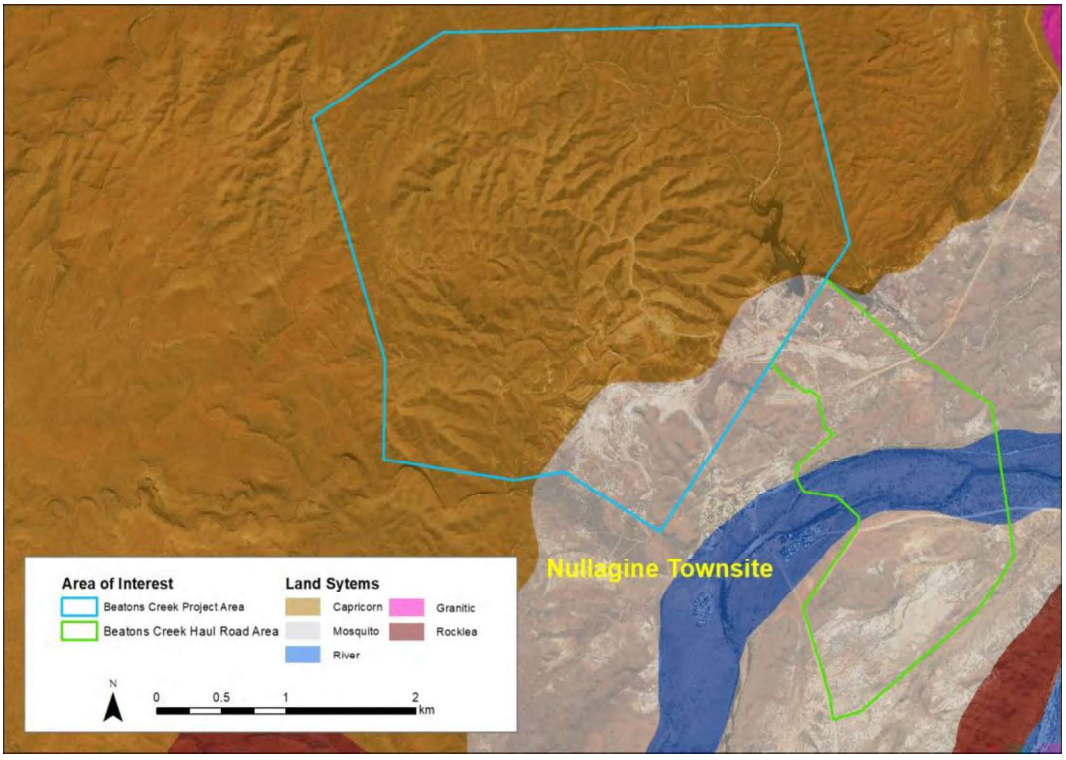

Figure 4: Land Systems in the Area of Interest

The Project Area is predominately located in one land system:

- the Capricorn Land System, which covers 5,296 km^2 (2.9% of the Pilbara), consists of hills and ridges of sandstone and dolomite supporting shrubby hard and soft spinifex grasslands (Van Vreeswyk, Payne, Leighton, & Hennig, 2004).

The Haul Road Area is located across two land systems:

- the Mosquito Land System, which covers 1,840 km^2 (1.0% of the Pilbara), is a unique system of stony plains and prominent ridges on schist and other metamorphic rocks that is restricted to several occurrences east of Nullagine (Van Vreeswyk, Payne, Leighton, & Hennig, 2004); and
- the River Land System, which covers 4,088 km^2 (2.3% of the Pilbara), consists of active flood plains and major rivers supporting grassy eucalypt woodlands, tussock grasslands and soft spinifex grasslands (Van Vreeswyk, Payne, Leighton, & Hennig, 2004).

1.5 Landform Patterns

Large scale patterns of vegetation distribution in the Pilbara are determined by soil and landform distribution and water availability (Department of Environment and Conservation, 2011), and the Department of Agriculture correlated vegetation types with landforms in land systems, in defining site types which are pastoral types based on combinations of land surface (landforms and soils), dominant perennial plant species, and vegetation structure in *Technical Bulletin No. 92 - An inventory and condition survey of the Pilbara region, Western Australia* (Van Vreeswyk, Payne, Leighton, & Hennig, 2004).

Landforms were mapped in the Area of Interest by CSIRO at 1:100,000 scale according to the slope relief landform pattern classification in Table 1.

Table 1: Slope Relief Classification

		Slope						
		Level <1%	**Very Gently Inclined 1-3%**	**Gently Inclined 3-10%**	**Moderately Inclined 10-32%**	**Steep 32-56%**	**Very Steep 56-100%**	**Precipitous >100%**
Relief	**Very High >300 m**	-	-	-	Rolling Mountains	Steep Mountains	Very Steep Mountains	Precipitous Mountains
	High 90-300 m			Undulating Hills	Rolling Hills	Steep Hills	Very Steep Hills	Precipitous Hills
	Low 30-90 m			Undulating Low Hills	Rolling Low Hills	Steep Low Hills	Very Steep Low Hills	Badlands
	Very Low 9-30 m		Gently Undulating Rises	Undulating Rises	Rolling Rises	Steep Rises	Badlands	
	Extremely Low <9 m	Level Plain	Gently Undulating Plain	Undulating Plain	Rolling Plain	Badlands		

Source: McDonald, Isbell, Speight, JG, & Hopkins (1990)

Figure 5 shows elevation across the Area of Interest. Figure 6 shows the slope relief classes across the Area of Interest.

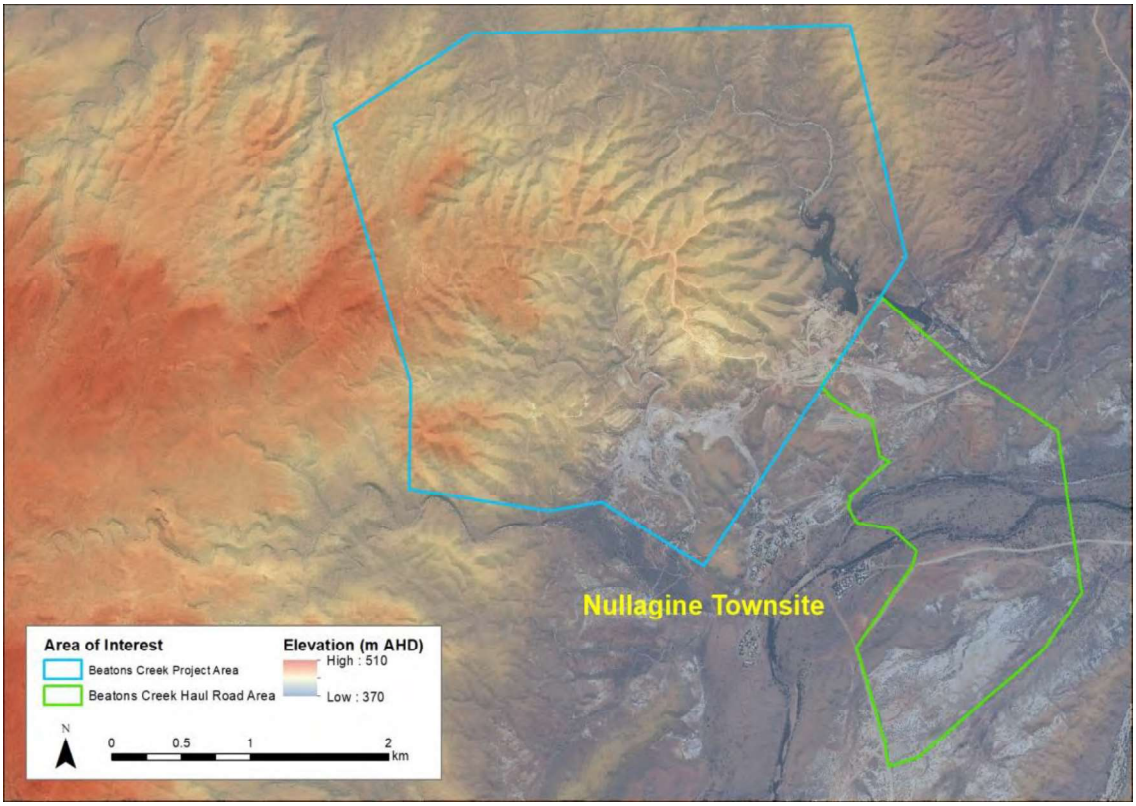

Figure 5: Elevation across the Area of Interest

Source: CSIRO (2012)

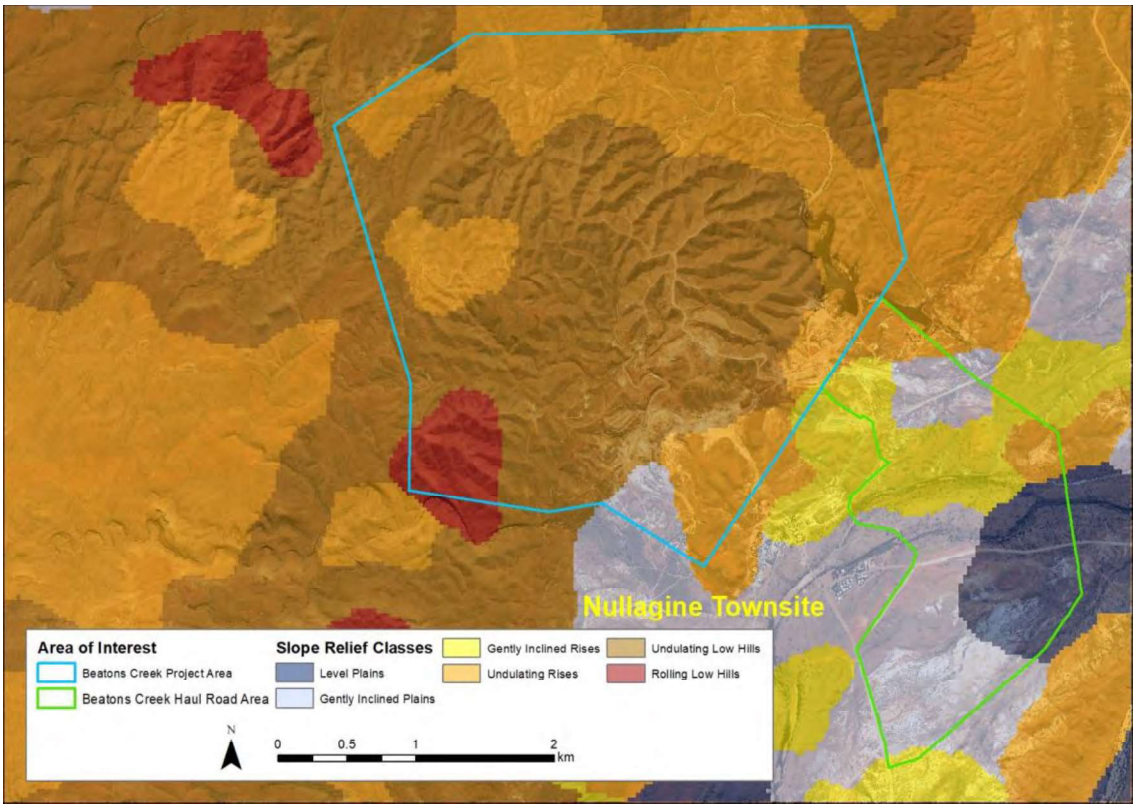

Figure 6: Slope Relief Classes across the Area of Interest

Source: CSIRO (2012)

2 METHOD

2.1 Field Surveys

Field surveys were undertaken by:

- MMWC Environmental on 2-9 September 2014; and
- Woodgis on 29-30 August 2018, 02-07 November 2018, 28 February 2019, 06-11 April 2019 and 20-25 April 2019.

The sampling distribution across the Area of Interest is shown in Figure 7.

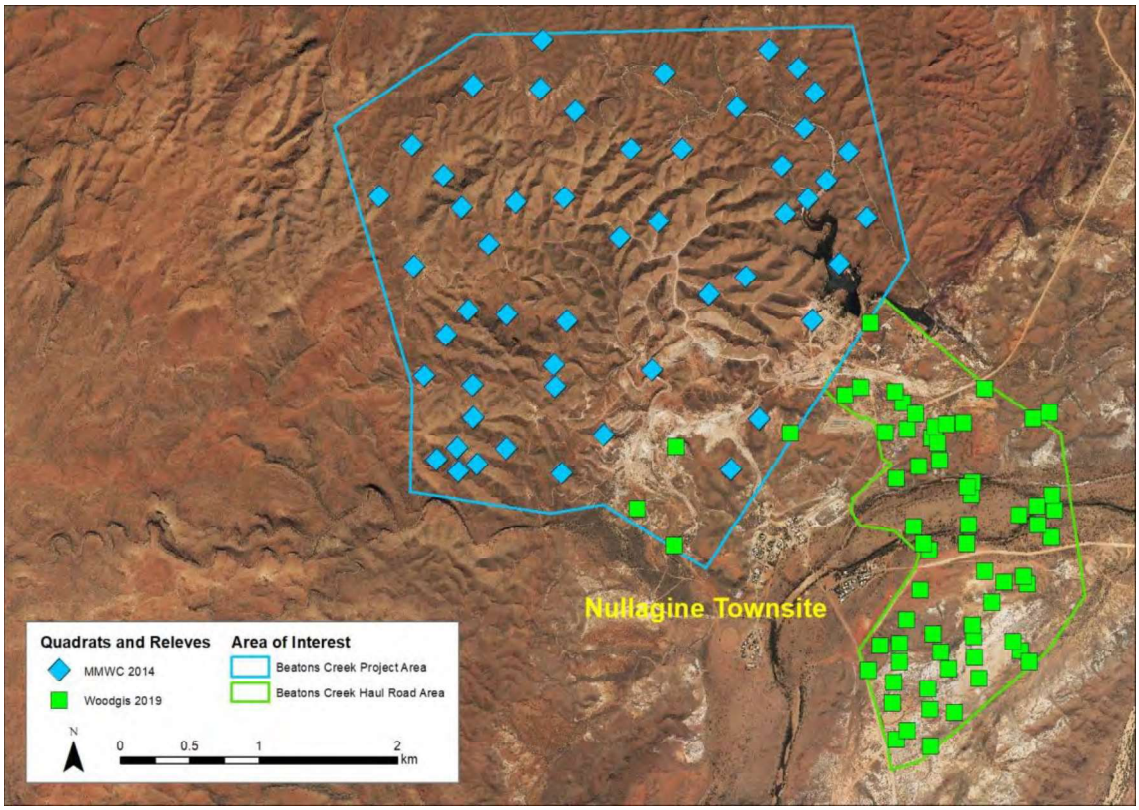

Figure 7: Vegetation Sampling

The stratification of sampling by land systems (Figure 4 on page 7) and landforms (Figure 6 on page 9) in Table 2 demonstrates each combination present was sampled at multiple locations (noting a number of landforms only occur on single land systems in the Area of Interest).

Table 2: Quadrats/Relevé Sampling by Landforms and Land Systems

		Land Systems			
		Capricorn	**Mosquito**	**River**	**Total**
Landforms	**Level Plains**		8	6	**14**
	Gently Inclined Plains		28	5	**33**
	Gently Inclined Rises		13	3	**16**
	Undulating Rises	17	6		**23**
	Undulating Low Hills	26			**26**
	Rolling Low Hills	5			**5**
	Total	**48**	**55**	**14**	**117**

2.2 Vegetation Description

Vegetation was sampled in 2500 m^2 quadrats by MMWC (2015) as is standard in the Pilbara, and in 900 m^2 quadrats in 2019 as this was the quadrat size used in nearby surveys for Millennium Minerals by Woodgis (Waters, 2017) in response to the fine scale mosaicking of the vegetation in the Mosquito Land System

Vegetation was described on the basis of structure (as per Table 3) and floristics. Shapefiles of vegetation types by MMWC (2015) were incorporated without alteration of boundaries, but polygons were relabelled to match the broader floristic analysis that incorporated additional data.

Table 3: Vegetation Structural Classification

Life form /height class	Canopy cover (%) 100 – 70	70 – 30	30 – 10	10 – 2
Trees over 30 m	Tall Closed Forest	Tall Open Forest	Tall Woodland	Tall Open Woodland
Trees 10 – 30 m	Closed Forest	Open Forest	Woodland	Open Woodland
Trees under 10 m	Low Closed Forest	Low Open Forest	Low Woodland	Low Open Woodland
Tree Mallee	Closed Tree Mallee	Tree Mallee	Open Tree Mallee	Very Open Tree Mallee
Shrub Mallee	Closed Shrub Mallee	Shrub Mallee	Open Shrub Mallee	Very Open Shrub Mallee
Shrubs over 2 m	Closed Tall Scrub	Tall Open Scrub	Tall Shrubland	Tall Open Shrubland
Shrubs 1 – 2 m	Closed Heath	Open Heath	Shrubland	Open Shrubland
Shrubs under 1 m	Closed Low Heath	Open Low Heath	Low Shrubland	Low Open Shrubland
Hummock Grasses	Closed Hummock Grassland	Hummock Grassland	Open Hummock Grassland	Very Open Hummock Grassland
Tussock Grasses	Closed Tussock Grassland	Tussock Grassland	Open Tussock Grassland	Very Open Tussock Grassland
Herbs	Closed Herbland	Herbland	Open Herbland	Very Open Herbland
Sedges	Closed Sedgeland	Sedgeland	Open Sedgeland	Very Open Sedgeland

Vegetation condition was rated according to Table 4. Shapefiles of vegetation condition by MMWC (2015) were incorporated without alteration with the exception that 'Very Poor' was relabelled 'Degraded'.

Table 4: Vegetation Condition Scale (Eremaean and Northern Botanical Provinces)

Condition	Description
Excellent	Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement.
Very Good	Some relatively slight signs of damage caused by human activities since European settlement. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds, or occasional vehicle tracks.
Good	More obvious signs of damage caused by human activity since European settlement, including some obvious impact on the vegetation structure such as that caused by low levels of grazing or slightly aggressive weeds.
Poor	Still retains basic vegetation structure or ability to regenerate it after very obvious impacts of human activities since European settlement, such as grazing, partial clearing, frequent fires or aggressive weeds.
Degraded	Severely impacted by grazing, very frequent fires, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weed species present including very aggressive species.
Completely Degraded	Areas that are completely or almost completely without native species in the structure of their vegetation; i.e. areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.

Source: EPA (2004)

The northwest corner of each quadrat established was:

- GPSed with a precision of less than 3 metre; and
- photographed looking southeast across the quadrat.

2.3 Targeted Fora

A DBCA database search on 24/04/2019 (reference number 22-0419FL), indicated there were 22 conservation significant vascular flora taxa within 50 km of the Area of Interest.

The targeted priority flora can be associated with the five major habitats listed in Table 5. Priority flora codes (P1, P2, P3 and P4) described in Appendix 1.

Table 5: Habitats of Threatened and Priority Flora within 50 km of Survey Area

Lifeform	Priority Species		Habitat
Trees, Mallees and Shrub >1m	P1	*Acacia aphanoclada*	Rocky hills, ridges and rises in skeletal stony soils
		Acacia cyperophylla var. *omearana*	Stony & gritty alluvium. Along drainage lines.
		Acacia fecunda	Associated with quartzite gibbers over grey-red skeletal soil
		Acacia sp. Nullagine	Rocky clay, low lying area between rocky hills.
		Cochlospermum macnamarae	Granite boulders.
	P3	*Eucalyptus rowleyi*	Red sandy loams on plains and very minor and broad flood-outs
Shrubs < 1m	P1	*Ptilotus wilsonii*	Stony gravelly soils. Rocky hills.
		Solanum sp. Mosquito Creek	Alluvial clays and clay loams
		Stemodia sp. Battle Hill	Cracking clay. Floodplain.
	P2	*Indigofera ixocarpa*	Skeletal red soils over massive ironstone.
	P3	*Rostellularia adscendens* var. *latifolia*	Ironstone soils. Near creeks, rocky hills.
	P4	*Lepidium catapycnon*	Skeletal soils on hillsides.
		Ptilotus mollis	Stony hills and screes.
Perennial Grass < 1m	P3	*Themeda* sp. Hamersley Station	Claypans
		Triodia basitricha	Crest of sandstone hill.
Annual Grass < 1m	P3	*Eragrostis crateriformis*	Clay-loam or clay. Creek banks, depressions. In Pilbara mainly coastal, also Millstream-Chichester NP
Annual Herb < 1m	P1	*Atriplex spinulosa*	Footslope of low hill, drainage floor with quartz covered surface, slopes of creek, stony pavement
	P3	*Goodenia* sp. East Pilbara	Red-brown clay soil, calcrete pebbles. Low undulating plain, swampy plains
		Nicotiana umbratica	Shallow soils. Rocky outcrops. Grows in shade of large boulders
		Swainsona thompsoniana	Gibber plains, crabhole plains and gilai
	P4	*Goodenia nuda*	Open depression. Brown sandy loam with granite stones.
Annual Sedge < 1m	P1	*Fimbristylis* sp. Shay Gap	Edge of small pool in basalt creekline.

