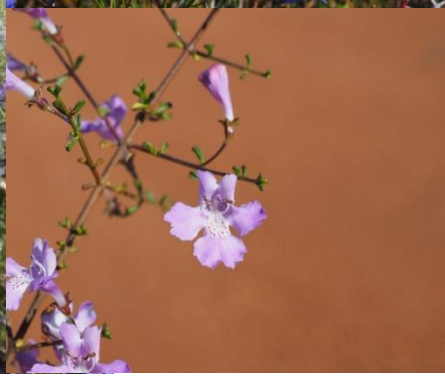
Rothsay Gold Project

Flora and Vegetation Assessment

EGAN STREET RESOURCES

MARCH 2017



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Rothsay Gold Project Flora and Vegetation Assessment

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Cover Photographs: Wildflower carpet on a basalt hill in the Rothsay Gold Project Study Area, October 2016, and insets: *Lobelia rhytidosperma* (top), *Cheiranthera simplicifolia* and *Hemigenia* sp. Yalgoo (A.M. Ashby 2624). All photos by Woodman Environmental Consulting.

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EXECUTIVE SUMMARY

Egan Street Resources (EganStreet) are the current proponent of the Rothsay Gold Project (the Project), located in the Midwest region of Western Australia. EganStreet are proposing to commence underground mining operations within 2 mining tenements. Woodman Environmental Consulting Pty Ltd (Woodman Environmental) were commissioned to undertake a Level 2 flora and vegetation survey of the tenement areas (Study Area) in 2016. The desktop review identified a total of 49 conservation significant flora taxa known to occur in the vicinity of the Study Area, of which 4 were known to occur within the Study Area itself.

The field survey was undertaken in early October 2016, which was considered to be an appropriate time for survey of the Study Area. A total of 35 quadrats measuring 20 m x 20 m were surveyed, with at least three quadrats placed in each discernible preliminary vegetation type identified on aerial photography. All vascular plant species were recorded within each quadrat, with identifications undertaken at the Western Australian Herbarium (WA Herb). In addition, targeted searching for significant flora taxa in likely habitat for such flora was also undertaken. It is considered that the Study Area was relatively well sampled, with 85.7% of the estimated taxon richness in the Study Area recorded within quadrats (using the Chao-2 estimator).

A total of 300 discrete vascular flora taxa and 1 putative hybrid were recorded within the Study Area by this survey.

A total of 17 listed significant flora taxa (all Priority flora as listed by the Department of Parks and Wildlife (DPaW)) were recorded by this survey, including four taxa which were not previously known to occur in the vicinity of the Study Area (*Bossiaea* sp. Jackson Range (G. Cockerton & S. McNee LCS 13614) (P3); *Calandrinia* sp. Warriedar (F. Obbens 04/09) (P2); *Gunniopsis divisa* (P3) and *Hemigenia tichbonii* (P1)).

No taxa listed as Threatened flora were recorded during the survey, however potential habitat for the Threatened taxon *Stylidium scintillans* was mapped. As *Stylidium scintillans* has a relatively short flowering period (late August – early September), it was unable to be surveyed for during the survey period.

Collections of four taxa (including *Hemigenia tichbonii* (P1)) are considered to be either extensions to the known range, or otherwise fill gaps in the known distribution of these taxa. These extensions are most likely due to lack of survey for these flora taxa within the general region. Likewise the collection of one putative hybrid (*Acacia ramulosa* var. *ramulosa* and a member of the Mulga (*Acacia aneura* and its allies) is not considered to be significant.

A total of 24 introduced taxa are known to occur in the Study Area, of which three taxa (*Brassica tournefortii*, *Echium plantagineum* and *Rumex vesicarius* (Ruby Dock)) are considered to be significant weeds. Of these, *Echium plantagineum* and *Rumex vesicarius* are relatively common around disturbance areas associated with historical mining and the Rothsay townsite.

Classification analysis was undertaken on quadrat data from the Study Area. The resulting classification dendrogram was examined, with 9 clusters of quadrats resolved, which were used to describe 9 Vegetation Types (VTs).

One listed significant vegetation entity is considered to occur in the Study Area, being:

- Blue Hills (Mount Karara/Mungada Ridge/Blue Hills) vegetation complexes (banded ironstone formation) PEC (Priority 1).

The above PEC is represented by VTs 2 and 3 in the Study Area.

In addition, it is considered that VTs 6, 7 and 9 are significant vegetation in a local context, due to their restricted occurrence in the Study Area. These VTs are also considered to be potential significant vegetation in a regional context, as they appear to be relatively uncommon and restricted in the region. This was supported by a secondary analysis of Study Area quadrat data with data from other quadrats located in the region. However, further investigation of other potential locations of these VTs would be required to determine whether they represent significant VTs in a regional context.

The majority of the vegetation of the Study Area was considered to be in 'Pristine' condition (Keighery 1994), excluding areas mapped as Cleared Land, and a single polygon mapped as VT 4d. Introduced taxa were often present, however major infestations of serious weeds were restricted to areas mapped as Cleared Land associated with historical mining and the Rothsay townsite and/or were present at low levels. Historical disturbance from mining activities was present in many areas, however this does not appear to have affected the overall condition of the vegetation. Goats were observed during the survey, however they do not currently appear to be affecting the condition of the vegetation.

It is likely that sufficient survey for the majority of taxa to inform an assessment of impacts of the Project has already been undertaken, however this is dependent on the location and nature of impacts of the Project. One possible exception is *Hemigenia tichbonii* (P1), as very little is known of the distribution and abundance of this taxon; further survey may be required if it is considered likely that this taxon will be impacted by the Project. Likewise, survey for *Stylidium scintillans* (Threatened) in appropriate habitat (VTs 2, 9 and laterised ironstone outcrops in VT 3) may also be required if it is considered likely that this taxon will be impacted by the Project.

1. INTRODUCTION

1.1 Project and Assessment Description

Egan Street Resources (EganStreet) are the current proponent of the Rothsay Gold Project (the Project), located approximately 300 km north north-east of Perth, 230 km south south-east of Geraldton and 60 km north-east of Perenjori, in the Midwest region of Western Australia (Figure 1). Gold was first mined near the now-abandoned town of Rothsay in the 1890s, with mining undertaken sporadically since that time until 1991. This includes partial exploitation of the Project's reserves via shallow open pits and underground mining techniques.

Since acquiring the Project, Eganstreet have compiled historical data and undertaken exploratory drilling, and are now proposing to commence underground mining operations within 2 mining tenements. In support of the proposed operations, EganStreet commissioned Woodman Environmental Consulting Pty Ltd (Woodman Environmental) in 2016 to undertake an assessment of the flora and vegetation values of these tenements.

1.2 Study Area Definition

The Project Study Area (the Study Area) is located in the Shire of Perenjori, encompassing the now-abandoned townsite of Rothsay, and comprises the mining tenements M59/39-1 and M59/40-1. It is primarily located on an Unmanaged Crown Reserve. A small portion of the Study Area is located on the former Karara Station pastoral lease, an area now classified as Unallocated Crown Land – Department Interest; this area is proposed for conservation as a Nature Reserve, and is currently managed by the Department of Parks and Wildlife (DPaW) (Figure 1). Further small portions of the Study Area are located on Vacant Crown Land, road reserves and other crown reserves, primarily associated with the abandoned townsite of Rothsay. The Study Area is 1,090 ha in size. The majority of the Study Area is remnant vegetation, however numerous small cleared areas are present, including Boonerong Road, an airstrip, and existing mining infrastructure (including open pits) (Figure 1).

1.3 Level of Assessment

The flora and vegetation assessment of the Study Area was undertaken at a Level 2 standard as defined by the Environmental Protection Authority (EPA) and DPaW Technical Guide for Flora and Vegetation Surveys for Environmental Impact Assessment (EPA and DPaW 2015). A Level 2 survey was undertaken because the Study Area is likely to support a high diversity of flora and vegetation, and likely contains a high number of significant flora taxa (EPA and DPaW 2015). There is also the potential for significant vegetation communities to be present.

Level 2 survey is defined as a background research/desktop study and reconnaissance survey (as required), followed by a detailed field survey within the proposal area (Study Area). A detailed field survey was considered appropriate, as several other detailed and targeted surveys have been conducted within and in the vicinity of the Study Area (e.g.

Markey and Dillon 2008; Meissner and Coppen 2014; Woodman Environmental 2008, 2012, 2014), which provide regional context when considering the flora and vegetation values of the Study Area. Because of the level of existing information available on the flora and vegetation of the Study Area, a reconnaissance survey prior to the detailed survey was not considered necessary.

This report presents the results of both the desktop and field survey components of the Level 2 survey of the Study Area. The results of the background research/desktop study, which include a review of known information relevant to the Study Area through all sources of literature available, are presented in Section 2. The results of the detailed field survey of the Study Area are presented in Section 5.

1.4 Aim and Objectives

The aim of the survey is to provide relevant flora and vegetation information to inform an application for a mining proposal for the Project. The overall objectives of the assessment were to:

- Compile a list of flora taxa (native and introduced) that occur within the Study Area;
- Identify and record the locations of flora taxa that occur within the Study Area that are one of the following (hereafter referred to as significant flora taxa):
    - Listed Threatened Species under the *Environment Protection and Biodiversity Conservation Act* 1999 (Commonwealth) (EPBC Act);
    - Threatened Flora under the *Wildlife Conservation Act* 1950 (WA) (WC Act);
    - Priority Flora taxa as classified by the Western Australian Department of Parks and Wildlife (DPaW); and
    - Other significant flora taxa as defined by EPA and DPaW (2015).
- Identify (as per EPA and DPaW 2015) and map the location of all Vegetation Types (VTs) that occur within the Study Area;
- Assess the condition of the remnant vegetation within the Study Area;
- Identify and map the location of VTs that occur within the Study Area that are one of the following (hereafter referred to as significant vegetation):
    - Threatened Ecological Community (TEC) under the EPBC Act;
    - TEC as classified by DPaW and endorsed by the WA Minister for the Environment;
    - 'Priority Ecological Community' (PEC) as classified by DPaW; and
    - Other significant vegetation as defined by EPA and DPaW (2015).

The survey and reporting works comply with the following documents:

- *Environmental Protection (Clearing of Native Vegetation) Regulations* 2004;
- *Environmental Factor Guideline – Flora and Vegetation* (EPA 2016);
- *Technical Guide - Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA and DPaW 2015).

2. BACKGROUND AND LITERATURE REVIEW

2.1 Climate

The Study Area is located within the Yalgoo sub-region of the Murchison region, in the Eremaean Province of Western Australia (Beard 1976, 1990). The climate is classified as semi-desert Mediterranean, with generally low annual rainfall occurring predominantly in winter; however, some rainfall also occurs in summer (Beard 1990). Figure 2 displays average monthly maximum and minimum temperatures and average monthly rainfall recorded for Paynes Find, the nearest long-term meteorological stations to the Study Area (Bureau of Meteorology 2017).

The highest average daily maximum temperature at Paynes Find occurs in January (37.3 °C) with the lowest average minimum temperature occurring in July (both 5.5 °C) (data from 1919 - 2017). The average annual rainfall is 283.9 mm (data from 1919 - 2017). Average monthly rainfall peaks from late autumn to early spring (May-August), with the highest rainfall on average received in June (41 mm). Rainfall received at Paynes Find prior to survey being conducted in 2016 exceeded the long-term average, with 307.4 mm received compared to the average of 250.1 mm for this period (Figure 1). This included higher than average rainfall for all months between March and August inclusive (Bureau of Meteorology 2017).

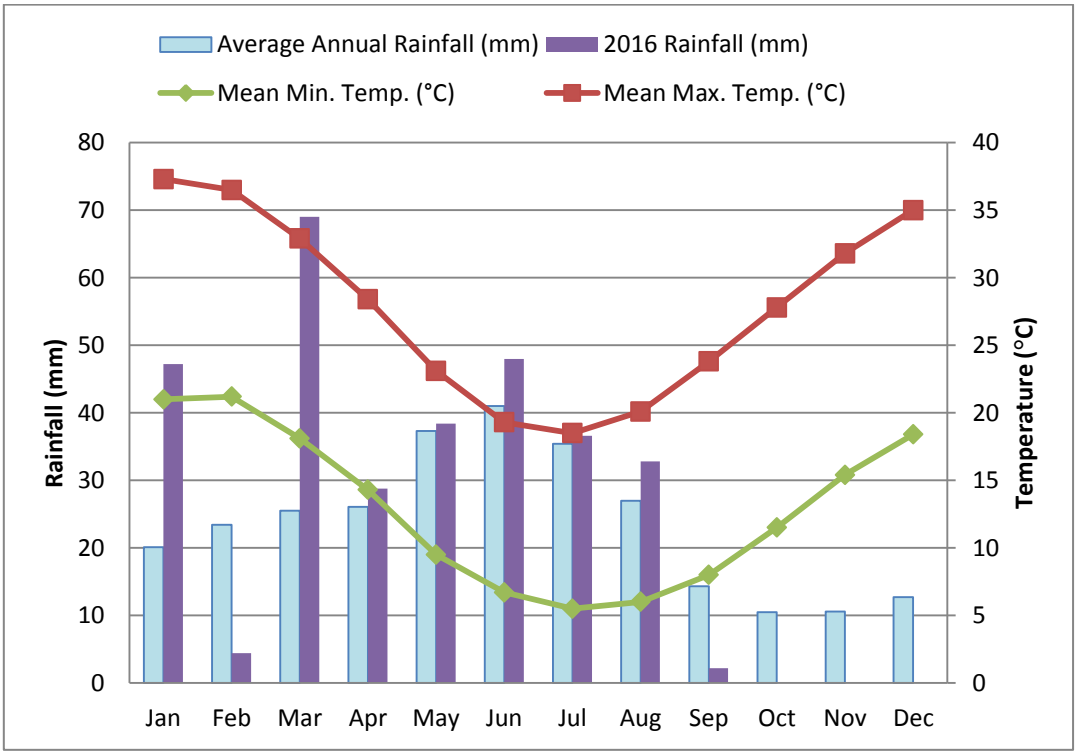

Figure 2: Mean Maximum and Minimum Temperatures (° Celsius) and Mean Rainfall (mm) for Paynes Find (Bureau of Meteorology 2017)

2.2 Geology, Landforms and Soils

The Murchison region consists of undulating topography, with occasional ranges of low hills and extensive sandplains within the eastern half of the region. Principal soils include shallow, earthy loam overlying red-brown hardpan, with shallow stony loams on hills and read earthy sands on sand plains. The geology of the region is that of Archaean granite with infolded volcanics and meta-sediments (greenstones) of like age, forming the Yilgarn Block (Beard 1990).

The Study Area occurs within the Warriedar Fold Belt, which is a series of low undulating hills of Archaean greenstone, composed of banded ironstone and basalts. Greenstone belts consist of metamorphosed volcanic rocks, including mafic rocks such as basalt and gabbro, associated with sedimentary rocks, such as banded ironstone, and are generally expressed at the surface as a series of ranges or hills. The Warriedar Fold Belt includes the larger area of the Blue Hills, Gnows Nest Range, Bullajungadeah Hills, Pinyalling Hill and the un-named hills in the south-west surrounding Mount Mulgine and the abandoned town of Rothsay (where the Study Area occurs) (Lipple *et al.* 1983, in Meissner and Coppen 2014). The Study Area occurs on the mafic rock formations at Rothsay, consisting mainly of basalt flows with thin subvolcanic intrusions of dolerite and gabbro (Lipple *et al.* 1983, in Meissner and Coppen 2014).

2.3 Regional Vegetation

The Study Area is located in the Yalgoo Interim Biogeographic Regionalisation for Australia (IBRA) region, specifically within the Tallering IBRA Subregion (Commonwealth of Australia 2012). The Yalgoo Bioregion is broadly equivalent to the Yalgoo Sub-region described by Beard (1976). Beard (1976) described the vegetation of this area as one of transition between the Eremaean and the Southwestern Province, with *Acacia aneura* being replaced in dominance by other Acacia species in the south-west of the Province. The vegetation of the region is characterised by low woodlands to open woodlands of *Eucalyptus*, *Acacia* and *Callitris* on red sandy plains of the Western Yilgarn Craton and southern Carnarvon Basin (Desmond and Chant 2001). In the vicinity of the Study Area, the vegetation was described as *A. ramulosa-A. acuminata* scrub on hills and *A. ramulosa-A. murrayana* on sandplains, with thickets of *A. ramulosa*, *A. acuminata* and *Melaleuca uncinata* (now considered to be *M. hamata* on midslope positions, and scrub of *Acacia ramulosa* with scattered *Callitris* and *Eucalyptus* in valleys (Beard 1976).

Beard (1976) mapped vegetation of the Yalgoo area (including the Study Area) related to physiognomy, at a scale of 1:1,000,000. The vegetation mapping by Beard (1976) was used by Shepherd *et al.* (2002) to describe vegetation system associations, at a scale of 1:250,000. Four vegetation system associations occur in the Study Area, as summarised in Table 1 and shown on Figure 3. Table 1 also presents the current extent of each vegetation system association in relation to its pre-European extent (Government of Western Australia 2015), and the percentage of the current extent of each vegetation system association currently protected for conservation (in DPaW-managed land). The vegetation system associations within the Study Area have undergone minimal clearing, with each having over 97 % of its pre-European extent remaining. Currently, these vegetation system associations

are not currently well-conserved (Table 1). However, significant proportions of these vegetation system associations are proposed to be conserved within the former pastoral leases in the vicinity of the Study Area, including ex-Karara, ex-Lochada and ex-Warriedar Stations (Government of Western Australia 2015).

Table 1: Extent of Vegetation System Associations within the Study Area (Government of Western Australia 2015)

Vegetation System Association	Description	Current Extent (ha)	Percentage of Pre-European Extent Remaining	Percentage of Current Extent Protected for Conservation
Yalgoo_355	Shrublands; bowgada & jam scrub with scattered York gum & red mallee	54,965.03	97.62	0
Yalgoo_358	Shrublands; bowgada & Acacia quadrimarginea on stony ridges	55,540.47	99.85	0
Yalgoo_420	Shrublands; bowgada & jam scrub	456,619.14	99.76	0.02
Yalgoo_936	Medium woodland; salmon gum	1,017.71	100	0

In 1998, the Department of Agriculture and Food described land systems within the Sandstone-Yalgoo-Paynes Find area, considering general ecological information, vegetation physiognomy and composition, patterns of variation, conservation status, gradational association and land system representation (Payne *et al.* 1998). Five land systems occur within the Study Area (Table 2).

