BHP BILLITON YEELIRRIE DEVELOPMENT COMPANY PTY LTD

Yeelirrie Project

Flora and Vegetation Survey

Baseline Report

February 2011

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28th February 2011

For:
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Report Ref: WB653

Document Status

Version	Date	Distribution
0	28.02.2011	URS Australia, Electronic

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Acknowledgements: Doug and Lucy Brownlie (Yakabindie Station), Gil and Dale O'Brien (Yeelirrie Homestead) Doug Blandford (DC Blandford & Associates), BHP Billiton Yeelirrie Development Company Pty Ltd field staff and contractors, HeliWest pilots (Simon, Luke, Mike and Brad).

Map Production by CAD Resources Pty Ltd

Executive Summary

The Proposed Yeelirrie Development (project) at Yeelirrie Pastoral Station, is some 700 km north-east of Perth and 500 km north of Kalgoorlie (Figure 1). BHP Billiton Yeelirrie Development Company Pty Ltd (BHPB Billiton), through URS Australia Pty Ltd, engaged Western Botanical to undertake an assessment of the flora and vegetation within an area referred to as the total study area. The total study area includes the areas studied both locally and regionally.

The Proposed Yeelirrie Development lies within study area 1. The local study area is defined as study areas 1, 2 and 3 (Figure 2), and the regional study area is defined as study areas 4 to 16 (Figure 3). During the assessment of study area 4 the north-western section was redefined as study area 3 (Figure 7).

The total study area (study areas 1 to 16), excluding study areas 8 and 9, lies in the Eremaean Botanical Province within the Murchison Biogeographic Region and the East Murchison (MUR1) subregion. Study area 8 lies within the West Murchison (MUR2) subregion, while study area 9 lies predominately within the Carnegie (GAS2) subregion of the Gascoyne Biogeographic Region.

The local study area falls between two Department of Agriculture Western Australia (DAWA) rangeland condition survey areas; the 'Sandstone-Yalgoo-Paynes Find' area and the 'North-eastern Goldfields' area.

Prior botanical knowledge of the Murchison Biogeographic Region consisted of broad scale regional flora surveys completed as part of rangeland condition surveys which provide a general account of vegetation and descriptions of land systems. More detailed surveys have been undertaken by the Department of Environment and Conservation (DEC) and the Western Australian Museum.

Western Mining Corporation Limited (WMC) completed flora and vegetation studies for the project as part of the WMC Draft Environmental Impact Statement (EIS) and Environmental Review and Management Programme (ERMP) for the project in 1979. None of the flora recorded at that time was considered rare and the majority of identified species were known to occur in similar landforms in the region. A number of the plants collected were at the time undescribed and it was not possible to

determine whether or not they were of particular botanical significance, as their regional distribution was not understood.

In the last 20 years, a number of flora and vegetation surveys including habitat mapping, have been undertaken in association with increased mining activities in the vicinity of the project. Western Botanical has undertaken the majority of these surveys. This report identifies species not identified during the WMC studies.

Survey effort

For the purposes of this report, Western Botanical completed both 'local' and 'regional' surveys. The local surveys are defined as study areas 1, 2 and 3. Study area 1 includes the project footprint area and the proposed 45 km access road from the Goldfields Highway. Study area 2 covers the proposed wellfields, quarry and buffers, and consists of five areas extending from borders of the north and south perimeter of study area 1. Study area 3, a satellite tenement, lies 30 km south-east of study area 1, and is a subset of study area 4. A section of the proposed access road, assessed as part of the study area 1, forms part of the northern boundary of study area 3.

Flora and vegetation surveys of the total study area were undertaken from December 2008 to December 2010, during which a total of 39 field visits were conducted. The proposed level of disturbance determined the level of survey detail in each study area.

Local study area surveys included mapping the vegetation communities and searching for, quantifying and distinguishing the extent of populations of significant species. In study area 1, the area studied in greatest detail, Western Botanical completed a Level 2 assessment of the flora and vegetation in accordance with Guidance Statement 51 issued by the Western Australian Environmental Protection Authority (EPA, 2004). This included mapping the vegetation communities, mapping the distribution and abundance of significant flora and assessing quadrats and relevés to provide a statistical analysis of the variation in the floristic composition of vegetation communities.

The regional surveys, defined as study areas 4 to 16, extended over an area of 185,000 square km and included targeted searches for significant flora and vegetation

communities of interest that were primarily associated with the Central Calcrete System within study area 1.

Land systems & vegetation communities

Contrasts in vegetation structure and species composition reflect soil chemical and physical properties, landscape position, hydrology and underlying geology. These vary significantly on a broad scale between land systems as defined by DAWA and also in the local study area in relation to soil landscapes defined by D.C. Blandford in *Soils and Soil Landscapes of the Yeelirrie Study Area* (Blandford, 2011). Further finer scale differences in vegetation structure and species composition were utilised to define vegetation communities in the local study area.

Many of the land systems found within the local study area are well represented in the wider biogeographical region. However, there is a considerable representation of land type 18, described as *calcrete drainage plains with mixed halophytic and non-halophytic shrublands* and its four component land systems, within the local study area. This is of interest due to the limited and disjunct distribution of this land type throughout the Sandstone-Yalgoo-Paynes Find and the North-eastern Goldfields Survey Areas. Regional representation of land type 18 (calcrete drainage plains), its four component land systems: Cunyu, Cosmo, Mileura and Melaleuca, and the vegetation communities supported within these land systems, are associated with the margins of salt lakes and occluded paleodrainage channels. These are an uncommon and geographically isolated series of land systems and vegetation communities within the broader region.

Fifty-two vegetation communities, which included one complex, were mapped within the local study area. Thirty-nine of these communities were represented in study area 1. The vegetation communities were aligned and associated with the four soil landscapes described by D.C. Blandford in *Soils and Soil Landscapes of the Yeelirrie Study Area* (Blandford, 2011): Granite Breakaway System, Sand Plain System, Playa System and Central Calcrete System (Calcrete System). A fifth system was added, Hardpan and Drainage System, which forms a continuum between the Sand Plain System and Playa System. A sixth system, the Saline Playa System, was also described in study area 3, which was not represented in study area 1 or 2.

Priority Ecological Communities

Western Botanical found no flora related Priority Ecological Communities (PECs) and Threatened Ecological Community (TECs) listed under the EPBC Act 1999 or WC Act 1950 as occurring within the study area 1.

Some vegetation communities, particularly those occurring within the Calcrete System of study area 1, are considered of interest as they are based on current information available of limited distribution. Some of these vegetation communities that are mapped in study area 1 fall within the descriptions of ecosystems at risk described by Cowan (2001) within the East Murchison IBRA subregion. These ecosystems are considered as being of limited distribution and at risk, and consequently, they are collectively considered to have conservation significance. The vegetation communities of interest within study area 1 are:

(i) Communities recognised by Cowan (2001) as being of limited distribution and at risk:

- CEgW *Eucalyptus gypsophila* Woodland on Calcrete, equivelent to Calcrete platform woodlands/shrublands of the north-east Goldfields (Pringle *et al.* 1994 - site type 8);
- CCpW *Casuarina pauper* Woodland on Calcrete, equivelent to Calcyphytic casuarina acacia woodlands/shrublands of the north-east Goldfields (Pringle *et al.* 1994 - site type 7); and
- CMxS *Melaleuca xerophila* Shrubland on Calcrete, equivalent to *Melaleuca* sp. nov. Low Closed to Open Forest Strand Community Near Wiluna.

(ii) Communities described by Western Botancial and known from within the local study area only:

- CApS *Atriplex* sp. Yeelirrie Station Shrubland on Calcrete. New community described by Western Botanical and is not documented to date. CApS is dominated by *Atriplex* sp. Yeelirrie Station on self-mulching clay in depressions and is confined to clay flats within the Calcrete System. Based on

current information available the CApS community is limited in distribution; and

- CRsS *Rhagodia* sp. Yeelirrie Station Shrubland on Calcrete. New vegetation community described by Western Botanical and is not documented to date. Based on current information available the CRsS community is limited in distribution.