Sources: WA Herbarium (1998-), (2015)

2.4 Floristic Analysis

A floristic analysis was undertaken in PC-ORD (McCune & Mefford, 2011):

- using data from all quadrats and relevés established in 2014 and 2019;
- based on presence/absence of perennial species only to limit the influence of differences in cover estimates by different surveyors and the influence of different seasons (rainfall);
- with a Group Average linkage method and Sorensen (Bray-Curtis) distance measure;
- assigning group membership to each quadrat/relevé at each step of the associated dendrogram;
- updating nomenclature from the 2014 survey, and excluding any records that could not be updated/made consistent with nomenclature of the WA Herbarium in 2019;
- excluding singleton sites in the dendrogram;
- excluding species with two or fewer occurrences from analysis as 'species with only one or two occurrences never yield an indicator value stronger than expected by chance' (McCune & Grace, Analysis of Ecological Communities, 2002);

An Indicator Species Analysis (ISA) was undertaken in at each level of grouping in the cluster analysis using the methods of Dufrêne and Legendre (1997):

- Figure 8 indicates that the dataset supports no more than approximately 25 vegetation types, as below this level in the dendrogram, additional clusters tended to be in the form of singletons (i.e. groups containing only one site were split off);
- Figure 9 indicates the ISA support for splitting the vegetation into approximately 14 vegetation types with these numbers of clusters coinciding with localised regions of low randomness in the allocation of species to groups (low p-values) and a high number of indicator species (species that co-occur with each other, $p<0.05$).

After examination of the initial analysis outputs, sites were omitted if they were outliers and/or specifically associated with degradation (fire, clearing, low diversity etc) rather soil/landscape position or their original vegetation type. The analysis re-run after the removal of sites H02, H09, H18, H20, H25, H26, H46, H56 and BCR29.

The final dendrogram shown in Figure 10:

- 8 vegetation types were defined in terms of the presence/absence of perennial species;
- 25 vegetation types/subtypes, were identified on the basis of finer divisions within the dendrogram (wit not all subtypes separating at the same level of the dendrogram) and/or differences in cover/dominance of species and/or distinct landscape/landform position.

Once the classification was established it was clear some sites were placed on ecotones, such as H23 and H54, and these were subsequently manually assigned to the most appropriate vegetation type/subtype.

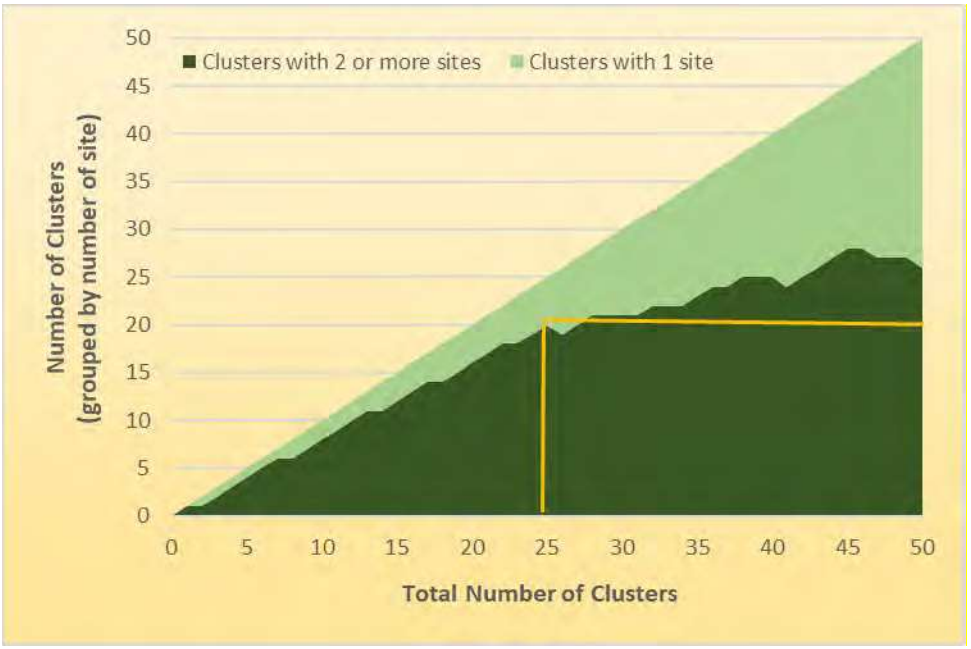

Figure 8: Number of single sites clusters as a proportion of total number of clusters

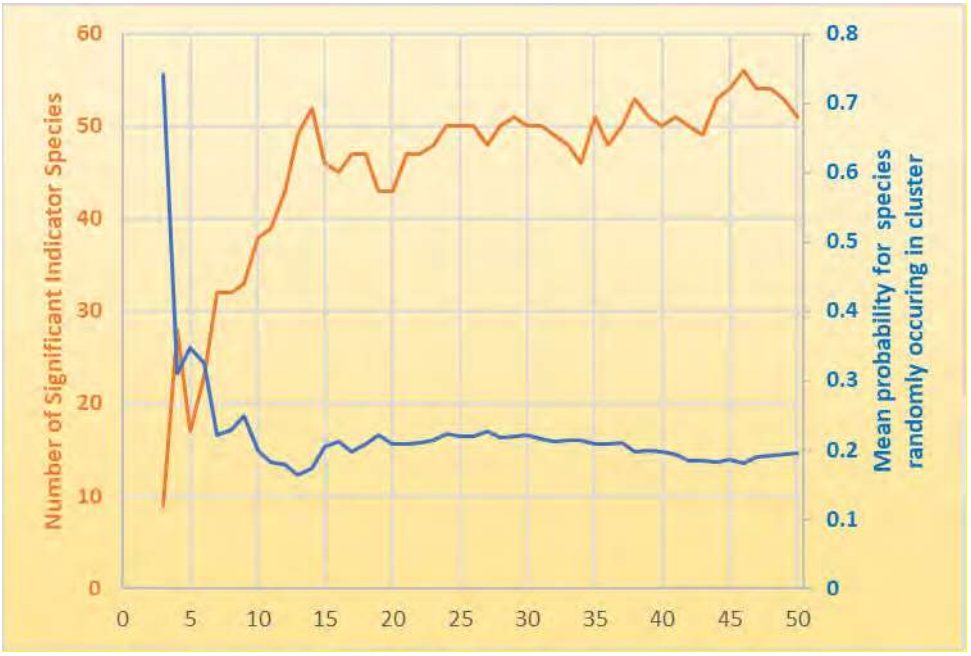

Figure 9: Indicator Species Analysis Output

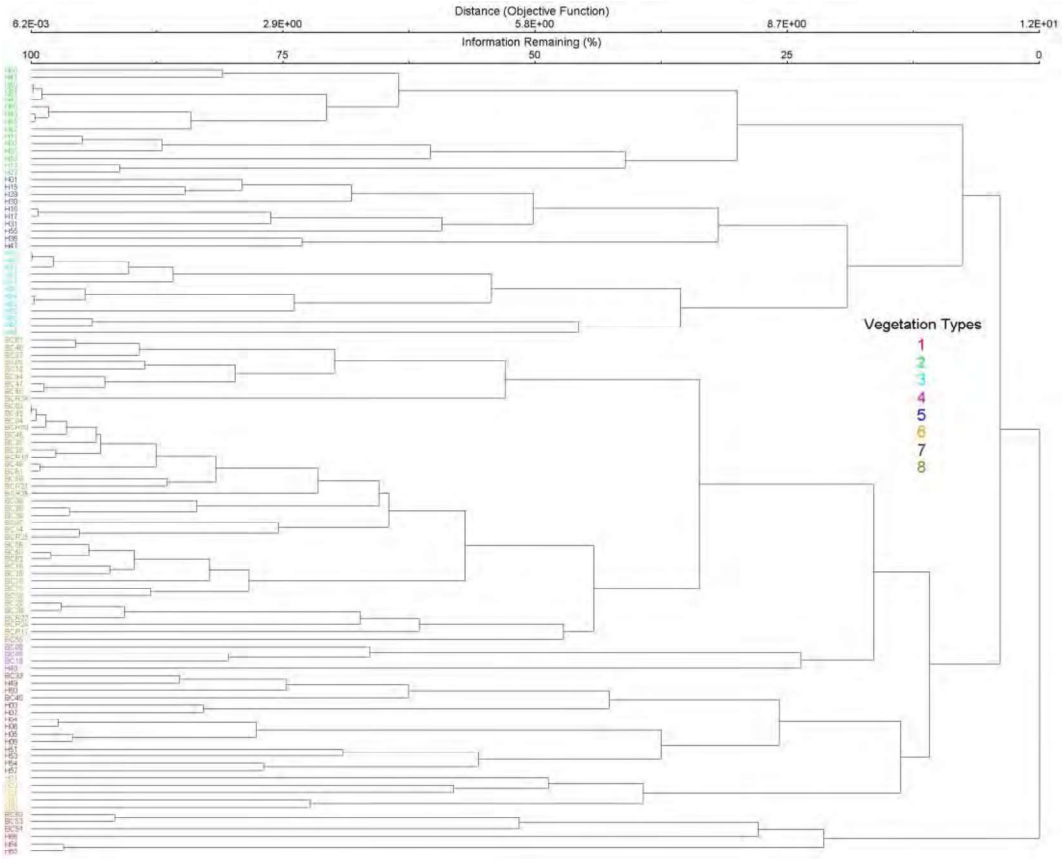

Figure 10: Dendrogram of Quadrats/Vegetation Types

2.5 Statewide and Regional Taxa Ranges / Distributions

The ranges (spatial extents) of taxa were auto-generated by the longest axis in polygons created by points using the following GIS datasets:

- Atlas of Living Australia (ALA, 2018)
- *An inventory and condition survey of the Pilbara region* (Van Vreeswyk, Payne, Leighton, & Hennig, 2004)
- NatureMap (DPaW, 2018)
  - Botanical survey of Hamersley Range uplands (van Leeuwen & Bromilow, 2002)
  - Cane River Flora Survey (part of Bush Blitz program)
  - Pilbara Biological Survey

The potential for local endemism was examined in Florabase (DEC, 2012) and NatureMap (DPaW, 2018) for taxa with a long polygon axis less than 150 km.

The potential for range extensions was examined in Florabase (DEC, 2012) and NatureMap (DPaW, 2018) for taxa more than 150 km outside the boundaries of their distribution polygons.

2.6 Personnel

The roles and experience of the personnel involved the production of this report are summarised in Table 6.

Table 6: Project Team

Team Member	Field Experience	Project Tasks
Andrew Waters Licence FB2000073 • Graduate Certificate in GIS • Bachelor of Science • Advanced Certificate of Horticulture • Certified Environmental Practitioner (EIANZ)	Since 1997 worked in: • Avon Wheatbelt • Esperance Plains • Geraldton Sandplains • Great Sandy Desert • Jarrah Forest • Little Sandy Desert • Mallee • Murchison • Pilbara • Swan Coastal Plain	• Report Writing Mapping • Flora Surveys •
Dr Shane Chalwell Licence FB62000076 • PhD (Plant communities of greenstone hills of the Eastern Goldfields of Western Australia as analogues for the rehabilitation of rocky waste dumps) • Bachelor of Science (Honours)	Since 2002 worked in: • Avon Wheatbelt • Central Ranges • Coolgardie • Dampierland • Esperance Plains • Gascoyne • Geraldton Sandplains • Great Sandy Desert • Jarrah Forest • Little Sandy Desert • Mallee • Murchison • Ord-Victoria Plains • Pilbara • Swan Coastal Plain	• Quadrats
Frank Obbens • Bachelor of Science (Honours) • research associate with the WA Herbarium where he is the leading expert on the genus *Calandrinia*	Since 1993 worked in: • Avon Wheatbelt • Carnarvon • Coolgardie • Gascoyne • Geraldton Sandplains • Great Sandy Desert • Great Victoria Desert • Jarrah Forest • Little Sandy Desert • Mallee • Murchison • Pilbara • Swan Coastal Plain • Warren • Yalgoo	• Plant Identifications

Andrew Waters and Dr Shane Chalwell are very familiar with the flora and vegetation in the vicinity, where they have conducted flora and vegetation surveys across more than 200 field days since 2016.

2.7 Limitations

Consistent with *Technical Guidance Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA, 2016) and reduce any possible misinterpretations of this report, an indication is provided below of the degree to which the following have limited data collection or the interpretation thereof:

- availability of contextual information at a regional and local scale;
- competency/experience of the team carrying out the survey, including experience in the bioregion surveyed;
- proportion of flora recorded and/or collected, any identification issues;
- was the appropriate area fully surveyed (effort and extent);
- access restrictions within the survey area;
- survey timing, rainfall, season of survey; and
- disturbance that may have affected the results of survey such as fire, flood or clearing.

2.7.1 Contextual Information

The flora of the Chichester IBRA subregion is relatively poorly known, with few intensive studies, and quadrat-based floristic data available from only some localities (DPaW, 2002).

The Department of Agriculture and Food Western Australia's ('DAFWA's') *Technical Bulletin No. 92 - An inventory and condition survey of the Pilbara region, WA* (Van Vreeswyk, Payne, Leighton, & Hennig, 2004) provides a regional framework for assessing the extent, condition and significance of vegetation at the level of subformations (which is the NVIS, National Vegetation Inventory System, equivalent of the site types referred to in Bulletin No. 92). This framework is particularly relevant to surveys in the Mosquito Land System where a Priority Ecological Community was defined in terms of a site type in this survey.

Relevant survey from the immediate surrounds, either commissioned by Novo or in the public domain include:

- *Millennium Minerals Ltd – Nullagine Priority Flora Census Update, October 2017* (Woodgis, 2017);
- *Vegetation of the MML Nullagine Tenements, October 2017/ version 3.1* (Waters, 2017);
- *Stony Plains of the Mosquito Land System PEC, May 2017/version 2.0* (Woodgis, 2017);
- *Landforms and Soils associated with a Priority Ecological Community within the Mosquito Land System near Nullagine, East Pilbara* (Land Assessment, 2016);
- *Beatons Creek Gold Project Flora and Vegetation Assessment* (MMWC, 2015);
- *Flora and Vegetation Survey of the Nullagine Survey Area* (Mattiske Consulting, 2011).

2.7.2 Team Competency/Experience

The expertise employed in the report was sufficient to provide confidence in the results and conclusions:

- field surveys were undertaken by Andrew Waters and Dr Shane Chalwell (Table 6 and page 16), who are very familiar with the flora and vegetation in the vicinity, having conducted flora and vegetation surveys in the bioregion for more than 5 years, and within 100 km of the Area of Interest across more than 200 field days since 2016.
- the identification of plant specimens was undertaken by Frank Obbens, a taxonomist and research associate of the WA Herbarium (where he is a leading expert on Calandrinia plants) with more than 15 years experience.
- identification of priority taxa observed by the surveyors in the vicinity (Table 8) were previously confirmed by:
    - Frank Obbens, a taxonomist and research associate of the WA Herbarium; and
    - experts at the Western Australian herbarium, Steve Dillon (2017) and Mike Hislop (2016), with Andrew Mitchell (2018) also consulted.

2.7.3 Proportion of Flora Recorded

Flora identification was not a limitations as demonstrated in Section 2.7.2.

In the Area of Interest 251 taxa recorded, with 218 taxa recorded in 117 quadrats/relevé sites, and 33 taxa recorded opportunistically. It is estimated that proportion of the total species present (Chao2 estimate, bias corrected using PC-ORD (McCune & Mefford, PC-ORD, 2011)) recorded were:

- 91% of an estimated 277 species in the overall Area of Interest;
- 86% of an estimated 201 species in the Project Area; and
- 91% of an estimated 195 species in the Haul Road Area.

The species accumulation curves in Figure 11.

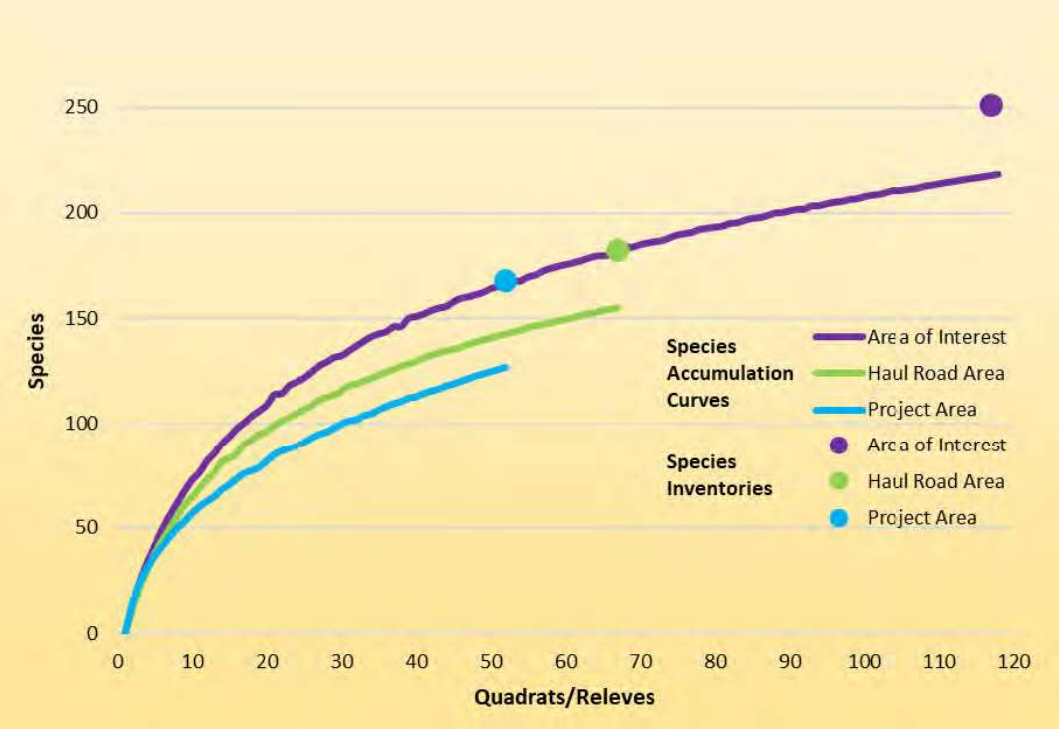

Figure 11: Species Accumulation Curves

2.7.4 Survey Effort and Extent

Access, resources and intensity of sampling was not a significant limitation.

There was a high level of access across the Area of Interest, with observations undertaken across the site and all landforms and land systems being sampled multiple times, as shown in Figure 7 on page 10 and Table 2 on page 10.

2.7.5 Timing and Weather

Timing and rainfall were not limiting factors for the surveys

Sampling of vegetation quadrats used in April 2019 was appropriate as:

- The survey was within the EPA (2016) recommendations for a survey 6-8 weeks post wet season (March-June);
- The preceding rainfall was similar to the long-term median (median rather than mean being a more meaningful index in areas of high rainfall variability). A comparison of rainfall from 1961 until 1990 (the period used as the climate reference or 'climate normal' by the Bureau of Meteorology) for Bonney Downs (station 4006), approximately 37 km south of Nullagine is shown in Figure 12; and
- Approximately 40% of taxa were flowering or fruiting (Table 7).

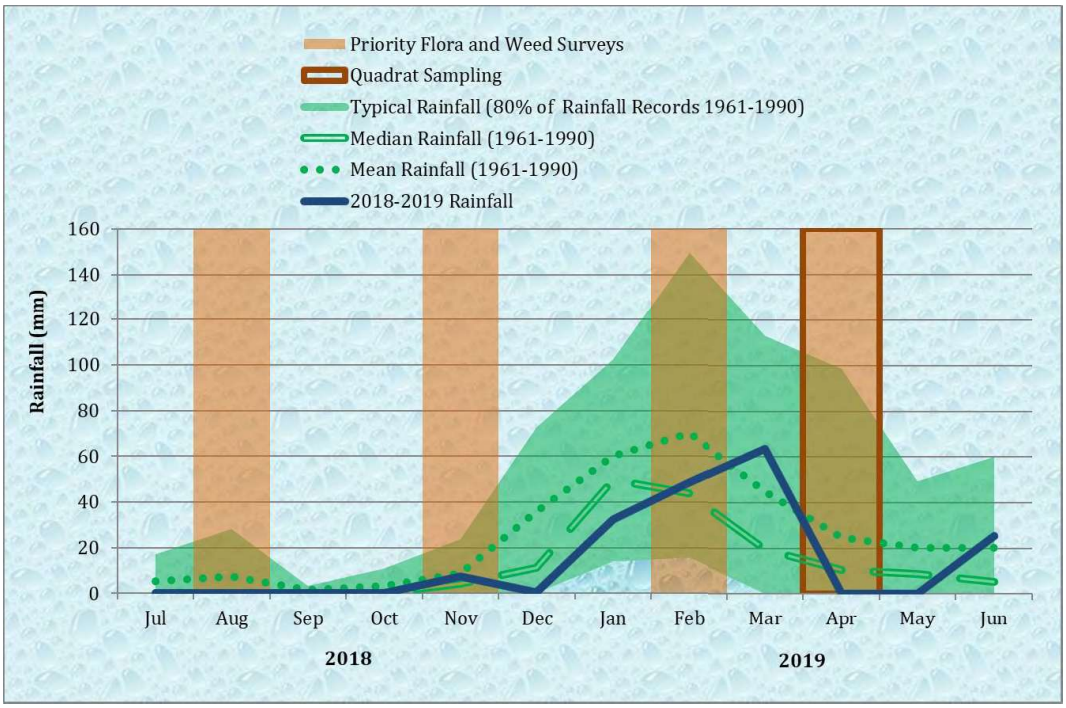

Figure 12: Rainfall over 2018/2019 Survey Period

Table 7: Flowering/Fruiting of Flora in April 2019

Flora Taxa	Flowering / Fruiting	Vegetative	Total
Annual / Short-lived Perennial Taxa	23	23	46
Long-lived Perennial Taxa	41	70	111
Total	**64**	**93**	**157**

The detectability of taxa is influenced by lifeforms and flowering times, and these characteristics are reflected in Table 8.