Table 2: Land Systems Located within the Study Area

Land System	Mapped Extent (ha)	Description of Land System
Graves	17,200	Basalt and greenstone rises and low hills, supporting eucalypt woodlands with prominent saltbush and bluebush understoreys.
Moriarty	82,500	Low greenstone rises and stony plains supporting halophytic and acacia shrublands with patchy eucalypt overstoreys.
Singleton	23,800	Rugged greenstone ranges with dense casuarina and acacia shrublands
Tealtoo	69,300	Level to gently undulating loamy plains with fine ironstone lag gravel supporting dense acacia shrublands.
Yowie	918,900	Loamy plains supporting shrublands of mulga and bowgada with patchy wanderrie grasses.

A search of DPaW's TEC and PEC database was undertaken, using a central point in the Study Area (GDA94 Zone 50 488000 E 6760000 S) with a radius of 20 km, to identify the presence of any DPaW-classified TECs and/or DPaW-classified PECs that coincide with the search area (DPaW 2016b). No DPaW-classified TECs coincide with the search area, however 1 DPaW-classified PEC coincides with the search area, being:

- Blue Hills (Mount Karara/Mungada Ridge/Blue Hills) vegetation complexes (banded ironstone formation) (Priority 1).

There are no known locations of this PEC within the Study Area; the nearest location is approximately 6 km north-west of the Study Area (Figure 4). Appendix B presents definitions, categories and criteria for TECs and PECs (DPaW 2013).

A search of the Commonwealth Department of the Environment and Energy (DoEE) database with regard to environmental matters of national significance listed under the EPBC Act was performed for the Study Area (DoEE 2016), using the same parameters as the DPaW TEC and PEC database search above. The results of this search indicate that no TECs listed under the EPBC Act coincide with the Study Area. The results of this search are presented in Appendix A.

2.4 Regional Flora

DPaW's Threatened flora databases, including the Western Australian Herbarium (WAHerb) specimen database, Threatened and Priority Flora database (TPFL), and Threatened and Priority Flora List (TP List), were searched for information regarding listed significant flora taxa known from within or in the immediate vicinity of the Study Area. The TPFL and WA Herb databases are interrogated for information that is directly known from within the search area (i.e. information from specimens housed at the WA Herb, or known records in the TPFL database), whereas the TP List returns information regarding conservation significant taxa from within the region of the search area. The search used the same parameters as the DPaW TEC and PEC database search (see Section 2.3).

A total of 104 taxa were returned from the database search. These taxa are presented in Appendix C. Of these, 43 taxa were from the WAHerb specimen and TPFL databases; a further 61 taxa were returned from the TP List only. While these 61 taxa are presented in Appendix C, they are not considered further in this report, as these taxa do not have known records within the search area. Of the 43 taxa known from the database search area, 3 taxa are listed as Threatened under the WC Act, and 40 are Priority flora taxa. Appendix D presents conservation codes for Western Australia flora (DPaW 2015).

Chamelaucium sp. Yalgoo (Y. Chadwick 1816) (P1) was returned from the search, however it is considered that this taxon is not currently known from within the database search area (Woodman Environmental field observations). *C.* sp. Yalgoo (Y. Chadwick 1816) is a rare taxon known from between Morawa and Yalgoo, some 70 km north-west of the database search area. All of the records of *C.* sp. Yalgoo (Y. Chadwick 1816) in the database search area are referable to either *Chamelaucium pauciflorum* subsp. Perenjori (B.J. Conn 2181) or *Chamelaucium* sp. Warriedar (A.P. Brown & S. Patrick APB 1100) (P1). This taxon has therefore not been included in the summary of significant flora for the Study Area (Section 2.6.1).

The search of the DoEE database (DoEE 2017) with regard to environmental matters of national significance listed under the EPBC Act (Appendix A) identified 4 flora taxa listed as Threatened Species, or habitat for such taxa, may occur in the search area. These were *Dasymalla axillaris*, *Eremophila viscida*, *Eucalyptus synandra*, *Gyrostemon reticulatus* and *Hybanthus cymulosus*. Of these taxa, only *Eucalyptus synandra* is known to occur within the

DPaW database search area, based on records in DPaW's Threatened flora databases. It is therefore considered that the remaining taxa returned from this search are not relevant to this assessment, as they are not known from within 40 km of the Study Area (DPaW 2007-). They are therefore not discussed further in this report. *Eucalyptus synandra* is however considered relevant to this assessment because it was also returned from the search of DPaW's Threatened flora databases.

The search of the DoEE database with regard to environmental matters of national significance listed under the EPBC Act identified that 2 significant invasive flora taxa, or habitat for the taxa, may occur within the Study Area and surrounds, being *Cenchrus ciliaris* (Buffel grass) and *Eichhornia crassipes* (Water Hyacinth) (DoEE 2017). *Cenchrus ciliaris* is not known from the vicinity of the Study Area; the known nearest record is located over 100 km away (DPaW 2007-), and it is therefore considered unlikely to occur within the Study Area. *Eichhornia crassipes* is known from within 20 km of the Study Area (DPaW 2007-); however this taxon is a floating aquatic that occurs in freshwater lakes or watercourses (WAHerb 1998-). As no such habitat is known to occur within or in the vicinity of the Study Area, it is considered very unlikely to occur within the Study Area.

A search of the WAHerb specimen database for records of introduced taxa within the Study Area and surrounds was performed using the online tool NatureMap (DPaW 2007-). A total of 37 introduced taxa were returned. These taxa are presented in Section 2.6.2. Of these taxa, *Eichhornia crassipes* (Water Hyacinth) is a Declared Pest in Western Australia under the *Biosecurity and Agriculture Management Act* 2007 (BAM Act) (Department of Agriculture and Food (DAF) 2017) and a listed Weed of National Significance (WoNS) (Australian Weeds Committee (AWC) 2017). However, as discussed above it is unlikely to occur within the Study Area. *Echium plantagineum* (Paterson's Curse), *Galium aparine* (Goosegrass) and *Rumex hypogaeus* (Doublegee) are also listed as Declared Pests.

2.5 Local Flora and Vegetation Surveys

A number of flora and vegetation surveys have been conducted within and in the vicinity of the Study Area; the most relevant surveys are discussed below.

Meissner and Coppen (2014) undertook a regional flora and vegetation survey for DPaW within the Warriedar Fold Belt, focussing on greenstone hills. A total of 50 quadrats measuring 20 m x 20 m were established on the Bullajungadeah Hills and the Rothsay / Mulgine hills for the survey. Two of these quadrats are located within the Study Area. A total of 6 VTs were described from the Study, 4 of which were recorded within Rothsay and Mulgine hills (including the Study Area). The potential significance of individual VTs was not discussed.

A total of 286 taxa represented by 36 families and 91 genera were recorded from the Warriedar Fold Belt study (Meissner and Coppen 2014). A total of 21 priority flora taxa (as currently listed as by DPaW) were recorded during the survey, as listed in Table 3. Fourteen weed species were recorded during the survey, as listed in Table 4.

Woodman Environmental (2012) undertook a regional flora and vegetation mapping survey of large areas adjacent to the Karara Iron Ore Project over 3 years, from 2008 to 2011, for Karara Mining Limited. This survey area partially overlaps the Study Area, with 3 quadrats located within the Study Area. Data from a total of 990 quadrats from 11 studies was used to assess the flora and vegetation of the survey area. A total of 32 VTs were mapped in the survey area; of these, 8 were mapped in the Study Area (VTs 6, 7, 10, 13, 19a, 29, 31 32). VTs 1, 2, 3, 4, 5, 6, 10 and 12 were considered to be of high conservation significance, as they occurred on banded ironstone formations or high in the landscape on restricted landforms within the region, and were potentially components of the Blue Hills (Mount Karara/Mungada Ridge/Blue Hills) vegetation complexes (banded ironstone formation) PEC (P1).

A total of 640 flora taxa, 2 known hybrids and 14 putative hybrids, from 70 families and 241 genera were recorded by the survey (Woodman Environmental 2012). Two Threatened flora taxa and 27 DPaW listed Priority flora taxa were recorded, as listed in Table 3. A total of 41 weed taxa were also recorded within the survey area, as listed in Table 4.

Woodman Environmental (2014) undertook an assessment of significant flora and vegetation for proposed exploratory drilling for the Rothsay Iron Ore Project in January 2014, for Auricup Resources Limited (now EganStreet). This area is located adjacent to the north-eastern edge of the Study Area. Proposed drill pads and access tracks which required clearing were surveyed for significant flora, and structural plant communities to be impacted were described. A total of 8 structural plant communities were recorded by this survey. The potential significance of the individual plant communities was not discussed.

A total of 4 Priority flora taxa were recorded by the survey, as listed in Table 3 (Woodman Environmental 2014). No introduced taxa were recorded during the survey.

Markey and Dillon (2008) undertook a regional flora and vegetation survey for DPaW covering the central extent of the Tallering Land System, focusing on small ironstone ranges in the northern Yilgarn region, as part of a series of surveys being conducted on ranges of prospectable banded ironstone formations and associated metasedimentary geologies. A total of 103 quadrats measuring 20 m x 20 m were assessed over the region with quadrats established on Mount Karara, Jasper Hill, Windaning Ridge, Warriedar Hill, Pinyalling Hill, Walagnumming Hill, Minjar Hill and the low strikes of ironstone west and north of Minjar Hill. Mount Karara and Windaning Ridge are located approximately 15 km to the north Study Area. Markey and Dillon (2008) identified a total of 8 VTs as occurring on banded ironstone ranges within the Central Tallering Landsystem. The potential significance of the individual VTs was not directly addressed, however VT 2 was noted as being restricted in distribution.

A total of 414 taxa and four hybrids from 69 families were recorded by the survey (Markey and Dillon 2008). There were 10 currently recognised significant flora taxa recorded by the survey, including 1 Threatened flora taxon and 9 Priority Flora taxa, as listed in Table 3. A total of 23 weed taxa (currently identified as introduced by WAHerb (1998-)) were also recorded by the survey, as listed in Table 4.

Woodman Environmental (2008) undertook a Level 2 survey of the Karara – Mungada Project Area, which included Mount Karara and Mungada Ridge. The Karara – Mungada Project Area is located approximately 10 km to the north of the Study Area. A total of 115 permanent quadrats measuring 20 m x 20 m were assessed as part of the survey, with an additional 41 quadrats established as part of the a regional survey of the central Tallering Land System (Markey and Dillon 2008) also included in the survey. There were also 129 detailed recording sites undertaken as part of the survey. A total of 23 VTs were described and mapped by the survey. Of these, 9 VTs were identified as being components of the Blue Hills (Mount Karara/Mungada Ridge/Blue Hills) vegetation complexes (banded ironstone formation) PEC (P1) including VTs 4, 8, 9, 10a, 10b, 11, 12, 13, and 14. Several other VTs were also considered to be of significance.

A total of 514 taxa represented by 202 genera and 72 families were recorded by the survey (Woodman Environmental 2008). A total of 12 currently recognised significant flora taxa were recorded within quadrats established by Woodman Environmental (not including those recorded by Markey and Dillon (2008)) including 1 Threatened flora taxon and 11 Priority flora taxa. *Chamelaucium* sp. Yalgoo (Y. Chadwick 1816) (P1) was listed as being recorded by this survey; however, as discussed in Section 2.4, it is now known that this taxon does not occur in the area surveyed. A total of 26 weed taxa were also recorded by the survey, with the majority of these taxa recorded in quadrats assessed by Markey and Dillon (2008).

2.6 Summary of Significant Flora and Introduced Flora

2.6.1 Significant Flora

A list of significant flora taxa that are known from the vicinity of the Study Area is presented in Table 3. This list has been compiled from the results of searches of DPaW's databases (from the WAHerb specimen database and TPFL database), and from local flora surveys undertaken in the vicinity of the Study Area (Section 2.5). A total of 49 significant taxa are known from the vicinity of the Study Area, including 3 Threatened flora taxa and 46 DPaW-classified Priority Flora taxa. Of these, 4 taxa are known to occur within the Study Area, based on records from the aforementioned sources: *Acacia karina* (P1), *Allocasuarina tessellata* (P1), *Chamelaucium* sp. Warriedar (A.P. Brown & S. Patrick APB 1100) (P1) and *Austrostipa blackii* (P3) (as shaded in Table 3) (Figure 5).

Table 3: Significant Flora Taxa Known from the Vicinity of the Study Area

Taxon	Status	Source			
		DPaW	Markey & Dillon (2008)	Meissner and Coppen (2014)	Woodman Environmental Surveys *
Acacia woodmaniorum	Threatened	x	x		x
Eucalyptus synandra[#]	Threatened	x			
Stylidium scintillans	Threatened	x			x
Acacia diallaga	P1			x	x
Acacia karina	P1	x	x	x	x
Acacia sulcaticaulis	P1	x		x	
Allocasuarina tessellata	P1	x		x	x

Taxon	Status	Source			
		DPaW	Markey & Dillon (2008)	Meissner and Coppen (2014)	Woodman Environmental Surveys *
Chamelaucium sp. Warriedar (A.P. Brown & S. Patrick APB 1100)	P1	x		x	x
Eremophila oldfieldii subsp. Karara (D. Coultas s.n. PERTH 07341717)	P1	x			
Eremophila sp. Rothsay (D. Coultas & J. Kelt s.n. PERTH 08200440)	P1	x			
Gnephosis setifera	P1	x			
Grevillea scabrida	P1	x		x	x
Hydrocotyle sp. Warriedar (P.G. Wilson 12267)	P1	x		x	
Lepidosperma sp. Blue Hills (A. Markey & S. Dillon 3468)	P1	x		x	x
Millotia dimorpha	P1	x	x	x	x
Prostanthera sp. Karara (D. Coultas & K. Greenacre Opp 8)	P1	x			x
Acacia diallaga	P2	x			
Calandrinia kalanniensis	P2	x			
Calandrinia sp. Warriedar (F. Obbens 04/09)	P2	x		x	
Persoonia kararae	P2	x			
Acacia subsessilis	P3			x	x
Angianthus micropodioides	P3	x			
Angianthus prostratus	P3				x
Austrostipa blackii	P3	x	x	x	x
Calotis sp. Perrinvale Station (R.J. Cranfield 7096)	P3	x			
Cyanicula fragrans	P3	x		x	x
Dicrastylis linearifolia	P3	x			x
Drummondita fulva	P3	x	x		x
Eremophila grandiflora	P3			x	x
Euryomyrtus recurva	P3	x			
Grevillea globosa	P3	x			x
Grevillea granulosa	P3	x			
Grevillea leptopoda	P3	x			
Grevillea subtiliflora	P3	x		x	x
Gunniopsis divisa	P3	x	x		x
Korthalsella leucothrix	P3	x			
Melaleuca barlowii	P3				x
Menkea draboides	P3	x			
Micromyrtus acuta	P3	x		x	x
Micromyrtus trudgenii	P3	x	x	x	x
Persoonia pentasticha	P3	x	x	x	x
Petrophile pauciflora	P3	x			x
Polianthion collinum	P3	x	x		x
Psammomoya implexa	P3	x	x		x
Rhodanthe collina	P3	x	x	x	x
Stenanthemum poicilum	P3	x		x	x
Xanthoparmelia dayiana	P3	x			
Dodonaea amplisemina	P4			x	
Wurmbea murchisoniana	P4	x			

Note: * - includes data from Woodman Environmental 2008, 2012 and 2014.

Note: # - denotes taxa returned from the search of the DoEE database with regard to environmental matters of national significance listed under the EPBC Act.
Note: shading denotes taxa with records in the Study Area.

2.6.2 Introduced Flora

A list of introduced flora taxa known from the vicinity of the Study Area is presented in Table 4. This has been compiled from WAHerb specimen data, and from local flora surveys (Section 2.5). A total of 53 introduced taxa are known to occur in the vicinity of the Study Area. Of these taxa, *Eichhornia crassipes* (Water Hyacinth) is a Declared Pest in Western Australia under the BAM Act (Department of Agriculture and Food (DAF) 2017) and a listed Weed of National Significance (WoNS) (Australian Weeds Committee (AWC) 2017). *Rumex hypogaeus* (Doublegee) and *Galium aparine* are also listed as Declared Pests in Western Australia.

Table 4: Introduced Flora Taxa Known from the Vicinity of the Study Area

Taxon	Common Name	Source				Comments
		DPaW	Markey & Dillon (2008)	Meissner and Coppen (2014)	Woodman Environmental Surveys*	
Agave americana	Century Plant	x				
Aira caryophyllea	Silvery Hairgrass				x	
Arctotheca calendula	Cape Weed	x	x		x	
Avena barbata	Bearded Oat				x	
Brassica tournefortii	Mediterranean Turnip	x	x	x	x	
Bromus diandrus	Great Brome				x	
Bromus rubens	Red Brome	x			x	
Centaurea melitensis	Maltese Cockspur	x			x	
Chenopodium glaucum	Glaucous Goosefoot	x				
Chenopodium murale	Nettle-leaf Goosefoot	x				
Cleretum papulosum	-	x	x	x	x	
Cuscuta epithymum	Lesser Dodder	x	x		x	
Cuscuta planiflora	-	x		x		
Cyperus tenellus	Tiny Flatsedge	x				
Echium plantagineum	Paterson's Curse	x			x	Declared Pest
Ehrharta longiflora	Annual Veldt Grass	x	x		x	
Eichhornia crassipes	Water Hyacinth	x				Declared Pest WoNS
Erodium aureum	-		x		x	
Erodium cicutarium	Common Storksbill	x	x		x	
Galium aparine	Goosegrass	x	x		x	Declared Pest
Hypochaeris glabra	Smooth Catsear	x	x	x	x	

Taxon	Common Name	Source				Comments
		DPaW	Markey & Dillon (2008)	Meissner and Coppen (2014)	Woodman Environmental Surveys*	
Lamarckia aurea	Goldentop	x	x		x	
Leontodon rhagadioloides	-	x				
Lysimachia arvensis	Pimpernel	x	x	x	x	
?*Malva parviflora*	Marshmallow				x	
Medicago minima	Small Burr Medic	x	x	x	x	
Medicago polymorpha	Burr Medic				x	
Mesembryanthemum crystallinum	Iceplant				x	
Mesembryanthemum nodiflorum	Slender Iceplant	x	x	x	x	
Monoculus monstrosus	-				x	
Oxalis corniculata	Yellow Wood Sorrel				x	
Parentucellia latifolia	Common Bartsia			x	x	
Paspalum dilatatum	-	x				
Pentameris airoides	False Hairgrass	x	x	x	x	
Petrorhagia dubia	-				x	
Rostraria pumila	-	x	x	x	x	
Rumex hypogaeus	Doublegee		x		x	Declared Pest
Rumex vesicarius	Ruby Dock			x	x	
Schismus barbatus	Kelch Grass	x		x		
Silene gallica	French Catchfly	x				
Silene nocturna	Mediterranean Catchfly	x	x	x	x	
Sisymbrium erysimoides	Smooth Mustard		x		x	
Sisymbrium runcinatum	-	x			x	
Solanum nigrum	Black Berry Nightshade	x				
Sonchus oleraceus	Common Sowthistle	x		x	x	
Spergula pentandra	Five Anther Spurry	x	x		x	
Stellaria media	Chickweed					
Tribulus terrestris	Caltrop	x				
Urospermum picroides	False Hawkbit	x	x		x	
Ursinia anthemoides	Ursinia	x	x		x	
Vulpia muralis	-	x	x		x	
Vulpia myuros forma myuros	-	x	x		x	
Zaluzianskya divaricata	Spreading Night Phlox				x	

3. METHODS

3.1 Personnel and Licensing

Table 5 lists the personnel involved in both fieldwork and plant identifications for the survey of the Study Area. The Project Manager (involved in fieldwork and plant identifications) has had extensive previous experience in conducting flora surveys in the vicinity of the Study Area (including previous surveys within the Study Area), and in nearby areas such as Blue Hills Range, Mungada Ridge and Mount Mulgine (located immediately to the north and north-east of the Study Area). All plant material was collected under the scientific licences pursuant to the WC Act Section 23C and Section 23F as listed in Table 5.