Phreatophytic vegetation

Limited analysis of Phreatophytic vegetation (vegetation that utilises groundwater) has been undertaken in the local study area. The following vegetation communities are potentially groundwater dependent due to the specific species found within them: CMGbS, CEgW, CMxS, CCpW, PLAET and PLAMi. In addition to these communities, many potentially phreatophytic species occur scattered throughout large expanses of the Sand Plain System and Hardpan and Drainage System. These species include *Melaleuca interioris*, *Grevillea berryana*, *Eucalyptus* and *Corymbia* species, which occur in the SAWS, SAMU, SAMA, SAGS, SACSG, SASP and / or HPMS vegetation communities. It is also believed that many of the species within the study area 1 survive on perched water within the soil profile.

Threatened Flora, Declared Rare Flora, Priority Flora and Flora of Conservation Interest

During the desktop study:

- no species of Threatened Flora, as defined under Commonwealth legislation (*Environment Protection and Biodiversity Conservation (EPBC) Act 1999*), were known to occur in or within or in the vicinity of study area 1;

- no Declared Rare Flora (DRF) as defined under the *Western Australian Wildlife Conservation (WC) Act 1950* were known to occur in or within the vicinity of study area 1;

- twenty-six Priority Flora taxa listed by the DEC were known to occur in the vicinity of study area 1; these include five ‘P1’, seventeen ‘P3’ and four ‘P4’ species; and

- five Priority Flora species were identified in the project footprint area; these include two P1 species and three P3 species.

During the surveys, Western Botanical recorded:

- no species of Threatened Flora in the total study area;
- no Declared Rare Flora (DRF) in the total study area;
- Eight Priority Flora species in study area 1; these include two ‘P1’, four ‘P3’ and one ‘P4’ species;
- Seven Priority Flora species in study area 2; these include two ‘P1’, five ‘P3’ species; and
- Three Priority Flora species in study area 3; these include one ‘P1’, and two ‘P3’ species.

Priority species, significant flora and species of interest within study area 1

The two Priority One species in study area 1 were: *Atriplex* sp. Yeelirrie Station (L. Trotter and A. Douglas LCH 25025) and *Rhagodia* sp. Yeelirrie Station (K.A. Shepherd et al. KS1396).

The other Priority species in study area 1 were: *Euryomyrtus inflata* P3, *Baeckea* sp. Sandstone (C.A. Gardner s.n. 26 Oct. 1963) P3, *Bossiaea eremaea* P3, *Eremophila arachnoides* subsp. *arachnoides* P3, *Olearia arida* P4 and *Comesperma viscidulum* P4.

Three species of significant flora represent new taxa that were recognised for the first time following these surveys: *Atriplex* sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025), P1 *Rhagodia* sp. Yeelirrie Station (K.A. Shepherd et al. KS1396) P1 and *Scaevola spinescens* terete leaf form (G. Cockerton & C. Ringrose LCH 14560). The latter undescribed species does not as yet appear on the Census of Vascular Flora and therefore does not appear on the FloraBase website (Western Australian Herbarium).

A further 12 species 'of interest', which are not considered to be of conservation significance, were also recorded in study area 1. Species of interest are classified within this report as being flora that represent either (i) significant range extensions or, (ii) are geographically restricted or, (iii) may be poorly collected and / or, (iv) require further taxonomic work. Particular focus was placed on *Templetonia incrassata,* which was a newly defined taxon during the survey period that has been poorly recorded in the Murchison region. Records within the study area 1 represent a significant range extension.

***Atriplex* sp. Yeelirrie Station (L. Trotter and A. Douglas LCH 25025) P1**

Atriplex sp. Yeelirrie Station is a new species recognised during these surveys that was listed as Priority One by the DEC in September 2009. To date, *Atriplex* sp. Yeelirrie Station has been found at two major locations only: (i) in two sub-populations within study area 1 and (ii) in ten sub-populations south-east of study area 1, within study area 3. The second location of *Atriplex* sp. Yeelirrie Station was recorded during the regional survey of study area 4. After the initial findings, a more

detailed survey was done in the north-western section of study area 4 which was redefined as study area 3.

Western Botanical has estimated, provided the taxon of *Atriplex* sp. Yeelirrie Station are the same in study areas 1 and 3, that 30.71% of the total known individuals of *Atriplex* sp. Yeelirrie Station (approximately 84,510) lie within the proposed open pit mine. A minor population of scattered individuals (< 50) was observed in a historical rehabilitation site to the south of the proposed pit in study area 1. The remainder of the known individuals of *Atriplex* sp. Yeelirrie Station (approximately 190,656) are located in a confined area of study area 3. *Atriplex* sp. Yeelirrie Station predominately occurs in the vegetation community described as *Atriplex* sp. Yeelirrie Station shrubland on calcrete (CApS). It occurs on self-mulching clay in depressions and is confined to clay flats within the Calcrete System.

During the regional surveys, particular focus was placed on locating additional populations of *Atriplex* sp. Yeelirrie Station. Initially six paleodrainage and lake systems were selected for investigation based on the distribution of 'Land Type 18', and its four land systems: Cunyu, Cosmo, Mileura and Melaleuca, and their associated vegetation communities.

A targeted flora survey was undertaken utilising a helicopter to visit the lake systems and select areas for targeted on-ground surveys. On-ground surveys were undertaken at the southern end of the Yeelirrie palaeochannel and Lake Miranda, Lake Way, Lake Mason and Lake Noondie. A second targeted flora survey was undertaken, utilising a helicopter, to search for additional populations of *Atriplex* sp. Yeelirrie Station at a further seven lake systems or paleodrainage systems. These systems were selected for investigation based on the presence of the Cunyu and Mileura land systems and areas of self-mulching clay. No additional populations of *Atriplex* sp. Yeelirrie Station were located.

Rhagodia sp. Yeelirrie Station (K.A. Shepherd et al. KS1396) P1

Rhagodia sp. Yeelirrie Station is a new species recognised during these surveys that was listed as Priority One by the DEC in August 2010. This taxon is new and distinct from known species of *Rhagodia* and is readily recognised in the field. While a preliminary investigation has been undertaken, a formal description has not yet been

prepared as adequate fruiting material has not yet been available. Western Botanical has estimated that a total of approximately 2,200 individuals occur within study area 1.

Rhagodia sp. Yeelirrie Station was recorded in five populations within study area 1 in the vegetation community described as *Rhagodia* sp. Yeelirrie Station shrubland on calcrete (CRsS). All five populations are associated with calcrete and Playa lakes. Four areas of this vegetation community (CRsS) occur outside the project footprint, while one population (approximately 100 individuals) occurs within the project footprint. Scattered individuals of *Rhagodia* sp. Yeelirrie Station also occur within *Melaleuca interioris* and *Acacia aneura* shrubland (PLAMi) vegetation, which fringes CRsS.

In addition to study area 1, this species in known only from the Coolgardie and Murchison Biogeographic regions and there are currently two voucher collections listed on FloraBase (Western Australian Herbarium, 2011). Collection localities include Rowles Lagoon (north-west of Kalgoorlie) and Pinnacles Station near Lake Noondie, the latter recorded during Western Botanical regional surveys in study area 7.

Priority species and species of interest within study area 2

Seven priority species were recorded from study area 2, including two Priority One flora, *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) and *Neurachne lanigera*, and five Priority Three flora, *Sauropus ramosissimus*, *Bossiaea eremaea*, *Euryomyrtus inflata*, *Calytrix erosipetala* and *Calytrix uncinata*.

Priority species and species of interest within study area 3

Western Botanical has estimated that there are a total of 190,656 *Atriplex* sp. Yeelirrie Station P1 individuals occurring within study area 3, a subset of study area 4. In addition, the following significant flora were recorded: *Bossiaea eremaea* P3, *Eremophila arachnoides* subsp. *arachnoides* P3, *Scaevola spinescens* terete leaf form and *Templetonia incrassata*.

Priority species and species of interest within regional study areas (study areas 4 to 16)

Regional surveys focused on determining the representation elsewhere of significant flora and vegetation communities of interest that were primarily associated with the Calcrete System within study area 1. This included searching for additional populations of *Atriplex* sp. Yeelirrie Station P1. A total of 13 paleodrainage and lake systems were surveyed during these targeted investigations. In addition to *Atriplex* sp. Yeelirrie Station, the following significant flora were recorded: *Rhagodia* sp. Yeelirrie Station P1, *Eremophila arachnoides* subsp. *arachnoides* P3, *Templetonia incrassata* and *Scaevola spinescens* terete leaf form.