Table 8: Detectability of Priority Flora Targeted in 2019

Detectability	Lifeform		Priority Species	Observed in vicinity by Surveyors	Confirmed in Census Area by Surveyors
High	Trees, Mallees and Shrub >1m	**P1**	***Acacia aphanoclada***	Yes	**Yes**
		P1	*Acacia cyperophylla* var. *omearana*		
		P1	*Acacia fecunda*		
		P3	*Eucalyptus rowleyi*		
		P1	*Acacia* sp. Nullagine		
		P1	*Cochlospermum macnamarae*		
	Shrubs < 1m	**P1**	***Ptilotus wilsonii***	Yes	**Yes**
		P1	*Solanum* sp. Mosquito Creek		
		P4	*Ptilotus mollis*		
		P1	*Stemodia* sp. Battle Hill		
		P2	*Indigofera ixocarpa*		
		P3	*Rostellularia adscendens* var. *latifolia*		
		P4	*Lepidium catapycnon*		
Moderate	Perennial Grass < 1m	P3	*Themeda* sp. Hamersley Station		
		P3	*Triodia basitricha*		
	Annual Grass < 1m	P3	*Eragrostis crateriformis*	Yes	
	Annual Herb < 1m	**P1**	***Atriplex spinulosa***	Yes	**Yes**
		P4	*Goodenia nuda*		
		P3	*Goodenia* sp. East Pilbara		
		P3	*Nicotiana umbratica*		
		P3	*Swainsona thompsoniana*		
	Annual Sedge < 1m	P1	*Fimbristylis* sp. Shay Gap		

Genera of moderate detectability species were targeted for collection in 2019. The species of those genera recorded were:

- *Eragrostis cumingii, Eragrostis eriopoda, Eragrostis tenellula* and *Eragrostis xerophila;*
- *Fimbristylis dichotoma;*
- *Goodenia cusackiana, Goodenia microptera* and *Goodenia muelleriana;*
- *Swainsona pterostylis;*
- *Themeda triandra;* and
- *Triodia brizoides, Triodia epactia, Triodia longiceps* and *Triodia wiseana.*

Indigofera ixocarpa P2, could not be found at Beatons Pool (where it was recorded in 1982 and 1984), just outside the Census Area. MMWC (2015) noted that 'there is a possibility it may no longer occur in the area'.

2.7.6 Disturbances

There was a high level of historic and current disturbances (Section 3.2 and page 26). This was generally dealt with by:

- labelling highly degraded units either as 'Not Assessed' or the most likely combination of vegetation types that would have occurred; and
- characterising subtypes, below the level at which all vegetation types could be grouped on the basis of presence/absence of perennial species alone.

3 RESULTS

3.1 Vegetation Types

3.1.1 Local Vegetation Units – Vegetation Types

'Vegetation type' is the term preferred by the EPA (2016) for local scale vegetation units at 1:10,000 – 1:40,000 scale as the term 'vegetation association' (which can be equivalent under the National Vegetation Information System framework) is commonly used at the regional scale in Western Australia.

Figure 13 shows the distribution, Table 9 characterises, and Table 10 lists the extents of the:

- 8 vegetation types are defined in terms of presence/absence of perennial species (Appendix 2 lists statistically significant indicator and common species for vegetation types); and
- 25 vegetation subtypes, where subtypes were identified within types on the basis of differences in cover/dominance of species and/or distinct landscape/landform position.

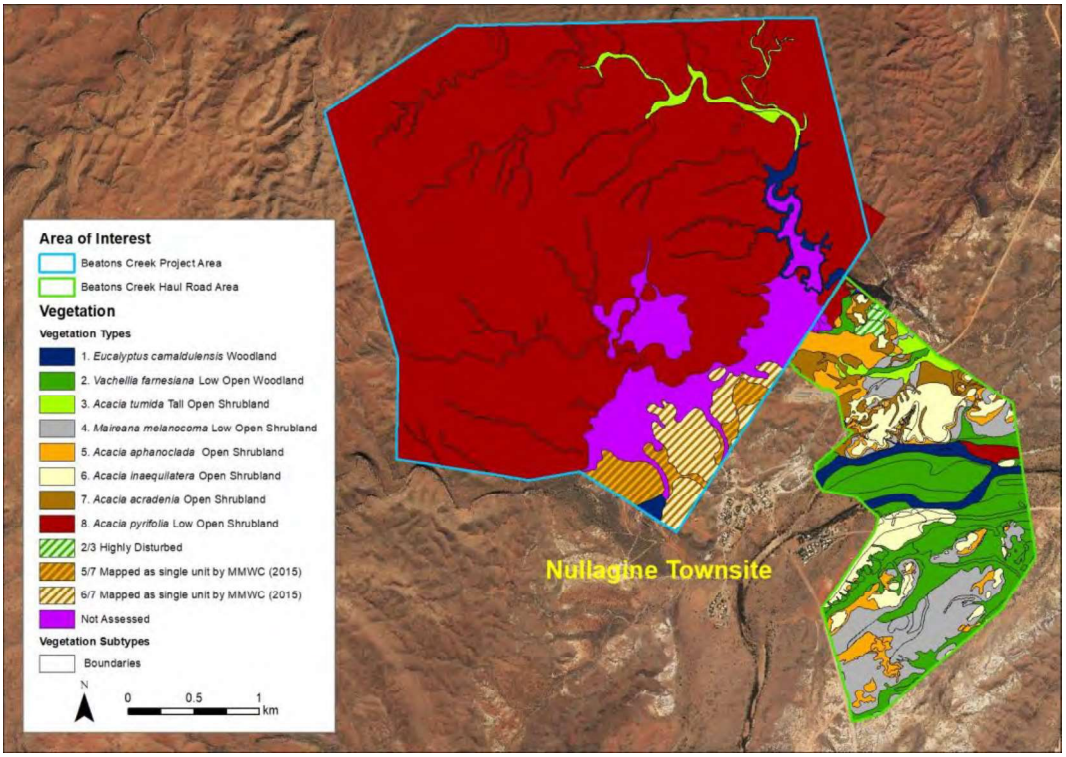

Figure 13: Distribution of Vegetation Types

Table 9: Characteristics of Vegetation Types/Subtypes

Landforms	Vegetation Type	Subtype Landforms	Indicative Subtype Species
Rivers	**1. *Eucalyptus camaldulensis, Melaleuca glomerata, Acacia coriacea* Woodland**	1a Riverbeds/banks	**sedges**: *Cyperus vaginatus*
		1b Waterholes	**sedges**: *Typha domingensis*
Non-Saline Plains	**2. *Vachellia farnesiana* Low Open Woodland over *Cenchrus ciliaris* Very Open Tussock-Tussock Grassland**	2a Lower Terraces of Rivers	**trees**: *Eucalyptus victrix, Acacia trachycarpa, Atalaya hemiglauca* **grasses**: *Cenchrus ciliaris, Cenchrus setigera*
		2b Upper Terraces of Rivers	**trees**: *Acacia sclerosperma, Atalaya hemiglauca, Hakea lorea* **grasses**: *Cenchrus ciliaris, Cenchrus setigera*
		2c Alluvial Plains	**shrubs**: *Solanum* sp. Mosquito Creek, *Pluchea ferdinandi-muelleri, Pluchea tetranthera, Sclerolaena hostilis* **grasses**: *Triodia longiceps*
		2d Open Depressions of Alluvial Plains	**shrubs**: *Acacia trachycarpa, Acacia ancistrocarpa, Acacia bivenosa* **grasses**: *Triodia longiceps*
		2e Minor Drainagelines of Alluvial Plains	**shrubs**: *Acacia tumida, Acacia bivenosa* **grasses**: *Triodia longiceps*
	3. *Acacia tumida, Acacia trachycarpa* Tall Open Shrubland over *Triodia epactia* Very Open Hummock-Hummock Grassland	3a Major Creeks	**shrubs**: *Melaleuca glomerata* **sedges**: *Cyperus vaginatus* sedges
		3b Floodplains of Major Creeks	**trees**: *Hakea lorea* **shrubs**: *Pluchea tetranthera* **grasses**: *Eragrostis eriopoda*
Saline Plains	**4. *Maireana melanocoma, Sclerolaena hostilis* Low Open Shrubland over *Triodia longiceps* Very Open Hummock Grassland**	4a Stony Plains	**shrubs**: *Frankenia setosa*
		4b Creeks Of Stony Plains	**shrubs**: *Melaleuca eleuterostachya, Acacia bivenosa*
Rises	**5. *Acacia aphanoclada / Acacia inaequilatera* Open Shrublands over *Triodia longiceps* Very Open Hummock Grassland**	5a Rises on Stony Saline Plains	**shrubs**: *Acacia aphanoclada* **grasses**: *Triodia wiseana*
		5b Rises on Stony Saline Plains	**shrubs**: *Acacia aphanoclada* **grasses**: *Triodia brizoides*
		5c Slopes on Plateaus	**shrubs**: *Acacia inaequilatera* **grasses**: *Triodia wiseana*
	6. *Acacia inaequilatera* Open Shrubland over Open Hummock Grassland	6a Plateaus on Rises	**grasses**: *Triodia epactia*
		6b Plateaus on Rises	**grasses**: *Triodia brizoides*
	7. *Acacia acradenia* Open Shrubland over Open Hummock Grassland	7a Slopes on Rises	**trees**: *Eucalyptus leucophloia* **shrubs**: *Acacia aphanoclada* **grasses**: *Triodia brizoides*
		7b Drainagelines on Rises	**shrubs**: *Acacia ancistrocarpa* **grasses**: *Triodia longiceps, Triodia epactia, Triodia brizoides*
Low Hills	**8. Scattered Low Trees of *Eucalyptus leucophloia over Acacia pyrifolia* Low Open Shrubland over Open Hummock Grassland**	8a Hills	**shrubs**: *Acacia hilliana, Acacia spondylophylla, Acacia orthocarpa* **grasses**: *Triodia brizoides, Triodia epactia*
		8b Hills	**shrubs**: *Acacia hilliana, Acacia spondylophylla* **grasses**: *Triodia brizoides*
		8c Hills	**shrubs**: *Senna glaucifolia* **grasses**: *Triodia brizoides, Triodia epactia*
		8d Hills	**shrubs**: *Acacia aphanoclada, Acacia orthocarpa, Acacia spondylophylla, Acacia adoxa* **grasses**: *Triodia brizoides*
		8e Upper Drainagelines on Hills	**shrubs**: *Acacia monticola*
		8f Lower Drainagelines on Hills	**shrubs**: *Acacia tumida*
		8g Creeks on Hills	**Shrubs**: *Eucalyptus victrix*

Table 10: Extents of Vegetation Types/Subtypes

Vegetation Type	Area (hectares)	Vegetation Subtype	Area (hectares)
1	32.5	1a	29.7
		1b	2.8
2	118.2	2a	21.6
		2b	33.5
		2c	47.9
		2d	8.1
		2e	7.1
3	21.1	3a	11.4
		3b	9.8
4	75.2	4a	66.6
		4b	8.6
5	40.3	5a	8.6
		5b	19.5
		5c	12.1
6	55.6	6a	16.7
		6b	38.9
7	26.1	7a	17.1
		7b	9.1
8	985.6	8a/b/c	926.5
		8d	24.3
		8e/8f	23.4
		8g	11.4
2/3	4.0	2e/3a/3b	4.0
5/7	26.1	5b/7a/7b	26.1
6/7	40.0	6a/6b/7a/7b	40.0
NA	107.1	Dam	10.5
		Cleared	96.6

3.1.2 Regional Vegetation Units – Vegetation Types

Forty-four site types (which are equivalent to vegetation subformations under the NVIS framework) were described across the Pilbara by Van Vreeswyk *et al.* (2004). Site types were based on combinations of land surface (landforms and soils), dominant perennial plant species, and vegetation structure and there is not always a definitive one-to-one relationship between vegetation types and site types and occasional anomalies and inconsistencies in descriptions/classification can arise due to differences in scale. Greatest value is attached to the dominant layer or layers. This is standard in vegetation mapping as it is the dominant layer that determines the physiognomy (form and morphological structure) of the vegetation and enables it to be characterised as forest, shrubland or grassland and so on (Beard, Beeston, Harvey, Hopkins, & Shepherd, 2013).

Vegetation types were assigned to the best matching site type, as per Table 11. The extents of site types are also listed in Table 11. Site type distribution is shown in Figure 14.

Table 11: Assignment of Local Vegetation Types/Subtypes to Regional Site Types

Regional Site Types	Vegetation Subtypes	Area (ha)
GMEW: Gallery melaleuca eucalypt woodland	1a Riverbeds/banks	32.5
	1b Waterholes	
DESG: Drainage spinifex grassland with eucalypt overstorey	8g Creeks on Hills	11.4
DAHW: Drainage acacia hummock grass shrubland/ woodland	2d Open Depressions of Alluvial Plains	49.9
	2e Minor Drainagelines of Alluvial Plains	
	3a Major Creeks	
	7b Drainagelines on Rises	
	8e Upper Drainagelines	
	8f Lower Drainagelines on Hills	
AEBG: Alluvial plain eucalypt buffel grass woodland	2a Lower Terraces of Rivers	21.6
APBG: Alluvial plain buffel grass grassland	2b Upper Terraces of Rivers	33.5
AHSG: Alluvial plain hard spinifex grassland	2c Alluvial Plains	47.9
ASSG: Alluvial plain soft spinifex grassland	3b Floodplains of Major Creeks	9.8
SSCG: Stony plain spinifex grassland with chenopod shrubs	4a Stony Plains	75.2
	4b Creeks of Stony Plains	
PHSG: Plain hard spinifex grassland	5a Rises on Stony Saline Plains	188.0
	5b Rises on Stony Saline Plains	
	5c Slopes on Rises	
	6a Plateaus on Rises	
	6b Plateaus on Rises	
	7a Slopes on Rises	
HSPG: Hill spinifex grassland	8a Hills	950.8
	8b Hills	
	8c Hills	
	8d Hills	
ASSG/DAHW	2e/3a/3b	4.0
Not Assessed	Dam	107.1
	Clearing	

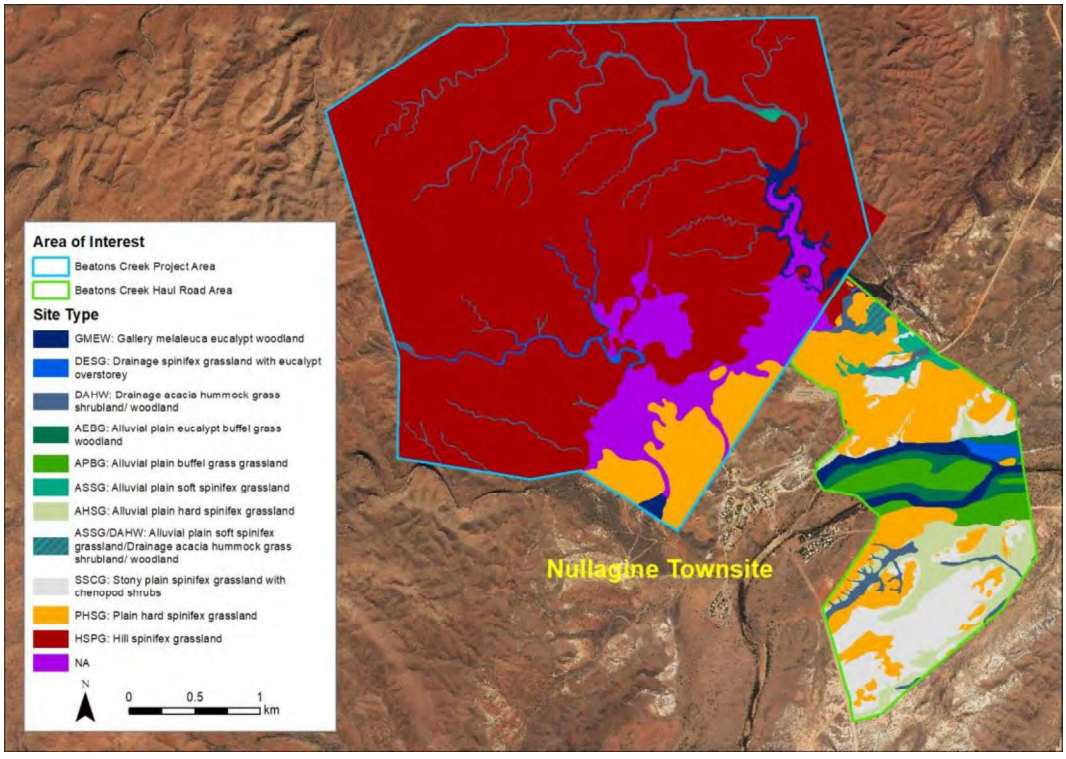

Figure 14: Distribution of Site Types

3.2 Vegetation Condition

The vegetation in Area of Interest has been subject to considerable degradation, with areas of mining activity (and an old 1:50,000 topographic map shows an aircraft landing strip through the centre of the Day Dawn Mine area), and the Shire of East Pilbara rubbish tip shown in in Figure 15. Major areas of degradation are shown in Figure 16, and the condition rating is shown in Figure 17.