Table 5: Personnel and Licensing Information

Personnel	Role	Flora Collecting Permit (WC Act)
David Coultas	Project Manager / Field Manager / Plant Identifications	SL011774 (Section 23C) 121-1516 (Section 23F)
Laura True	Fieldwork	-

3.2 Aerial Photography Interpretation

Initial interpretation of ortho-rectified aerial photography at a scale of 1:10,000 was conducted to determine preliminary vegetation patterns present within the Study Area, with quadrats allocated based on these patterns. A minimum of three quadrats were allocated to each discernible vegetation pattern where possible; such replication is required for meaningful results to be produced following floristic analysis of quadrat data, and to provide local context for VT distribution.

3.3 Field Survey Methods

The field survey was conducted from the 3rd – 11th of October, 2016. It is considered that this visit was conducted in the most appropriate time to survey in the Yalgoo Bioregion, as the majority of taxa in this region flower in early Spring.

Access to the Study Area was achieved on foot and by vehicle using existing vehicle and exploration tracks. However, parts of the Study Area were not accessible by vehicle, necessitating access by foot only.

A total of 35 non-permanent flora survey quadrats measuring 20 m x 20 m were established during survey. This quadrat size is the standard size used in flora and vegetation surveys in the Yalgoo Bioregion, as outlined in EPA and DPaW (2015). At least 3 quadrats were surveyed within each vegetation pattern initially identified from aerial photography interpretation.

All vascular flora taxa that were visually identifiable within each quadrat were recorded. At least one reference specimen of most taxa (excluding common, distinctive taxa) encountered was collected for verification and identification purposes.

The following information was recorded at each quadrat:

- Personnel;
- Unique quadrat number;
- Date of survey;
- GPS (Global Positioning System) coordinates (GDA (Geocentric Datum of Australia) 94);
- Site photograph;
- Topography (including landform type and aspect);
- Soil colour and type (including the presence of any rock outcropping and surface stones);
- Vegetation condition (EPA and DPaW 2015; adapted from Keighery 1994: scale presented in Appendix E);
- Approximate time since fire;
- Presence of disturbance (if any);
- Percentage foliage cover (for each taxon); and
- Height (m) (for each taxon, excluding climbers/aerial shrubs).

Mapping notes of vegetation pattern boundaries and distribution were also taken while traversing on foot and by vehicle. This was to aid in mapping polygons of vegetation patterns that were not allocated quadrats. Not all vegetation pattern polygons received quadrats because of time constraints, however many polygons could be confidently allocated to a final VT using a combination of mapping notes and aerial photograph interpretation. Additional flora taxa were also recorded opportunistically in the Study Area via a search in the general vicinity of each quadrat, and during traverses on foot between quadrats.

Specific, targeted searching for significant flora taxa was undertaken within selected areas of appropriate habitat. Grid searching was undertaken in these areas at a spacing of 50 m. If populations of known significant flora taxa were identified, a representative collection of material was made, and the abundance and spatial distribution (using GPS coordinates) of individuals within each population was recorded where possible.

All areas traversed in the Study Area are presented as track logs on Figure 6, along with quadrat locations.

3.4 Plant Collection and Identification

Specimens of any unknown taxa that were collected were pressed for later identification at the WA Herbarium. Identifications were undertaken by experienced botanist David Coultas. External experts of particular families or genera were consulted for any specimens considered to be difficult to identify or of taxonomic interest.

Taxon nomenclature generally follows *FloraBase* (WAHerb 1998-) with all names checked against the current DPaW Max database to ensure their validity. However, in cases where names of plant taxa have been published recently in scientific literature but have not been adopted on *FloraBase* (WAHerb 1998-), nomenclature in the published literature is followed. The conservation status of each taxon was checked against *FloraBase*, which provides the most up-to-date information regarding the conservation status of flora taxa in Western Australia.

Specimens of interest, including significant flora taxa, range extensions of taxa and potential new taxa, will be sent to the WA Herbarium for consideration for vouchering as soon as practicable. However, this process is via donation, and the WA Herbarium may not voucher all specimens, in accordance with its own requirements. The specimen vouchering will be supported by completed Threatened and Priority Flora Report Forms submitted to DPaW (Species and Communities Branch) in the case of listed significant flora (e.g. Threatened and Priority flora taxa).

3.5 Floristic Analysis

Classification analysis of floristic data from the Study Area was conducted using the 35 quadrats established by this survey of the Study Area, together with 5 additional quadrats located within the Study Area that were established during previous surveys (Meissner and Coppen 2014; Woodman Environmental 2012; see Section 2.5). The analysis used 104 taxa; taxa belonging to several categories were removed prior to analysis, as listed below:

- Ephemeral or annual taxa – the presence of ephemeral or annual taxa is strongly influenced by seasonal conditions, with fewer taxa and individuals usually present following below-average rainfall; additionally, this removes temporal variation in the presence of annual taxa between surveys conducted in differing seasons and years;
- Perennial taxa that produce annual flowering/fruiting parts that are essential for identification – such taxa include geophytic taxa (e.g. *Drosera macrantha*, *Cyanicula amplexans*) and grasses (e.g. *Austrostipa eremophila*) that can only be identified from flowering or fruiting material, however only produce such material at particular times of the year. Removal of such taxa from the analysis removes temporal variation in the presence of such taxa between surveys conducted in differing seasons and years;
- Introduced taxa – introduced taxa were removed as their distributions are generally defined by the presence of disturbance (e.g. clearing, animal movement) rather than particular habitat types;
- Singletons (taxa recorded only once in the quadrat dataset) – singletons were removed, as a preliminary analysis including singletons indicated that they provided little information in the dataset;
- Taxa where identification was unclear – such taxa were removed from the analysis where identification was unclear due to poor available material in the field.

All taxa removed from the classification analysis (excluding introduced taxa and known hybrids) are presented in Appendix F.

Initially, an OptimClass analysis was undertaken to determine the most suitable approach to classification based on the available data. OptimClass (Tichý *et al*. 2010) evaluates the quality of a set of different partitions of the same dataset, based on the number of taxa that are faithful to clusters of that partition. Faithful taxa are identified using the Fisher's exact test for the right-tailed hypothesis, which is a suitable measure of statistical fidelity of taxa to clusters of quadrats (Sokal and Rohlf 1995; Chytrý *et al*. 2002).

For the OptimClass analysis a selection of the most widely-used techniques in community ecology were tested, including Unweighted Pair-Group Method using Arithmetic Averages (UPGMA), Beta Flexible Clustering and Ward's Method in combination with a Bray-Curtis Index, Similarity Ratio, Chord Distance and none or logarithmic and/or power transformations of species percentage foliage cover. The cluster analyses used to calculate OptimClass values were performed using the software packages JUICE 7.0.123 (Tichý 2002) and PC-ORD 5.32 (McCune and Mefford 2006).

After OptimClass analysis, other association measures not available within PC-ORD were tested using the software PATN V3.12 (Belbin and Collins 2009).

The results of both analyses influenced the selection of a classification analysis using a 1-layer data matrix (presence/absence data only), with Beta Flexible Clustering (β = -0.1) as the clustering tool, and Two-Step (Belbin1980) as the association measure. This resulted in an ordination stress value of 0.0763; Belbin and Collins (2009) suggest that a stress value of less than 0.1 indicates that the analysis parameters are a good fit for the dataset.

The above classification analysis was conducted using PATN, with the results of the classification produced as a dendrogram. A taxon and quadrat matrix was produced, with the matrix sorted into taxon groups generated from the classification. Indicator taxon analysis (INDVAL) was conducted using PC-Ord (McCune and Mefford 2011) using the method of Dufrene and Legendre (1997). The INDVAL measures were used to determine the indicator taxa for each VT and a Monte Carlo permutation test was used to test for the significance of the indicator taxa.

A second floristic analysis was conducted, to assess the similarity of quadrats located in the Study Area to quadrats established in the wider region. For this analysis, all quadrats in the Study Area were included, along with quadrats from a number studies conducted in the wider region ("regional dataset"), including:

- Markey and Dillon (2008);
- Woodman Environmental (2008);
- Woodman Environmental (2012); and
- Meissner and Coppen (2014).

This analysis replicated the parameters of the analysis of Study Area floristic data described above. This resulted in an ordination stress value of 0.1297; although higher than the value returned for the analysis of Study Area floristic data only, this value indicates that the analysis parameters were a reasonable fit for the dataset (Belbin and Collins 2009).

3.6 Vegetation Type Mapping and Description

The classification analysis of Study Area floristic data suggested that a 7-cluster classification of quadrats may be appropriate for the data analysed; the resulting dendrogram and taxon group matrix were therefore initially examined at the 7-cluster level, to determine the plausibility of clusters with regard to taxon groups, and also field observations and indicator taxon analysis. This process determined a final number of clusters, which were considered to represent VTs.

Manual reassigning of some quadrats within the dendrogram to more appropriate VTs was undertaken after classification analysis, following detailed investigation of individual quadrat datasets, and examination of field notes. All quadrats manually reassigned were found to be located within the interface of 2 VTs, and therefore possessed taxa common to both. Those manually reassigned are denoted in Appendix G.

VT descriptions have been adapted from the National Vegetation Information System (NVIS) Australian Vegetation Attribute Manual Version 6.0 (ESCAVI 2003), as stipulated by EPA and DPaW (2015). This model follows nationally-agreed guidelines to describe and represent VTs, so that comparable and consistent data is produced nation-wide. It should be noted that the NVIS system utilises vegetation descriptions derived from structural characteristics of the individual community units, while the VTs presented in this report have been derived from analysis of quadrat floristics, excluding any structural data. VTs therefore may include multiple structural types. Considering the effect of disturbance factors such as fire on vegetation structure, this approach is designed to provide a map of VTs that reflect taxon composition and the influences of the physical and chemical environment rather than disturbance history.

It should also be noted that this report describes VTs at the NVIS Sub-Association level, rather than the Association level as stipulated by EPA and DPaW (2015). This level is considered more appropriate for the vegetation of the Study Area, as generally the vegetation possessed 1 or more additional strata to the traditional 3-stratum classification system used at the Association level.

The locations of quadrats within each VT were used in conjunction with aerial photography interpretation and field notes taken during survey to develop VT mapping polygon boundaries. These VT mapping polygon boundaries were then digitised using Geographic Information System (GIS) software.

3.7 Vegetation Condition Mapping

Vegetation condition was recorded at all quadrats, and also opportunistically within the Study Area where areas of disturbance to vegetation were noted (e.g. weed infestations, areas of historical clearing, mineral exploration). Vegetation condition was described using the vegetation condition scale presented in EPA and DPaW (2015) (as adapted from Keighery (1994)), and is presented in Appendix E. Vegetation condition polygon boundaries for the Study Area were developed using this information in conjunction with aerial photography interpretation, and were digitised as for VT polygon boundaries.

3.8 Significant Flora and Vegetation

3.8.1 Significant Flora

EPA (2016) defines flora taxa to be considered significant for a range of reasons, including, but not limited to the following:

- Being identified as a Threatened or Priority species (listed significant taxa);
- Locally endemic or associated with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems);
- New species or anomalous features that indicate a potential new species;
- Representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- Unusual species, including restricted subspecies, varieties or naturally occurring hybrids;
- Relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

Significant taxa are discussed in Sections 5.1.2 – 5.1.4, with reference to the above categories.

No classification of the potential local significance of recorded significant flora taxa has been undertaken as part of this assessment. It is considered that such a classification is best undertaken as part of any overall impact assessment that may need to be undertaken for the Project, as significant flora information may change prior to such an impact assessment being conducted.

3.8.2 Significant Vegetation

As per EPA (2016), vegetation may be considered significant for a range of reasons, including, but not limited to the following:

- Being identified as a Threatened or Priority Ecological Community (listed significant vegetation);
- Having restricted distribution;
- Degree of historical impact from threatened processes;
- A role as a refuge;
- Providing an important function required to maintain ecological integrity of a significant ecosystem.

These criteria are generally applicable to VTs mapped in the Study Area, and are therefore used to determine whether a VT is locally significant (with 'local' referring to the Study Area). It is more difficult to apply these criteria in a regional context, as there is no publicly-available Yalgoo Bioregion-wide dataset of VTs. To attempt to provide regional context for the VTs mapped in the Study Area, a second floristic analysis was undertaken, using quadrats located in the Study Area together with quadrats located in the wider region (see Section 3.5). The results of this analysis were used to infer potential regional distribution and potential regional significance of the VTs mapped in the Study Area. The results of this

analysis were also used to determine the relationships of VTs mapped in the Study Area to the Blue Hills (Mount Karara/Mungada Ridge/Blue Hills) vegetation complexes (banded ironstone formation) PEC, as this PEC was defined by Woodman Environmental (2008) using a similar floristic analysis.

Significant vegetation is discussed in Section 5.2.4.

4. ADEQUACY AND LIMITATIONS OF SURVEY

4.1 Adequacy of Survey

The Study Area covers 1,090 ha, with 35 quadrats established within it by this survey, and a further 5 quadrats established within it by previous surveys. Quadrats were established in all preliminary vegetation patterns discernable by initial aerial photograph interpretation (see Section 3.2 and 3.3), both to adequately sample variation in vegetation throughout the Study Area, and to ensure adequacy of sampling for vascular plant taxa. The number of quadrats established in the Study Area is considered to be an acceptable number given the diversity of topography and soil types noted in the Study Area.

To provide an indication of the adequacy of this survey, a taxon accumulation curve was produced using PC-Ord (V 6) (McCune and Mefford 2011). Taxon accumulation curves represent a theoretical model of the relationship between sampling intensity and taxon accumulation; when sampling intensity is increased, taxon accumulation is reduced, and a taxon accumulation curve becomes asymptotic.

The taxon accumulation curve for quadrat data from the Study Area was generated using all native taxa (both annual and perennial) recorded within each quadrat, including quadrats established by previous surveys. Taxon accumulation calculations for the Study Area were then undertaken via PC-Ord, utilising the Chao-2 estimator for species richness (Chao 1987), and compared to the actual number of taxa recorded in the Study Area. This gives some indication as to whether sufficient quadrats have been surveyed to adequately sample the species richness in the Study Area. As the generation of species accumulation curves includes quadrat data only, and not opportunistically-recorded taxa, the indication of adequacy of survey provided is considered to be conservative.

Figure 7 presents the species accumulation curve generated from quadrat data from the Study Area. Using the Chao-2 estimator, the recorded number of taxa within quadrats is equivalent to 85.7 % of the estimated taxon richness in the Study Area. It is therefore considered that the Study Area was relatively-well sampled with regard to this estimation measure.

It is of interest that the estimated number of native taxa in the Study Area using Chao-2 was 272; when opportunistic records of taxa are included, 300 taxa (excluding hybrids) were recorded in the Study Area (see Section 5.1.1), indicating that the Study Area was relatively well-sampled.

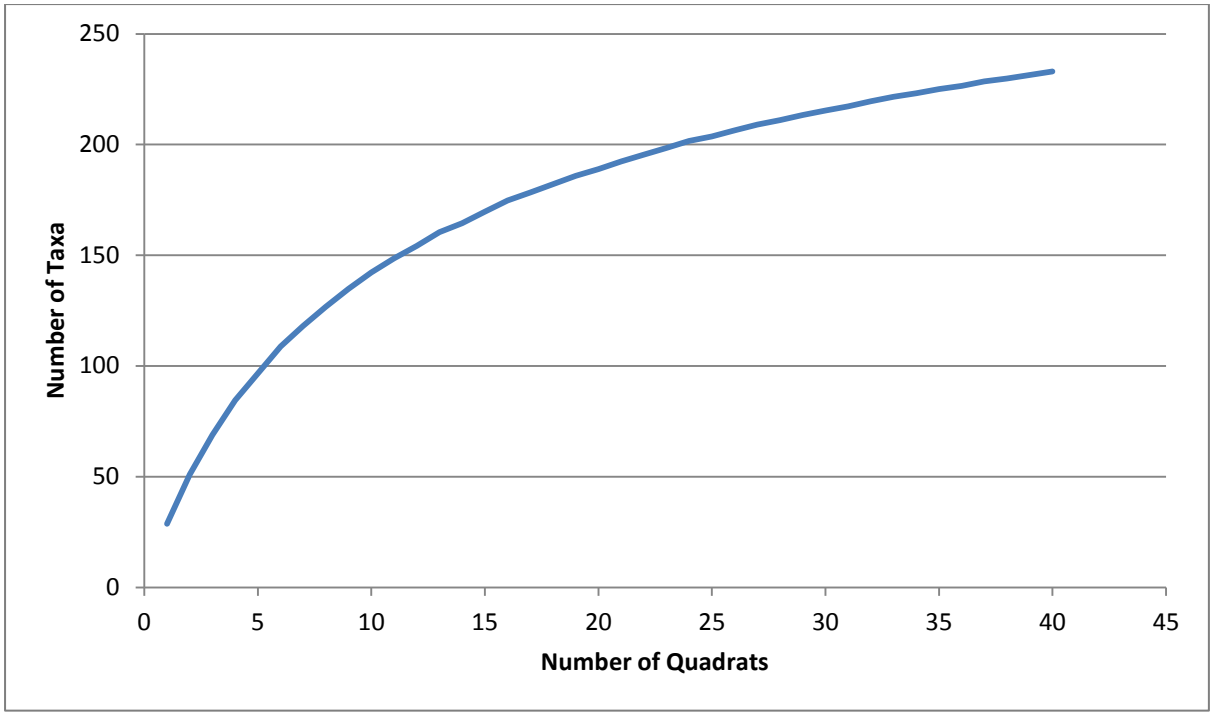

Figure 7: Study Area Quadrat Data Species Accumulation Curve

Another adequacy of survey measure is that developed by Mueller-Dombois and Ellenberg (1974), who suggest that an adequacy cut-off point might be when a 10 % increase in quadrats surveyed results in a 5 % (or less) increase in taxa recorded. This measure was also calculated using all native taxa recorded within each quadrat. The number of quadrats established in the Study Area satisfies this adequacy measure suggested by Mueller-Dombois and Ellenberg (1974), with the final taxon increase value of 2.56 % recorded following the final 10 % increase in quadrats.