Flora recorded within the local study area (study areas 1, 2 and 3)

A total of 577 taxa from 199 genera and 62 families were recorded within the local study area, including 11 non-endemic weed species. Most species recorded from the survey area are widespread and common in the region and occur across a range of land systems and soil types.

Weeds

Eleven weed species were recorded within the study area 1: *Acetosa vesicaria* (Ruby Dock), *Sonchus oleraceus* (Common Sowthistle), *Citrullus lanatus* (Afghan Melon or Pie Melon), *Tribulus terrestris* (Caltrop), *Cenchrus ciliaris* (Buffel Grass), *Lysimachia arvensis* (Pimpernel), *Cuscuta planiflora* (Dodder), *Erodium aureum*, *Portulaca oleracea* (Purslane), *Emex australis* (Doublegee), and *Opuntia* sp (a Cactus). Further, *Carrichtera annua* (Wards Weed) is suspected to be present as dead stems reminiscent of this species were observed. Weeds noted are generally non-aggressive species; however, the presence of *Acetosa vesicaria* in areas rehabilitated in 2004 is a concern as these areas could potentially act as a weed seed source in future.

Tribulus terrestris and *Citrullus lanatus* were also recorded in study area 3.

Vegetation Condition

Although the Murchison and North-eastern Goldfields regions are largely uncleared, the ecological integrity of these regions has been degraded by the combined effects of grazing by sheep, cattle, goats, rabbits and elevated populations of kangaroos (Van

Vreeswyk Godden, (1998). The local study area containing the Yeelirrie uranium deposit has been subject to long-term historical pastoral grazing and various exploration activities over the last forty years, which resulted in land clearing. The majority of the vegetation within the local study area is in 'excellent' condition (based on the ranking scale of Keighery 1994) with the exception of the historical rehabilitation areas in the project footprint, which are in a 'degraded' condition. Vegetation condition of the local study area reflected seasonal conditions. The effects of past grazing activities were more evident on palatable shrub species and were accentuated during poor seasonal conditions.

Assurance

This report was completed in accordance with the scope provided by BHP Billiton Yeelirrie Development Company Pty Ltd. The scope of work was undertaken by a team that included nineteen people over a period of two years. Flora and vegetation surveys were conducted using best practice principles and coordinated and led by botanists who had the relevant training and experience. Where possible all methods and results have been standardized. All limitations to vegetation surveys, plant identification and reporting have been provided in the relevant sections of the report.

To the best of their knowledge the authors verify that is report is complete and accurate at the time of publication.

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1. Introduction

BHP Billiton Yeelirrie Development Company Pty Ltd (BHPB Billiton) proposes to develop the Proposed Yeelirrie Development (project) in the North-eastern Goldfields of Western Australia within the Yeelirrie Pastoral Station, which lies in the Shire of Wiluna (Figure 1). The site is located at an elevation of between 480 and 595 m above sea level, approximately 550 km due east of the Port of Geraldton, 500 km north of Kalgoorlie, 110 km north-west of Leinster, 80 km south of Wiluna and 60 km west of the Mt Keith nickel mine.

1.1. Scope of submission

BHP Billiton Yeelirrie Development Company Pty Ltd (BHPB Billiton), through URS Australia Pty Ltd, engaged Western Botanical to undertake an assessment of the flora and vegetation within an area referred to as the total study area.

The total study area includes both areas studied locally (study areas 1, 2 and 3, Figure 2) and regionally (study areas 4 to 16), as presented by (Figure 3).

The scope included:

A Level 2 assessment of the flora and vegetation, within study area 1, suitable for the purposes of an ERMP in accordance with Guidance Statement 51 issued by the Western Australian Environmental Protection Authority (EPA, 2004). This included mapping the vegetation communities at a scale of 1:10,000 within study area 1, mapping the distribution and abundance of significant flora, and establishing and assessing 182 quadrats and 180 relevés within study area 1 to provide a numerical analysis of the variation in the floristic composition of vegetation communities. A greater survey effort was undertaken within the project footprint of study area 1.

Floristic surveys within study area 2, which included mapping the vegetation communities at a scale of 1:20,000, searching for and recording the extent of significant species.

Floristic surveys within study area 3, which included mapping the vegetation communities at a scale of 1:10,000, and mapping the distribution and abundance of significant flora, with particular focus on *Atriplex* sp. Yeelirrie Station.

Undertaking regional surveys to provide a regional context for the distribution of flora species and vegetation communities of conservation significance or interest that were recognised within study area 1. This included the species of interest and communities primarily associated with calcrete. The reasoning behind regional surveys is further defined in Section 1.11.

1.2. Location of study areas

For the purposes of completing this report, Western Botanical undertook both 'local' and 'regional' surveys. Local surveys included the areas defined as study areas 1, 2 and 3, with an area of 48,901 ha, 42,028 ha and 9,843 ha, respectively. The largest of these areas was defined as study area 1 and formed the focus of the flora and vegetation assessments conducted by Western Botanical. These study areas and their relationship to the Ministerial Temporary Reserve (TR70/6899) (MTR) is shown in Figure 2.

Study area 1 includes the project footprint area and the proposed 45 km access road from the Goldfields Highway. Study area 2 consists of five areas extending out from the boundary of study area 1 and includes the proposed quarry site, wellfields and buffers of the project.

Study area 3 is located on both Yeelirrie and Albion Downs Station, 30 km south-east of the proposed project footprint (located in study area 1) with a section of the proposed access road from study area 1 forming part of the northern boundary. Study area 3 was first assessed as part of the regional surveys and occurs in the north-west tip of study area 4 (discussed below) which includes the Yeelirrie Palaeochannel and Lake Miranda. Further detail of the relationship between study areas 3 and 4 is provided in Section 2.1.3.

The regional surveys are defined as study areas 4 to 16, as shown in Figure 3 and extend over an area of approximately 185,000 square km (Table 8 and Table 9). The regional surveys included targeted searches for significant flora and vegetation

communities of interest that were primarily associated with the Calcrete System within study area 1.