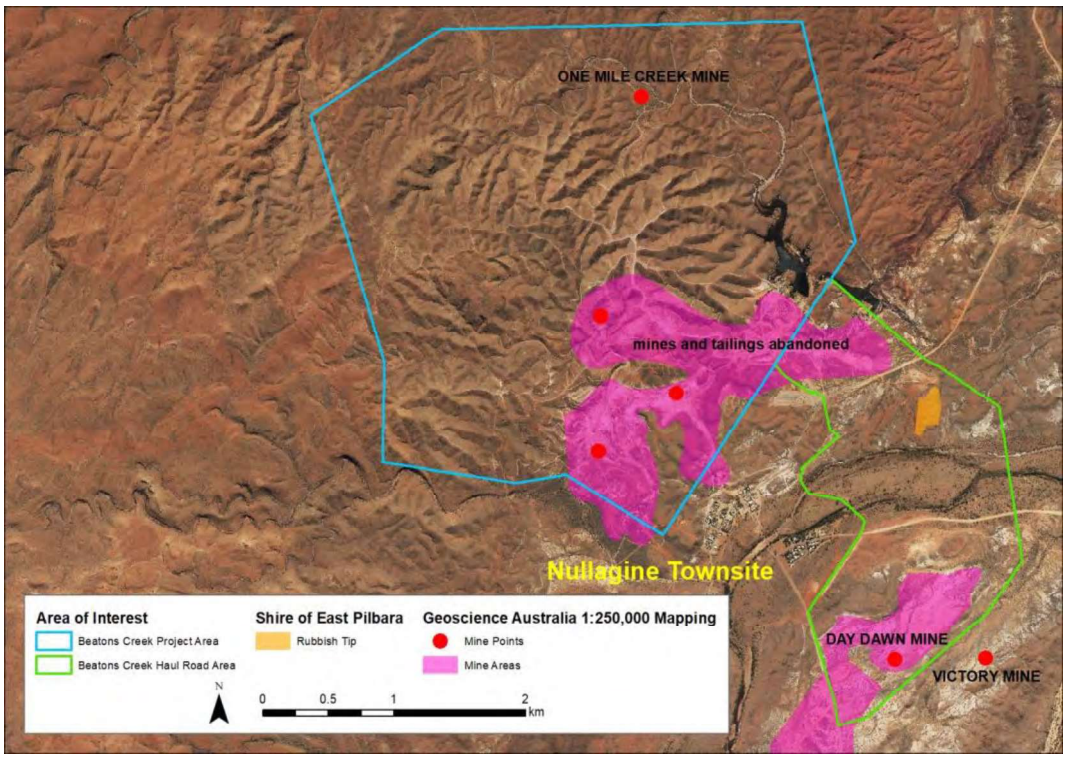

Figure 15: Larger Areas of Historic Clearing

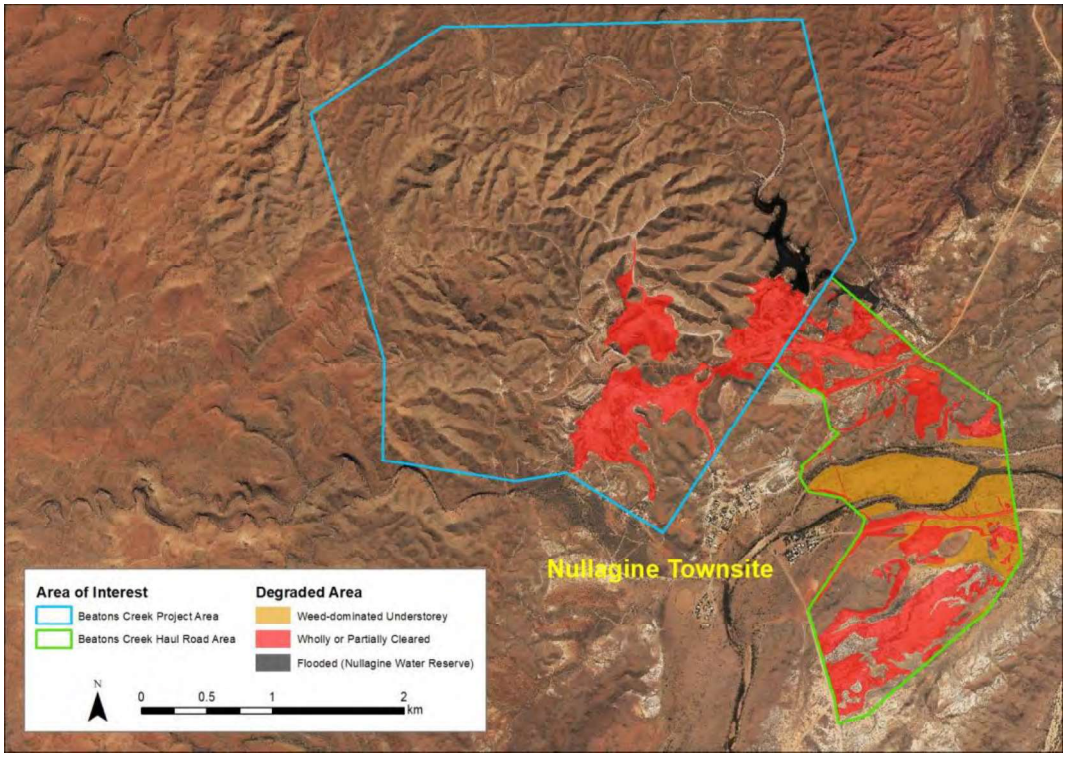

Figure 16: Larger Areas of Degradation

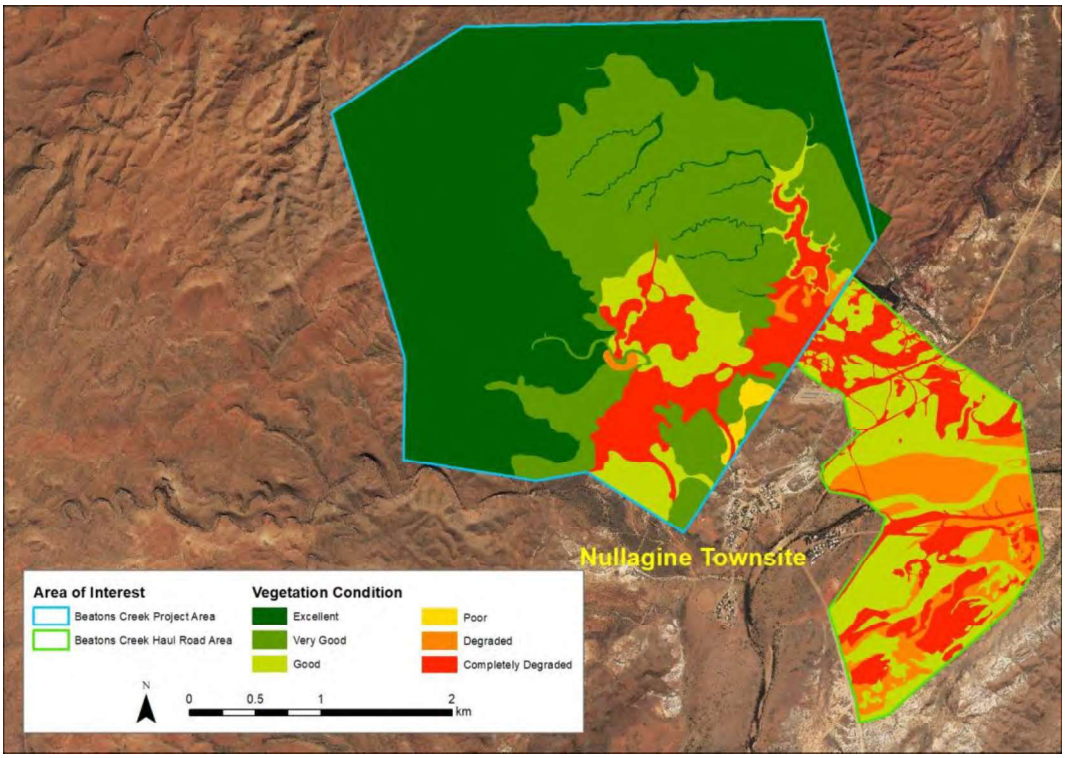

Figure 17: Condition Rating

The Area of Interest, which covers 1,532 hectare, includes substantial areas of degradation:

- 215 hectares of 'active' clearing (Photo 1 and Photo 2) and 'passive' clearing (Photo 3);
- 97 hectares dominated by weeds (Photo 4); and
- 13 hectares of flooding (Photo 5).

Photo 1: Example of Historic Mining Area north of Nullagine

Photo 2: Example of Historic Mining Area south of Nullagine

Photo 3: Example of Clearing through Soil Loss

Photo 4: Example of Weed (Buffel Grass) Dominated Area

Photo 5: Example of Flooding (Nullagine Water Reserve)

3.3 Flora

3.3.1 Native Flora

In the Area of Interest, a total of 241 native taxa were recorded (Appendix 3):

- 91% of present species were recorded (Section 2.7.3 on page 18);
- 46 families were recorded, the most diverse being FABACEAE with 55 taxa and POACEAE with 32 taxa;
- 118 genera were recorded, the most diverse being Acacia with 31 taxa and Ptilotus with 10 taxa;
- The land systems were floristically distinct, of species recorded in quadrats/releves:
  - 7% of species were recorded across the three land systems
  - 30% species were recorded across two land systems
  - 63% species were recorded in only one of the land systems

No threatened taxa have been recorded within 50 km of the Area of Interest (DBCA database search 22-0419FL). The abundance/distribution of priority taxa in the Area of Interest is summarized in Table 12.

Table 12: Priority Flora Confirmed in Area of Interest

Priority Species	Photos Maps	Population/s in 2019 Census Area (994 hectares)	Habitat / Comment
***Acacia aphanoclada* P1** Abundant local endemic tree	Photo 6 Figure 18	**4,713 plants** **69.6 ha***	Vegetation Subtypes: 5a, 5b, 7a, 8d
***Acacia cyperophylla* var. *omearana* P1** Abundant local endemic tree	Photo 7 Photo 11 Figure 19	**0 plants** **0 hectares**	Along Beatons Creek, the population was continuous over the 1 km where the south-east boundary was confirmed and may be largely continuous over 12 km of the creek. Occurs on rock slabs upstream west of Beatons Pool (which may represent the 'core' habitat) and on stony/sandy creeks downstream to the east
***Atriplex spinulosa* P1** Abundant local endemic shrub	Photo 8 Figure 20	**75.2 ha*** **444 - 1,667 plants /ha**	Vegetation Subtypes: 4a, 4b Densities at 2 sites • 444 plants/ha • 1,667 plants/ha
***Ptilotus wilsonii* P1** Abundant shrub in restricted area	Photo 9 Figure 21	**2,015 plants** **66.6 ha* (no plants located in this habitat – see comments)**	Vegetation Subtypes: 4a (restricted areas within) Appears to respond to disturbance with plants only in one area. This area was mapped as disturbed and not interpretable by MMWC (2015) Co-ordinates of MMWC record (199,359mE, 7,577,352mN) appears erroneous - no plants there and its 500m east of any habitat or confirmed plants
***Solanum* sp. Mosquito Creek P1** Abundant local endemic shrub	Photo 10 Figure 22	**63.1 hectares** **22 - 6,533 plants /ha**	Vegetation Subtypes: 2c, 2d, 2e Densities at 3 unburnt sites • 22 plants/ha - 156 plants/ha Density at 1 burnt site • 6,533 plants/ha

***Haul Road Area only - excludes habitat mapped as cleared by MMCW** (2015) **in Project Area**

Photo 6: ***Acacia cyperophylla*** **var.** ***omearana*** **P1**

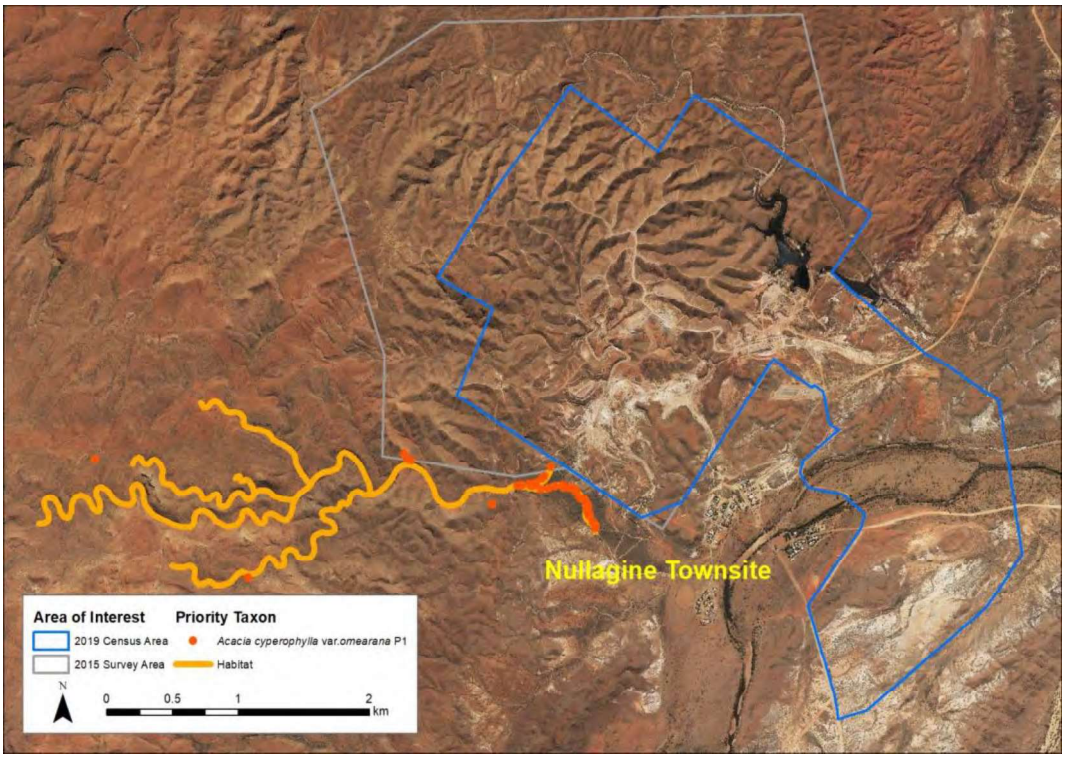

Figure 18*:* ***Acacia cyperophylla*** **var.** ***omearana*** **P1**

Photo 7: *Acacia aphanoclada* P1

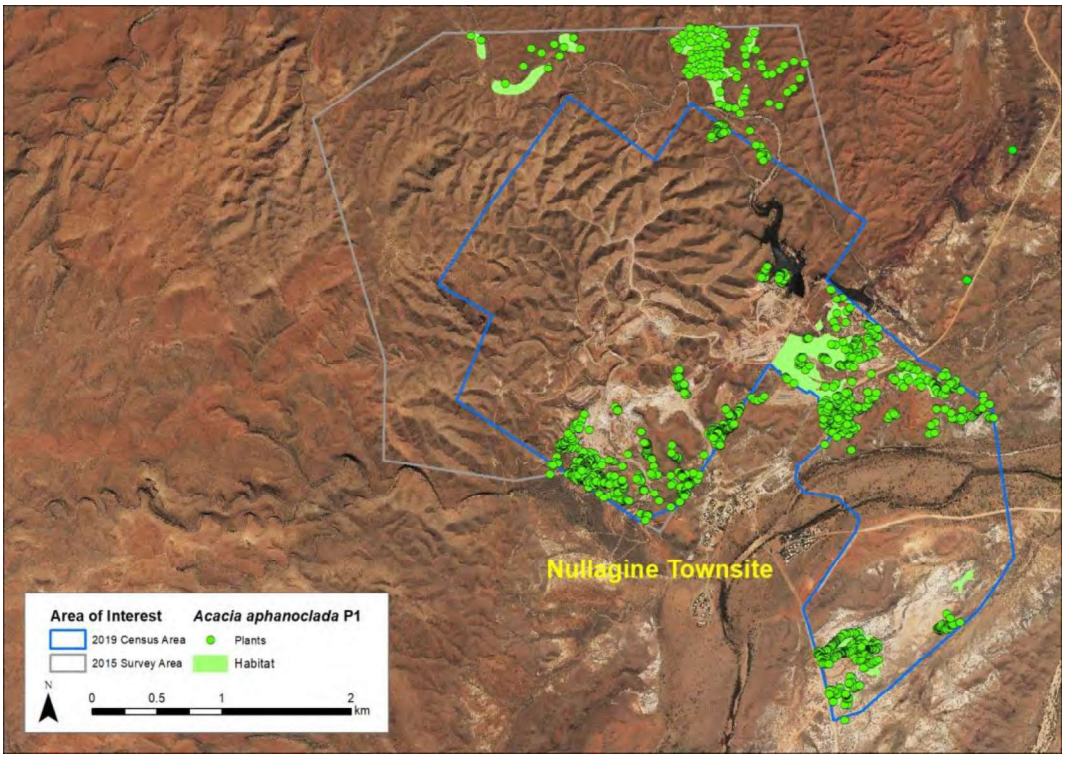

Figure 19: *Acacia aphanoclada* P1

Photo 8: *Atriplex spinulosa* P1

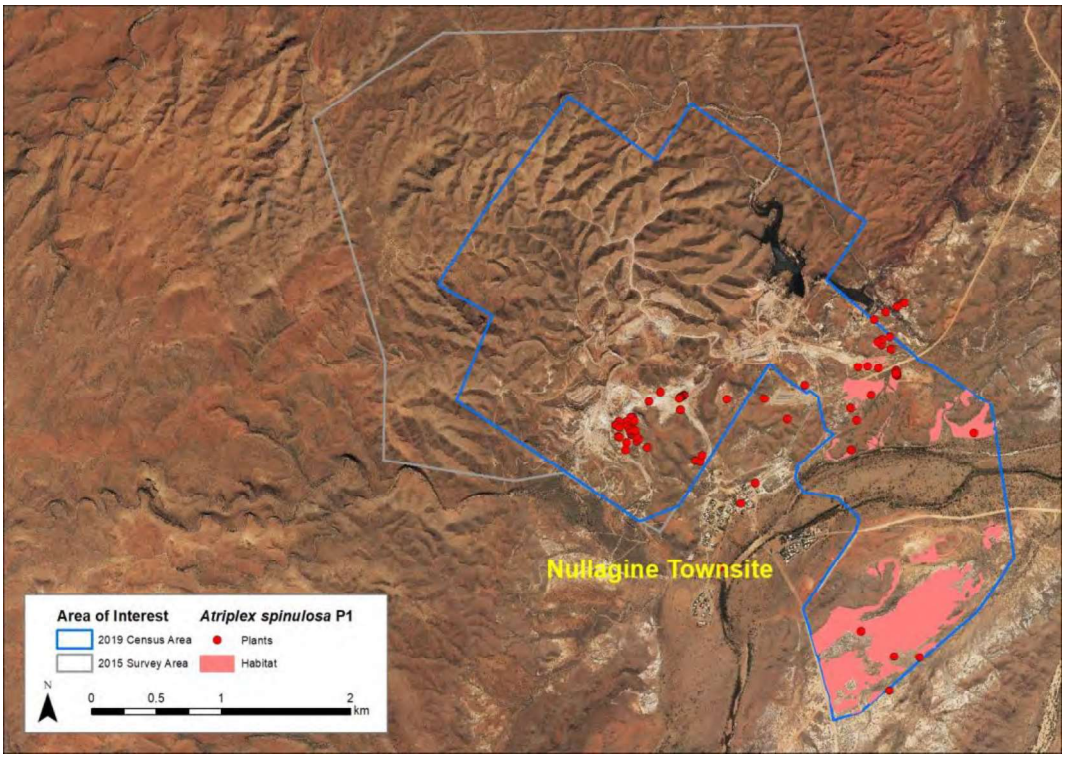

Figure 20*: Atriplex spinulosa* P1

NB: Observations in Census Area to confirm habitat only and are not comprehensive

Photo 9: *Ptilotus wilsonii* P1

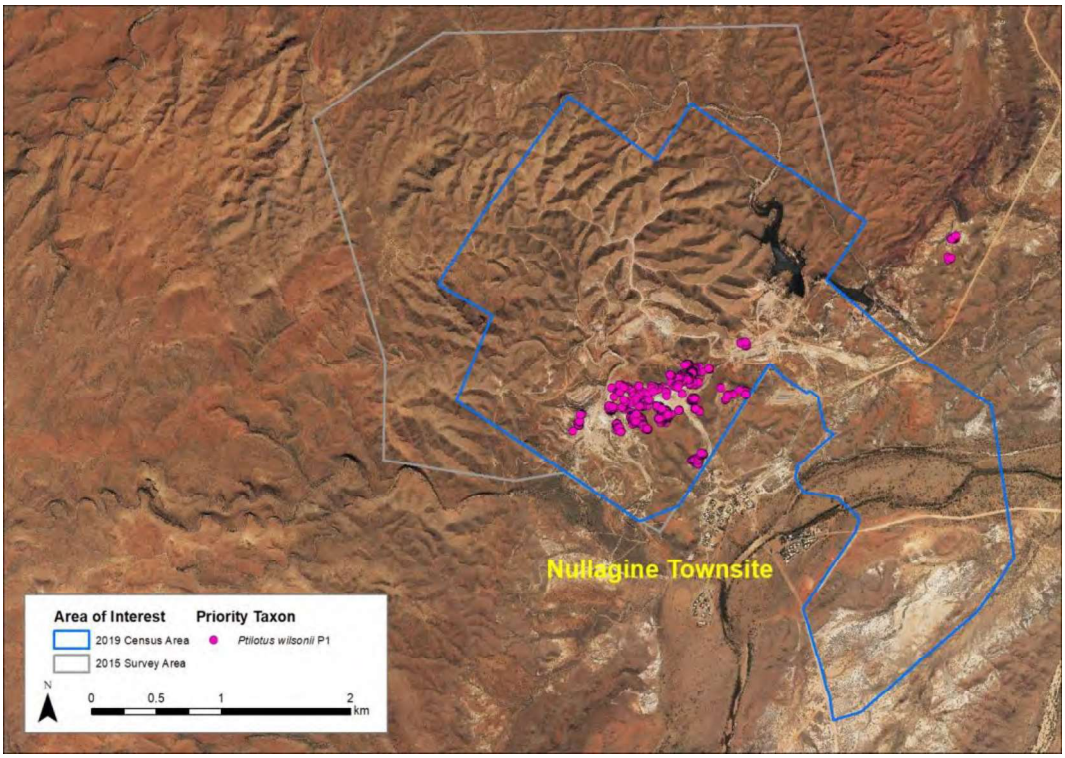

Figure 21: *Ptilotus wilsonii* P1

NB: MMWC record (199,359 m East, 7,577,352 m North) removed
no plants could be found there in 2019 and it is 500 m east of any habitat or confirmed plants

Photo 10: *Solanum* sp. Mosquito Creek P1

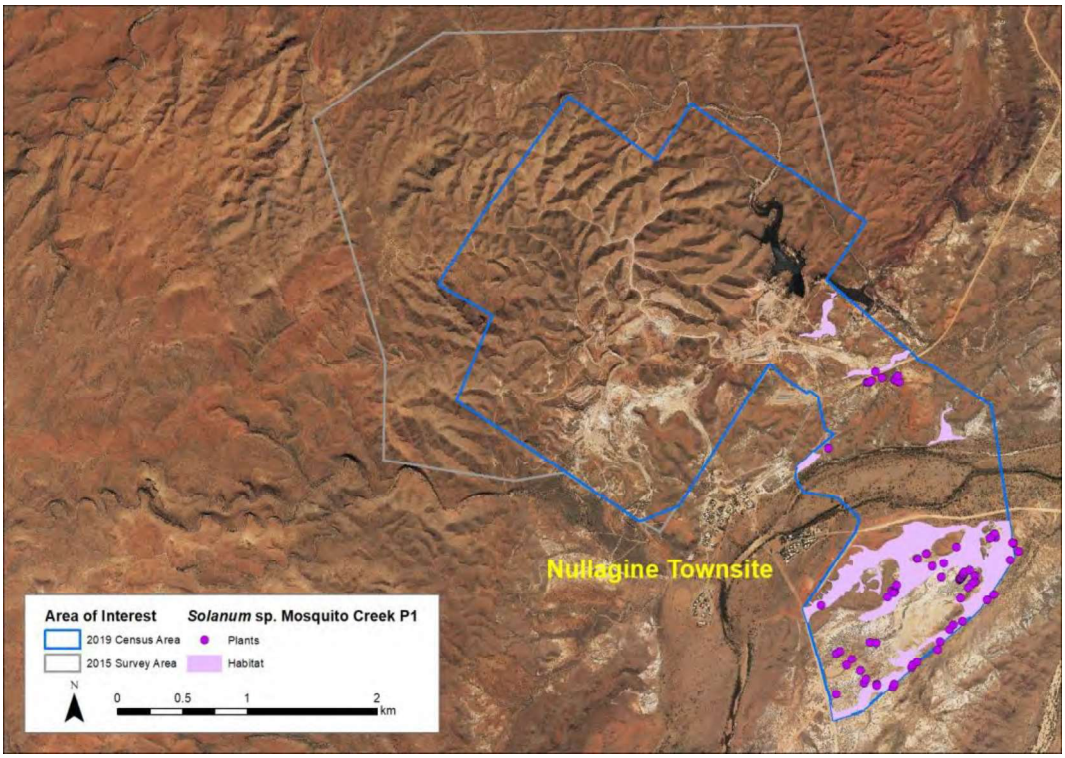

Figure 22: *Solanum* sp. Mosquito Creek P1

NB: Observations in Census Area to confirm habitat only and are not comprehensive

3.3.2 Weeds

The characteristics of the 10 weeds confirmed in the Area of Interest are summarised in Table 13 and the 4 species that are sometimes listed as weeds but should be treated as natives in the vicinity are characterised in Table 14.