4.2 Limitations of Survey

Table 6 presents the limitations of the flora and vegetation survey of the Study Area in accordance with EPA (2015).

Table 6: Limitations of the Flora and Vegetation Survey of the Study Area

Limitation	Limitation of Survey	Comment
Level of survey	No	Level 2 Detailed Survey: The detailed field survey conducted in October 2016, within the usual peak flowering season in the Yalgoo Bioregion. Replicated quadrats were established in each vegetation pattern identified in the Study Area. EPA and DPaW (2015) indicates that survey should also be undertaken in other seasons, and it is noted that some perennial taxa expected to occur in the Study Area flower in other seasons (e.g. Winter). However, it is considered that survey in the peak flowering season only is adequate in this case, as it considered likely that most taxa that flower outside the peak flowering season could be identified during the survey period.
Competency /experience of the consultant(s) carrying out the survey	No	Senior personnel undertaking the survey have had extensive experience in conducting similar assessments, including assessments within the Study Area, and in nearby areas including Blue Hills Range, Mungada Ridge and Mount Mulgine.
Scope (floral groups that were sampled; some sampling methods not able to be employed because of constraints?)	No	All vascular groups that were present during the detailed survey were sampled. No constraints prevented appropriate sampling techniques (quadrat establishment, targeted searching and opportunistic recording) being employed.
Proportion of flora identified, recorded and/or collected	Partial	A high proportion of perennial vascular taxa were recorded based on the intensity and method of survey. A high proportion of ephemeral vascular taxa were recorded based on the intensity and method of survey, and above-average rainfall prior to the survey. Unknown vascular taxa were collected, with specimens identified at the WA Herbarium. Adequacy of survey measures indicate a high percentage of taxa expected to occur in the Study Area was recorded (Chao-2 estimator), and the number of quadrats established in the Study Area satisfies the criterion suggested by Mueller-Dombois and Ellenberg (1974), with an increase of 2.56 % in species recorded per increase of 10 % of quadrats. The survey identified potential habitat for the Threatened taxon *Stylidium scintillans*; this taxon was not recorded, however the survey may have been conducted subsequent to the flowering period of taxon. All potential habitat for this taxon has been clearly identified. Some other geophytic taxa, including orchid taxa (e.g. *Caladenia* sp., *?Cyanicula fragrans* (P3)), could also not be positively identified, as the survey was conducted subsequent to their flowering periods.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data	No	Sources of information used included government databases (DPaW, DoEE) and numerous reports and unpublished data from the vicinity of the Study Area (Markey and Dillon 2008, Meissner and Coppen 2014, Woodman Environmental 2008, 2012, 2014). Good contextual information for the Study Area was available prior to the survey.
The proportion of the task achieved and further work which might be needed	Potential partial	The Level 2 survey was completed, with the survey including some targeted searching for significant flora taxa, and identification of potential habitat for the Threatened taxon *Stylidium scintillans*. No further survey within the Study Area is considered necessary at this time however searching for particular significant flora taxa may be required depending on the location of future impact areas.

Limitation	Limitation of Survey	Comment
Timing/weather/season/cycle	Partial	The field survey was conducted in Spring, corresponding with the optimum flowering period for the Yalgoo Bioregion. The flowering period was considered by Woodman Environmental to be good, with above-average rainfall prior to the survey.
Disturbances (e.g. fire, flood, accidental human intervention etc.), which affected results of survey	No	Although historical disturbances associated with exploration were apparent, these did not appear to have significantly impacted the flora taxa present and are therefore not considered to have affected the results of the survey.
Intensity of survey	No	The survey intensity was considered adequate, with replication of quadrats in VTs and a relatively large amount of foot searching undertaken throughout the Study Area.
Completeness and mapping reliability	No	The survey of the Study Area is considered complete in terms of mapping of VTs. Specific searching for significant flora taxa was undertaken for some species, with further searching in final impact areas potentially required. Mapping reliability was considered good as high resolution aerial photography was used, with 35 quadrats established in the Study Area and 5 additional quadrats in the Study Area utilised, however in some instances mapping boundaries were difficult to determine from aerial photography. Foot and vehicle transects were employed to aid in mapping which increased the reliability.
Resources and experience of personnel	No	Adequate resources including experienced field personnel and taxonomists with appropriate expertise in Yalgoo Bioregion flora were utilised.
Remoteness and/or access problems	No	Access to the Study Area was considered adequate, given the relatively small size of the Study Area and the number of usable vehicle tracks within it.

5. RESULTS

5.1 Flora of the Study Area

5.1.1 Vascular Flora Census

A total of 300 discrete vascular flora taxa and 1 putative hybrid were recorded in the Study Area by this survey. These taxa represent 59 families and 163 genera. The most well-represented families were Asteraceae (53 taxa), Fabaceae (31 taxa) Chenopodiaceae (22 taxa), Poaceae (17 taxa) and Myrtaceae (16 taxa).

Considering the 5 additional quadrats located within the Study Area (Woodman Environmental 2012; Meissner and Coppen 2014), as well as known records of significant flora taxa (see Section 2.6), a further 13 taxa are known to occur within the Study Area. A total of 313 discrete vascular flora taxa and 1 putative hybrid are therefore known to occur in the Study Area. These taxa represent 59 families and 165 genera, with Asteraceae (55 taxa), Fabaceae (32 taxa), Chenopodiaceae (23 taxa), Poaceae (18 taxa) and Myrtaceae (16 taxa) the most well-represented families.

It should be noted that one taxon with a record located in the Study Area, *Chamelaucium* sp. Warriedar (A.P. Brown & S. Patrick APB 1100) (P1), is not considered to occur within the Study Area. This is discussed in Section 5.1.2.

Average taxon richness per quadrat was 31.6 (± 7.5), with the greatest number of taxa recorded in a single quadrat being 48, and the lowest number being 18. A full list of taxa is presented in Appendix H, with raw quadrat data and parameters presented in Appendix I.

5.1.2 Summary of Significant Flora Taxa

Table 7 presents a list of significant flora taxa recorded in the Study Area, together with location information. A total of 17 significant flora taxa were recorded during this survey of the Study Area; all are listed significant flora taxa, including 6 taxa Priority 1, 1 Priority 2 and 10 Priority 3 taxa.

There is one record of *Chamelaucium* sp. Warriedar (A.P. Brown & S. Patrick APB 1100) (P1) located within the Study Area, from DPaW's WAHerb specimen database (Figure 5). However, this was recorded in 1977 and the GPS location was allocated manually based on a relatively broad locality description (55 km north-east of Perenjori on the road to Rothsay). This location was investigated during the 2016 survey, with field personnel familiar with identifying this taxon. No *Chamelaucium* sp. Warriedar (A.P. Brown & S. Patrick APB 1100) individuals were found in the vicinity of this location. This taxon is endemic to basalt hills in the general vicinity of the Study Area, however despite relatively extensive searching in such habitat in the Study Area, no individuals of this taxon were located. It is therefore considered that the coordinates of the WAHerb specimen database record are erroneous. This taxon is not considered to occur within the Study Area.

No Threatened flora taxa were recorded within the Study Area. However, habitat for *Stylidium scintillans* (T) was recorded within the Study Area. Although no individuals were recorded, it is considered possible that the time of survey was later than the flowering

period of this taxon, and that it may occur in the Study Area; this taxon has only been collected in late August and early September (WAHerb 1998-). However, this taxon only occurs in very specific habitat, namely on duricrust or weathered granite breakaways; Woodman Environmental have conducted extensive surveys for this taxon within the general vicinity of the Study Area. It was therefore possible to identify areas of potential habitat for this taxon, using a combination of field observations and aerial photograph interpretation; such areas are generally obvious, appearing as areas of lighter-coloured soil. The areas of potential habitat for *Stylidium scintillans* are outlined on Figure 8.1, and are discussed further in Section 5.1.3.

No other taxa recorded in the Study Area are considered to be significant flora taxa; this is discussed further in Section 5.1.4. It is also considered unlikely that any further significant flora taxa occur in the Study Area, based on the methods and intensity of survey of the Study Area (see Section 4.2). This includes all other listed significant flora taxa identified as occurring in the vicinity of the Study Area by the desktop review (see Section 2.6.1).

It should be noted that a full census of individuals was not conducted for any of the significant flora taxa listed in Table 7; numbers of locations and individuals are therefore considered to be minimum estimates only. In particular, there were a number of significant flora taxa which were dominant taxa on the low basalt hills within Study Area (e.g. *Allocasuarina tessellata* (P1), *Acacia karina* (P1)); the actual number of individuals of such taxa within the Study Area is likely to be much higher than the numbers presented in Table 7.

It should also be noted that because of the scale that VTs have been mapped at (1:10,000), significant flora locations are occasionally included within VTs that are generally not considered to be preferred habitat for such taxa. This is especially pertinent for VT boundaries that are not clear-cut, e.g. VTs 4 and VTs 6, 7 and 8 in the Study Area. Therefore, VTs considered to be preferred habitat are designated in Table 7. All other VTs are not considered to be preferred habitat.

Locations of significant flora taxa are presented in Appendix J and Figures 8.2-8.18.

Table 7: Summary of Significant Flora Taxa Known from within the Study Area

Taxon	Status	Number of Locations Recorded in Study Area in 2016	Number of Individuals Recorded in Study Area in 2016	Total Number of Locations Known in the Study Area *	Total Number of Individuals Known in the Study Area *	Vegetation Types
Acacia karina	P1	303	6,057	364	8,835	3, 4^, 6, 8, C (road verge)
Allocasuarina tessellata	P1	354	26,695	356	-	1, 4^, 5, 6, 7, 8
Grevillea scabrida	P1	177	4,320	177	4,320	1, 4^, 5, 6, 7, 8
Hemigenia tichbonii	P1	3	Not counted	3	Not counted	4^
Lepidosperma sp. Blue Hills (A. Markey & S. Dillon 3468)	P1	43	1,610	43	1,610	2^, 5, C (road verge)
Millotia dimorpha	P1	100	18,595	100	18,595	4^, 6, 7
Calandrinia sp. Warriedar (F. Obbens 04/09)	P2	2	10	2	10	3^
Austrostipa blackii	P3	20	1,035	21	1,035	4^, 5
Bossiaea sp. Jackson Range (G. Cockerton & S. McNee LCS 13614)	P3	1	15	1	15	8^
?Cyanicula fragrans	P3	1	1	1	1	4^
Grevillea globosa	P3	2	10	2	10	1^
Grevillea subtiliflora	P3	54	284	54	284	4^, 8
Gunniopsis divisa	P3	4	140	4	140	3, 6^
Micromyrtus trudgenii	P3	12	280	12	280	1, 2^, 3^, 4, 8
Persoonia pentasticha	P3	49	96	49	96	1, 2^, 3, 4^, 5^, 6, 7, 8^
Rhodanthe collina	P3	97	25,865	97	25,865	4^, 5, 6, 8
Stenanthemum poicilum	P3	4	52	4	52	5, 8^

*Includes data from DPaW (2016d), Meissner and Coppen (2014) and Woodman Environmental (2012)

^Designates preferred habitat.

5.1.3 Listed Significant Flora Taxa

As mentioned above, the Threatened taxon *Stylidium scintillans* (Plate 1) was not recorded in the Study Area by this survey, however potential habitat for this taxon was identified, and it is considered possible that the time of survey was later than the flowering period of this taxon, meaning individuals were not observable. A total of 11 small areas of potential habitat were identified, as outlined on Figure 8.1. These correspond to all areas mapped as VT 2 and VT 9 (see Section 5.2), as well as 2 small portions of polygons mapped as VT 3, where laterite outcropping occurs at surface. These areas require investigation during the flowering period of *Stylidium scintillans* to determine whether it is present.

Plate 1: ***Stylidium scintillans*** **(Threatened) (Photo: Woodman Environmental)**

Acacia karina (P1) is a straggling, woody shrub growing to 1.5 m high (Plate 2), that generally occurs on rocky slopes of banded ironstone and basalt hills (WAHerb 1998-; Woodman Environmental field observations). This taxon has a known range of approximately 80 km in Western Australia (where it is endemic), from north-east of Perenjori (ex- Karara Station) in the north-west, to Mount Gibson Station in the south-east (DPaW 2007-) (Figure 8.2). Woodman Environmental (2010) conducted a regional survey for this taxon in 2009, to attempt to quantify its distribution and abundance across its known range. As of December 2009, 233,387 individuals were known from 39 sub-populations. The majority of sub-populations are located in the proposed conservation reserves of ex-Karara and ex-Warriedar Stations (Woodman Environmental 2010).

Acacia karina (P1) was recorded at 303 point locations by this survey of the Study Area, with 6,057 individuals recorded across these point locations (Appendix J). An additional 61 point locations are known from the Study Area (DPaW 2016d; Meissner and Coppen 2014; Woodman Environmental 2012), with 2,778 individuals recorded across these point locations. This taxon was abundant within the Study Area on low basalt hills within VT 4 (Figure 8.2). As a result, a full census was not undertaken for this taxon, and it is likely that the actual number of individuals within the Study Area is much higher than the numbers presented. It is also known from numerous records in the vicinity of the Study Area (Figure 8.2).

Plate 2: *Acacia karina* (P1) (Photos: Woodman Environmental)

Allocasuarina tessellata (P1) is a dioecious shrub or tree growing to 3-5 m high (Plate 3). It occurs almost exclusively on greenstone (dolerite or basalt) hills (WAHerb 1998-; Woodman Environmental field observations). This taxon has a range of approximately 80 km in Western Australia (where it is endemic), from north-east of Perenjori (ex-Karara Station) in the north-west, to Mount Gibson Station in the south-east (Figure 8.3). *Allocasuarina tessellata* is known from 82 records in DPaW's Threatened flora databases, representing approximately 18 broad localities, 4 of which occur in the proposed conservation reserves of ex-Karara and ex-Warriedar Stations (DPaW 2007-).

Allocasuarina tessellata (P1) was recorded at 354 locations point locations by this survey of the Study Area, with 26,695 individuals recorded across these point locations (Appendix J). An additional 2 point locations are known from the Study Area, however no counts of individuals are available (DPaW 2016d, Meissner and Coppen 2014, Woodman Environmental 2012). As with *Acacia karina*, *Allocasuarina tessellata* was abundant within the Study Area on low basalt hills within VT 4 (Figure 8.3). As such, a full census was not undertaken for this taxon, and it is likely that the actual number of individuals within the Study Area is much greater than that presented. It is also known from numerous records in the vicinity of the Study Area (Figure 8.2).

Plate 3: ***Allocasuarina tessellata*** **(P1) (Photos: Woodman Environmental)**

Grevillea scabrida (P1) is a densely-branched low shrub to 1.5 m high (Plate 4), generally occurring on greenstone (dolerite, basalt) hills and drainage lines associated with such hills (WAHerb 1998-; Woodman Environmental field observations). This taxon has a range of approximately 87 km in Western Australia (where it is endemic), from north-east of Perenjori within DPaW-managed ex-Karara / ex-Warriedar Stations in the north-west, to Mount Gibson Station in the south-east (Figure 8.4). This taxon is known from 89 records in DPaW's Threatened flora databases, representing approximately 25 broad localities, 8 of which occur in the proposed conservation reserves of ex-Karara and ex-Warriedar Stations (DPaW 2007-).

Grevillea scabrida (P1) was recorded at 177 point locations by this survey of the Study Area, with 4,320 individuals recorded across these point locations (Appendix J). This taxon was relatively common within the Study Area on low basalt hills within VT 4 (Figure 8.4). A full census was not undertaken for this taxon, and the actual number of individuals present within the Study Area is likely to be much greater number than that presented. It is also known from numerous records in the vicinity of the Study Area (Figure 8.4).

Plate 4: *Grevillea scabrida* (P1) (Photos: Woodman Environmental)

Hemigenia tichbonii (P1) is an openly branched shrub growing to 1.5 m high (Plate 5). This species has only recently been described, however appears to be restricted to granite or greenstone (basalt, dolerite) hills (WAHerb 1998-, Thiele and Guerin 2016). It is known from only 5 records in DPaW's Threatened flora databases, all at one locality over a range of approximately 8 km on Mount Gibson Station, however Theile and Guerin (2016) note that it is known from 3 broad localities over a range of 65 km, from Mount Gibson Station in the south-east to south-west of Payne's Find in the north-west (Figure 8.5). In any case, the collection of this taxon in the Study Area represents a new locality and range extension for this taxon.

Hemigenia tichbonii was recorded at 3 point locations within the Study Area by this survey (Appendix J). Counts of individuals were not undertaken for this taxon, as it was not recognised as a significant taxon at the time of field survey, however it was generally uncommon at the recorded locations. It was restricted to the low basalt hills mapped as VT 4 (Figure 8.5).

Subsequent to this survey being conducted, re-examination of an anomalous collection of a *Hemigenia* from the regional flora and vegetation mapping survey conducted by Woodman Environmental (2012) determined that the collection also represented *H. tichbonii*. This species was recorded at 3 point locations by that survey, all within 8 km of the Study Area (Figure 8.5); these are considered to occur within the same broad locality as the Study Area. Part of this locality is within the proposed conservation reserve of ex-Karara Station.