Figure 1. Proposed Yeelirrie Development location map

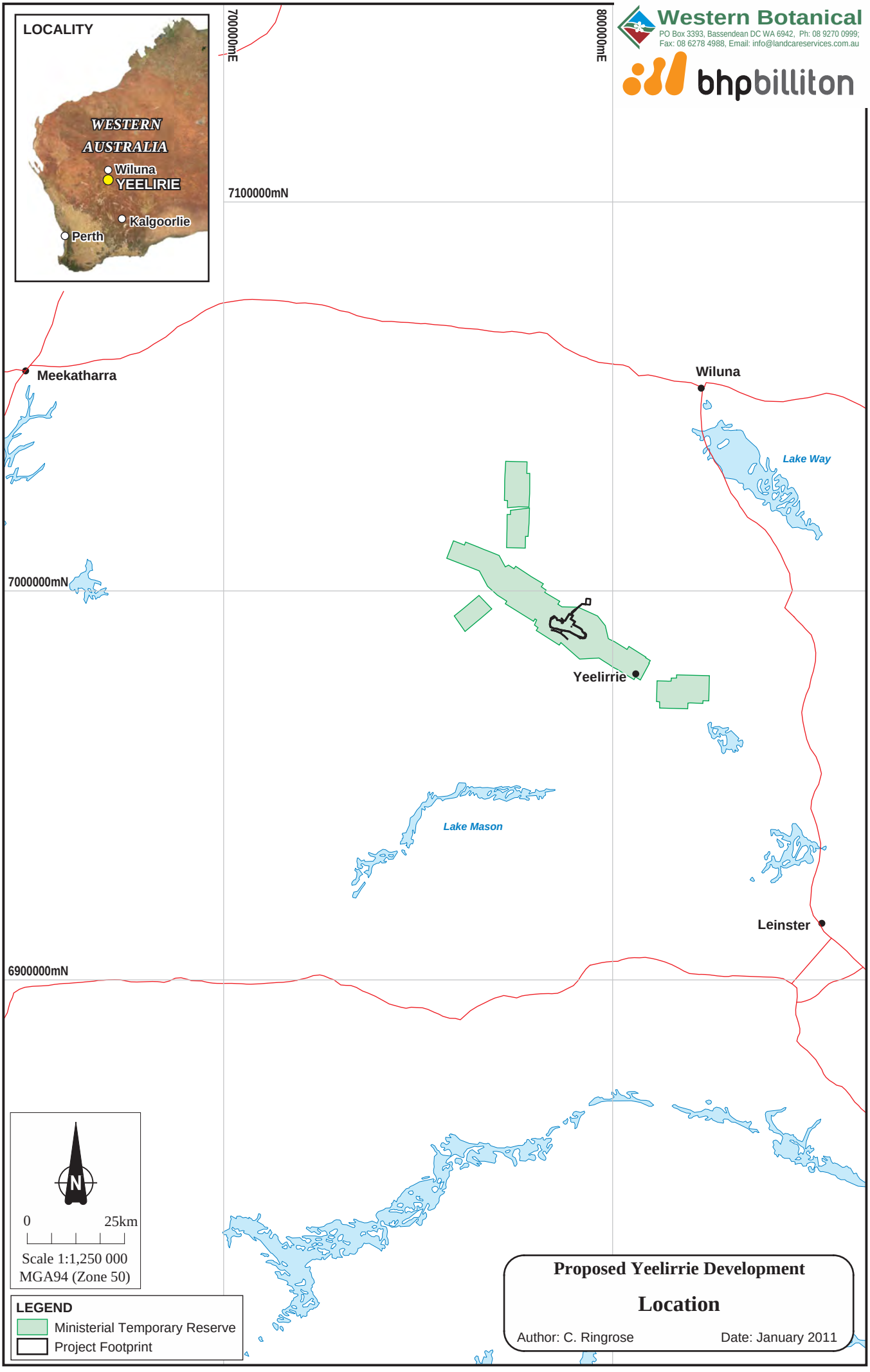

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Figure 2. Location map of the Ministerial Temporary Reserve (TR70/6899) and the local study areas (study areas 1, 2 and 3)

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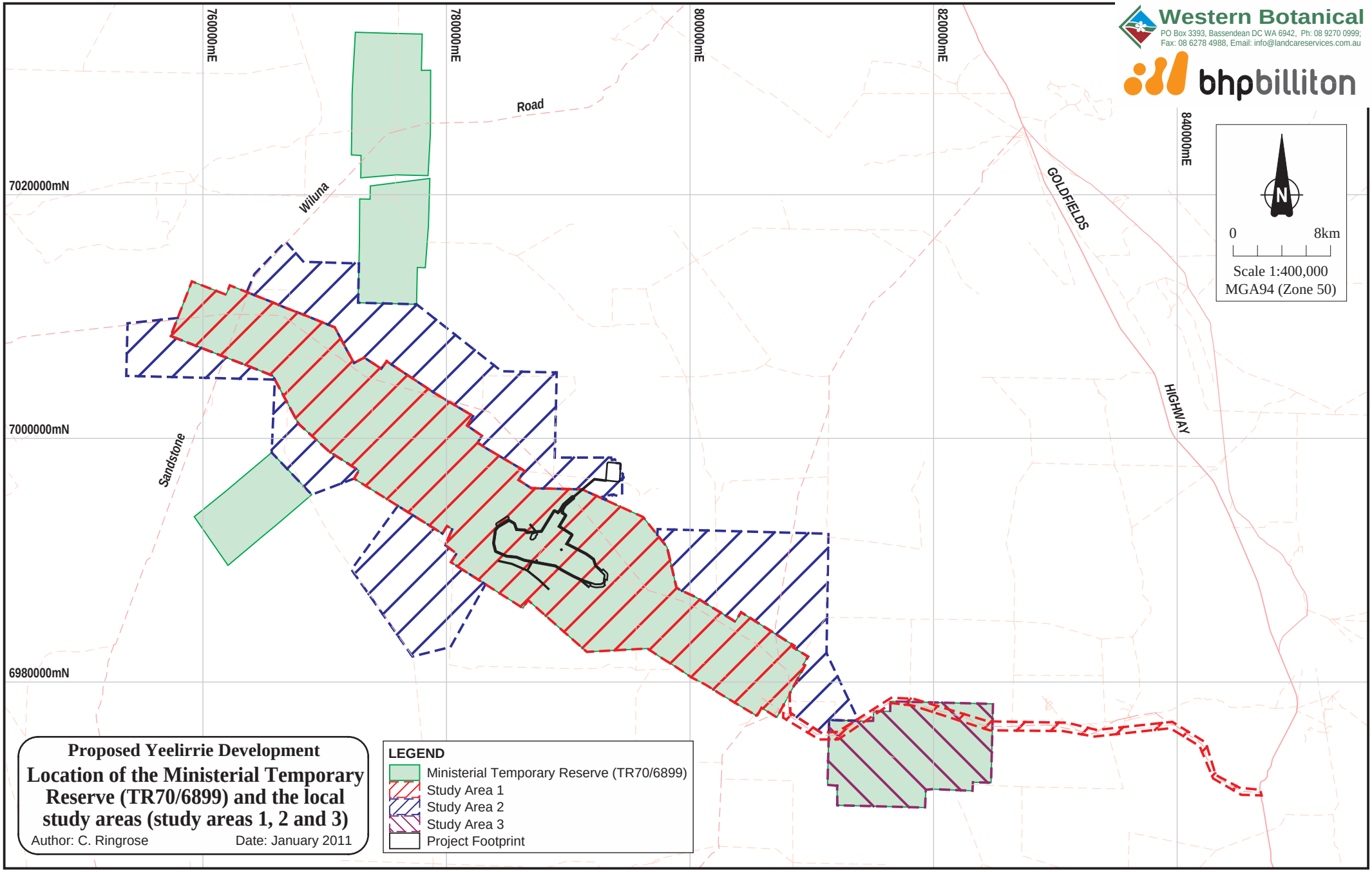


Proposed Yeelirrie Development

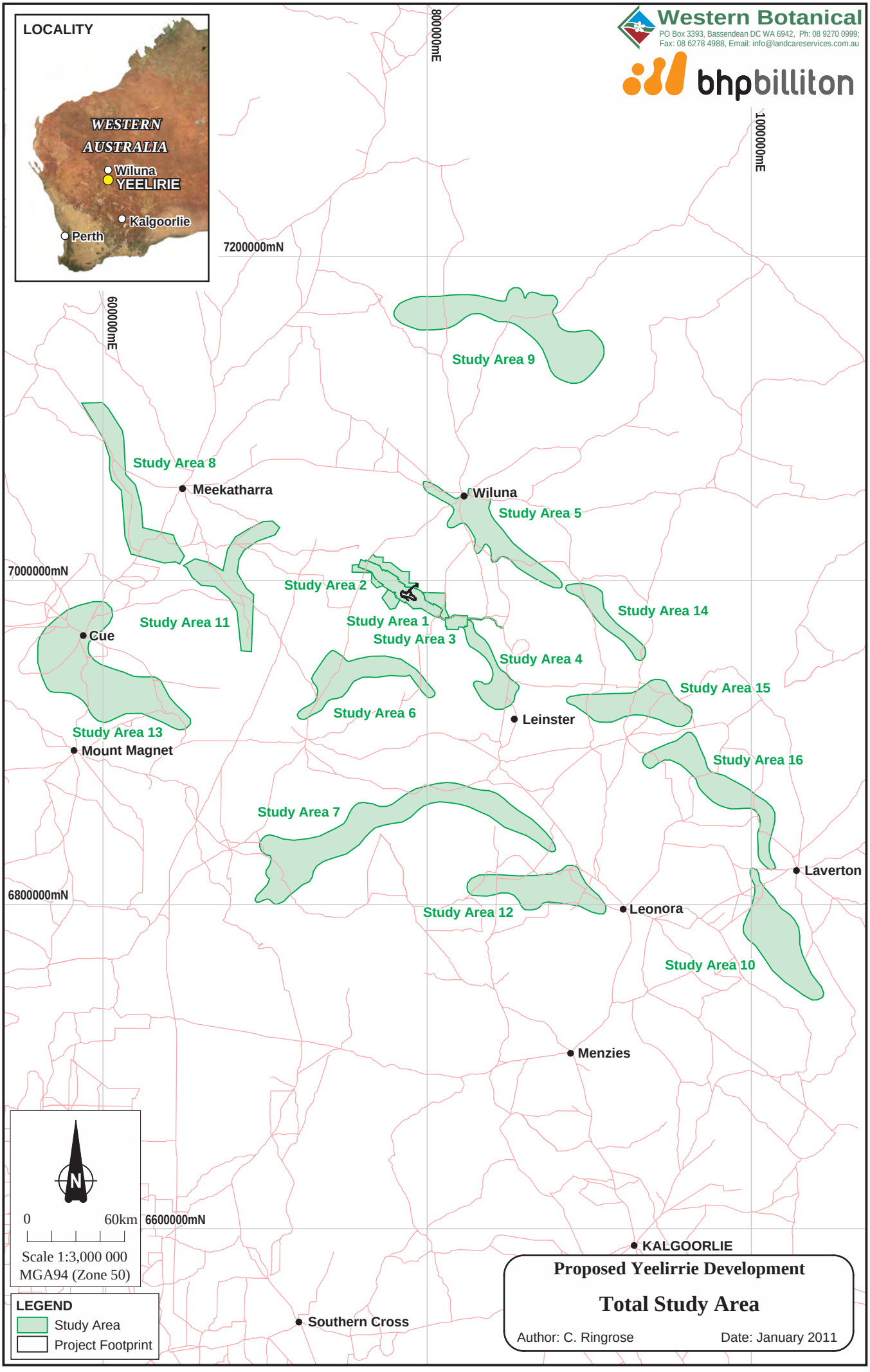
Location of the Ministerial Temporary Reserve (TR70/6899) and the local study areas (study areas 1, 2 and 3)