All of the weeds, except *Calotropis procera,* are listed as 'Permitted – S11' and not assigned a control category (i.e. they are not required to be controlled) under the Biosecurity and Agriculture Management (BAM) Act 2007. *Calotropis procera* is a Declared Pest, under the BAM Act but there is no compliance around reporting it and no assigned management control category, although Department of Primary Industries and Regional Development strongly urges land holders and administrators to undertake control (Edwards, 2018). *Calotropis procera* was mapped as comprehensively as possible in the Area of Interest.

Given the degraded state of the vegetation in the vicinity of the Nullagine townsite, it is likely that not all weed species and not all locations of weeds were recorded. There is also a high probability of additional weeds becoming established over time given:

- significant potential weed sources, including:
    - the abutting Nullagine townsite and the Shire of East Pilbara rubbish tip
    - the public Nullagine-Marble Bar Road
    - the Nullagine River
- significant potential vectors, including:
    - birds visiting the
    - vehicles on the public Nullagine-Marble Bar Road

It is noted that a number of weeds not yet recorded in the Area of Interest, are in the vicinity:

- *The Flora and Vegetation Survey of the Nullagine Survey Area* (Mattiske Consulting, 2011) included records of:
    - *Rumex vesicarius* (Ruby Dock)
    - *Argemone ochroleuca* subsp*. ochroleuca* (Mexican Poppy)
- garden and verge plantings in the Nullagine townsite represent a significant source of weed propagules that could autonomously spread into adjacent Novo tenements, including :
    - *Tamarix aphylla* (Athel Pine), one of 32 Weeds of National Significance listed by the Australian Government (Department of the Environment and Energy, 2019) as already causing significant agricultural, forestry and environmental damage. It is a thicket-forming tree that has the potential to serious weed of arid zone watercourses (Hussey, Keighery, Dodd, Lloyd, & Cousens, 2007), with seed that is dispersed by wind, water and animals (Department of the Environment and Energy, 2019)
    - *Tipuana tipu* (Rosewood) is one of 28 plant species on the *Alert List for Environmental Weeds* listed by the Australian Government (Department of the Environment and Energy, 2019) as a weed with the potential to threaten biodiversity and cause other environmental damage, although currently only in the early stages of establishment. Its prolific seed capability (up to 10 000 seeds per plant), coupled with wind and water dispersal mechanisms (when near waterways), allows it to establish widely (Department of the Environment and Energy, 2019).

Table 13: Weed Characterisation

Weed	Comments
Declared Weeds (Figure 23)	
Calotropis procera **(Calotrope)**	• 0% (0 out of 763) of inventory sites across the Pilbara (Van Vreeswyk, Payne, Leighton, & Hennig, 2004) • 1.5 million hectares of the Pilbara has some infestation of Calotropis across it (Bell, 2015)
Shrubs / Trees (Figure 24)	
Aerva javanica **(Kapok Bush)**	• 6% (45 out of 763) of inventory sites across the Pilbara (Van Vreeswyk, Payne, Leighton, & Hennig, 2004) • Invades a range of habitats, especially disturbed areas, but also invades undisturbed areas including rockpiles (Trudgen, M.E. & Associates, 2002) • Able to grow in many habitats (Keighery, 2010)
Azadirachta indica **(Neem)**	• 0% (0 out of 763) of inventory sites across the Pilbara (Van Vreeswyk, Payne, Leighton, & Hennig, 2004) • 0% (0 out of 103) of wetland sites across the Pilbara (Lyons, 2015) • Widespread across northern Australia in many creek, river and drainage systems (NTG, 2019) • Occurs near creeks and in disturbed areas (Western Australian Herbarium, 1998-) • Invades and competes with native plant species even in intact areas (NTG, 2019) • Can dominate riparian environments (NTG, 2019)
Phoenix dactylifera **(Date Palm)**	• <1% (1 out of 763) of inventory sites across the Pilbara (Van Vreeswyk, Payne, Leighton, & Hennig, 2004) • 1% (1 out of 103) of wetland sites across the Pilbara (Lyons, 2015) • Major weed of river banks and courses (Keighery, 2010) • Forms dense thickets by suckering, and seed spread by birds (Hussey, Keighery, Dodd, Lloyd, & Cousens, 2007) • Spreading in arid wetlands (Hussey, Keighery, Dodd, Lloyd, & Cousens, 2007)
Perennial Grasses (Figure 25)	
Cenchrus ciliaris **(Buffel Grass)**	• Most frequently recorded weed in the Pilbara - 28% (217 out of 763) of inventory sites across the Pilbara (Van Vreeswyk, Payne, Leighton, & Hennig, 2004) • Most frequently recorded weed in Pilbara wetlands - 46% (47 out of 103) of wetland sites across the Pilbara (Lyons, 2015) • *Cenchrus ciliaris* and to a lesser degree *Cenchrus setiger* are widespread in the Pilbara, with these grasses dominating 3,434 km^2, or 1.8%, of the Pilbara (Van Vreeswyk, Payne, Leighton, & Hennig, 2004) • Able to grow in many habitats (Keighery, 2010)
Cenchrus setiger **(Birdwood Grass)**	• 4% (28 out of 763) of inventory sites across the Pilbara (Van Vreeswyk, Payne, Leighton, & Hennig, 2004) • Third most frequently recorded weed in Pilbara wetlands - 17% (18 out of 103) of wetland sites across the Pilbara (Lyons, 2015) • Able to grow in many habitats (Keighery, 2010)
Cynodon dactylon **(Couch)**	• Observed on the creek between the Nullagine Water Reserve and the Nullagine-Marble Bar Road • Occurs in wetlands and urban areas (Keighery, 2010) • <1% (1 out of 763) of inventory sites across the Pilbara (Van Vreeswyk, Payne, Leighton, & Hennig, 2004) • 22% (23 out of 103) of wetland sites across the Pilbara (Lyons, 2015)
Perennial Herbs (Figure 26)	
Malvastrum americanum **(Spiked Malvastrum)**	• 9% (70 out of 763) of inventory sites across the Pilbara (Van Vreeswyk, Payne, Leighton, & Hennig, 2004) • 8% (8 out of 103) of wetland sites across the Pilbara (Lyons, 2015) • Able to grow in many habitats (Keighery, 2010) • Occurs in many arid habitats across the Kimberley, Pilbara and Gascoyne regions (Hussey, Keighery, Dodd, Lloyd, & Cousens, 2007) • Also recorded nearby by Mattiske Consulting (2011)
Annual Herbs (Figure 26)	
Citrullus amarus **(Afghan Melon)**	• Observed in the Shire of East Pilbara rubbish tip • Occurs in highly disturbed sites (Keighery, 2010) • 0% (0 out of 763) of inventory sites across the Pilbara (Van Vreeswyk, Payne, Leighton, & Hennig, 2004) • 0% (0 out of 103) of wetland sites across the Pilbara (Lyons, 2015) • Previously referred to as *Citrullus lanatus* (Western Australian Herbarium, 1998-)
Euphorbia hirta **(Asthma Plant)**	• 0% (0 out of 763) of inventory sites across the Pilbara (Van Vreeswyk, Payne, Leighton, & Hennig, 2004) • 0% (0 out of 103) of wetland sites across the Pilbara (Lyons, 2015) • Occurs in highly disturbed sites (Keighery, 2010) • Common and widespread between the Kimberley, Cue, Onslow and Carnarvon, occuring in many habitats, especially watercourses and lawns (Hussey, Keighery, Dodd, Lloyd, & Cousens, 2007)

Table 14: Species not to be Managed as Weeds

Weed	Comments
Shrubs / Trees	
***Vachellia farnesiana* (Mimosa Bush)**	• Recorded in WA in 1861 and may be recategorized as a native plant in the future (Keighery, 2010) • Occurs in many habitats, especially alluvium and grazed rangelands (Keighery, 2010) • 6% (47 out of 763) of inventory sites across the Pilbara (Van Vreeswyk, Payne, Leighton, & Hennig, 2004) • 14% (14 out of 103) of wetland sites across the Pilbara (Lyons, 2015)
Annual Grasses	
***Echinochloa colona* (Awnless Barnyard Grass)**	• Presence in the Pilbara likely predates European settlement (Keighery, 2010) • Occurs in 9% (9 out of 103) of wetland sites across the Pilbara (Lyons, 2015)
Annual Herbs	
***Flaveria trinervia* (Speedy Weed)**	• Synonyms of *Flaveria trinervia* (*F. australasica* and *F. trimera*) are considered indigenous to Australia (Keighery, 2010) • 3% (23 out of 763) of inventory sites across the Pilbara (Van Vreeswyk, Payne, Leighton, & Hennig, 2004) • 16% (16 out of 103) of wetland sites across the Pilbara (Lyons, 2015)
***Portulaca oleracea* (Purslane)**	• Considered native to tropical and arid Western Australia (including the Pilbara), but introduced into temperate Western Australia and a few towns in the tropical north (Keighery, 2013) • 5% (37 out of 763) of inventory sites across the Pilbara (Van Vreeswyk, Payne, Leighton, & Hennig, 2004) • 9% (9 out of 103) of wetland sites across the Pilbara (Lyons, 2015)

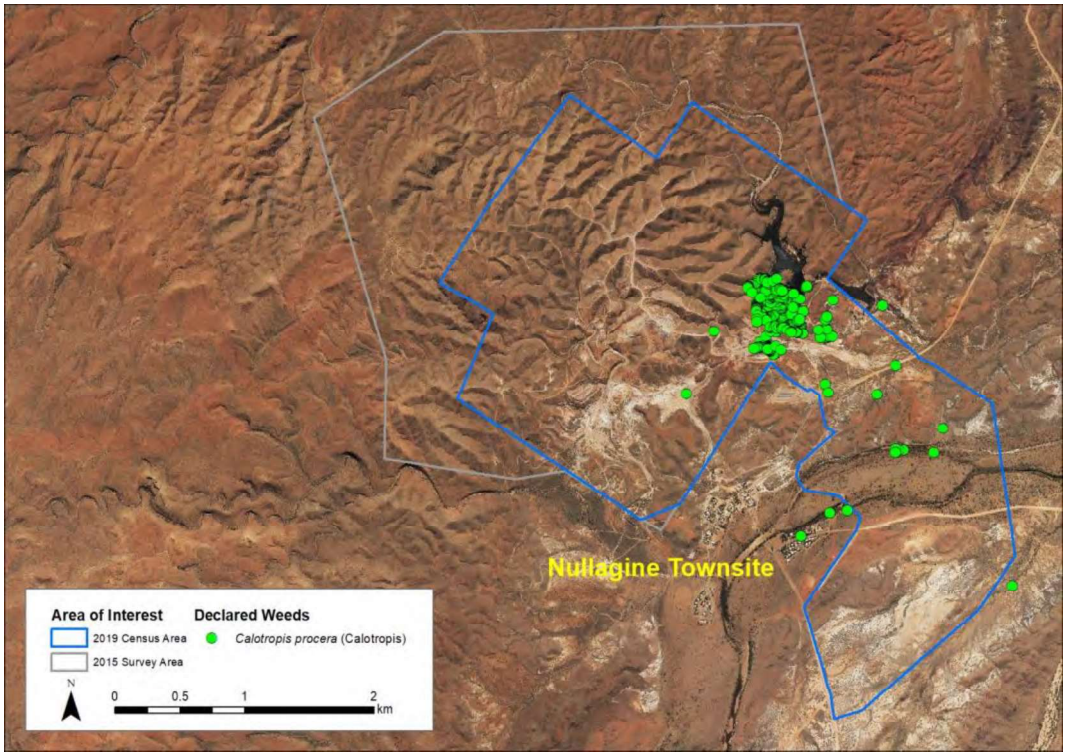

Figure 23: Declared Weed Distribution

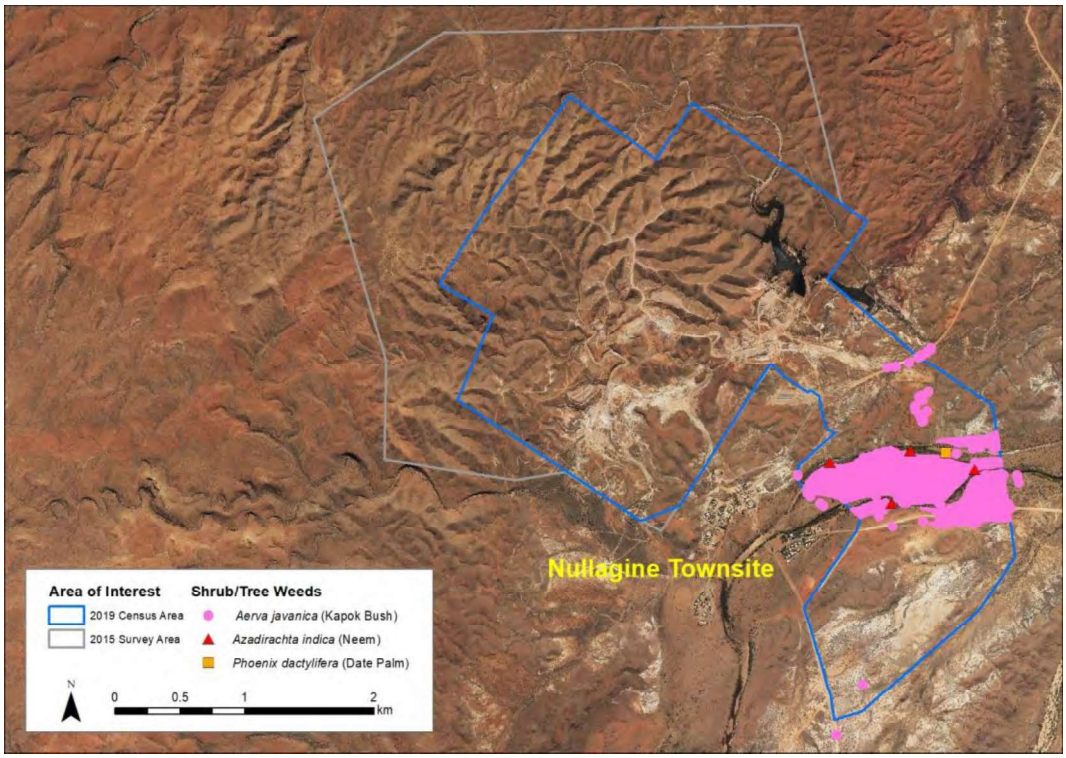

Figure 24: Shrub/Tree Weed Distributions

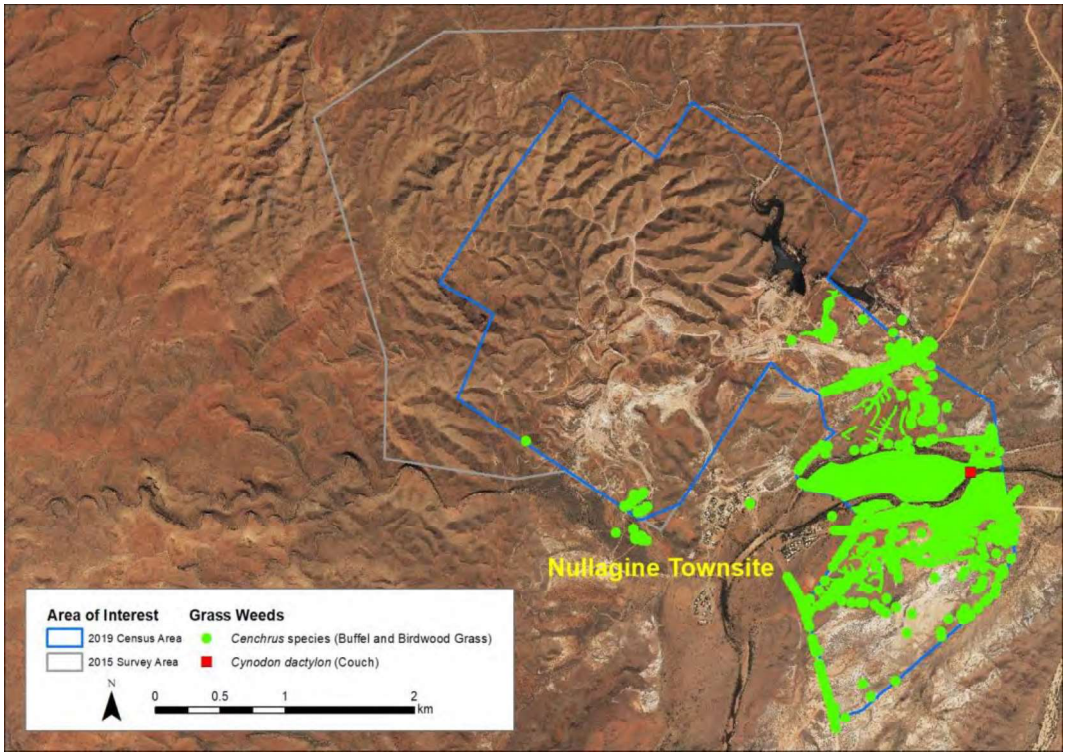

Figure 25: Grass Weed Distributions

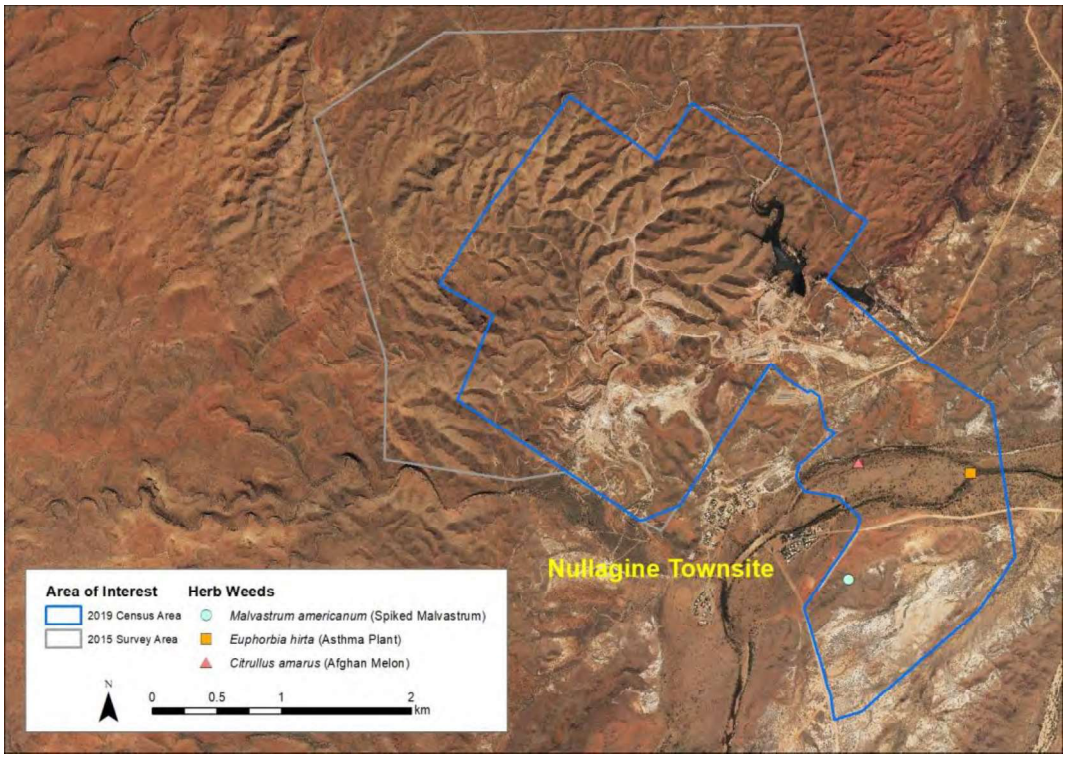

Figure 26: Herb Weed Distributions

4 Assessment of Conservation Significance

4.1 Regional Significance of the Vegetation

The EPA (2016) stated that vegetation may be considered significant for its:

- listing as threatened or priority ecological communities;
- restricted distribution;
- degree of historical impact from threatening processes;
- role as a refuge; and
- requirement to maintain ecological integrity of a significant ecosystem.

These factors are addressed in this report with reference to:

- Vegetation System Associations;
- Land Systems;
- Site Types;
- Ecological Communities;
- Surface Water and Groundwater Dependent Ecosystems;
- Refugia;
- Diversity; and
- Conservation Estate.

4.1.1 Vegetation System Associations

The EPA established a position of applying a presumption against clearing of vegetation in areas where native vegetation had already been extensively cleared (in *Position Statement No. 2* (EPA, 2000) and *Guidance Statement 10* (EPA, 2006)). The scale used to determine the extent of vegetation types is that of the Vegetation System Association, which:

- are the finest scale of mapping units used in the Comprehensive, Adequate and Representative (CAR) reserve system analysis for Western Australia (Government of Western Australia, 2015); and
- were mapped in the Pilbara at 1:1,000,000 scale by the Department of Agriculture and the Department of Environment and Conservation (Beard J. B., 2013).