Plate 5: ***Hemigenia tichbonii*** **(P1) (Photo: Woodman Environmental)**

Lepidosperma sp. Blue Hills (A. Markey & S. Dillon 3468) (P1) is a sedge growing to 0.7 m high (Plate 6), generally occurring on ironstone or granite hills, and drainage lines associated with such features (WAHerb 1998-; Woodman Environmental field observations). The distribution of this taxon in Western Australia, where it is endemic, is currently unclear, owing to the uncertainty surrounding the taxonomy of the genus *Lepidosperma*. DPaW Threatened flora database records indicate it has a range of approximately 80 km, from north-east of Perenjori (ex- Karara Station) in the north-west, to Mount Gibson Station in the south-east (Figure 8.6). However, a survey for this taxon conducted by Woodman Environmental indicates that its distribution is far wider, with records stretching from near Mullewa in the north-west to Ninghan Station in the south-east, over a distance of approximately 200 km. DPaW Threatened flora database records indicate that this taxon is known from approximately 16 broad localities (DPaW 2007-), however Woodman Environmental (2009) indicates that the number of known localities is in excess of 30. A number of localities occur within the proposed conservation reserves of ex- Karara and ex-Warriedar Stations) (DPaW 2007-). Estimates by Woodman Environmental put the number of known individuals at in excess of 80,000 (Woodman Environmental 2008, 2009).

Lepidosperma sp. Blue Hills (A. Markey & S. Dillon 3468) (P1) was recorded at 43 point locations by this survey of the Study Area, with 1,610 individuals recorded across these point locations (Appendix J). It was recorded on the margins of duricrust outcrops in VT 2, and along a drainage line in VT 5 (Figure 8.6). The number of point locations and individuals recorded is considered likely to represent a full census of this taxon in the Study Area; it is considered unlikely to occur elsewhere in the Study Area. It is also known from several records in the vicinity of the Study Area (Figure 8.6).

Plate 6: ***Lepidosperma*** **sp. Blue Hills (A. Markey & S. Dillon 3468) (P1) (Photo: Woodman Environmental)**

Millotia dimorpha (P1) is an erect annual herb growing to 10 cm high (Plate 7), that is restricted to shaded sites on ironstone, granite and basalt hills (WAHerb 1998-; Woodman Environmental field observations). It has a range of approximately 108 km in Western Australia (where it is endemic), from south-east of Mullewa in the north-west, to north east of Perenjori (ex-Karara Station) in the south-east (Figure 8.7). This taxon is known from 53 records in DPaW's Threatened flora databases, representing approximately 12 broad localities, 5 of which occur within the proposed conservation reserves of ex-Karara and ex-Lochada Stations (DPaW 2007-).

Millotia dimorpha (P1) was recorded at 100 point locations by this survey of the Study Area, with 18,595 individuals recorded across these point locations (Appendix J). This taxon was relatively common within the Study Area, occurring in shaded sites on low basalt hills within VT 4 (Figure 8.7). A full census was not undertaken for this taxon, and it is likely that the actual number of individuals within the Study Area is much higher than the number presented, although this number would vary depending on seasonal conditions across years. It is also known from numerous records in the vicinity of the Study Area (Figure 8.7).

Plate 7: *Millotia dimorpha* (P1) (Photos: Woodman Environmental)

Calandrinia sp. Warriedar (F. Obbens 04/09) (P2) is a succulent, semi-erect annual herb growing to 3 cm high (Plate 8), and is restricted to exposed rocky sites on granite or duricrust outcropping, often on breakaways or flats (WAHerb 1998-; Woodman Environmental field observations). This taxon has a range of approximately 100 km in Western Australia (where it is endemic), and is known from 8 records in DPaW's Threatened flora databases, from north-east of Morawa on Mellenbye Station in the north-west to north-east of Perenjori (ex- Karara Station) in the south-east (Figure 8.8). These records represent 8 braod localities, 6 of which are in the proposed conservation reserves of ex-Karara, ex-Warriedar and ex-Lochadada Stations (DPaW 2007-).

Calandrinia sp. Warriedar (F. Obbens 04/09) (P2) was recorded at 2 point locations by this survey of the Study Area, with 10 individuals recorded across these point locations (Appendix J). Both recorded locations were on exposed duricurst outcropping, in VT 3 (Figure 8.8). A full census was not conducted; it is considered likely that further locations and individuals occur in the Study Area, although they are likely to be restricted to the duricrust outcrops mapped as VT 2. It has not been recorded in the vicinity of the Study Area previously (Figure 8.8).

Plate 8: ***Calandrinia* sp. Warriedar (F. Obbens 04/09) (P2) (Photo: Woodman Environmental)**

Austrostipa blackii (P3) is a tufted perennial, grass growing to 1 m high (Plate 9) that generally occurs on rocky hills (WAHerb 1998-; Woodman Environmental field observations). It has a range of approximately 580 km in Western Australia, from north of Perenjori in the north-west to south of Kambalda in the south-east (Figure 8.9). This taxon is widespread across the southern half of Australia, with records in South Australia, New South Wales, Victoria and Tasmania (Atlas of Living Australia 2017). This taxon is known from 98 records in DPaW's Threatened flora databases that represent approximately 33 broad localities, 13 of which occur within conservation reserves (some of which are proposed) including Tutanning Nature Reserve, Mount Manning Nature Reserve, Kambalda Nature Reserve, and ex-Karara, ex- Warriedar, ex- Mount Jackson, ex-Jaurdi and ex-Credo Stations (DPaW 2007-).

Austrostipa blackii (P3) was recorded at 20 point locations by this survey of the Study Area, with 1,035 individuals recorded across these point locations (Appendix J). An additional point location is known from the Study Area, however no counts of individuals are available (Woodman Environmental 2012) (Woodman Environmental 2012). This taxon was relatively common within the Study Area, occurring on low basalt hills within VT 4 (Figure 8.9). A full census was not undertaken for this taxon, and it is likely that the actual number of individuals within the Study Area is much higher than the number presented. It is also known from several records in the vicinity of the Study Area (Figure 8.9).

Plate 9: *Austrostipa blackii* (P3) (Photo: Woodman Environmental)

Bossiaea sp. Jackson Range (G. Cockerton & S. McNee LCS 13614) (P3) is a spinescent shrub growing to 1.7 m high (Plate 10), occurring on duricrust, laterite or granitic breakaways (WAHerb 1998-; Woodman Environmental field observations). It occurs across a range of approximately 325 km within Western Australia (where it is endemic), from north-east of Perenjori in the north-west, to north-east of Southern Cross in the south-east (Figure 8.10). This taxon is known from 37 records in DPaW's Threatened flora databases representing approximately 11 broad localities, 2 of which are in conservation reserves including Geeraning Nature Reserve and the Mount Manning Helena and Aurora Ranges Conservation Park (DPaW 2007-).

Bossiaea sp. Jackson Range (G. Cockerton & S. McNee LCS 13614) (P3) was recorded at 1 location within the Study Area by this survey (Appendix J), with 15 individuals recorded. It was recorded on the slopes of a lateritic breakaway mapped as VT 8 (Figure 8.10). The number of point locations and individuals recorded is considered likely to represent a full census of this taxon in the Study Area; it is considered unlikely to occur elsewhere in the Study Area, with most other areas of suitable habitat visited during the survey. It has not been recorded in the vicinity of the Study Area previously (Figure 8.10).

Plate 10: ***Bossiaea* sp. Jackson Range (G. Cockerton & S. McNee LCS 13614) (P3) (Photo: Woodman Environmental)**

Cyanicula fragrans (P3) is a tuberous, perennial orchid growing to 10 cm high. It generally in shaded sites associated with granite or basalt hills (WAHerb 1998-; Woodman Environmental field observations). It is endemic to Western Australia where it has a known range of approximately 210 km, occurring from north of Morawa in the north-east to east of Lake Moore in the south-east (Figure 8.11). This taxon is known from 17 records in DPaW's Threatened flora databases representing 9 broad localities, 2 of which are located within the proposed conservation reserves of ex-Karara and ex-Warriedar Stations (DPaW 2007-).

A specimen suspected to be *Cyanicula fragrans* (?*Cyanicula fragrans*) was collected within the Study Area during this survey (Appendix J), the identification could not be confirmed with certainty as the plant had significantly dried up at the time of the survey. It should be noted that there was enough material to rule out the somewhat superficially similar taxa *Cyanicula amplexans* and *Pheladenia deformis*, both of which are known to occur in the general vicinity of the Study Area. As *Cyanicula fragrans* also has been previously collected in the general vicinity of the Study Area (Woodman Environmental 2012; Meissner and Coppen 2014), it is considered likely that the collection represents this taxon. This taxon was recorded at 1 point location by this survey of the Study Area, with 1 individual recorded. It was recorded in a shaded site on a low basalt hill within VT 4 (Figure 8.11). It is considered likely that further individuals occur in the Study Area in similar habitat. It is also known from a record (where identification has been confirmed) in the vicinity of the Study Area (Figure 8.11).

Plate 11: *Cyanicula fragrans* (P3) (Photo: Woodman Environmental)

Grevillea globosa (P3) is a spreading, somewhat domed shrub growing to 3 m high (Plate 12), and occurs on red loam and yellow sand, usually on the slopes of hills (WAHerb 1998-; Woodman Environmental field observations). This taxon has a range of approximately 190 km in Western Australia (where it is endemic), from north-east of Mullewa in the north-west, to west of Paynes Find in the south-east (Figure 8.12). It is known from 48 records in DPaW's Threatened flora databases representing approximately 37 broad localities, 8 of which are within proposed conservation reserves including the DPaW managed ex-Barnong and ex-Karara Stations (DPaW 2007-).

Grevillea globosa (P3) was recorded at 2 point locations by this survey of the Study Area, with 10 individuals recorded across these point locations (Appendix J). It was recorded on the lower slopes of an ironstone hill within VT 1. A full census was not conducted; it is considered likely that further locations and individuals occur in the Study Area in VT 1 (Figure 8.12). It is also known from several records in the vicinity of the Study Area (Figure 8.12).

Plate 12: ***Grevillea globosa*** **(P3) (Photos: S. J. Patrick - Florabase (WAHerb 1998-))**

Grevillea subtiliflora (P3) is an erect to spreading shrub with divided, somewhat spiny leaves to 2.5 m high (Plate 13) that is restricted to greenstone (basalt, dolerite) hills (WAHerb 1998-; Woodman Environmental field observations). It is known over a range of approximately 70 km in Western Australia (where it is endemic), from ex-Warriedar Station in the north-west to Mount Gibson Station in the south-east (Figure 8.13). This taxon is known from 68 records in DPaW's Threatened flora databases representing 29 broad localities, 7 of which occur within the proposed conservation reserves of ex-Warriedar and ex-Karara Stations (DPaW 2007-).

Grevillea subtiliflora (P3) was recorded at 54 point locations by this survey of the Study Area, with 284 individuals recorded across these point locations (Appendix J). This taxon was relatively common within the Study Area, occurring in shaded sites on low basalt hills within VT 4 (Figure 8). A full census was not undertaken for this taxon, and it is likely that the actual number of individuals within the Study Area is much higher than the number presented (Figure 8.13). It is also known from numerous records in the vicinity of the Study Area (Figure 8.13).

Plate 13: *Grevillea subtiliflora* (P3) (Photo: Woodman Environmental)

Gunniopsis divisa (P3) is a succulent, prostrate annual herb with large white flowers (Plate 14), which generally occurs in slightly saline clay soils on flats and plains (WAHerb 1998-; Woodman Environmental field observations). This taxon is endemic to Western Australia, occurring across a range of approximately 340 km, from east-north-east of Meekatharra near Mount Gould in the north, to north-east of Perenjori (ex- Karara Station) in the south (Figure 8.14). It is known from 32 records in DPaW's Threatened flora databases representing approximately 16 broad localities, 3 of which are located within the proposed conservation reserves of ex-Karara, ex-Warriedar and ex-Woolgorong Stations (DPaW 2007-).

Gunniopsis divisa (P3) was recorded at 4 point locations by this survey of the Study Area, with 140 individuals recorded across these point locations (Appendix J). It was recorded on slightly saline flats and plains in *Eucalyptus* woodland within VT 8 (Figure 8.14). A full census was not conducted; it is considered likely that further locations and individuals occur in the Study Area in similar habitat. It has not been recorded in the vicinity of the Study Area previously (Figure 8.14).

Plate 14: *Gunniopsis divisa* (P3) (Photos: Woodman Environmental)

Micromyrtus trudgenii (P3) is a spindly shrub to 3 m high (Plate 15). It is known to occur on the tops and slopes of hills and ridges, usually on ironstone, duricrust or greenstone (WAHerb 1998-; Woodman Environmental field observations). This taxon occurs across a range of approximately 95 km within Western Australia (where it is endemic), from Badja Station in the north, to north-east of Perenjori (ex- Karara Station) in the south (Figure 8.15). There are 82 records in DPaW's Threatened flora databases representing approximately 16 broad localities, 9 of which occur within the proposed conservation reserves of ex-Karara and ex-Warriedar Stations (DPaW 2007-).

Micromyrtus trudgenii (P3) was recorded at 12 point locations by this survey of the Study Area, with 280 individuals recorded across these point locations (Appendix J). It was recorded primarily on duricrust and laterite breakaways (Figure 8.15). A full census was not conducted; it is considered likely that further locations and individuals occur in the Study Area. It is also known from numerous records in the vicinity of the Study Area (Figure 8.15).

Plate 15: *Micromyrtus trudgenii* (P3) (Photo: Woodman Environmental)

Persoonia pentasticha (P3) is a low, spreading shrub usually to 1 m high (Plate 16), that occurs on a variety of soils and topographic sites (WAHerb 1998-; Woodman Environmental field observations). It is endemic to Western Australia, occurring from near Mullewa in the north-west, to Mount Gibson Station in the south-east, across a range of approximately 250 km (Figure 8.16). This taxon is known from 65 records in DPaW's Threatened flora databases representing approximately 34 broad localities. Of these, 12 localities occur within conservation reserves (some of which are proposed), including East Yuna Nature Reserve, Barrabarra Nature Reserve, Bowgarder Nature Reserve, and ex-Barnong, ex-Karara and ex-Warriedar Stations (DPaW 2007-).

Persoonia pentasticha (P3) was recorded at 49 point locations by this survey of the Study Area, with 96 individuals recorded across these point locations (Appendix J). It was recorded in a variety of habitats and VTs (Figure 8.16). A full census was not conducted, and although generally uncommon in the Study Area, it is considered likely that further locations and individuals occur. It is also known from numerous records in the vicinity of the Study Area (Figure 8.16).

Plate 16: *Persoonia pentasticha* (P3) (Photo: Woodman Environmental)

Rhodanthe collina (P3) is an erect annual herb to 0.25 cm high (Plate 17) that generally occurs on rocky hills and in drainage lines associated with such hills (WAHerb 1998-; Woodman Environmental field observations). It occurs across a range of approximately 180 km within Western Australia (where it is endemic), from Mingenew in the west, to ex-Thundelarra Station in the east (Figure 8.17). There are 90 records of this taxon in DPaW's Threatened flora databases representing 28 broad localities, 15 of which occur in conservation reserves (some of which are proposed), including Mingenew Nature Reserve, and ex-Karara, ex-Warriedar, ex-Thundelarra and ex-Kadji Kadji Stations (DPaW 2007-).

Rhodanthe collina (P3) was recorded at 97 point locations by this survey of the Study Area, with 25,865 individuals recorded across these point locations (Appendix J). This taxon was relatively common within the Study Area, occurring primarily on low basalt hills within VT 4 (Figure 8.17). A full census was not undertaken for this taxon, and it is likely that the actual number of individuals within the Study Area is much higher than the number presented, although this number would vary depending on seasonal conditions across years. It is also known from numerous records in the vicinity of the Study Area (Figure 8.17).

Plate 17: *Rhodanthe collina* (P3) (Photo: Woodman Environmental)

Stenanthemum poicilum (P3) is a low, spreading shrub to 0.5 m high (Plate 18), that generally occurs on rocky (often basalt, ironstone or laterite) hill slopes and breakaways (WAHerb 1998-; Woodman Environmental field observations). The majority of records for this taxon occur across a range of approximately 170 km within Western Australia (where it is endemic), from near Mullewa in the north-west to White Wells Station in the south-east (Figure 8.18). There is also a disjunct record located over 400 km to the south-east, within the Bremer Range. It is known from 53 in DPaW's Threatened flora databases representing 17 broad localities, 7 of which occur within conservation reserves (some of which are proposed), including Wilroy Nature Reserve, Canna Nature Reserve, and ex-Karara and ex-Warriedar Stations (DPaW 2007-).

Stenanthemum poicilum (P3) was recorded at 4 point locations by this survey of the Study Area, with 52 individuals recorded across these point locations (Appendix J). It was recorded on the slopes of lateritic breakaways mapped as VT 8 (Figure 8). The number of point locations and individuals recorded is considered likely to represent a full census of this taxon in the Study Area; it is considered unlikely to occur elsewhere in the Study Area, with most other areas of suitable habitat visited during the survey. It is also known from several records in the vicinity of the Study Area (Figure 8.18).

Plate 18: *Stenanthemum poicilum* (P3) (Photos: Woodman Environmental)

5.1.4 Other Significant Flora Taxa

There were flora taxa recorded in the Study Area belong to following categories of significant flora, as defined by EPA (2016):

- Representative of the range of a species (range extensions and major gaps in know distributions); and
- Unusual species (hybrid).

These taxa are discussed further below, with regard to their potential significance. No taxa are considered to belong to any of the remaining categories of significant flora taxa as defined by EPA (2016) (see Section 3.8.1).

Representative of the range of a species

Records of the following taxa in the Study Area represent extensions to the known range of the taxon, or fill major gaps in the known range of the taxon:

- *Hemigenia tichbonii* (P1) (range extension);
- *Melaleuca lateriflora* (range extension);
- *Euphorbia philochalix* (gap in known range); and
- *Maireana eriosphaera* (gap in known range).

Hemigenia tichbonii is a listed significant flora taxon, as discussed in Section 5.1.3.