Author: C. Ringrose Date: January 2011

LEGEND

- Ministerial Temporary Reserve (TR70/6899)
- Study Area 1
- Study Area 2
- Study Area 3
- Project Footprint

Figure 3. Total study area (study areas 1 to 16)



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1.3. Bioregion

The total study area (study area 1 to 16), excluding study areas 8 and 9, lies in the Eremaean Botanical Province within the Murchison Biogeographic Region and the East Murchison (MUR1) subregion (Figure 4). Study area 8 lies within the West Murchison (MUR2) subregion, while study area 9 lies predominately within the Gascoyne Biogeographic Region and the Carnegie (GAS2) subregion. The local study area (study areas 1, 2 and 3) lies in the East Murchison (MUR1) subregion. Bioregions and subregions are areas of land with similar climate, geology, landform, vegetation and animal communities (Thackway and Creswell, 1995). There are 85 Bioregions in Australia and 403 subregions (Interim Biogeographic Regionalisation for Australia (IBRA), Version 6.1).

The Murchison 1 subregion, with an area of 7,847,996 ha, covers northern parts of the 'Southern Cross' and 'Eastern Goldfields' Terranes of the Yilgarn Craton. This subregion is characterised by; its internal drainage, extensive areas of elevated red desert sand plains with minimal dune development; salt lake systems associated with the occluded paleodrainage system; and broad plains of red-brown soils and breakaway complexes as well as red sand plains (Cowan, 2001). The vegetation in this region is dominated by Mulga (*Acacia aneura*) woodlands, often rich in ephemeral; hummock grasslands, saltbush shrublands and *Halosarcia* (now *Tecticornia*) shrublands (*ibid.*).

The Murchison bioregion is used primarily for grazing of native pastures by cattle and sheep whilst also supporting mining (predominately nickel and gold). Most of the mining occurs on pastoral lands. Yeelirrie became a pastoral lease in the mid 1920s and livestock were grazed until 1972 when Western Mining Corporation (WMC) purchased the property. Following the acquisition by WMC, the livestock were removed from the pastoral lease but bores and tanks were maintained (WMC, 1979). In 2005 BHP Billiton acquired Yeelirrie Station and it was again grazed for a period prior to recent destocking.

Figure 4. Total study area within the Eastern Murchison (MUR1) subregion of Western Australian IBRA Bioregions


LOCALITY
WESTERN AUSTRALIA
Wiluna
YEELIRIE
Kalgoorlie
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6800000mN
6600000mN
GAS3
Augustus
LSD2
Trainor
GAS2
Carnegie
MUR2
Western Murchison
MUR1
Eastern Murchison
YAL1
Yalgoo
COO2
Southern Cross
COO3
Eastern Goldfield
AW1
Ancient Drainage
GVD1
Shield
Study Area 1
Study Area 2
Study Area 3
Study Area 4
Study Area 5
Study Area 6
Study Area 7
Study Area 8
Study Area 9
Study Area 10
Study Area 11
Study Area 12
Study Area 13
Study Area 14
Study Area 15
Study Area 16
Meekatharra
Wiluna
Cue
Mount Magnet
Leinster
Leonora
Laverton
Menzies
Southern Cross
N
0
60km
Scale 1:3,000 000
MGA94 (Zone 50)
LEGEND
Study Area
Proposed Yeelirrie Development
Total study area within the Eastern Murchison (MUR1) subregion of Western Australia IBRA Bioregions
Author: C. Ringrose
Date: January 2011
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1.4. Climate

The climate in the Murchison Region is classified as arid with a variable temporal and spatial rainfall distribution. Regional rainfall averages around 250 mm per year, however, both the quantity and frequency of rainfall is highly variable.

Yeelirrie typically has an erratic rainfall pattern and may have extended periods without significant rainfall events. No month is considered consistently wet and any month can record zero rainfall. Meteorological data collected over 80 years for Yeelirrie Station shows an average annual rainfall of 240 mm (median 221 mm). The lowest annual rainfall of 43 mm was recorded in 1950 and the highest of 507 mm was recorded in 1975 (Bureau of Meteorology, 2011).

Yeelirrie is located towards the inland extreme of two separate weather systems. The main influence on the climate is the east-west belt of high-pressure systems that lies over the southern portions of Australia throughout the year. During summer this belt of high-pressure systems moves southward and the climate at Yeelirrie also becomes influenced by the northern monsoonal system (DEC, 1979). Significant summer rainfall usually originates from tropical cyclones that pass over the coast between Port Hedland and Carnarvon and cross the state in a south-easterly direction (Pringle *et al.*, 1994).

On average 56% (135 mm) of the rainfall recorded is received during the 'summer' (warmer) months – December, January, February, March and April, with March recording the highest mean monthly rainfall of 31 mm (*ibid.*). The proportion of rainfall received in the warmer months for the years 2006, 2007, 2008 and 2010 was above the long-term average at 74% (322 mm), 81% (138 mm), 61% (139 mm) and 57% (157mm) respectively (Figure 5). The proportion of rainfall received during the warmer months of 2009 was below the long-term average at 52% (80 mm) (Figure 5).

The total annual rainfall for the four years prior to reporting was below the long-term average (240 mm): 2007 (169 mm), 2008 (228 mm) and 2009 (153 mm) (Bureau of Meteorology, 2010). This indicates that the rainfall received during the cooler months in these years was significantly less than average. The total annual rainfall for

2010 at 277.6 mm was above the long-term average (Bureau of Meteorology, 2011). The annual rainfall in 2006 was also well above the long-term average, at 436 mm.

The timing of rainfall is often more relevant to vegetation growth than the amount of rain an area receives. Rain received in the cooler months (May to September) is usually more effectual for vegetation growth than rain received in the warmer months (December to April). Although, rainfall received during the warmer months can help to lessen the extremity of the long, hot and dry periods, and relieve the requirement for plants to aestivate (Pringle *et al.*, 1994). Effective winter rainfall allows perennial trees and shrubs to flower and fruit while summer rainfall stimulates perennial grasses to flower and seed.

From meteorological data collected at Yeelirrie between 1973 and 2010, the mean summer temperatures (December to February) were 35.5°C at 3pm and 28.6°C at 9am. The mean winter temperatures (June to August) were 19.3°C at 3pm and 12.2°C at 9am (Bureau of Meteorology, 2011).