In non-constrained areas (i.e. outside urban areas), such as the Area of Interest, the presumption against clearing applies:

- where the total extent remaining of a regional vegetation type is below a threshold of 30% of its estimated pre-European settlement extent; or
- when clearing would result in the percentage remaining falling below 30%.

The context of the proposed clearing in terms of these regional vegetation units is shown in Table 15.

Table 15: Extents and Reservation of System-Associations

System Association	Pre-European Extent	Current Extent	% Remaining	% Current Extent Protected for Conservation (% of Pre-European Extent)
Abydos Plain – Chichester 173.1	622,162 ha	618,398 ha	99.4 %	0 %
Abydos Plain – Chichester 190.1	169,200 ha	169,051 ha	99.9 %	0 %

Source: **Government of Western Australia** (2015)

NB: **Areas rounded to nearest hectare as per recommendation of Government of Western Australia** (2015)

The absence of conservation reserves in the system associations is typical of the Pilbara. Only 37 of the 140 system associations in the Pilbara IBRA Region contain conservation reserves (Government of Western Australia, 2015).

4.1.2 Land Systems

The three land systems in the Area of Interest are extensive and generally in good to very good condition in the Pilbara, as indicated in Table 16.

Table 16: Regional Extents and Condition of Land Systems

Land System	Extent in Pilbara	Vegetation Condition in Pilbara	Soil Erosion in Pilbara
Capricorn	529,600 ha	Very Good-Good 98% Fair 2%	Nil 100%
Mosquito	184,000 ha	Very Good-Good 95% Fair 3% Poor-Very Poor 2%	Nil 97% Minor 1% Moderate 1% Severe 1%
River	408,800 ha	Very Good-Good 82% Fair 13% Poor-Very Poor 5%	Nil 94% Minor 5% Moderate 1%

Source: Van Vreeswyk, Payne, Leighton, & Hennig (2004)

4.1.3 Site Types

Of the ten site types characterised in Table 17:

- One site type is a Priority Ecological Community not recorded in a conservation reserve and is discussed in Section 4.1.4:
  - SSCG: Stony plain spinifex grassland with chenopod shrubs
- Seven site types are relatively widespread, well represented in conservation estate and in good condition:
  - GMEW: Gallery melaleuca eucalypt woodland;
  - HSPG: Hill spinifex grassland
  - PHSG: Plain hard spinifex grassland
  - AHSG: Alluvial plain hard spinifex grassland
  - ASSG: Alluvial plain soft spinifex grassland
  - DAHW: Drainage acacia hummock grass shrubland/ woodland
  - DESG: Drainage spinifex grassland with eucalypt overstorey
- Two site types are defined in terms of the dominance of buffel grass (a weed species) and they should not be targeted for conservation:
  - AEBG: Alluvial plain eucalypt buffel grass woodland
  - APBG: Alluvial plain buffel grass grassland

Table 17: Extents and Reservation of Sites Types

Site Types in Survey Area	Land Systems In (out of 102)	Condition across Pilbara	Occurrence and Conservation across Pilbara
GMEW **Gallery melaleuca eucalypt woodland**	4	94% Good 6% Fair 0% Poor	GMEW vegetation is not particularly threatened by pastoral land use, although there may be locally altered environments near water holes. GMEW is in Karijini and Millstream-Chichester National Parks. It is well represented on unallocated Crown land, 6 of the 34 DAFWA traverse records were on unallocated Crown land.
DESG **Drainage spinifex grassland with eucalypt overstorey**	12	97% Good 3% Fair 0% Poor	DESG is in Millstream-Chichester National Park and Meentheena Conservation Park and also on unallocated Crown land.
AEBG **Alluvial plain eucalypt buffel grass woodland**	2	90% Good 5% Fair 5% Poor	These site types are defined in terms of the dominance of buffel grass (a weed species) and they should not be targeted for conservation. The plains which now support these site types presumably once supported native tussock grasses and/or saltbush shrubs.
APBG **Alluvial plain buffel grass grassland**	12	79% Good 17% Fair 4% Poor	
DAHW **Drainage acacia hummock grass shrubland/ woodland**	36	91% Good 7% Fair 2% Poor	DAHW is well represented in conservation reserves. It is in Karijini National Park and in Meentheena Conservation Park, and in unallocated Crown land.
ASSG **Alluvial plain soft spinifex grassland**	28	76% Good 17% Fair 7% Poor	ASSG is represented, although poorly, on conservation reserves. It is in Cane River Nature Reserve and in Meentheena Conservation Park. It was also recorded on unallocated Crown land. Of the 525 DAFWA traverse records, 19 were on conservation reserves and 15 were on unallocated Crown land.
AHSG **Alluvial plain hard spinifex grassland**	15	81% Good 14% Fair 5% Poor	AHSG is represented in conservation reserves. It is in Cane River Nature Reserve and Meentheena Conservation Park. It was also recorded on unallocated Crown land.
SSCG **Stony plain spinifex grassland with chenopod shrubs**	2	87% Good 9% Fair 4% Poor	SSCG is a Priority Ecological Community. SSCG is uncommon and unusual in terms of plant species composition. It is locally impacted by grazing and mining disturbance and is largely confined to the Mosquito Land System. SSCG was not recorded on conservation reserves in the Pilbara. Two of the 67 DAFWA traverse records were on unallocated Crown land. This site type should be considered for reservation.
PHSG **Plain hard spinifex grassland**	53	98% Good 2% Fair 0% Poor	PHSG is the most common site type in the Pilbara. PHSG is well represented in conservation reserves in the Pilbara. It is in Karijini and Millstream-Chichester National Parks, Cane River Nature Reserve and the Meentheena Conservation Park. It occurs extensively on unallocated Crown land.
HSPG **Hill spinifex grassland**	44	100% Good 0% Fair 0% Poor	HSPG is represented in conservation reserves in the Pilbara. It is in the Karijini National Park and Meentheena Conservation Park. It also occurs extensively on unallocated Crown land in the Pilbara.

Source: Van Vreeswyk, Payne, Leighton, & Hennig (2004)

4.1.4 Ecological Communities

DBCA maintains a state-wide dataset of ecological communities (naturally occurring biological assemblages that occur in a particular type of habitat) that are:

- Threatened Ecological Communities (TECs), which are ecological communities at risk of extinction through human action or inaction; and
- Priority Ecological Communities (PECs) for which there is insufficient information available for consideration as a TEC, or which are rare communities that are not currently threatened.

The detailed descriptions for each of the ecological communities conservation status codes used by DBCA are provided in Appendix 1. In addition to the recognition of significance by the Government of Western Australia through these listing, 17 of the TECs are also listed as Matters of National Environmental Significance (threatened ecological communities) and protected under the Commonwealth *EPBC Act 1999.*

There is only one terrestrial TEC in the Pilbara (DPaW, 2016). This TEC, Themeda grasslands on cracking clays (Hamersley Station), was characterised as *Alluvial plain kangaroo grass grassland* of the Brockman Land System (Site Type APKG) in *Technical Bulletin No. 92 - An inventory and condition survey of the Pilbara region, Western Australia* (Van Vreeswyk, Payne, Leighton, & Hennig, 2004). This vegetation type has not been recorded in the vicinity of Nullagine, and is not present in the survey area where there are no cracking clays.

Maireana melanocoma, Sclerolaena hostilis Low Open Shrubland over *Triodia longiceps* Very Open Hummock Grassland within minor drainagelines of *Melaleuca eleuterostachya* and *Acacia bivenosa* (Vegetation Type 4) were mapped in the Area of Interest. This vegetation type corresponds to the 'Stony saline plains of the Mosquito Land System', which are listed as a Priority 3(iii) Priority Ecological Community (PEC) by DBCA (2019), and defined as:

> *Triodia longiceps* perennial grasslands with scattered *Maireana melanocoma* and *Sclerolaena* species and includes Priority flora taxa *Atriplex spinulosa* (P1) and *Ptilotus wilsonii* (P1) dissected by drainage lines dominated by (but not limited to) *Melaleuca eleuterostachya* and *Acacia bivenosa* occurring on saline red brown non-cracking clays with a mantle of quartz gravel and neutral subsurface soil material on level to undulating plains. Largely restricted to an area east of Nullagine.

The stony saline plains of the Mosquito Land System in the Area of Interest:

- cover 75.2 hectares (Table 10 and Figure 13);
- where almost entirely occupied the Day Dawn Mine operations (Figure 15);
- are generally degraded to completely degraded (Figure 16 and Figure 17) with very low native plant cover (Photo 2).

Prior to a 2017 there was a poor understanding of the PEC in terms of its definition, extent and condition. Targeted studies by Land Assessment (2016) and Woodgis (2017) concluded that the PEC:

- could be more robustly characterised, with the recommended wording now reflected in the DBCA (2019) description;
- is extensive and the estimate by Van Vreeswyk, Payne, Leighton, & Hennig (2004) of 46,000 ha was reasonable;
- was generally in good condition; and
- the 'uncommon and unusual plant species composition' values in northern occurrences of the ecological community around, and to the east of Nullagine, relate to the Mosquito Land System being a centre of local endemism with a high degree of vegetation mosaicing rather than the stony saline plains community itself.

4.1.5 Species Diversity

The Area of Interest does not support high species diversity:

- It is not located in the only area listed for high species and ecosystem diversity in the Chichester IBRA Subregion, 'Cracking clay communities of the Chichester Range and Mungaroona Range' (DPaW, 2002);
- It contains site types typically supporting low to moderate diversity. Of the 44 site types characterised by DAFWA (Van Vreeswyk, Payne, Leighton, & Hennig, 2004), the 6 site types supporting the highest diversity are associated with *Acacia aneura* (Mulga) stands, and these are not present in the Area of Interest.

4.1.6 Surface Waters and Groundwater Dependent Ecosystems

Flora associated with surface water and groundwater dependent ecosystems (GDEs) can have restricted distributions (EPA, 2016), and hydrological features may support significant flora and vegetation (EPA, 2016).

The Bureau of Meteorology (2018) has mapped:

- terrestrial GDEs which interact with groundwater from the watertable or in the capillary zone; and
- aquatic GDEs which include rivers, springs, and wetlands that rely on groundwater that has been discharged to the surface, for example, as baseflow or spring flow.

The Bureau of Meteorology (2018) identified there was a moderate potential for aquatic and terrestrial GDEs in the Haul Road Area associated with the Nullagine River (Figure 27), noting that these polygons represent areas within which vegetation-groundwater interactions potentially occur (interactions not necessarily occurring across the entirety of polygons).

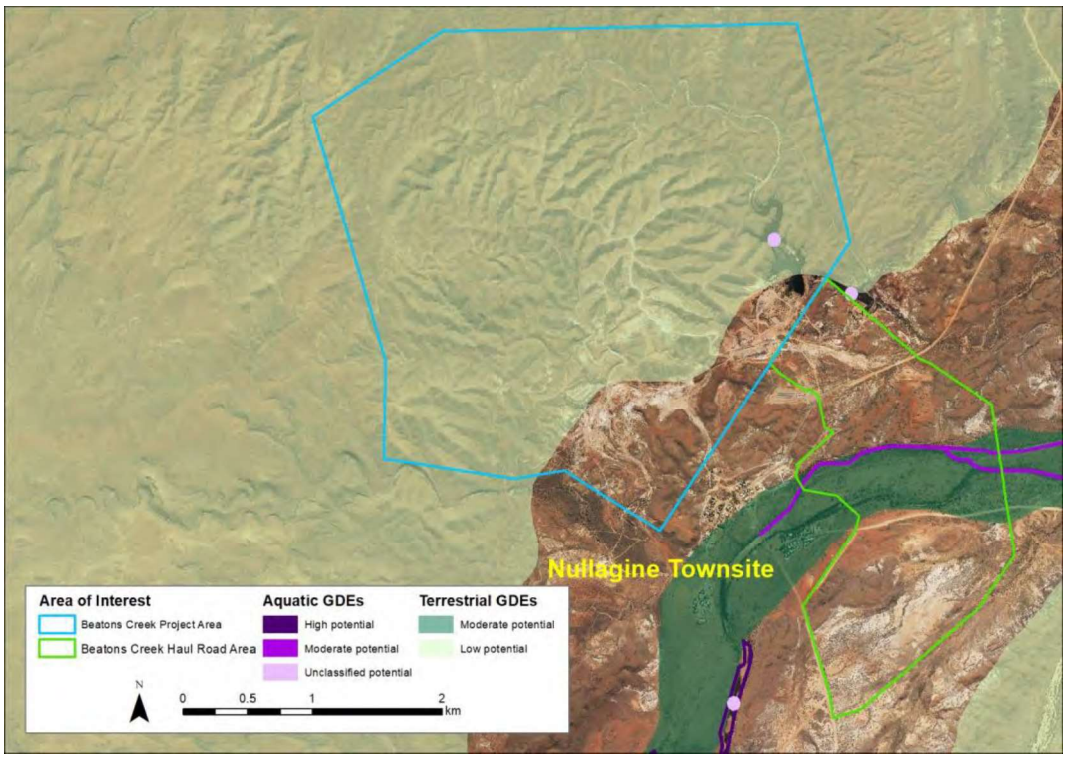

Figure 27: Potential GDEs in the Area of Interest

The 'unclassified' potential aquatic GDEs relate to the artificial Nullagine Reservoir.

Several potential GDEs are shown along the Nullagine River, and *Melaleuca argentea* and *Eucalyptus camaldulensis* were present, and both are:

- listed as groundwater dependent by Lyons (2015);
- indicative of Vegetation Type 1 (Figure 13); and
- widespread in the Pilbara.

Typha domingensis, which grows in Vegetation Type 1, is not indicative of GDEs:

- drawdown resulting in dry soil lasting 3 years has been shown to reduce *Typha domingensis* vigour, but elimination requires more than 5, and possiblly as many as 7 or more consecutive years of dry soil (Robert, 2014)*;*
- *Typha domingensis* readily colonises areas through natural seed dispersal (Chambers, 1995); and
- *Typha domingensis* has been recorded at sites in the Pilbara with water levels as low as -4.89 m (watertable below ground level) (Loomes, 2010).

Eucalyptus victrix, which occurs along river in the Area of Interest, is not indicative of GDEs. Batini (2009) found that *Eucalyptus victrix*:

- may at times draw at least some of its water needs from the capillary zone above the shallow groundwater table, especially when this rises rapidly after rain;
- can grow where no access to groundwater is available; and
- is quite a resilient tree, able to survive some flooding, rapid rises and falls of up to 10 m in the groundwater table and also extended periods of drought.

4.1.7 Refugia

Vegetation can be significant if it through long-term isolation, or as a remnant of a previously more widely distributed habitat, may act as an important refuge for flora that require specific biotic or abiotic conditions (EPA, 2016). Refuges provide habitat for taxa with preferences for stability/low seasonality, seclusion from fire, or for permanent water, or rainforest elements, with mesic features , or other derivatives that are now isolated (e.g. specific soil types) (EPA, 2004).

With a decrease in traditional burning, fire frequency and intensity has increased with a number of plant communities being replaced by more uniform and extensive Triodia grasslands in central Australia (Paltridge & Latz, 2009).

Examples of refugia include isolated hills (e.g. Banded Ironstone or Greenstone Formations or granite outcrops) which are remnants of an ancient eroding surface, islands, permanent wetlands in arid areas, permanent damplands in wetter regions which may retain Gondwanic elements, patches of ancient paleodrainage which have habitat that is not yet affected by secondary salinity as a result of clearing (especially in agricultural areas), and mound springs (EPA, 2004).

The vegetation in the Area of Interest is naturally dominated by Triodia and no fire sensitive vegetation, or examples of refugia listed above, were identified.

The time since fire is shown in on the basis of 250 metre scale mapping (Figure 28).

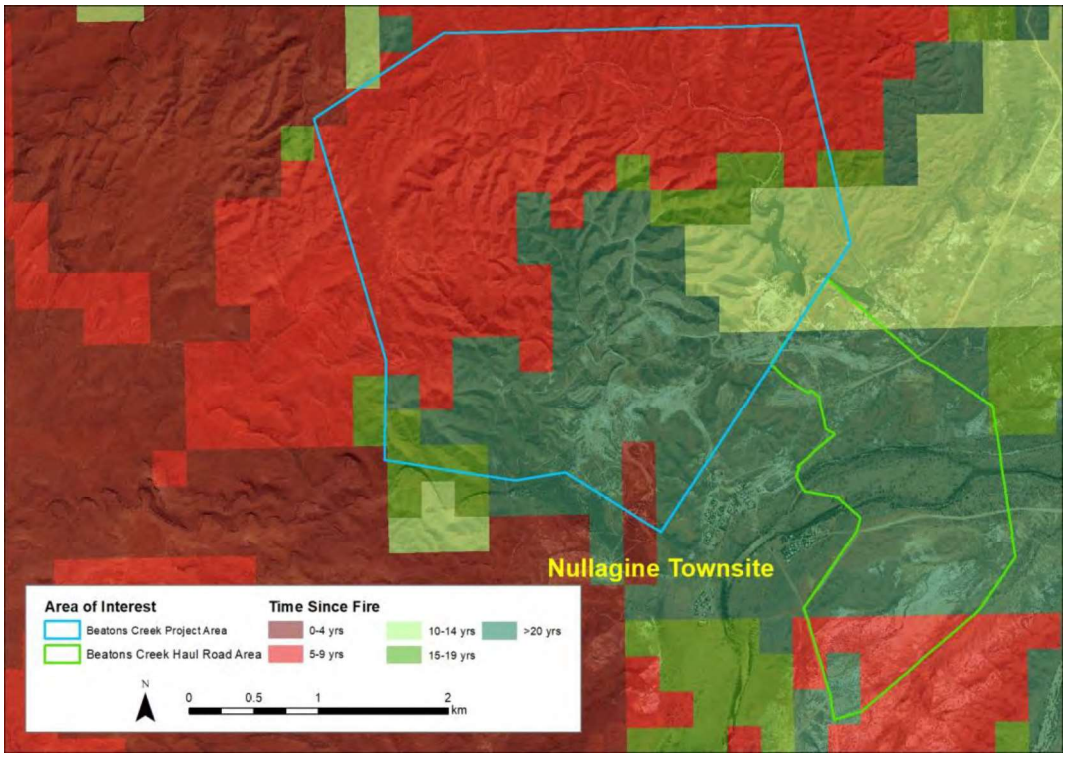

Figure 28: Time Since Fire in the Area of Interest

Source: http://www.firenorth.org.au/nafi3/

The most likely refugia in the vicinity is along Beaton Creek Gorge (to the south and west of the Area of Interest), where there are rock slabs supporting the core of the *Acacia cyperophylla* var. *omearana* P1 population (Figure 18 and Photo 11) and contributing to surface water in Beatons Pool (Photo 12).

Photo 11: *Acacia cyperophylla* var. *omearana* P1 on rock slabs along Beatons Creek George

Photo 12: Beatons Pool

4.1.8 Conservation Estate

The Area of Interest is not in, or contiguous with, any conservation estate or DBCA managed lands.

4.2 Regional Significance of Native Flora

The EPA (2016) stated that flora may be considered significant for being:

- threatened or priority species
- locally endemic or associated with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems)
- representative of the range of a species (particularly, at the extremes of range recently discovered range extensions, or isolated outliers of the main range)
- relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.
- new species or anomalous features that indicate a potential new species
- unusual species, including restricted subspecies, varieties or naturally occurring hybrids

4.2.1 Threatened and Priority Flora

Under the *Wildlife Conservation Act 1950*, the Western Australian Minister for the Environment may declare species of protected flora to be Threatened Flora if they are considered to be in danger of extinction, rare or otherwise in need of special protection. The Department of Biodiversity Conservation and Attractions also maintain lists of Priority Flora that covers poorly known species and species that have been adequately surveyed and are considered to be rare but not currently threatened. The definitions of categories of conservation significant species are listed in Appendix 1. In addition to this recognition of significance by the Government of Western Australia, some Threatened Flora (Declared Rare Flora) are additionally also listed as Matters of National Environmental Significance (threatened species) and protected under the Commonwealth *EPBC Act 1999.*

No threatened taxa have been recorded within 50 km of the Area of Interest (DBCA database search 22-0419FL). The abundance/distribution of priority taxa in the Census Area is placed in a regional context in Table 18.

Table 18: Regional Context of Priority Flora

Priority Species	**Population/s in 2019 Census Area** (994 hectares)	**Population/s in northern Mosquito Land System** (174,464 hectares) (Woodgis, 2017)	**Regional Extent** (DPaW, 2016)
Acacia aphanoclada **P1**	4,713 plants 69.6 ha*	Abundant local endemic, widespread on hills Abundance • 25,859 plants counted • 1,550,000 plants estimated total	40 km north-south 65 km east-west
Atriplex spinulosa **P1**	75.2 ha* 444 - 1,667 plants /ha	Abundant local endemic, widespread on stony saline plains Extents • 1,626 ha of habitat directly mapped • 36,000 hectares estimated total Densities • 5,700 plants/ha (mean) • 167-30,500 plants/ha	40 km north-south 65 km east-west
Ptilotus wilsonii **P1**	2,015 plants 66.6 ha* (no plants located in this habitat – see Table 12)	Shrub in disjunct and restricted areas Abundance • 3,220 plants counted	70 km north-south 220 km east-west
Solanum **sp. Mosquito Creek** **P1**	63.1 hectares 22 - 6,533 plants /ha	Abundant local endemic, widespread on *Triodia longiceps* alluvial plains Extents • 693 ha of habitat directly mapped Densities *T. longiceps-P. ferdinand-muelleri* vegetation type • 55 plants/ha (mean) *E. rowleyi-A. trachycarpa* vegetation type • 25 plants/ha (mean) Burnt areas • 544-2,044 plants/ha Disturbed area • 1,325 plants/ha	20 km north-south 50 km east-west

***Haul Road Area only - excludes habitat mapped as cleared by MMCW** (2015) **in Project Area**

4.2.2 Locally Endemic Taxa

Taxa with a range less than 150 kilometres are considered to be locally endemic and vulnerable to change (climatic, hydrological or disease induced) or catastrophic events (land clearing, fire or flood), and many are listed as Threatened or Priority taxa (Hearn, Keighery, & Burrows, 2003).