Melaleuca lateriflora is a common, widespread taxon in the southern part of Western Australia, with a range of over 800 km (DPaW 2007-). The record of this taxon in the Study Area extends its range approximately 30 km to the north-east. This record is not considered to represent a significant extension to the known range of this taxon, with the absence of other records in the general vicinity of the Study Area likely reflecting a lack of survey in appropriate habitat in the general vicinity of the Study Area. It is likely to occur in other areas in the vicinity of the Study Area. This taxon is not considered to be a significant taxon in the context of the Study Area.

Euphorbia philochalix is also a widespread taxon in the southern part of W.A., with a range of over 900 km (DPaW 2007-), and also extends to the Northern Territory. The record of this taxon in the Study Area fills a gap in its known range of approximately 450 km (DPaW 2007-). This taxon is small and somewhat cryptic, being very similar to *Euphorbia drummondii* (it was previously included under this taxon) (Halford and Harris 2012), and it is likely that the absence of records within the aforementioned gap in its known range is due to it being overlooked, or to lack of survey in appropriate habitat. It is likely to occur in other areas in the vicinity of the Study Area. It is not considered to be a significant taxon in the context of the Study Area.

Maireana eriosphaera is a widespread taxon in W.A., with a range of over 900 km (DPaW 2007-), and also extends to the Northern Territory. The record of this taxon in the Study Area fills a gap in its known range of approximately 240 km (DPaW 2007-). The absence of other records in the general vicinity of the Study Area likely reflects a lack of survey in appropriate habitat in the general vicinity of the Study Area; it is likely to occur in other

areas in the vicinity of the Study Area. It is not considered to be a significant taxon in the context of the Study Area.

Unusual Species

A putative hybrid between *Acacia ramulosa* var. *ramulosa* and a member of the Mulga (*Acacia aneura* and its allies) group of taxa (possibly *Acacia caesaneura*) was recorded in the Study Area. The collection of this putative hybrid had pods intermediate between the large terete pods of *Acacia ramulosa* var. *ramulosa* and the flat, wide (almost rounded) pods of *Acacia caesaneura*. Putative hybrids between *Acacia ramulosa* var. *ramulosa* and Mulga taxa are known to occur and are well-represented in herbarium collections (Maslin and Reid 2012; World Wide Wattle 2017). The putative hybrid recorded in the Study Area is therefore not considered to be a significant taxon in the context of the Study Area.

5.1.5 Introduced Taxa

A total of 22 introduced flora taxa were recorded by this survey of the Study Area. Table 8 presents a list of the introduced flora taxa recorded in the Study Area, together with location information, and ratings for each introduced taxon under the Environmental Weed Strategy for Western Australia (DPaW 1999) (Appendix K). Introduced taxa were most abundant around the disturbance areas associated with historical mining, and the abandoned Rothsay townsite, and in the larger drainage lines in the Study Area. One particularly large infestation of introduced taxa (predominantly *Centaurea melitensis* (Maltese Cockspur) and *Rumex hypogaeus* (Doublegee)) was noted in an old scrape to the north of the Rothsay townsite (Plate 19).

Considering the 5 additional quadrats located within the Study Area (Woodman Environmental 2012; Meissner and Coppen 2014), a further 2 introduced flora taxa are known to occur within the Study Area (Table 8), bringing the total number of introduced taxa known from the Study Area to 24. Additional locations of several weed taxa recorded by this current survey of the Study Area were also recorded at these quadrats.

No counts of individuals of introduced taxa were recorded, however notes were made on their general abundance; these are presented in Table 8.

The majority of the introduced taxa recorded are cosmopolitan species that are generally not considered to cause significant environmental impact, in particular the ability to change the structure, composition and function of ecosystems (DPaW 1999). Such taxa are rated as Moderate or below (see Table 8), and are not considered to be significant weeds, excluding 3 taxa (*Cleretum papulosum* subsp. *papulosum*, *Cuscuta planiflora* and *Spergula pentandra*), which were not rated by DPaW (1999), but are not considered to be serious (Hussey *et al.* 2007).

Three taxa, being *Brassica tournefortii*, *Echium plantagineum* and *Rumex vesicarius* (Ruby Dock), are considered to be significant weeds capable of causing significant environmental impacts (DPaW 1999; Hussey *et al.* 2007). *Echium plantagineum*, although not rated by DPaW (1999), has the ability to invade native vegetation and displace native taxa (Hussey *et al.* 2007), and therefore is considered to be a significant weed. *Brassica tournefortii* does

not appear to be a significant issue in the Study Area, as it was not recorded by this survey, however was recorded in native vegetation by previous surveys (Woodman Environmental 2012; Meissner and Coppen 2014). However, both *Echium plantagineum* and *Rumex vesicarius* are relatively common around disturbance areas associated with historical mining and the Rothsay townsite. Additionally, *Rumex vesicarius* is also well-known to establish and dominate newly rehabilitated sites in the Goldfields of Western Australia (Brearley and Osborne 1996).

Of the introduced taxa known from the Study Area, *Echium plantagineum* and *Rumex hypogaeus* (Doublegee) are also listed as Declared Pests under the BAM Act (DAF 2017). However, there are no specific management requirements for these taxa in the Shire of Perenjori (DAF 2017).

Locations of introduced flora taxa are presented in Appendix J, and presented on Figure 9.

Plate 19: Infestation of Introduced Taxa in Old Scrape to North of Rothsay Townsite

Table 8: Summary of Introduced Taxa Known from within the Study Area

Taxon	Common Name	Number of Locations Recorded in Study Area in 2016	Total Number of Locations Known in the Study Area*	Abundance Notes	Vegetation Types	Environmental Weeds Rating (DPaW 1999)
**Arctotheca calendula*	Capeweed	2	2	Uncommon in Study Area	7, C	Moderate
**Brassica tournefortii*	Mediterranean Turnip	-	2	Unknown, presumed to be uncommon in Study Area	8	High
**Bromus rubens*	Red Brome	2	2	Unknown	7	Moderate
**Centaurea melitensis*	Maltese Cockspur	7	7	Common in Study Area, particularly around historical mining disturbance areas and Rothsay townsite, and in drainage lines	5, 7, 8, C	Moderate
**Cleretum papulosum* subsp. *papulosum*	-	4	4	Common in Study Area in areas with slightly saline soils	6, 8	Not rated – to be advised
**Cuscuta epithymum*	Lesser Dodder	4	4	Common in Study Area, parasitising annual/ephemeral taxa	1, 7, 9	Moderate
**Cuscuta planiflora*	Small-seeded Dodder	-	1	Unknown, presumed to be uncommon in Study Area	4	Not rated – to be advised
**Echium plantagineum*	Paterson's Curse	5	5	Generally uncommon in Study Area, however abundant at several disturbance areas associated with historical mining	7, 8, C	Not rated – to be advised
**Hypochaeris glabra*	Smooth Cat's Ear	2	2	Generally uncommon in Study Area, however abundant in 2 drainage lines	4, 5	Moderate
**Lamarckia aurea*	Goldentop	1	1	Uncommon in Study Area	7	Moderate
**Lysimachia arvensis*	Pimpernel	1	1	Uncommon in Study Area	C	Moderate

Taxon	Common Name	Number of Locations Recorded in Study Area in 2016	Total Number of Locations Known in the Study Area*	Abundance Notes	Vegetation Types	Environmental Weeds Rating (DPaW 1999)
**Medicago minima*	Small Burr Medic	2	3	Uncommon in Study Area	8, C	Mild
**Mesembryanthemum nodiflorum*	Slender Iceplant	7	8	Common in Study Area in areas with slightly saline soils	6, 7, 8	Mild
**Parentucellia latifolia*	Common Bartsia	1	1	Uncommon in Study Area	5	Moderate
**Pentameris airoides* subsp. *airoides*	False Hairgrass	12	14	Common in the Study Area, at rocky sites	2, 4, 5, 6, 7, 8	Moderate
**Petrorhagia dubia*	Velvet Pink	1	1	Uncommon in Study Area	4	Mild
**Rostraria pumila*	Rough Cat's Tail	3	4	Uncommon in Study Area	7, 8	Moderate
**Rumex hypogaeus*	Doublegee	1	1	Uncommon in Study Area, restricted to historical mining disturbance areas	C	Low
**Rumex vesicarius*	Ruby Dock	5	5	Generally uncommon in Study Area, however abundant at some historical mining disturbance areas and Rothsay townsite.	7, 8, C	High
**Schismus barbatus*	Kelch Grass	1	1	Uncommon in Study Area	7	Moderate
**Silene nocturna*	Mediterranean Catchfly	1	1	Uncommon in Study Area	6	Mild
**Sisymbrium erysimoides*	Smooth Mustard	2	3	Uncommon in Study Area	7, 8	Low
**Sonchus oleraceus*	Common Sowthistle	1	1	Uncommon in Study Area	7	Moderate
**Spergula pentandra*	Five-anthered Spurry	4	4	Uncommon in Study Area	7, 8, C	Not rated – to be advised

5.2 Vegetation of the Study Area

5.2.1 Vegetation Type Mapping

Examination of the quadrat classification dendrogram at the 7-cluster level found that one cluster was not plausible, as it consisted of 2 quadrats established within the interface of 2 VTs. These quadrats were manually reassigned to other clusters, as discussed in Section 3.6. However, one cluster could plausibly be divided further into 2 discrete clusters, and a second cluster could plausibly be divided into 3 discrete clusters. This resulted in 9 clusters being recognised, which are considered to represent VTs.

Appendix G presents the classification dendrogram, with the clusters representing VTs designated, as well as quadrats that were manually reassigned to other clusters (see Section 3.6). The original 7 clusters suggested by classification analysis as potentially being appropriate for the data analysed are also colour-coded in Appendix G. Appendix L presents the associated two-way table output from the analysis, with clusters representing VTs and manually reassigned quadrats also designated. Appendix M presents the results of the indicator taxon analysis.

At a higher level in the classification dendrogram, the 9 VTs were arranged into 3 broad groups, as outlined below:

- Group 1 (VTs 1, 2 and 3) generally corresponds to shrublands associated with ironstone substrates, including ironstone hills and their outwashes, and duricrust outcrops.
- Group 2 (VTs 4, 5 and 9) generally corresponds to shrublands associated with basalt substrates, including basalt hills and their outwashes.
- Group 3 (VTs 6, 7 and 8) generally corresponds to Eucalypt woodland associated with deeper, slightly saline soils in valleys and on plains.

The VTs described in the Study Area are summarised in Table 9 below, including:

- Description of the VT (as per Section 3.6);
- Total area mapped in the Study Area;
- Number of quadrats (and identifiers) established;
- Presence of significant taxa;
- Average taxon richness;
- Indicator taxa;
- Representative photograph; and
- Description of variation within the VT with regard to structure and taxon composition.

VT mapping is presented on Figure 10. Figure 10 includes the locations of all quadrat undertaken during this survey, as well as the locations of quadrats undertaken by Meissner and Coppen (2014) and Woodman Environmental (2012) which are located within the Study Area.

A matrix of VTs and taxa recorded within them is presented in Appendix N.

As discussed in Section 5.2.2, because of the scale that VTs have been mapped at (1:10,000), significant flora locations are occasionally included within VTs that are generally not considered to be preferred habitat for such taxa. Therefore, VTs considered to be preferred habitat are designated in Table 9. All other VTs are not considered to be preferred habitat.

All photographs in Table 9 are by Woodman Environmental.

Table 9: Summary of Vegetation Types Mapped in the Study Area

VT	Summary	Photograph
1	**Description:** Tall shrubland to open shrubland of mixed species dominated by *Acacia latior*, *Acacia sibina*, *Melaleuca nematophylla* and occasionally *Acacia incognita* over mid open to sparse shrubland dominated by *Aluta aspera* subsp. *hesperia* over low sparse shrubland dominated by *Xanthosia kochii* and *Dianella revoluta* over low open to sparse forbland dominated by *Waitzia acuminata* var. *acuminata*, *Helipterum craspedioides*, *Velleia rosea*, *Brunonia australis* and *Haloragis odontocarpa* forma *rugosa* on red brown to pale brown clay loam soils with ironstone gravel on lower slopes and undulating plains **Area mapped:** 98 ha (9.0 %) **Sampling:** 5 quadrats (ES-01, ES-06, ES-10, ES-19, ES-31) **Significant Taxa:** *Allocasuarina tessellata* (P1), *Grevillea scabrida* (P1), *Grevillea globosa* (P3)^, *Micromyrtus trudgenii* (P3), *Persoonia pentasticha* (P3) **Indicator Taxa:** *Acacia latior, Acacia sibina, Aluta aspera* subsp. *hesperia, Monachather paradoxus* **Average Taxon Richness per Quadrat:** 26 ± 6 **Variation:** This VT was generally structurally uniform, although occasionally the tall shrubland stratum was present as a sparse shrubland. The most notable variation in this VT was the dominant *Acacia* taxon in the tall shrubland stratum; *Acacia latior* was most frequently dominant, however in the southern part of the Study Area, it was replaced by *Acacia incognita*, with little to no change in the composition of other taxa, including co-dominants in the tall shrubland stratum. These taxa are very closely related; both are members of the informal *Acacia coolgardiensis* group (Maslin and Buscumb 2008), appear to prefer similar soil types (somewhat heavy loams), and are known to be sympatric or parapatric in some areas (Maslin and Buscumb 2008).	 **Plate 20:** Typical VT 1 (Quadrat ES-06)

VT	Summary	Photograph
2	**Description:** Tall open to sparse shrubland of mixed species dominated by *Acacia aulacophylla* and *Acacia umbraculiformis* over mid open to sparse shrubland of mixed species dominated by *Philotheca brucei* subsp. *brucei*, *Thryptomene costata*, *Mirbelia* sp. Bursarioides (T.R. Lally 760) and *Grevillea extorris* over sparse low shrubland of mixed species dominated by *Prostanthera patens* and *Astroloma serratifolium* over sparse low forbland of mixed species dominated by *Borya sphaerocephala*, *Waitzia acuminata* var. *acuminata* and *Podolepis lessonii* on pale brown clay loam with duricrust stones over duricrust outcropping on low breakaways **Area mapped:** 20 ha (1.8 %) **Sampling:** 3 quadrats (ES-11, ES-18, ES-25) **Significant Taxa:** *Lepidosperma* sp. Blue Hills (A. Markey & S. Dillon 3468) (P1)^, *Micromyrtus trudgenii* (P3)^, *Persoonia pentasticha* (P3)^ **Indicator Taxa:** *Acacia aulacophylla*, *Acacia umbraculiformis*, *Astroloma serratifolium*, *Mirbelia* sp. Bursarioides (T.R. Lally 760), *Prostanthera patens*, *Sida* sp. dark green fruits (S. van Leeuwen 2260) **Average Taxon Richness per Quadrat:** 30 ± 10 **Variation:** This VT was generally structurally uniform. Compositionally, there was some variation in the dominant taxa within the tall and mid shrubland strata; for example, *Acacia aulacophylla, Acacia umbraculiformis* and *Thryptomene costata* were absent from 1 quadrat each. However, this was considered to be relatively minor in the context of this unit, and reflects the relatively high taxon richness in these strata.	 **Plate 21:** Typical VT 2 (Quadrat ES-18)

VT	Summary	Photograph
3	**Description:** Tall shrubland to open shrubland of mixed species dominated by *Acacia ramulosa* var. *ramulosa*, *Acacia assimilis* subsp. *assimilis*, *Allocasuarina acutivalvis* subsp. *prinsepiana*, *Melaleuca nematophylla* and *Calycopeplus paucifolius* over mid open to sparse shrubland dominated by *Philotheca brucei* subsp. *brucei*, *Eremophila latrobei* subsp. *latrobei* and *Eremophila clarkei* over low sparse shrubland dominated by *Xanthosia kochii* over low sparse forbland of mixed species including *Waitzia acuminata* var. *acuminata*, *Calocephalus multiflorus* and *Cheilanthes sieberi* subsp. *sieberi* on red brown clay loam soils with banded or laterised ironstone stones over banded or laterised ironstone outrcropping on upper slopes and crests of low hills **Area mapped:** 37 ha (3.4 %) **Sampling:** 3 quadrats (ES-28, ES-30, ES-32) **Significant Taxa:** *Acacia karina* (P1), *Calandrinia* sp. Warriedar (F. Obbens 04/09) (P2)^, *Gunniopsis divisa* (P3), *Micromyrtus trudgenii* (P3)^, *Persoonia pentasticha* (P3) **Indicator Taxa:** *Acacia assimilis* subsp. *assimilis*, *Acacia ramulosa* var. *ramulosa*, *Allocasuarina acutivalvis* subsp. *prinsepiana*, *Calycopeplus paucifolius*, *Eremophila latrobei* subsp. *latrobei*, *Melaleuca nematophylla*, *Xanthosia kochii* **Average Taxon Richness per Quadrat:** 25 ± 4 **Variation:** Structurally, this VT graded towards a sparse tall shrubland in areas with significant rock outcrop at the surface, including at quadrat ES-32, where a large amount of laterised ironstone was present at the surface. Compositionally, there was some variation in the dominant taxa within the mid shrubland strata depending on the amount and type of rock outcropping at the surface; for example, *Thryptomene costata* was dominant only where laterised ironstone outcropping was present (ES-32), while *Eremophila clarkei, Hibbertia arcuata* and *Philotheca sericea* were only present when banded ironstone outcropping was at the surface. However, this variation was considered to be relatively minor in the context of this unit, and reflects the relatively high taxon richness in this stratum.	 **Plate 22:** Typical VT 3 (Quadrat ES-30)