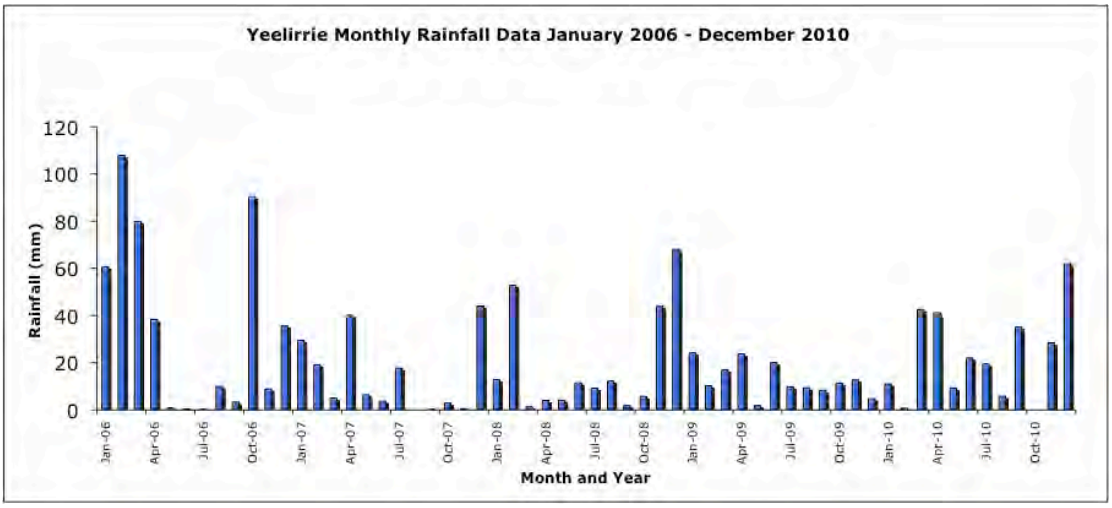

Figure 5. Yeelirrie Station monthly rainfall data from January 2006 to December 2010 (adapted from Bureau of Meteorology data, 2011)

1.5. Geology

Although not a part of Western Botanical's scope, a brief description of the geology of study areas 1, 2 and 3 has been included to provide physical framework to the flora and vegetation communities surveyed.

These study areas occur at the northern end of the Yilgarn Craton in the Eastern Goldfield Province. The Yilgarn Craton, with an age of approximately 2.5 gigaannum (Ga) (Griffin, 1990), encompass a large portion of the Western Australian landmass, 657,000 square km. The Eastern Goldfield Province is a typical Archaean granite-greenstone terrain, characterised by large areas of granitoid lithology and generally narrow, linear or arcuate belts of greenstone (*ibid.*).

There are several well-preserved major paleodrainage systems within the Yilgarn Craton that were active in the Early Tertiary period. Chains of playa lakes border these drainage systems. Some drainage is now internal but when active (significant flow ceased by Late Miocene) all the networks drained externally (Hocking and Cockbain, 1990, *after* van der Graff, 1977).

1.6. Soils and soil landscapes

Although not a part of Western Botanical's scope a brief description of the soil and landforms of study area 1 has been included. Where possible study areas 2 and 3 have also been included as the vegetation communities of the area are closely associated.

The interrelationships between the physical environment and vegetation communities is well documented and are apparent on both broad and local scales. Contrasts in vegetation structure and species composition reflect soil chemical and physical properties, landscape position, aspect, hydrology and underlying geology. These vary significantly on a broad scale between land systems as defined by DAWA, discussed further in Section 1.7, and also in the local study area in relation to soil landscapes defined by D.C. Blandford in *Soils and Soil Landscapes of the Yeelirrie Study Area* (Blandford, 2011).

In *Soils and Soil Landscapes of the Study Area* (2011), DC Blandford described four soil landscapes within study area 1, these are: Colluvial/ Alluvial Sand Plain System, Playa System, Central Calcrete System and Granite System.

The Colluvial/ Alluvial Sand Plain System extends from the central valley of study area 1 to the granite breakaways. The sand plains are characterised by inconsistent

soil profiles and have varying degrees of moisture retention according to the thickness and composition of gravels in the soil horizon (*ibid.*).

The Playa System soil landscape is a transition zone that reflects the interaction between the sand plain and central calcrete of study area 1 and is the major drainage focus for surface runoff along the valley floor. The Playa System comprises the following units: playas (shallow depressions), flats with scalds, and flats with sink holes (*ibid.*).

The Central Calcrete System (Calcrete System) is a variable soil landscape that occupies the central zone of the valley floor and has four recognized units: calcrete rises, depressions, flats, and clay flats. Each of these units has a distinctive soil stratigraphy (*ibid.*).

The Granite System has three key units and a highly variable transition zone to the sand plain. The system units are the breakaway plateau surface, the breakaway itself, and a foot slope. Breakaways are a prominent feature in the landscape and are characterised by a well-developed pallid zone dominated by kaolinitic material (*ibid.*).

1.7. Land Systems of the local study area (study areas 1, 2 and 3)

The local study area (study areas 1, 2 and 3) falls between two rangeland condition survey areas: the 'Sandstone-Yalgoo-Paynes Find' area (Payne *et al.*, 1998) and the 'North-eastern Goldfields' area (Pringle *et al.*, 1994). From these two surveys, sixteen land systems representing ten land types have been mapped at a scale of 1:500,000 within the local study area (Figure 6). Each land system that occurs within the local study area is described below and a summary is presented in Table 1. The terminology used to describe the land systems in this report reflects the scale of the rangeland condition surveys undertaken by the above authors and their descriptions published within each corresponding Technical Bulletin.

Figure 6. Land systems within the local study areas

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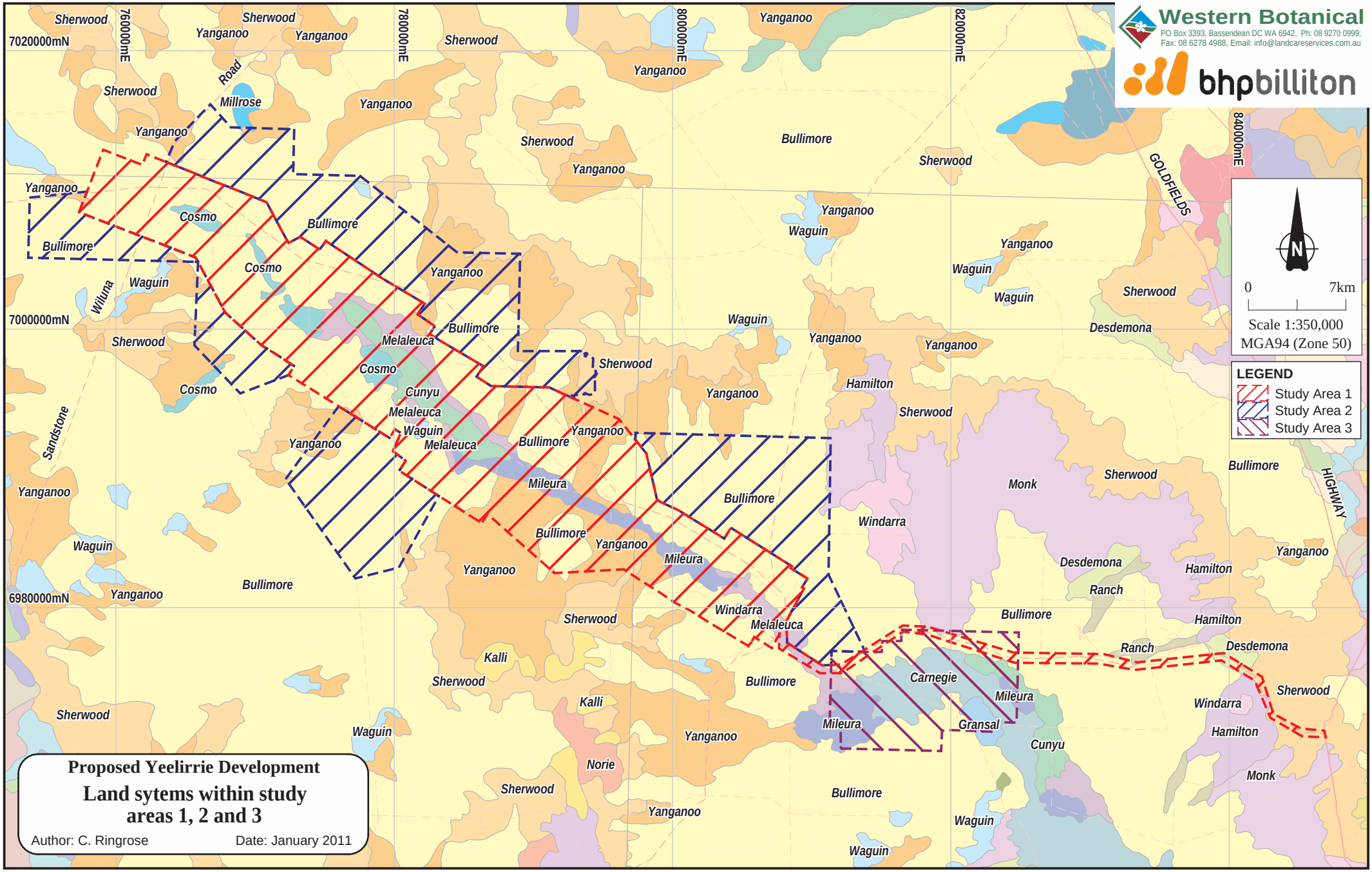