The only taxa identified with ranges of less than 150 km, based on the GIS analysis (see Section 2.5) were:

- *Acacia aphanoclada* P1, with a range of 40 km north-south and 65 km east-west;
- *Acacia cyperophylla* var. *omearana* P1, with a range of 120 km north-south and 60 km east-west;
- *Atriplex spinulosa* P1, with a range of 40 km north-south and 65 km east-west; and
- *Solanum* sp. Mosquito Creek P1, with a range of 20 km north-south and 50 km east-west.

4.2.3 Disjunct Taxa / Range Extensions

The preservation of representative populations throughout the range of the distribution of a species is required to ensure the retention of (genetic) variation within a species. The Government of Western Australia (2000) has indicated that additional attention/consideration should be given to plant populations that are at the ends of geographic range of the plant or disjunct. Disjunct populations being those separated by more than 150 kilometres because of climate or soils, or 50 – 150 kilometres because of soils or habitats (Hearn, Keighery, & Burrows, 2003).

There is a relatively low density of Atlas of Living Australia (ALA, 2018) and Florabase (DEC, 2012) records in the Pilbara, even for common and widespread species, so determining whether populations are at the limits of their distributions or disjunct is problematic.

The taxa most likely to be at, or near the limits, of their ranges (using the method in Section 2.5), are:

- Northern limits
  - *Eleocharis pallens*
  - *Frankenia setosa*
  - *Gompholobium oreophilum*
  - *Grevillea berryana*
  - *Podolepis capillaris*
- Eastern limit
  - *Melaleuca bracteata*
  - *Swainsona pterostylis*

Major distributional outliers associated with springs, spring-fed river pools or gorge habitats such as *Cladium procerum*, *Phragmites karka, Imperata cylindrica* and *Adiantum capillus-veneris* (Lyons, 2015), were not recorded in the Area of Interest. Taxa associated with wetlands and alluvial plains most likely to be disjunct populations were:

- in the Nullagine Water Reserve Dam
  - *Ammannia auriculata*
  - *Potamogeton tricarinatus*
- on the alluvial plains south of Nullagine
  - *Neptunia monosperma*

4.2.4 Relictual Taxa

Relictual flora are plants that are relicts of previous climatic periods that either have 'primitive' reproductive systems (e.g. ferns), or are adapted to specific niches that have significantly contracted since the Gondwanan era (Hearn, Keighery, & Burrows, 2003). Many relictual flora are relatively common and widespread, but are associated with specific habitats such as swamps, wetlands, rivers and rock outcrops (Hearn, Keighery, & Burrows, 2003).

Relictual plants in the Pilbara may persist from a humid tropical paeleoclimate, and are now more typical of tropical habitats further north (Department of Environment and Conservation, 2011) and some 'Kimberley' species present in the Pilbara can be considered relictual (Blackwell, Trudgen, & Weston, 1979).

Twenty-six relictual species were identified on the Burrup Peninsula by Blackwell, Trudgen and Weston (1979) and/or in Millstream Chichester National Park around wetlands by the Department of Environment and Conservation (2011). Of these species, the following five were recorded in the Area of Interest, all of which are widespread in both the Pilbara and Kimberley:

- *Rhynchosia minima*
- *Erythrina vespertilio*
- *Alysicarpus muelleri*
- *Flueggea virosa* subsp*. melanthesoides*
- *Tinospora smilacina*

4.2.5 Undescribed Taxa / Unusual Forms

Plant taxa with distinctive features or unusual forms not formally recognised through taxonomy are considered to have elevated conservation significance in EPA Guidance Statement No. 51 (EPA, 2004).

No species meeting these criteria were located in the Area of Interest.

The following putative hybrids were recorded in the Area of Interest, although natural hybridisation occurs between numerous Acacia species (Piccinin, Murphy, & Ladiges, 2004), (Orchard & Wilson, 2001):

- *Acacia aphanoclada* x *pyrifolia* var. *pyrifolia*, which has been recorded as a few, small, scattered populations in the vicinity of Nullagine, low in the landscape, often along dry watercourses on low rocky hills (Maslin & J. E. Reid, 2010). In it unknown whether this hybrid produces viable seed and there is insufficient information to justify listing it at as a threatened or priority taxon (Maslin & J. E. Reid, 2010);
- *Acacia trachycarpa* × *tumida* var. *pilbarensis*, which has been recorded scattered across the Pilbara and for which there has been insufficient information to justify its listing as a priority taxon (Maslin & J. E. Reid, 2010). It has occasionally been used for amenity planting in Karratha and Dampier (Maslin & J. E. Reid, 2010); and
- *Acacia monticola* x *trachycarpa*, which has been recorded just north of Nullagine along a rocky creek, and between Tom Price and Karratha on skeletal soil along a drainage line among low rocky hills (Maslin & J. E. Reid, 2010). Field examination and other study is required to confirm the provisional hybrid determination (Maslin & J. E. Reid, 2010). There is insufficient information to justify listing it at as a threatened or priority taxon (Maslin & J. E. Reid, 2010).

Bibliography

BOM. (2018, 12 15). *Groundwater Dependent Ecosystems Atlas*. Retrieved from Bureau of Meteorology : http://www.bom.gov.au/water/groundwater/gde/index.shtml

ALA. (2018, 11 25). Retrieved from Atlas of Living Australia: http://www.ala.org.au

Batini, F. (2009). *Eucalyptus victrix, Karijini National Park.* Perth: unpublished report for the EPA.

Beard, J. (1975). *The Vegetation of the Pilbara Area. Explanatory Notes to Sheet 5 1:1,000,000 Vegetation Series.* Perth: UWA Press.

Beard, J. B. (2013). *Pre-European Vegetation – Western Australia (NVIS Compliant version 20110715).* Perth: Department of Agriculture and Food Western Australia.

Beard, J., Beeston, G., Harvey, J., Hopkins, A., & Shepherd, D. (2013). The vegetation of Western Australia at the 1:3,000,000 scale. Explanatory memoir. Second edition. *Conservation Science Western Australia, 9*(1), 1-152.

Bell, L. (2015, 05 26). *Weeding out calotropis in the Pilbara and Kimberley*. (ABC) Retrieved from ABC News: http://www.abc.net.au/news/rural/2015-05-26/pilbara-calotropis-threat/6490866

Blackwell, M., Trudgen, M., & Weston, A. (1979). *Vegetation and Floristics of the Burrup Peninsula.* Perth: unpublished report by Blackwell and Cala Landscape Consultants for Woodside Petroleum Development Pty Ltd.

Chambers, J. (1995). *A Guide to Emergenet Wetland Plants of South Western Australia* . Perth: Murdoch University.

CSIRO. (2012). *1 arc-second SRTM-derived Smoothed Digital Elevation Model* . Canberra: Commonwealth Scientific and Industrial Research Organisation.

DBCA. (2019, August 15). *Threatened ecological communities*. Retrieved from Department of Biodiversity, Conservation and Attractions: https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/wa-s-threatened-ecological-communities

DEC. (2012, 03 14). *FloraBase*. Retrieved 03 14, 2012, from Florabase: http://florabase.calm.wa.gov.au/

Department of Environment and Conservation. (2011). *Millstream Chichester National Park and Mungaroona Range Nature Reserve Management Plan No. 69 2011.* Perth: Department of Environment and Conservation.

Department of the Environment and Energy. (2019, 06 11). *Weeds of National Significance*. Retrieved from Department of the Environment and Energy: https://www.environment.gov.au/biodiversity/invasive/weeds/weeds/lists/wons.html

Dillon, S. (2017). *RE: Maireana / Sclerolaena DNA from Mosquito Land System.* email 23/02/2017: Senior Technical Officer (Plant Identification), WA Herbarium, DBCA.

DPaW. (2002). *A Biodiversity Audit of WA's 53 Biogeographical Subregions 2002*. (DPaW) Retrieved 07 04, 2016, from Pilbara Region Biological Survey 2002-2013, Previous Pilbara Biodiversity Audits: https://www.dpaw.wa.gov.au/about-us/science-and-research/biological-surveys/117-a-biodiversity-audit-of-wa

DPaW. (2016). *NatureMap: Mapping Western Australia's Biodiversity*. Retrieved July 1, 2016, from http://naturemap.dpaw.wa.gov.au/

DPaW. (2016). *Threatened ecological communities*. Retrieved 07 04, 2016, from Threatened ecological communities: https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/wa-s-threatened-ecological-communities

DPaW. (2018, 07 22). *NatureMap: Mapping Western Australia's Biodiversity*. (Department of Parks and Wildlife) Retrieved 10 29, 2018, from Department of Parks and Wildlife: URL: https://naturemap.dpaw.wa.gov.au/

Dufrêne, M., & Legendre, P. (1997). Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecological Monographs, 67*, 345-366.

Edwards, L. (2018). *RE: declared pest requirements - Calotropis procera.* Perth: Technical Officer, Pest and Disease Information Service, Sustainability and Biosecurity, Department of Primary Industries and Regional Development.

EPA. (2000). *Position Statement No. 2 - Environmental Protection of Native Vegetation in Western Australia.* Perth: Environmental Protection Authority.

EPA. (2004). *Guidance No. 56: Guidance Statement for Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia.* Perth: Environmental Protection Authority.

EPA. (2004). *Guidance Statement No. 51 - Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia .* Perth: Environmental Protection Authority.

EPA. (2006). *Guidance Statement No. 10 - Level of Assessment for Proposals Affecting Natural Areas Within the System 6 Region and Swan Coastal Plain Portion of the System 1 Region.* Perth: Environmental Protection Authority.

EPA. (2016). *Technical Guidance Flora and Vegetation Surveys for Environmental Impact Assessment.* Western Australia: Environmental Protection Authority.

Government of Western Australia. (2000). *Bush Forever. Volume 2: Directory of Bush Forever Sites.* Perth: Western Australian Planning Commission.

Government of Western Australia. (2015). *2015 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Current as of May 2016.* Perth: WA Department of Parks and Wildlife, https://www2.landgate.wa.gov.au/web/guest/downloader.

Government of Western Australia. (2017). *2016 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Current as of October 2016.* Perth: WA Department of Parks and Wildlife, https://www2.landgate.wa.gov.au/web/guest/downloader. Retrieved from https://www2.landgate.wa.gov.au/web/guest/downloader

Hearn, R., Keighery, G., & Burrows, N. (2003). *Management of Significant Flora Values in South-West Forests and Associated Ecosystems.* Perth: Department of Environment and Conservation.

Hislop, M. (2016). *Re: ACC/6992/E.* email, 09/11/2016: identifications botanist, WA Herbarium, DBCA.

Hussey, B., Keighery, G., Dodd, J., Lloyd, S., & Cousens, R. (2007). *Western Weeds, A guide to the weeds of Western Australia. 2nd Edition. .* Perth: The Weeds Society of Western Australia.

Keighery, G. (2010). The naturalised vascular plants of the Pilbara region, Western Australia. *Records of the Western Australian Museum, Supplement 78*, 299-311.

Keighery, G. (2013). Weedy native plants in Western Australia: an annotated checklist. *Conservation Science Western Australia, 8*(3), 259–275.

Land Assessment. (2016). *Landforms and Soils associated with a Priority Ecological Community within the Mosquito Land System near Nullagine, East Pilbara.* Perth: unpublished report for Millenium Minerals Ltd.

Loomes, R. (2010). *Determining water level ranges of Pilbara riparian species, Environmental water report series, report no. 17.* Perth: Department of Water, Government of Western Australia.

Lyons, M. (2015). The riparian flora and plant communities of the Pilbara region of Western Australia. *Records of the Western Australian Museum, Supplement 78*, 485–513.

Maslin, B. L., & J. E. Reid, J. (2010). *Wattles of the Pilbara. CD-ROM, Version 1.0.* Perth: Department of Environment and Conservation.

Mattiske Consulting. (2011). *Flora and Vegetation Survey of the Nullagine Survey Area.* Perth: unpublished report by Mattiske Consulting Pty Ltd for Northwest Resources Limited.

McCune, B., & Grace, J. (2002). *Analysis of Ecological Communities.* Gleneden Beach, Oregon: MjM Software.

McCune, B., & Mefford, M. (2011). *PC-ORD.* Gleneden Beach, Oregon, USA: MjM Software.

McDonald, R., Isbell, R., Speight, JG, W., & Hopkins, M. (1990). *Australian Soil and Land Survey Field Handbook.* Canberra: CSIRO Australia.

Mitchell, A. (2018). *Solanum Sp. Mosquito Creek.* email: 14/02/2018: Principal Botanist, Newland Environmental.

MMWC. (2015). *Beatons Creek Gold Project Flora and Vegetation Assessment.* Perth: unpublished report for Novo Resources.

NTG. (2019). *Weeds - Neem*. Retrieved from Northern Territory Government information and services: https://nt.gov.au/environment/weeds/weeds-in-the-nt/A-Z-list-of-weeds-in-the-NT/neem

Orchard, A., & Wilson, A. (. (2001). *Flora of Australia Volume 11A, Mimosaceae, Acacia part 1.* Melbourne: ABRS/CSIRO Publishing.

Paltridge, R., & Latz, P. (2009). *Fire Management Plan for the Mann Ranges and Musgrave Ranges Fire Management Regions of the Anangu Pitjantjatjara Yankunyjatjara Lands.* Alice Springs: Report by Desert Wildlife Services for APY Land Management.

Piccinin, R., Murphy, D., & Ladiges, P. (2004). Morphometric Study of a Hybrid Population of Acacia verniciflua and A. aspera (Acacia subgenus Phyllodineae). *Muelleria, 19*, 9–18.

Robert, J. (2014). Typha and Phragmites: Similiarities and Differences. In J. Roberts, & H. Kleinert, *Managing Typha and Phragmites, Report for workshop held 16th June 2014.* Huntly, Victoria: North Central Catchment Management Authority.

Trudgen, M.E. & Associates. (2002). *A flora, vegetation and floristic survey of the Burrup Peninsula, some adjoining areas and part of the Dampier Archipelago, with comparisons to the floristics of areas on the adjoining mainland. Vols. 1 & 2.* Perth: Unpublished report by M.E. Trudgen and Associates for the Department of Mineral and Petroleum Resources.

van Leeuwen, S., & Bromilow, B. (2002). *Botanical survey of Hamersley Range uplands. National Reserve System Project N709, final report, May 2002.* Kensington, W.A.: Department of Conservation & Land Management.

Van Vreeswyk, A., Payne, A., Leighton, K., & Hennig, P. (2004). *Technical Bulletin No. 92 - An inventory and condition survey of the Pilbara region, Western Australia.* Perth: Department of Agriculture.

WA Herbarium. (2015). *Rare and Priority Plans of the Pilbara.* Brisbane: LucidMobile.

Waters, A. (2017). *Vegetation of the MML Nullagine Tenements, October 2017/ version 3.1.* Perth: unpublished report by Woodgis and Plantecology Consulting for Millennium Minerals Ltd .

Western Australian Herbarium. (1998-). *FloraBase - the Western Australia Flora*. (Department of Biodiversity, Conservation and Attractions) Retrieved 2018, from https://florabase.dpaw.wa.gov.au

Woodgis. (2017). *Stony Plains of the Mosquito Land System PEC, May 2017/version 2.0, .* Perth: unpublished report by Woodgis and Plantecology Consulting for Millennium Minerals Ltd.

Woodgis. (2017). *Millennium Minerals Ltd – Nullagine Priority Flora Census Update, October 2017.* Perth: unpublished report by Woodgis and Plantecology for Millennium Minerals Ltd.

Woodgis. (2017). *Stony Plains of the Mosquito Land System PEC, May 2017/version 2.0.* Perth: unpublished report by Woodgis and Plantecology Consulting for Millennium Minerals Limited.

APPENDIX 1: DBCA CONSERVATION CODES

DBCA – Ecological Community Codes

Presumed Totally Destroyed (PD)

An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future.

An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant **and either** of the following applies (A or B):

A) Records within the last 50 years have not been confirmed despite thorough searches of known or likely habitats **or**

B) All occurrences recorded within the last 50 years have since been destroyed

Critically Endangered (CR)

An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated.

An ecological community will be listed as **Critically Endangered** when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. This will be determined on the basis of the best available information, by it meeting **any one or more of** the following criteria (A, B or C):

A) The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 90% **and either or both** of the following apply (i or ii):

i) geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is imminent (within approximately 10 years);

ii) modification throughout its range is continuing such that in the immediate future (within approximately 10 years) the community is unlikely to be capable of being substantially rehabilitated.

B) Current distribution is limited, **and one or more** of the following apply (i, ii or iii):

i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 10 years);

ii) there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes;

iii) there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes.

C) The ecological community exists only as highly modified occurrences that may be capable of being rehabilitated if such work begins in the immediate future (within approximately 10 years).

Endangered (EN)

An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future.

An ecological community will be listed as **Endangered** when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. This will be determined on the basis of the best available information by it meeting **any one or more of** the following criteria (A, B, or C):

A) The geographic range, and/or total area occupied, and/or number of discrete occurrences have been reduced by at least 70% since European settlement **and either or both** of the following apply (i or ii):

i) the estimated geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is likely in the short term future (within approximately 20 years);

ii) modification throughout its range is continuing such that in the short term future (within approximately 20 years) the community is unlikely to be capable of being substantially restored or rehabilitated.

B) Current distribution is limited, **and one or more** of the following apply (i, ii or iii):

i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the short term future (within approximately 20 years);

ii) there are few occurrences, each of which is small and/or isolated and all or most occurrences are very vulnerable to known threatening processes;

iii) there may be many occurrences but total area is small and all or most occurrences are small and/or isolated and very vulnerable to known threatening processes.

C) The ecological community exists only as very modified occurrences that may be capable of being substantially restored or rehabilitated if such work begins in the short-term future (within approximately 20 years).

DBCA – Ecological Community Codes continued

Vulnerable (VU)

An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range.

An ecological community will be listed as **Vulnerable** when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future. This will be determined on the basis of the best available information by it meeting **any one or more of** the following criteria (A, B or C):

A) The ecological community exists largely as modified occurrences that are likely to be capable of being substantially restored or rehabilitated.

B) The ecological community may already be modified and would be vulnerable to threatening processes, is restricted in area and/or range and/or is only found at a few locations.

C) The ecological community may be still widespread but is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes.

Priority One: Poorly-known ecological communities

Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.

Priority Two: Poorly-known ecological communities

Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.

Priority Three: Poorly known ecological communities

(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or:

(ii) communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or;

(iii) communities made up of large, and/or widespread occurrences, that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes.

Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.

Priority Four: Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.

(a) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands.

(b) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.

(c) Ecological communities that have been removed from the list of threatened communities during the past five years.

Priority Five: Conservation Dependent ecological communities

Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

DBCA – Flora Codes

Threatened Flora (Declared Rare Flora - Extant Taxa)
Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.

Presumed Extinct Flora (Declared Rare Flora – Extinct)
Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such.

Priority One: Poorly-known taxa
Taxa that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.

Priority Two: Poorly-known taxa
Taxa that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.

Priority Three: Poorly Known taxa
Taxa that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.

Priority Four: Rare, Near Threatened and other taxa in need of monitoring
(a) Rare. Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.
(b) Near Threatened. Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.
(c) Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

Priority Five: Conservation Dependent taxa
Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the taxa becoming threatened within five years.