VT	Summary	Photograph
4	**Description:** Low open woodland to woodland dominated by *Allocasuarina dielsiana* and *Melaleuca hamata* over tall shrubland to open shrubland dominated by *Acacia acuminata* and *Allocasuarina tessellata* over mid sparse shrubland dominated by *Acacia karina* and occasionally *Melaleuca radula* over low open to sparse forbland and tussock grassland of mixed species including *Waitzia nitida*, *Lobelia rhytidosperma*, *Goodenia berardiana*, *Ptilotus helipteroides* and *Austrostipa blackii* on red clay-loam soils with basalt stones on the slopes and crests of low hills **Area mapped:** 369 ha (33.8 %) **Sampling:** 7 quadrats (ES-03, ES-04, ES-17, ES-24, ES-26, ROTH-03, KIOP-208) **Significant Taxa:** *Acacia karina* (P1)^, *Allocasuarina tessellata* (P1)^, *Grevillea scabrida* (P1)^, *Hemigenia tichbonii* (P1)^, *Millotia dimorpha* (P1)^, *Austrostipa blackii* (P3)^, ?*Cyanicula fragrans* (P3)^, *Grevillea subtiliflora* (P3)^, *Micromyrtus trudgenii* (P3), *Persoonia pentasticha* (P3)^, *Rhodanthe collina* (P3)^ **Indicator Taxa:** *Acacia acuminata, Acacia karina* (P1)*, Allocasuarina dielsiana, Allocasuarina tessellata* (P1)*, Hemigenia tichbonii* (P1)*, Melaleuca radula, Solanum lasiophyllum, Tricoryne tuberosa* **Average Taxon Richness per Quadrat:** 30 ± 6 **Variation:** There was relatively large structural variation in this VT which appears to be closely related to topographical position. In situations where this VT occurred on slopes, particularly those facing west and south, the tall shrubland stratum was dense to the point that most other lower strata were very limited in development. However, on the crests of hills, other flat areas on hills and areas with significant basalt outcropping, the tall shrubland stratum graded towards sparse, with the mid and low strata being well-developed. Topographical position also influenced composition to an extent; taxa such as *Acacia umbraculiformis* (low woodland stratum), *Thryptomene costata* (mid-stratum) and *Borya sphaerocephala* (low stratum) were prominent on the crests of hills, other flat areas on the hills and areas with significant basalt outcropping, but were virtually absent from the slopes.	 **Plate 23:** Typical VT 4 (Quadrat ES-17)

VT	Summary	Photograph
		 **Plate 24:** Variant of VT 4 (Quadrat ES-04)

VT	Summary	Photograph
5	**Description:** Low open woodland dominated by *Melaleuca hamata* over tall shrubland to open shrubland of mixed species dominated by *Acacia ramulosa* var. *ramulosa* and *Acacia tetragonophylla* and *Acacia sibina* over low sparse shrubland dominated by *Eremophila eriocalyx* and *Ptilotus obovatus* over low sparse forbland of mixed species including *Waitzia acuminata* var. *acuminata*, *Calocephalus multiflorus*, *Velleia rosea*, *Ptilotus gaudichaudii* subsp. *eremita* and *Cephalipterum drummondii* on red or red brown clay loam soils with quartz and ironstone gravel on lower slopes, undulating plains and in minor drainage lines **Area mapped:** 157 ha (14.4 %) **Sampling:** 7 quadrats (ES-07, ES-13, ES-22, ES-23, ES-29, ES-34, ES-35) **Significant Taxa:** *Allocasuarina tessellata* (P1), *Grevillea scabrida* (P1), *Lepidosperma* sp. Blue Hills (A. Markey & S. Dillon 3468) (P1), *Austrostipa blackii* (P3), *Persoonia pentasticha* (P3)^, *Rhodanthe collina* (P3), *Stenanthemum poicilum* (P3) **Indicator Taxa:** *Acacia tetragonophylla*, *Eremophila eriocalyx* **Average Taxon Richness per Quadrat:** 30 ± 6 **Variation:** There was relatively large structural and compositional variation in this VT. One area contains a low woodland stratum of *Eucalyptus kochii* subsp. *amaryssia*, which is not present elsewhere in the Study Area. Several areas have a relatively well-developed mid stratum dominated by *Thryptomene costata* (e.g. ES-07) – these areas appear to coincide with granite outcropping at or just below the soil surface. One area also had a well-developed low shrubland stratum dominated by *Grevillea pityophylla*; this area had lighter-coloured soils than usual for this VT, which possibly indicates that granite or duricrust is just below the surface; elsewhere in the Study Area, *Grevillea pityophylla* is restricted to areas with granite or duricrust outcropping.	 **Plate 25:** Typical VT 5 (Quadrat ES-29)

VT	Summary	Photograph
		 **Plate 26:** Variant of VT 5 (Quadrat ES-07)

VT	Summary	Photograph
6	**Description:** Low open woodland dominated by *Eucalyptus clelandii* over low sparse shrubland of mixed species dominated by *Acacia erinacea, Eremophila pantonii* and *Ptilotus obovatus* over low sparse chenopod shrubland of mixed species including *Sclerolaena fusiformis, Sclerolaena drummondii*, *Sclerolaena diacantha*, *Maireana georgei* and *Maireana trichoptera* over low sparse tussock grassland and forbland of mixed species including *Austrostipa scabra* subsp. *scabra*, *Calandrinia baccata, Ptilotus nobilis* and **Mesembryanthemum nodiflorum* on pale brown clay loam soils with predominantly calcrete gravel on lower slopes and low rises **Area mapped:** 16 ha (1.5 %) **Sampling:** 2 quadrats (ES-02, ES-09) **Significant Taxa:** *Acacia karina* (P1), *Allocasuarina tessellata* (P1), *Grevillea scabrida* (P1), *Millotia dimorpha* (P1), *Gunniopsis divisa* (P3)^, *Persoonia pentasticha* (P3), *Rhodanthe collina* (P3) **Indicator Taxa:** *Acacia erinacea*, *Eremophila pantonii, Eucalyptus clelandii, Maireana georgei, Sclerolaena drummondii, Sclerolaena fusiformis* **Average Taxon Richness per Quadrat:** 28 ± 11 **Variation:** There was little structural and compositional variation in this VT based on the limited area mapped in the Study Area, however species richness was somewhat lower where significant amounts of calcrete stones were present at the surface, possibly indicating less favourable conditions for growth where the soil is more calcareous.	 **Plate 27:** Typical VT 6 (Quadrat ES-09)

VT	Summary	Photograph
7	**Description:** Low open woodland dominated by *Eucalyptus salubris* over sparse tall to mid shrubland of mixed species including *Eremophila pantonii* and *Exocarpos aphyllus* over low sparse samphire shrubland dominated by *Tecticornia disarticulata* over low sparse chenopod shrubland of mixed species including *Rhagodia drummondii*, *Sclerolaena densiflora, Sclerolaena diacantha*, *Maireana tomentosa* subsp. *tomentosa* and *Enchylaena tomentosa* var. *tomentosa* over low sparse tussock grassland and forbland of mixed species including *Erymophyllum glossanthus*, *Austrostipa scabra* subsp. *scabra*, *Ptilotus gaudichaudii* subsp. *eremita* and **Rostraria pumila* on pale brown clay loam soils with colluvial gravel on lower slopes and flats **Area mapped:** 26 ha (2.4 %) **Sampling:** 2 quadrats (ES-12, ES-27) **Significant Taxa:** *Allocasuarina tessellata* (P1), *Grevillea scabrida* (P1), *Millotia dimorpha* (P1), *Persoonia pentasticha* (P3) **Indicator Taxa:** *Atriplex ?bunburyana*, *Atriplex semilunaris, Enchylaena tomentosa* var. *tomentosa, Eucalyptus salubris, Maireana tomentosa* subsp. *tomentosa, Tecticornia disarticulata* **Average Taxon Richness per Quadrat:** 37 ± 6 **Variation:** There was little structural and compositional variation in this VT based on the limited area mapped in the Study Area.	 **Plate 28:** Typical VT 7 (Quadrat ES-12)

VT	Summary	Photograph
8	**Description:** Low open woodland dominated by *Eucalyptus loxophleba* subsp. *supralaevis* and/or *Eucalyptus salubris* over tall sparse shrubland of mixed species including *Eremophila oldfieldii* subsp. *oldfieldii*, *Eremophila oppositifolia* subsp. *angustifolia*, *Acacia tetragonophylla* and *Exocarpos aphyllus* over sparse mid shrubland of mixed species including *Senna artemisioides* subsp. *filifolia*, *Dodonaea inaequifolia* and *Scaevola spinescens* over low sparse shrubland and tussock grassland of mixed species including *Acacia erinacea*, *Ptilotus obovatus* and *Austrostipa elegantissima* over low sparse chenopod shrubland of mixed species including *Maireana georgei*, *Maireana trichoptera*, *Sclerolaena diacantha*, *Sclerolaena densiflora* and *Rhagodia drummondii* over low sparse tussock grassland and forbland of mixed species including *Austrostipa scabra* subsp. *scabra*, *Cephalipterum drummondii*, *Ptilotus nobilis, Zygophyllum ovatum* and *Mesembryanthemum nodiflorum* on red, red brown or brown clay loam soils with colluvial gravel, and occasionally with laterite outcropping, on lower slopes, plains and occasionally lateritic breakaways **Area mapped:** 313 ha (28.7 %) **Sampling:** 10 quadrats (ES-05, ES-08, ES-14, ES-15, ES-16, ES-21, ES-33, ROTH-04, KIOP-202, KIOP-212) **Significant Taxa:** *Acacia karina* (P1), *Allocasuarina tessellata* (P1), *Grevillea scabrida* (P1), *Bossiaea* sp. Jackson Range (G. Cockerton & S. McNee LCS 13614) (P3)^, *Grevillea subtiliflora* (P3), *Micromyrtus trudgenii* (P3), *Persoonia pentasticha* (P3)^, *Rhodanthe collina* (P3), *Stenanthemum poicilum* (P3)^ **Indicator Taxa:** *Austrostipa elegantissima*, *Eremophila oldfieldii* subsp. *oldfieldii, Eucalyptus loxophleba* subsp. *supralaevis, Rhagodia drummondii, Senna artemisioides* subsp. *filifolia* **Average Taxon Richness per Quadrat:** 34 ± 8 **Variation:** Structurally and compositionally this VT was relatively uniform across the Study Area. In some areas, the tall shrubland and mid shrubland strata were poorly developed and graded towards isolated shrubs only, however were otherwise typical. The dominant tree species in the low open woodland stratum varied across the Study	 **Plate 29:** Typical VT 8 (Quadrat ES-08)

VT	Summary	Photograph
	Area; generally, *Eucalyptus loxophleba* and *Eucalyptus salubris* dominated individually or co-dominated however occasionally *Eucalyptus clelandii* co-dominated with 1 or both of these species. The most significant variation corresponded to several small lateritic breakaways; on these features, the low open woodland was reduced to isolated trees of *Eucalyptus salubris*. There were also several taxa in the tall shrubland and low shrubland strata on these features that were not recorded elsewhere in this VT, and in some cases the entire Study Area, including *Allocasuarina acutivalvis* subsp. *prinsepiana* and *Melaleuca lateriflora* in the tall shrubland stratum, and *Hibbertia exasperata, Bossiaea* sp. sp. Jackson Range (G. Cockerton & S. McNee LCS 13614) (P3), *Stenanthemum poicilum* (P3) and *Acacia andrewsii* in the low shrubland stratum. This reflects the rocky nature of these features compared to the typical soils of this VT. However, the other strata on these features were generally typical.	 **Plate 30:** Variant of VT 8 (Quadrat ES-14)

VT	Summary	Photograph
9	**Description:** Tall sparse shrubland of mixed species including *Melaleuca hamata* and *Acacia acuminata* over mid shrubland dominated by *Thryptomene costata* and *Malleostemon tuberculatus* over low sparse shrubland of mixed species dominated by *Grevillea pityophylla*, *Hemigenia* sp. Yalgoo (A.M. Ashby 2624), *Stachystemon intricatus* and *Eremophila eriocalyx* over low sparse forbland of mixed species including *Borya sphaerocephala*, *Waitzia acuminata* var. *acuminata*, *Calocephalus multiflorus*, *Velleia rosea* and *Goodenia berardiana* on red brown clay loam soils with ironstone gravel on undulating plains **Area mapped:** 7 ha (0.6 %) **Sampling:** 1 quadrat (ES-20) **Significant Taxa:** - **Indicator Taxa:** - **Average Taxon Richness per Quadrat:** 34 ± 8 **Variation:** There was little structural and compositional variation in this VT based on the limited area mapped in the Study Area.	 **Plate 31:** Typical VT 9 (Quadrat ES-20)

^Denotes preferred habitat for a significant taxon.

5.2.2 Other Areas Described

Areas discernible at 1:10,000 scale where no vegetation occurred because of human disturbance were mapped as 'Cleared Land' (C). This included infrastructure associated with historical mining (pits, roads, tailings dam), the Rothsay townsite, and other major roads and tracks (Figure 10). A total of 46 ha of 'Cleared Land' has been mapped, representing 4.3 % of the Study Area. Smaller tracks were not mapped as 'Cleared Land' because of their small size.

One area near the existing tailings dam appears to have been cleared but left to re-grow; this has been mapped as a degraded area of VT 4 (VT 4d), as it is a slope of a basalt hill, with re-growing taxa typical of VT 4 (e.g. *Acacia karina* (P1), *Acacia acuminata*). A total of 1.9 ha of VT 4d has been mapped, representing 0.2 % of the Study Area.

5.2.3 Summary of Significant Vegetation

One listed significant vegetation entity is considered to occur in the Study Area, being:

- Blue Hills (Mount Karara/Mungada Ridge/Blue Hills) vegetation complexes (banded ironstone formation) PEC (Priority 1).

The above PEC is represented by VTs 2 and 3 in the Study Area. These VTs are identified in Table 10 below, and are discussed further in Section 5.2.4.

Several of the remaining VTs mapped in the Study Area are also considered to be significant vegetation in a local and regional context for reasons other than formal listing, as defined by EPA (2016). These VTs are also identified in Table 10 below, and are discussed further in Section 5.2.5.

Table 10: Summary of Significant Vegetation in the Study Area

VT	Local Context	Regional Context
1	Not considered significant in a local context • Mapped over several relatively large occurrences in the Study Area.	Not considered significant in a regional context • Quadrats within this VT appear similar to many other quadrats located in the wider region based on results of floristic analysis of the regional dataset; such quadrats are widespread in the region.
2	**Considered significant in a local context** • Considered to form part of the Blue Hills (Mount Karara/Mungada Ridge/Blue Hills) vegetation complexes (banded ironstone formation) PEC (Priority 1) based on results of floristic analysis of the regional dataset. • Mapped over several small occurrences in the Study Area. • May provide habitat for the Threatened taxon *Stylidium scintillans* (requires further survey).	**Considered significant in a regional context** • Considered to form part of the Blue Hills (Mount Karara/Mungada Ridge/Blue Hills) vegetation complexes (banded ironstone formation) PEC (Priority 1) based on results of floristic analysis of the regional dataset. • Quadrats within this VT appear similar to a number of other quadrats located in the wider region based on results of floristic analysis of the regional dataset; such quadrats are primarily located in the Mungada Ridge area.
3	**Considered significant in a local context** • Considered to form part of the Blue Hills (Mount Karara/Mungada Ridge/Blue Hills) vegetation complexes (banded ironstone formation) PEC (Priority 1) based on results of floristic analysis of the regional dataset. • Mapped over several small occurrences in the Study Area. • May provide habitat for the Threatened taxon *Stylidium scintillans* (requires further survey) (laterised ironstone outcrops).	**Considered significant in a regional context** • Considered to form part of the Blue Hills (Mount Karara/Mungada Ridge/Blue Hills) vegetation complexes (banded ironstone formation) PEC (Priority 1) based on results of floristic analysis of the regional dataset. • Quadrats within this VT appear similar to a number of other quadrats located in the wider region based on results of floristic analysis of the regional dataset; such quadrats are primarily located in the Mount Karara and Mungada Ridge area.
4	Not considered significant in a local context • Mapped over several relatively large occurrences in the Study Area.	Not considered significant in a regional context • Quadrats within this VT appear similar to a number of other quadrats located in the wider region based on results of floristic analysis of the regional dataset; such quadrats are widespread in the region.
5	Not considered significant in a local context • Mapped over several relatively large occurrences in the Study Area.	Not considered significant in a regional context • Quadrats within this VT appear similar to a number of other quadrats located in the wider region based on results of floristic analysis of the regional dataset; such quadrats are widespread in the region.
6	**Considered significant in a local context** • Mapped over several small occurrences in the Study Area.	**Considered significant in a regional context** • Quadrats within this VT appear similar to a relatively small number of other quadrats located in the wider region based on results of floristic analysis of the regional dataset; such quadrats are generally restricted to the vicinity of Rothsay.

VT	Local Context	Regional Context
7	**Considered significant in a local context** • Mapped over several small occurrences in the Study Area.	**Considered significant in a regional context** • Quadrats within this VT appear similar to a relatively small number of other quadrats located in the wider region based on results of floristic analysis of the regional dataset; such quadrats are generally restricted to the vicinity of Rothsay.
8	Not considered significant in a local context • Mapped over a number of large occurrences in the Study Area.	Not considered significant in a regional context • Quadrats within this VT appear similar to a number of other quadrats located in the wider region based on results of floristic analysis of the regional dataset; such quadrats are widespread in the region.
9	**Considered significant in a local context** • Mapped over 2 small occurrences in the Study Area. • May provide habitat for the Threatened taxon *Stylidium scintillans* (requires further survey).	**Considered significant in a regional context** • Quadrat within this VT does not appear to be especially similar to other quadrats located in the wider region based on results of floristic analysis of the regional dataset; regional distribution therefore unknown.

5.2.4 Listed Significant Vegetation

It is considered that the Blue Hills (Mount Karara/Mungada Ridge/Blue Hills) vegetation complexes (banded ironstone formation) PEC (Priority 1) occurs in the Study Area. This PEC is considered to be represented by VTs 2 and 3.

The presence of this PEC in the Study Area as VTs 2 and 3 has been determined using the results of the analysis of the regional dataset (see Section 3.5). In the resulting classification dendrogram, the quadrats within VT 3 in the Study Area are nested within a cluster together with a number of quadrats established within the Karara – Mungada Project Area by Woodman Environmental (2008). This cluster is within a larger grouping of quadrats that are predominantly located on banded ironstone hills. Examination of the classification analysis by Woodman Environmental (2008) indicates that the majority of these quadrats were located within VTs described by that survey that represent the Blue Hills (Mount Karara/Mungada Ridge/Blue Hills) vegetation complexes (banded ironstone formation) PEC. This apparently close relationship between quadrats from the Study Area within VT 3, and those within Woodman Environmental (2008) VTs that represent the Blue Hills (Mount Karara/Mungada Ridge/Blue Hills) vegetation complexes (banded ironstone formation) PEC, is considered to be adequate justification for VT 3 being a component of the PEC.