Proposed Yeelirrie Development

Land sytems within study areas 1, 2 and 3

Author: C. Ringrose Date: January 2011

Table 1. Land types and land systems represented within the local study area

Land type number	Land type description	Land system	Study area (ha)		
			1	2	3
3	Low hills and quartz strewn plains with Mulga shrublands	Millrose	n/a	13.12	n/a
4	Breakaways, stony plains and sandy surfaced plains on granite with Mulga shrublands and minor halophytic shrublands	Sherwood	418.38	503.08	n/a
		Waguin	154.21	99.38	n/a
8	Stony plains with Acacia shrublands and halophytic shrublands	Gransal	n/a	n/a	440.49
9	Stony plains and occasional low rises with Acacia-Eremophila shrublands	Windarra	99.50	n/a	n/a
10	Sandplains with Spinifex hummock grasslands	Bullimore	31,380.66	36,239.98	9,909.71
13	Wash plains on hardpan with Mulga shrublands	Hamilton	46.33	n/a	n/a
		Ranch	10.98	n/a	n/a
14	Wash plains and sandy tracts on hardpan, with Mulga shrublands and Wanderrie Grasses	Monk	45.04	145.06	57.15
		Yanganoo	6,398.74	4,803.48	n/a
16	Plains with deep sandy soils supporting Acacia shrublands and occasionally with Wanderrie Grasses	Desdemona	141.43	n/a	n/a
18	Calcrete drainage plains with mixed halophytic and non-halophytic shrublands	Cosmo	1,772.55	24.09	n/a
		Cunyu	2,432.40	n/a	424.44
		Melaleuca	3,441.40	200.44	248.80
		Mileura	2,559.24	n/a	1,236.99
20	Salt lakes and fringing alluvial plains with halophytic shrublands	Carnegie	n/a	n/a	3,525.10

Land systems associated with paleodrainage channels and calcrete expressions

Four land systems mapped within the local study area are associated with paleodrainage channels and calcrete expressions and are described as follows.

Cosmo: This land system represents level sandplains enclosing and occasionally covering gently undulating low-rise calcrete platforms and calcrete plains with drainage foci, depressions collecting intermittent sheet flow.

Cunyu: Undulating calcrete platforms to 4 m relief, calcrete, level hardpan and alluvial plains influenced and subjected to sheet flow represent the dominant land form features of the Cunyu land system. Intervening drainage floors and occasional drainage foci are present.

Melaleuca: Comprised of level loamy plains with irregular marginal sandy banks and sandsheet plains. Gently inclined calcrete rubble plains, concentrated unchannelled drainage lines and drainage foci complete the dominant landform features.

Mileura: Representing the Mileura land system is a mosaic of gently undulating calcrete platforms and calcrete rubble plains with level alluvial plains. Saline hardpan plains with sandy banks intersected with unincised drainage tracts and drainage foci conclude the Mileura land system.

Land systems associated with breakaways, sandsheets, stony plains and hardpan wash plains

Twelve land systems mapped within the local study area are associated with breakaways, sandsheets and hardpan wash plains, and are described as follows.

Millrose: Gently undulating stony plains on hardpan and granite with irregularly distributed sandy wanderrie banks characterise the Millrose land system. Mulga shrublands and Wanderrie Grasses compose the vegetation of the Millrose land system.

Sherwood: Granite breakaways to 20 m relief with gently inclined lower footslopes, opening onto gritty surfaced, stony/ saline and hardpan loamy plains are the predominant features. Low quartz and granite rises, alluvial plains and flow concentrated drainage tracts constitute the remaining features.

Waguin: This land system is representative of sandplains and low weathered granite breakaways to 6 m relief. These gentle elevations descend onto lower footslopes with level to gently undulating stony quartz plains, gritty surface plains, loamy alluvial hardpan plains and drainage floors dominated by sheet flow and shallow channels.

Gransal: Stony plains and low rises based on granite, supporting halophytic shrublands characterise the Gransal land system.

Windarra: Saline stony, gritty quartz and hardpan plains are the dominant features with low granite rises and occasional channelled drainage floors.

Bullimore: Aeolian, fluvial and colluvial influenced gently undulating sandsheet plains represent 85% of the Bullimore land system. Level loamy plains subject to sheet flow, linear sand dunes, concentrated sheet flow drainage tracts and rare dissected weathered granite tracts combine to round out the Bullimore land system.

Hamilton: This land system is composed of a mosaic of stony hardpan plains intersected with dendritic drainage lines and sandy banks.

Ranch: Gently inclined hardpan and loamy plains with sandsheets characterise the Ranch land system. Irregular sheet flow is concentrated into broad drainage zones and shallow incised creek lines, with drainage foci of variable size and distribution.

Monk: Hardpan plains and loamy tracts with stony hardpan plains located within the higher elevated topography. Parallel shallow and narrow drainage lines with broader drainage tracts and sandy banks negotiate the land system.

Yanganoo: Level to gently inclined depositional hardpan loamy plains are the dominant feature with *Acacia aneura* groves, broad shallow drainage tracts, sandy banks and sandsheet plains intermittently represented.

Desdemona: Extensive level loamy plains are a dominant landform feature of the Desdemona land system. Completing the land system are bordering sandsheets and hardpan plains subject to dispersed runoff concentrated into poorly defined narrow drainage lines.

Carnegie: Salt lakes with extensive fringing saline plains, dunes and sandy banks, supporting low halophytic shrublands and scattered tall *Acacia* shrublands are representative of the Carnegie land system. The lakebeds are highly saline, gypsiferous and mainly unvegetated.

Details of the area (ha) of each land system and their proportional representation within the two regions are presented in Table 2. The considerable representation of land type 18, and its four land systems (Cosmo, Cunyu, Melaleuca and Mileura) within the study areas is of interest with reference to the land types' limited occurrence throughout the Sandstone-Yalgoo-Paynes Find and the North-eastern Goldfields survey areas. Regional representation of these four land systems has a high spatial association with the margins of salt lakes and occluded paleodrainage channels. These are an uncommon, geographically disjunct and isolated series of land systems within the broader region. Other land systems found within the local study area are well represented in the wider region.

Vegetation associated with land type 18, paleodrainage channels and calcrete expressions, can also be considered to have a limited occurrence throughout the Sandstone-Yalgoo-Paynes Find and the North-eastern Goldfields survey areas. As introduced in the previous Section, contrasts in vegetation structure and species composition reflect soil chemical and physical properties, landscape position, aspect, hydrology and underlying geology. Certain vegetation communities are associated wherever groundwater calcretes (calcium carbonate) have accumulated – generally in paleodrainage channels between and adjacent to salt lakes.