APPENDIX 2: INDICATOR SPECIES OF VEGETATION TYPES

Table 19: Indicator and Common Species for Vegetation Types 1-4

Taxa	1	2	3	4	5	6	7	8
Eucalyptus camaldulensis subsp. *refulgens*	**Ic**							
Melaleuca glomerata	**Ic**							
Acacia coriacea subsp. *pendens*	**Ic**							
Melaleuca argentea	I							
Flueggea virosa subsp. *melanthesoides*	I							
Plumbago zeylanica	I							
Vigna lanceolata var. *lanceolata*	I							
Cyperus vaginatus	I							
Typha domingensis	I							
Boerhavia schomburgkiana		**Ic**						
Cenchrus setiger		**Ic**						
Cenchrus ciliaris		**Ic**				c		
Acacia sclerosperma subsp. *sclerosperma*		I						
Aerva javanica		I						
Atalaya hemiglauca		I						
Vachellia farnesiana		I						
Acacia maitlandii			**Ic**					
Acacia trachycarpa x tumida var. *pilbarensis*			**Ic**					
Cassytha capillaris			**Ic**					
Corymbia hamersleyana			**Ic**					
Eragrostis eriopoda			**Ic**					
Hibiscus sturtii var. *campylochlamys*			**Ic**					
Hybanthus aurantiacus			**Ic**					
Indigofera monophylla			**Ic**					
Isotropis atropurpurea			**Ic**					
Pluchea tetranthera			**Ic**					
Scaevola browniana subsp. *browniana*			**Ic**					
Waltheria virgata			**Ic**					
Acacia tumida var. *pilbarensis*			**Ic**					c
Triodia epactia			**Ic**			c	c	c
Corymbia candida subsp. *dipsodes*			I					
Calytrix carinata			I					
Eriachne benthamii			I					
Santalum lanceolatum			I					
Acacia trachycarpa			c					
Acacia bivenosa			c		c		c	
Frankenia setosa				**Ic**				
Sclerolaena hostilis				**Ic**				
Sclerolaena cornishiana				I				
Maireana melanocoma				I				

I = statistically significant indicator c= common (occurs in =>50% of sites)

Table 20: Indicator and Common Species for Vegetation Types 5-8

Taxa	1	2	3	4	5	6	7	8
Acacia aphanoclada					**Ic**			
Triodia wiseana					**Ic**			
Triodia longiceps		c		c	**Ic**		c	
Acacia arrecta					I			
Corchorus parviflorus			c			Ic		
Acacia inaequilatera						**Ic**		
Eriachne mucronata						**Ic**		
Rhynchosia minima						**Ic**		
Senna glutinosa subsp. *glutinosa*						**Ic**		
Trigastrotheca molluginea						**Ic**		
Senna glutinosa subsp. *pruinosa*						I		
Triodia brizoides						c	**Ic**	c
Senna symonii					c		**Ic**	
Acacia acradenia							**Ic**	
Cymbopogon ambiguus							**Ic**	
Acacia ancistrocarpa							I	
Aristida holathera var. *holathera*							I	
Cucumis variabilis							I	
Paraneurachne muelleri							I	
Eucalyptus leucophloia subsp. *leucophloia*			c				c	**Ic**
Grevillea wickhamii subsp. hispidula			c				c	**Ic**
Acacia monticola								**Ic**
Acacia pyrifolia var. *pyrifolia*								**Ic**
Acacia spondylophylla								**Ic**
Gompholobium oreophilum								**Ic**
Goodenia stobbsiana								**Ic**
Acacia adoxa var. *adoxa*								I
Acacia hilliana								I
Acacia orthocarpa								I
Dodonaea coriacea								I
Senna glaucifolia								I

I = statistically significant indicator c= common (occurs in =>50% of sites)

APPENDIX 3: FLORA INVENTORY

Table 21: Flora Inventory of Land Systems in the Area of Interest

Family	Taxa	Capricorn land system	Mosquito land system	River land system	Opportunistic
Aizoaceae	*Trianthema glossostigmum*	1			
Aizoaceae	*Trianthema triquetrum*		1	1	
Amaranthaceae	**Aerva javanica*			1	
Amaranthaceae	*Achyranthes aspera*		1		
Amaranthaceae	*Alternanthera nana*	1			
Amaranthaceae	*Amaranthus undulatus*			1	
Amaranthaceae	*Gomphrena cunninghamii*		1	1	
Amaranthaceae	*Ptilotus astrolasius*		1		
Amaranthaceae	*Ptilotus axillaris*				1
Amaranthaceae	*Ptilotus calostachyus*	1	1		
Amaranthaceae	*Ptilotus fusiformis*	1	1		
Amaranthaceae	*Ptilotus incanus*				1
Amaranthaceae	*Ptilotus nobilis* subsp. *nobilis*				1
Amaranthaceae	*Ptilotus obovatus*		1		
Amaranthaceae	*Ptilotus polystachyus*		1		
Amaranthaceae	*Ptilotus rotundifolius*				1
Amaranthaceae	***Ptilotus wilsonii P1***		1		
Apocynaceae	**Calotropis procera*		1		
Apocynaceae	*Carissa lanceolata*		1		
Apocynaceae	*Cynanchum floribundum*				1
Araliaceae	*Trachymene oleracea* subsp. *oleracea*				1
Asteraceae	*Calocephalus beardii*	1			
Asteraceae	*Centipeda minima* subsp. *macrocephala*	1			
Asteraceae	*Centipeda minima* subsp. *minima*	1			
Asteraceae	*Chrysocephalum apiculatum*	1			
Asteraceae	*Pluchea dentex*	1			
Asteraceae	*Pluchea ferdinandi-muelleri*	1	1		
Asteraceae	*Pluchea rubelliflora*	1	1		
Asteraceae	*Pluchea tetranthera*	1	1		
Asteraceae	*Podolepis capillaris*	1			
Asteraceae	*Pterocaulon serrulatum* var. *velutinum*		1		
Asteraceae	*Pterocaulon sphacelatum*		1		
Asteraceae	*Pterocaulon sphaeranthoides*				1
Asteraceae	*Rhodanthe margarethae*	1			
Asteraceae	*Streptoglossa decurrens*				1
Boraginaceae	*Ehretia saligna* var. *saligna*	1			
Boraginaceae	*Heliotropium chrysocarpum*	1	1		
Boraginaceae	*Heliotropium skeleton*				1
Boraginaceae	*Trichodesma zeylanicum* var. *zeylanicum*	1		1	
Brassicaceae	*Lepidium pedicellosum*	1			
Capparaceae	*Capparis spinosa* var. *nummularia*				1
Capparaceae	*Capparis umbonata*		1	1	
Caryophyllaceae	*Polycarpaea holtzei*				1

Family	Taxa	Capricorn land system	Mosquito land system	River land system	Opportunistic
Chenopodiaceae	*Atriplex codonocarpa*				1
Chenopodiaceae	***Atriplex spinulosa P1***		1		
Chenopodiaceae	*Dysphania plantaginella*	1			
Chenopodiaceae	*Dysphania rhadinostachya* subsp. *rhadinostachya*				1
Chenopodiaceae	*Maireana carnosa*		1		
Chenopodiaceae	*Maireana georgei*		1		
Chenopodiaceae	*Maireana melanocoma*		1		
Chenopodiaceae	*Maireana tomentosa* subsp. *tomentosa*	1			
Chenopodiaceae	*Rhagodia eremaea*			1	
Chenopodiaceae	*Salsola australis*				1
Chenopodiaceae	*Sclerolaena bicornis*		1		
Chenopodiaceae	*Sclerolaena cornishiana*		1		
Chenopodiaceae	*Sclerolaena cuneata*		1		
Chenopodiaceae	*Sclerolaena diacantha*		1		
Chenopodiaceae	*Sclerolaena eriacantha*				1
Chenopodiaceae	*Sclerolaena hostilis*		1		
Cleomaceae	*Cleome viscosa*			1	
Convolvulaceae	*Bonamia erecta*		1		
Convolvulaceae	*Bonamia media*	1			
Convolvulaceae	*Bonamia pannosa*		1		
Convolvulaceae	*Bonamia pilbarensis*		1	1	
Convolvulaceae	*Bonamia rosea*	1			
Convolvulaceae	*Evolvulus alsinoides* var. *villosicalyx*		1	1	
Cucurbitaceae	**Citrullus amarus*				1
Cucurbitaceae	*Cucumis variabilis*	1	1	1	
Cyperaceae	*Bulbostylis barbata*	1	1		
Cyperaceae	*Cyperus hesperius*	1			
Cyperaceae	*Cyperus iria*		1		
Cyperaceae	*Cyperus ixiocarpus*	1			
Cyperaceae	*Cyperus vaginatus*			1	
Cyperaceae	*Fimbristylis dichotoma*		1		
Elatinaceae	*Bergia pedicellaris*	1			
Euphorbiaceae	*Euphorbia australis* var. *subtomentosa*	1			
Euphorbiaceae	*Euphorbia biconvexa*		1	1	
Euphorbiaceae	*Euphorbia boophthona*	1			
Euphorbiaceae	*Euphorbia careyi*	1		1	
Euphorbiaceae	*Euphorbia trigonosperma*				1
Fabaceae	**Vachellia farnesiana*		1	1	
Fabaceae	*Acacia acradenia*	1	1		
Fabaceae	*Acacia adoxa* var. *adoxa*	1			
Fabaceae	*Acacia adsurgens*	1			
Fabaceae	*Acacia ampliceps*			1	
Fabaceae	*Acacia ancistrocarpa*		1	1	
Fabaceae	***Acacia aphanoclada P1***	1	1		
Fabaceae	*Acacia aphanoclada x pyrifolia* var. *pyrifolia*				1
Fabaceae	*Acacia arrecta*		1		

Family	Taxa	Capricorn land system	Mosquito land system	River land system	Opportunistic
Fabaceae	*Acacia bivenosa*	1	1	1	
Fabaceae	*Acacia colei* var. *colei*	1			
Fabaceae	*Acacia coriacea* subsp. *pendens*	1	1	1	
Fabaceae	***Acacia cyperophylla* var. *omearana P1***				1
Fabaceae	*Acacia dictyophleba*	1			
Fabaceae	*Acacia hilliana*	1	1		
Fabaceae	*Acacia inaequilatera*		1	1	
Fabaceae	*Acacia ligulata*			1	
Fabaceae	*Acacia maitlandii*	1			
Fabaceae	*Acacia monticola*	1			
Fabaceae	*Acacia orthocarpa*	1			
Fabaceae	*Acacia pruinocarpa*	1			
Fabaceae	*Acacia pyrifolia* var. *pyrifolia*	1		1	
Fabaceae	*Acacia retivenea* subsp. *clandestina*	1			
Fabaceae	*Acacia sclerosperma* subsp. *sclerosperma*			1	
Fabaceae	*Acacia spondylophylla*	1			
Fabaceae	*Acacia stellaticeps*				1
Fabaceae	*Acacia synchronicia*		1		
Fabaceae	*Acacia synchronicia (broad phyllode variant)*				1
Fabaceae	*Acacia trachycarpa*	1	1	1	
Fabaceae	*Acacia trachycarpa x ? monticola*				1
Fabaceae	*Acacia trachycarpa x tumida* var. *pilbarensis*	1			
Fabaceae	*Acacia tumida* var. *pilbarensis*	1	1		
Fabaceae	*Alysicarpus muelleri*			1	
Fabaceae	*Cullen lachnostachys*				1
Fabaceae	*Cullen pogonocarpum*		1		
Fabaceae	*Erythrina vespertilio*			1	
Fabaceae	*Gompholobium oreophilum*	1			
Fabaceae	*Indigofera monophylla*	1	1		
Fabaceae	*Isotropis atropurpurea*	1	1		
Fabaceae	*Neptunia monosperma*		1		
Fabaceae	*Petalostylis cassioides*	1			
Fabaceae	*Petalostylis labicheoides*	1	1		
Fabaceae	*Rhynchosia minima*		1	1	
Fabaceae	*Senna artemisioides* subsp. *helmsii*		1		
Fabaceae	*Senna artemisioides* subsp. *oligophylla*		1		
Fabaceae	*Senna glaucifolia*	1	1		
Fabaceae	*Senna glutinosa* subsp. *glutinosa*	1	1		
Fabaceae	*Senna glutinosa* subsp. *pruinosa*		1	1	
Fabaceae	*Senna glutinosa* subsp. *x luerssenii*	1	1		
Fabaceae	*Senna notabilis*	1	1		
Fabaceae	*Senna symonii*		1		
Fabaceae	*Sesbania cannabina*		1		
Fabaceae	*Swainsona pterostylis*			1	
Fabaceae	*Swainsona stenodonta*				1
Fabaceae	*Tephrosia supina*	1			

Family	Taxa	Capricorn land system	Mosquito land system	River land system	Opportunistic
Fabaceae	*Vigna lanceolata* var. *lanceolata*			1	
Frankeniaceae	*Frankenia setosa*		1		
Gentianaceae	*Schenkia clementii*	1			
Goodeniaceae	*Dampiera candicans*	1			
Goodeniaceae	*Goodenia cusackiana*	1	1		
Goodeniaceae	*Goodenia lamprosperma*	1			
Goodeniaceae	*Goodenia microptera*	1	1	1	
Goodeniaceae	*Goodenia muelleriana*		1		
Goodeniaceae	*Goodenia stobbsiana*	1			
Goodeniaceae	*Goodenia triodiophila*	1			
Goodeniaceae	*Scaevola browniana* subsp. *browniana*	1			
Haloragaceae	*Gonocarpus ephemerus*	1			
Haloragaceae	*Haloragis gossei* var. *gossei*		1		
Lamiaceae	*Clerodendrum floribundum* var. *angustifolium*				1
Lamiaceae	*Clerodendrum tomentosum* var. *lanceolatum*	1			
Lauraceae	*Cassytha capillaris*	1	1		
Lythraceae	*Ammannia auriculata*	1			
Lythraceae	*Ammannia baccifera*	1			
Malvaceae	**Malvastrum americanum*		1		
Malvaceae	*Abutilon lepidum*			1	
Malvaceae	*Abutilon* sp. Dioicum (A.A. Mitchell PRP 1618)	1	1		
Malvaceae	*Abutilon* sp. Pilbara (W.R. Barker 2025)		1		
Malvaceae	*Corchorus parviflorus*	1	1	1	
Malvaceae	*Corchorus walcottii*				1
Malvaceae	*Gossypium australe*		1		
Malvaceae	*Hibiscus coatesii*				1
Malvaceae	*Hibiscus sturtii* var. *campylochlamys*	1	1		
Malvaceae	*Sida arenicola*	1			
Malvaceae	*Sida echinocarpa*	1		1	
Malvaceae	*Sida fibulifera*	1	1		
Malvaceae	*Sida* sp. Pilbara (A.A. Mitchell PRP 1543)	1	1		
Malvaceae	*Waltheria indica*	1			
Malvaceae	*Waltheria virgata*	1			
Marsileaceae	*Marsilea hirsuta*		1		
Meliaceae	**Azadirachta indica*			1	
Menispermaceae	*Tinospora smilacina*	1			
Molluginaceae	*Glinus oppositifolius*				1
Molluginaceae	*Trigastrotheca molluginea*	1	1	1	
Montiaceae	*Calandrinia quadrivalvis*	1			
Moraceae	*Ficus brachypoda*	1			
Myrtaceae	*Calytrix carinata*	1	1		
Myrtaceae	*Corymbia candida* subsp. *dipsodes*	1	1		
Myrtaceae	*Corymbia deserticola* subsp. *deserticola*	1			
Myrtaceae	*Corymbia hamersleyana*	1	1		
Myrtaceae	*Eucalyptus camaldulensis* subsp. *refulgens*	1	1	1	
Myrtaceae	*Eucalyptus leucophloia* subsp. *leucophloia*	1	1		

Family	Taxa	Capricorn land system	Mosquito land system	River land system	Opportunistic
Myrtaceae	*Eucalyptus victrix*	1		1	
Myrtaceae	*Melaleuca argentea*	1		1	
Myrtaceae	*Melaleuca bracteata*			1	
Myrtaceae	*Melaleuca eleuterostachya*		1		
Myrtaceae	*Melaleuca glomerata*	1		1	
Nyctaginaceae	*Boerhavia schomburgkiana*		1	1	
Phyllanthaceae	*Flueggea virosa* subsp. *melanthesoides*			1	
Phyllanthaceae	*Phyllanthus maderaspatensis*	1	1		
Phyllanthaceae	*Synostemon rhytidospermus*		1		
Plantaginaceae	*Stemodia grossa*	1	1		
Plantaginaceae	*Stemodia viscosa*	1	1		
Plumbaginaceae	*Plumbago zeylanica*			1	
Poaceae	**Cenchrus ciliaris*	1	1	1	
Poaceae	**Cenchrus setiger*		1	1	
Poaceae	**Cynodon dactylon*			1	
Poaceae	**Echinochloa colona*		1		
Poaceae	*Aristida contorta*		1		
Poaceae	*Aristida holathera* var. *holathera*	1	1		
Poaceae	*Chloris pectinata*		1		
Poaceae	*Chrysopogon fallax*		1	1	
Poaceae	*Cymbopogon ambiguus*	1	1		
Poaceae	*Cynodon convergens*		1		
Poaceae	*Cynodon prostratus*		1		
Poaceae	*Dactyloctenium radulans*		1		
Poaceae	*Diplachne fusca* subsp. *fusca*				1
Poaceae	*Enneapogon caerulescens*		1		
Poaceae	*Enneapogon lindleyanus*				1
Poaceae	*Eragrostis cumingii*	1	1		
Poaceae	*Eragrostis eriopoda*	1	1		
Poaceae	*Eragrostis tenellula*		1		
Poaceae	*Eragrostis xerophila*		1		
Poaceae	*Eriachne benthamii*	1			
Poaceae	*Eriachne helmsii*		1		
Poaceae	*Eriachne lanata*	1			
Poaceae	*Eriachne mucronata*	1	1	1	
Poaceae	*Leptochloa digitata*			1	
Poaceae	*Paraneurachne muelleri*		1	1	
Poaceae	*Paspalidium basicladum*			1	
Poaceae	*Sporobolus actinocladus*		1		
Poaceae	*Sporobolus australasicus*		1		
Poaceae	*Themeda triandra*		1	1	
Poaceae	*Triodia brizoides*	1	1	1	
Poaceae	*Triodia epactia*	1	1	1	
Poaceae	*Triodia longiceps*	1	1	1	
Poaceae	*Triodia wiseana*		1		
Poaceae	*Xerochloa barbata*		1		

Family	Taxa	Capricorn land system	Mosquito land system	River land system	Opportunistic
Portulacaceae	*Portulaca oleracea*		1	1	
Potamogetonaceae	*Potamogeton tricarinatus*	1		1	
Proteaceae	*Grevillea berryana*				1
Proteaceae	*Grevillea pyramidalis* subsp. *leucadendron*	1	1		
Proteaceae	*Grevillea wickhamii* subsp. *hispidula*	1	1		
Proteaceae	*Hakea chordophylla*		1		
Proteaceae	*Hakea lorea* subsp. *lorea*	1	1	1	
Pteridaceae	*Cheilanthes brownii*	1			
Pteridaceae	*Cheilanthes sieberi*		1		
Rubiaceae	*Synaptantha tillaeacea* var. *tillaeacea*				1
Santalaceae	*Santalum lanceolatum*	1			
Sapindaceae	*Atalaya hemiglauca*	1		1	
Sapindaceae	*Dodonaea coriacea*	1			
Scrophulariaceae	*Eremophila latrobei* subsp. *latrobei*	1			
Scrophulariaceae	*Eremophila longifolia*			1	
Solanaceae	*Nicotiana benthamiana*	1			
Solanaceae	*Solanum horridum*	1	1	1	
Solanaceae	*Solanum phlomoides*	1			
Solanaceae	***Solanum* sp. Mosquito Creek (A.A. Mitchell et al. AAM 10795) P1**		1		
Solanaceae	*Solanum sturtianum*				1
Typhaceae	*Typha domingensis*			1	
Violaceae	*Hybanthus aurantiacus*	1	1	1	
Zygophyllaceae	*Tribulus occidentalis*		1	1	
Zygophyllaceae	*Tribulus suberosus*	1	1		

APPENDIX 4: VEGETATION PHOTOS

Vegetation Type 1
Eucalyptus camaldulensis, Melaleuca glomerata, Acacia coriacea Woodland

Vegetation Subtype 1a

H64

H65

Vegetation Subtype 1b

H66

Vegetation Type 2
Vachellia farnesiana Low Open Woodland over *Cenchrus ciliaris* Very Open Tussock-Tussock Grassland

Vegetation Subtype 2a

H42

H43

H59

Vegetation Subtype 2a continued

H60

H61

H62

Vegetation Subtype 2b

H41

H45

H58

Vegetation Subtype 2c

H11

H14

H37

H38

Vegetation Subtype 2d

H19

H22

Vegetation Subtype 2e

H13

H26

Vegetation Type 3
Acacia tumida, Acacia trachycarpa Tall Open Shrubland over *Triodia epactia* Very Open Hummock-Hummock Grassland

Vegetation Subtype 3a

Only sampled in Project Area by MMCW (2015)

Vegetation Subtype 3b

H48

Vegetation Type 4
Maireana melanocoma, Sclerolaena hostilis Low Open Shrubland over *Triodia longiceps* Very Open Hummock Grassland

Vegetation Subtype 4a

H10

H12

H27

Vegetation Subtype 4a continued

H28

H33

H44

H52

Vegetation Subtype 4a continued

H63

Vegetation Subtype 4b

H32

H34

H35

H54

Vegetation Type 5
Acacia aphanoclada Open Shrubland over
Triodia longiceps Very Open Hummock Grassland

Vegetation Subtype 5a

H16

H17

H29

Vegetation Subtype 5a continued

H31

H55

Vegetation Subtype 5b

H15

H30

Vegetation Subtype 5c

H23

H47

H36

Vegetation Type 6
Acacia inaequilatera Open Shrubland over Open Hummock Grassland

Vegetation Subtype 6a

H09

H20

H24

Vegetation Subtype 6a continued

H25

H39

Vegetation Subtype 6b

H18

H21

H40

H46

Vegetation Type 7
Acacia acradenia Open Shrubland over
Open Hummock Grassland

Vegetation Subtype 7a

H01

H02

H03

Vegetation Subtype 7a continued

H49

H50

Vegetation Subtype 7b

H04

H05

H06

H07

Vegetation Subtype 7b continued

H08

H51

H53

H57

Vegetation Type 8
Scattered Low Trees of *Eucalyptus leucophloia over* *Acacia pyrifolia* Low Open Shrubland over Open Hummock Grassland

Vegetation Subtype 8a

H56

Vegetation Subtype 8b-8g

Only sampled in Project Area by MMCW (2015)