Two quadrats within VT 2 (ES-11 and ES-18) in the Study Area also nested within a cluster together with a number of quadrats established within the Karara – Mungada Project Area by Woodman Environmental (2008), in the same larger grouping of quadrats as those within VT 3. Examination of the classification analysis by Woodman Environmental (2008) indicates that the majority of these quadrats were located within VTs described by that survey that represent the Blue Hills (Mount Karara/Mungada Ridge/Blue Hills) vegetation complexes (banded ironstone formation) PEC. Interestingly, the remaining quadrat within VT 2 (ES-25) in the Study Area nested within a cluster that is within a larger grouping sister to the grouping containing quadrats located on banded ironstone hills; this sister grouping

contains quadrats predominantly located on duricrust outcrops. Although the majority are not located within the area mapped by Woodman Environmental (2008), some of the quadrats most similar to ES-25 are located within VTs mapped by Woodman Environmental (2008) that represent the Blue Hills (Mount Karara/Mungada Ridge/Blue Hills) vegetation complexes (banded ironstone formation) PEC. Further investigation would be required to ascertain why ES-25 is apparently relatively dissimilar to the other quadrats within VT 2 in the context of the regional dataset, however this is beyond the scope of this report.

The apparent similarity between quadrats from the Study Area within VT 2, and those within Woodman Environmental (2008) VTs that represent the Blue Hills (Mount Karara/Mungada Ridge/Blue Hills) vegetation complexes (banded ironstone formation) PEC, is also considered to be adequate justification for VT 2 being a component of the PEC.

Figure 11 shows the distribution of this PEC in the Study Area. Extracts from the dendrogram showing the above-mentioned clusters and groupings are presented in Appendix O.

5.2.5 Unlisted Significant Vegetation

It is considered that VTs 2, 6, 7 and 9 are of local significance, and VTs 6, 7 and 9 are of potential regional significance.

VTs 6, 7 and 9 are all considered to be significant vegetation in a local context, because of their restricted occurrence in the Study Area; all have been mapped over a limited number of occurrences that constitute less than 3 % of the total area of the Study Area. In addition, VTs 2 and 9 (and laterised ironstone outcrops in VT 3) may represent habitat for the Threatened flora taxon *Stylidium scintillans*.

These VTs are also considered to be potentially significant in a regional context. This has been inferred from the results of the analysis of the regional dataset (see Section 3.5).

VTs 6 and 7 are closely related, with one primary difference being the presence of *Eucalyptus clelandii* as a low open woodland in VT 6, and *Eucalyptus salubris* as a low open woodland in VT 7. Both quadrats from VT 7, and 1 quadrat from VT 6 (ES-09), are nested within small clusters within a relatively small grouping of quadrats in the regional dataset classification dendrogram. This grouping is comprised of quadrats primarily located in the general vicinity of the Study Area, with most quadrats containing either *Eucalyptus salubris* or *Eucalyptus clelandii*. This grouping is distinct from a much larger grouping that contains the remaining quadrat from VT 6 (ES-02), as well as all quadrats from the related VT 8; this grouping also contains numerous quadrats over a wide area within the region, with such quadrats generally characterised by the presence of *Eucalyptus loxophleba* subsp. *supralaevis* as a low open woodland. Further investigation would be required to ascertain why ES-02 is apparently distantly related to the other quadrat within VT 6 in the context of the regional dataset, however this is beyond the scope of this report.

Based on the results of the classification of the regional dataset, it is therefore considered that VTs 6 and 7 may have restricted regional distribution and occurrence, and therefore represent potentially significant vegetation in a regional context.

VT 9 is only represented by a single quadrat (ES-20) in the Study Area. This quadrat forms a cluster with a single other quadrat in the regional dataset classification dendrogram; examination of this quadrat indicates that it does not appear to be especially similar. This cluster is within a larger grouping that contains quadrats from VT 4 (vegetation on basalt hills); the location of this quadrat with quadrats from VT 4 is a similar result to the classification analysis of Study Area floristic data only (see Section 5.2.1), however ES-20 is not especially similar to any of the quadrats in this VT.

It is therefore considered that the regional distribution and occurrence of VT 9 is unknown. For this reason, it is considered that VT 9 represents potentially significant vegetation in a regional context.

The remaining VTs mapped in the Study Area (VTs 1, 4, 5 and 8) are not considered to be significant vegetation in a local or regional context. A number of relatively large occurrences of each were mapped in the Study Area; they are therefore considered to be locally common and widespread. It is likely that they are all represented by numerous large occurrences in the region based on the results of the regional dataset classification analysis; quadrats within these VTs were nested within large clusters together with numerous quadrats that are located throughout the region. VT 4 appears to have the most limited distribution, being restricted to the Rothsay and Mount Mulgine areas; however it is likely to be represented by numerous large occurrences in these areas (Woodman Environmental field observations).

No VTs mapped in the Study Area, or components of such VTs, are considered to represent groundwater-dependent ecosystems (GDEs).

It is considered that the VTs mapped in the Study Area do not meet any further criteria for significant vegetation as defined by EPA (2016).

5.2.6 Vegetation Condition

Excluding the areas mapped as Cleared Land, and the single polygon mapped as VT 4d, the vegetation in the Study Area was considered to be in 'Pristine' condition (Keighery 1994). Introduced taxa were often present, however were not serious weeds, and/or were present at low levels. Historical disturbance from mining activities was present in many areas, however this does not appear to have affected the overall condition of the vegetation. Goats were observed during the survey, however they do not currently appear to be affecting the condition of the vegetation. Major infestations of serious weeds were restricted to areas mapped as Cleared Land associated with historical mining and the Rothsay townsite (see Section 5.1.5). Areas mapped as Cleared Land were not allocated condition scores, as they do not constitute vegetation in the context of the condition scale used by this survey (Keighery 1994).

The single polygon mapped as VT 4d is considered to be in 'Good' condition. This area appears to have been previously cleared, and has re-grown to an extent, however not to a state approaching the areas of VT 4 in the Study Area.

6. DISCUSSION

6.1 Flora of the Study Area

A total of 300 discrete vascular flora taxa and 1 putative hybrid were recorded within the Study Area. This number was expected; both the greenstone and banded ironstone hills within and in the vicinity of the Study Area are known to contain relatively diverse floras; however the floras are very different from each other (Meissner and Coppen 2014). The Study Area also contains valleys and plains with deeper soils, which contributed further taxa to the overall total. Although further taxa are likely to be present in the Study Area, as not all parts were accessed, it is considered that the Study Area has been well sampled; this is supported by the adequacy of survey measures tested in Section 4.1.

Although the survey was conducted towards the end of what is considered to be the most appropriate time for survey (late winter to early spring), the above-average rainfall received by the Study Area prior to the survey in 2016 is considered to have promoted an excellent flowering season that extending longer than usual, and therefore the timing of the survey has not significantly affected the survey results. This is supported by the significant number of ephemeral taxa recorded; of the 300 taxa recorded, 114 were ephemeral. This compares favourably with Meissner and Coppen (2014), who recorded 137 ephemeral taxa (out of a total of 286), albeit over a much larger geographical area.

The number of significant flora taxa (17) recorded in the Study Area was also considered to be high, particularly given the relatively small size of the Study Area. However, this was also not unexpected, given the high levels of endemism of flora taxa on the greenstone and banded ironstone hills in the vicinity of the Study Area (Markey and Dillon 2008; Meissner and Coppen 2014), which has resulted in many taxa being listed as significant. In particular, the greenstone hills contain many significant flora taxa compared to other areas in the Study Area, with VT 4 (mapped on basalt hills) being the preferred habitat for 10 of the 17 significant flora taxa.

No Threatened flora taxa are known to occur in the Study Area, however potential habitat for *Stylidium scintillans* (Threatened) was identified and mapped. A survey for this taxon during its known flowering period (late August-early September) would be required to determine if it occurs in the Study Area; however, this is only necessary if the Project is likely to impact the potential habitat, either indirectly or directly.

The remaining significant flora taxa are Priority flora; it is likely that sufficient survey for the majority of taxa to inform an assessment of impacts of the Project has already been undertaken. However, this is dependent on the location and nature of impacts of the Project. One possible exception is *Hemigenia tichbonii* (P1), a taxon that has not previously been recorded in the vicinity of the Study Area. Very little is known of the distribution and abundance of this taxon; it is currently known from only a few locations, albeit over a reasonable range, with no information available on abundance at most locations. Further survey may be required if it is considered likely that this taxon will be impacted by the Project. It is of note that this taxon now appears to share a similar distribution to a number

of taxa endemic or near-endemic to basalt hills (*Acacia karina* (P1), *Allocasuarina tessellata* (P1), *Grevillea scabrida* (P1), *Grevillea subtiliflora* (P3)), occurring on the basalt hills near Rothsay and Mount Mulgine, as well as those on Ninghan and Mount Gibson Stations, approximately 50 km to the south south-east of Rothsay.

Two serious weeds, *Echium plantagineum* (Paterson's Curse) and *Acetosa vesicaria* (Ruby Dock), were recorded in the Study Area, and were particularly prevalent in some cleared areas associated with historical mining and the Rothsay townsite. Other less serious weeds were also prevalent in such areas, Mapping and control of these taxa is recommended, particularly within proposed impact areas; it is likely that these taxa may invade new disturbance areas, including rehabilitation areas. It is important that proposed Project impacts also employ appropriate hygiene procedures, including post-impact inspections, to manage the potential introduction and spread of introduced taxa, particularly in regard to the serious weed taxa mentioned above.

6.2 Vegetation of the Study Area

Nine VTs were defined and mapped in the Study Area. This number was expected, given the variety of geologies and topographies in the Study Area, coupled with the differing floras on the predominant geological and topographical units (basalt and ironstone hills).

The parameters used for the classification analysis in this assessment are considered to have produced a robust classification with ecologically plausible clusters of quadrats that were used to define VTs. However, some clusters contained a small number of quadrats (in the case of VT 9, only 1), and therefore some VTs were defined using limited data. This issue frequently arises when sampling is restricted to a small area, and may result in the description of somewhat artificial VTs that reflect the limited level of sampling. However, the classification analysis of the regional dataset also broadly supported the final definition of VTs in the Study Area. The VTs described in the Study Area are therefore considered to be a relatively accurate reflection of the floristic, geological and topographical variability of the Study Area.

VT 9 is somewhat anomalous in the Study Area, being represented by a single quadrat and being mapped over a very small area. Both the classification analysis of data from the Study Area only, as well as of the regional dataset, indicates that this VT is most closely related to VT 4. However, examination of quadrat data indicates that it is not especially similar to any of the quadrats in this VT, or any quadrats within the regional dataset, and is therefore better considered to be a discrete VT, rather than an extreme variation of VT 4. VT 9 also occurs on an undulating plain with what is thought to be granite bedrock close to the surface, rather than on basalt hills as for VT 4. It is considered likely that this VT occurs to the south of the Study Area; this area has not been sampled by any of the studies included in the regional dataset. However, further sampling would be required to determine if this is the case.

The Blue Hills (Mount Karara/Mungada Ridge/Blue Hills) vegetation complexes (banded ironstone formation) PEC (Priority 1) is considered to occur in the Study Area, being

represented by VTs 2 and 3. This was determined through analysis of the regional dataset, which included the quadrat dataset from Woodman Environmental (2008); this dataset was originally used to define the PEC. It should be noted that the resulting classification of the regional dataset could not be directly compared to the classification of the Woodman Environmental (2008) dataset; therefore, it could not be determined whether VTs 2 and 3 were directly equivalent to any of the Woodman Environmental (2008) VTs considered to represent the PEC. This is because the addition of quadrats from the regional dataset to the Woodman Environmental (2008) dataset resulted in re-arrangement of the Woodman Environmental (2008) quadrats; this is to be expected when a large amount of additional data is included in an analysis. However, the analysis indicated that quadrats from VTs 2 and 3 were closely similar to many quadrats that are located in areas mapped as the PEC by Woodman Environmental. This coupled with the location of the quadrats in VTs 2 and 3 on banded ironstone, or areas associated with such formations, is considered to be justification for recognising VTs 2 and 3 as representing the PEC. The method used to determine the presence of this PEC in the Study Area is in line with that recommended by EPA and DPaW (2015).

Several VTs are considered to potentially represent significant vegetation, in both a local and regional context. As mentioned above, VT 9 does not appear to be represented in the regional dataset; its distribution outside the Study Area is therefore unknown, however it is considered likely to occur to the south of the Study Area. In the case of VTs 6 and 7, both are considered to occur outside the Study Area, with this assumption supported by the classification analysis of the regional dataset. However, they are likely to be relatively geographically restricted and limited in occurrence size, based on the small number of similar quadrats in the regional dataset, the locations of similar quadrats in the region, and field observations by Woodman Environmental, which indicate that they have a close association with the basalt hills in the vicinity of Rothsay. They are therefore also considered to represent potentially significant vegetation, with further investigation of occurrences outside the Study Area required to accurately determine their significance.

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WOODMAN ENVIRONMENTAL

OUR REFERENCE: CO-0013-2018

Ben O'Grady
Environmental Superintendent
Egan Street Resources Ltd

Dear Ben,

Rothsay Gold Project – targeted survey for *Stylidium scintillans* (Threatened)

Woodman Environmental Consulting Pty Ltd (Woodman Environmental) were requested by Egan Street Resources Ltd (Egan Street) to conduct a targeted survey for *Stylidium scintillans* (Threatened) in the Rothsay Gold Project Study Area (Study Area), as shown on Figure 1. The requirement for a targeted search for this taxon was based on the identification of potential habitat for this taxon in the Study Area during a detailed survey of the Study Area in 2016 (Figure 1). This habitat was not searched in detail in 2016 as the timing of the survey was outside the known flowering period for this taxon, with flowers required for detection and positive identification.

The targeted survey was conducted on the 27th and 28th August 2018; this is within the known flowering period of this taxon according to records lodged at the W.A. Herbarium. It is also considered that the weather conditions required for flowering in this species occurred prior to the survey being conducted; according to the Bureau of Meteorology, 152.2 mm of rain was received by Karara Station, located close to the Study Area, from May to August 2018, compared to the long-term average of 159.4 mm over this period. A brief visit to a known population of this taxon located approximately 12 km north-east of the Study Area on the 27th August confirmed that this taxon was in flower at the time of survey, with approximately 20 plants seen in full flower. The targeted survey was conducted by experienced botanists David Coultas, who has conducted a number of previous surveys for this taxon, and Marlee Starcevich. All areas of potential habitat identified by the detailed survey in 2016 were transected on foot; these transects are displayed in the form of GPS track logs on Figure 1.

No individuals of *Stylidium scintillans* (Threatened) were recorded by this survey. It is therefore considered highly unlikely that this taxon occurs in the Study Area. This is despite the clear similarity between potential habitat identified in the Study Area, and that at known populations such as the one visited as part of this survey. However, previous surveys for this taxon by Woodman Environmental returned similar results, with this taxon not found at a number of areas in the general vicinity of the Study Area that are considered very similar to locations that the taxon was found (Woodman Environmental field observations). The specific conditions required to support this taxon are currently unknown.

Whilst conducting the targeted survey for *Stylidium scintillans* (Threatened), three additional significant flora taxa were opportunistically recorded in the Study Area: *Menkea draboides* (P3), *Micromyrtus acuta* (P3) and *Petrophile pauciflora* (P3). *Menkea draboides* (P3) is a small, inconspicuous ephemeral taxon; it was recorded at a single location in the Study Area during this survey (Figure 1), with 100 plants noted. However, it may be more widespread in the Study Area, as it is easily overlooked. *Micromyrtus acuta* (P3) and *Petrophile pauciflora* (P3) are relatively conspicuous and readily identifiable shrubs that were also only recorded at single locations during this survey, with 40 and 10 plants noted respectively. It is not expected that these taxa occur widely in the Study Area, and they may only occur at these locations, as they were not recorded by the detailed survey in 2016. Photographs of these taxa are provided below (all photographs by Woodman Environmental).

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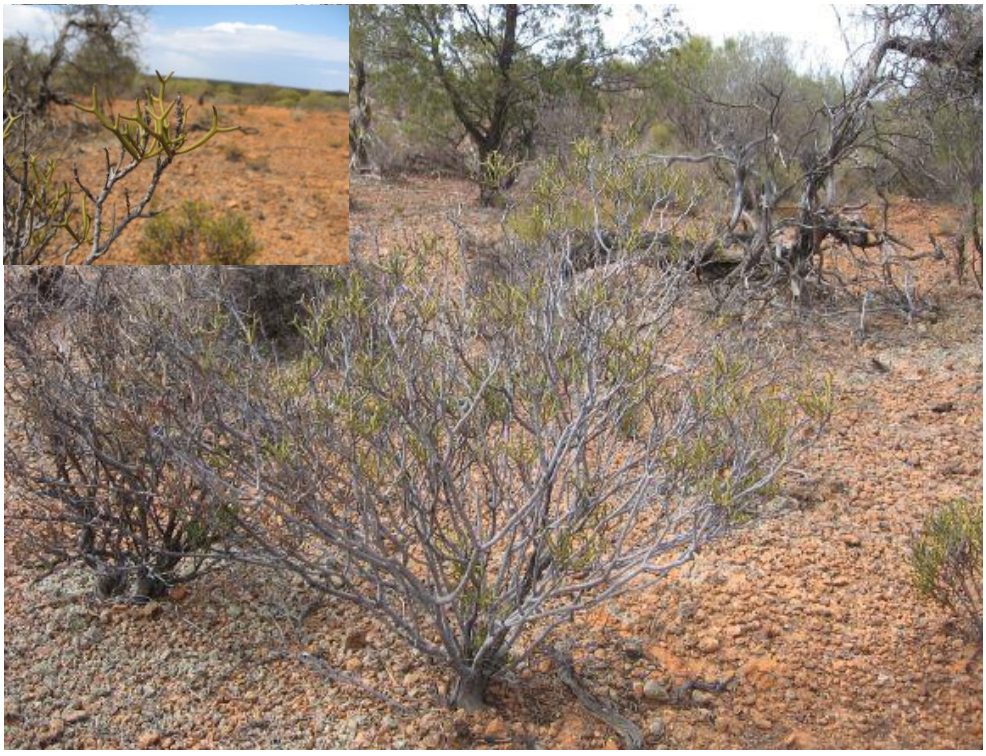
Additionally, 2 further locations of *Calandrinia* sp. Warriedar (F. Obbens 04/09) (P2), a taxon that was recorded during the detailed survey in 2016, were opportunistically recorded during this current survey (Figure 1). It was common at both locations over a small spatial area, with 200 plants estimated at each location.

Menkea draboides **(P3) in middle ground with white flowers and flattened-cylindrical fruits; note that the fleshy, rounded leaves in the foreground do not belong to this species**

***Micromyrtus acuta* (P3)**



***Petrophile pauciflora* (P3)**

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Kind regards,

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