Table 2. Land system extent within the local study area and regional representation

Land type	Land system	Sandstone-Yalgoo-Paynes Find area (ha)	North-eastern Goldfields area (ha)	Total Mapped area (ha)	Local study area (ha)	Proportion within study area of total occurrence (%)
3	Millrose	n/a	n/a	53,500*	13	0.02
4	Sherwood	345,800	387,500	733,300	921	0.13
4	Waguin	124,900	74,500	199,400	254	0.13

Land type	Land system	Sandstone-Yalgoo-Paynes Find area (ha)	North-eastern Goldfields area (ha)	Total Mapped area (ha)	Local study area (ha)	Proportion within study area of total occurrence (%)
8	Gransal	80,000	274,100	354,100	440	0.12
9	Windarra	37,000	193,800	230,800	99	0.04
10	Bullimore	624,900	2,401,300	3,026,200	71,530	2.36
13	Hamilton	32,500	113,000	145,500	46	0.03
13	Ranch	29,800	65,500	95,300	11	0.01
14	Monk	182,200	816,200	998,400	247	0.02
14	Yanganoo	327,600	87,500	415,100	11,202	2.70
16	Desdemona	4000	252,400	256,400	141	0.06
18	Cosmo	5000	14,100	19,100	1,797	9.41
18	Cunyu	35,800	31,000	66,800	2,857	4.28
18	Melaleuca	12,900	26,700	39,600	3,008	7.60
18	Mileura	70,000	55,000	125,000	3,796	3.04
20	Carnegie	864,900	550,600	1,415,500	3,525	0.25

*Millrose land system is not present within Technical Bulletin No. 87 and Technical Bulletin No. 90. Total mapped area comes from the Millrose land system's presence within Technical Bulletin No. 84.

1.8. Previous regional botanical surveys

Prior botanical knowledge of the Murchison region consisted of broad scale regional flora surveys, including a general account of vegetation (Gardner, 1942 and Beard, 1976), and descriptions of land systems and vegetation across the Austin Botanical District in the Wiluna and Glengarry areas completed as part of rangeland condition surveys (Mabbutt *et al.*, 1963). Regional vegetation mapping of the Murchison region has been produced at a very broad scale of 1:1,000,000 (Beard, 1976 and 1979).

Pringle *et al.* (1994) and Payne *et al.* (1998) describe their survey area at two scales; the broader land system, as described in Section 1.7, and the individual vegetation unit (site type or habitat group). Habitat groups or site types are described in terms of land surface, dominant taxa, and dominant vegetation structure.

Initial assessment of ore body area in *Flora and Vegetation Assessment of Portion of Proposed Confirmation Drilling Program – Part 1* (Cockerton and Ringrose, 2009) and *Significant Flora Assessment of Remainder of Proposed Confirmation Drilling Program – Phase 1B* (Cockerton *et al.*, 2009) demonstrated a clear correlation of vegetation community types with significant and clear-cut changes in soil and topography.

During the current survey, 21 site types or habitat groups described by Pringle *et al.* (1994) and Payne *et al.* (1998) were recognised within the local study area (Table 3). These habitat groups occurred in the Sand Plain and Granite Systems, which are well represented in the North-eastern Goldfields and Sandstone-Yalgoo-Paynes Find survey areas (*ibid.*). Where possible the vegetation unit descriptions (site type or habitat group) defined by Pringle *et al.* (1994) and Payne *et al.* (1998) in land system mapping were adopted in the current vegetation mapping (see Section 2.3).

Table 3. Habitat groups represented within the local study area, adapted from Pringle *et al* (1994) and Payne *et al* (1998)

Habitat group or site type
Sand plain spinifex hummock grassland characterised by deep sands supporting hummock grassland (SASP)
SASP with a well-developed *Eucalyptus gongylocarpa* tree stratum (SAGS)
SASP with a low heath stratum of Myrtaceous shrubs (SAHS)
SASP with a tall tree stratum dominated by Mulga (*Acacia aneura* and *A. ayersiana*) (SAMU)
SASP with mixed *Acacia* (commonly known as wattles), and occasionally proteaceous tall shrub strata including *Hakea* and *Grevillea* (SAWS)
SASP with substantial mallee (SAMA)
SASP with a well-developed shrub stratum generally on sand dunes (SDSH)
Mulga shrublands with sparse sclerophyll understoreys associated with hardpan plains (HPMS)
Mulga groves on hardpan plains They have distinct boundaries with sparse intergrove communities (GRMU)
Wanderrie bank Mulga grassy shrublands, consists of very low sandy banks of red sand on hardpan (WABS)
Drainage tract Mulga shrublands occur on narrow unincised linear drainage zones receiving concentrated run-on (DRMS)
Stony plain *Acacia-Eremophila* shrublands occur on stony plains and are

Habitat group or site type
characterised by shallow, poorly developed soil profiles and substantial stony mantles (SAES)
Breakaway foot slope chenopod low shrubland, occurs on gently inclined foot slopes and alluvial plains of weathered granite (BCLS)
Calcrete platform Jam (*Acacia burkittii*) shrubland (JAMS)
Upland small Bluebush species shrublands (USBS)
Calcrete platform woodlands / shrublands (CAPW)
Mixed chenopod shrublands with Mulga overstorey (MHHS)
Sandy bank lake shrublands (SBLS)
Frankenia low shrublands (FRAN)
Samphire low shrublands (SAMP)
Silver Saltbush low shrublands (SSAS)

The first detailed surveys of the Eastern Goldfields Region were undertaken by the DEC and the Western Australian Museum (Burbidge *et al.*, 1995, Dell *et al.*, 1992, Dell *et al.*, 1998, Hall *et al.*, 1994, How *et al.*, 1992 and McKenzie and Hall, 1992).

Recent regional flora surveys in the Murchison have been undertaken by the DEC at Lake Mason and Black Range conservation reserves in 2004 and 2005 (Mark Cowan, DEC, pers comm.). Surveys were conducted at 24 sites within the Brooking, Nubev, Bullimore, Norie, Challenge, Kalli, Carnegie, Monitor, Cunyu, Woodline, Yanganoo, Violet, Gabanintha, Waguin, Sherwood and Miluera land systems. Some 309 taxa were recorded including two species with conservation significance: *Eremophila arachnoides* subsp. *arachnoides* P3 was recorded in the Cunyu land system and *Grevillea inconspicua* P4 was recorded in the Gabanintha land system.

At a finer scale, in the last 20 years, a number of flora and vegetation surveys including habitat level mapping, have been undertaken in association with increased mining activities in the vicinity of the study area. The majority of these have been undertaken by Western Botanical (including the current authors). These include the Mt Keith Operation (Cockerton, 1996a and 2004, Cockerton and Stratford, 1997a, Cockerton and O'Keefe, 2006a, Cockerton and True, 2006, Western Botanical, 2008a), Yakabindie Nickel Mine Project (*ecologia* Ecological Consultants, 1990a,

1990b and 1995, Cockerton *et al*., 2006, Cockerton and O'Keefe, 2006b, Western Botanical 2008b), Agnew Gold Operations (Cockerton and Stratford, 1996), and Leinster Nickel Operations (Cockerton and Stratford, 1997b and 1997c, Kern, *et al*., 2007, Western Botanical, 2007 and 2008c).

1.9. Botanical surveys within the local study area

Broad scale vegetation mapping of the region by Beard (1976) indicates five vegetation units within study areas 1, 2 and 3, as listed below.

1. Mulga (*Acacia aneura*), Mallee (*Eucalyptus kingsmillii*) and Spinifex (*Triodia basedowii*) shrub steppe on sand plains.

2. Mulga (*Acacia aneura*) and Wattles (*Acacia* spp.) with Saltbush (*Atriplex* spp.) or Bluebush (*Maireana* spp.) succulent steppe.

3. Saltbush (*Atriplex* spp.), Bluebush (*Maireana* spp.) and Samphire (*Tecticornia* spp.) communities succulent steppe.

4. Mulga (*Acacia aneura*) low woodland.

5. Mulga (*Acacia aneura*) and *A. quadrimarginea* scrub.

Studies of the flora and vegetation of the Ministerial Temporary Reserve were completed as part of the Draft EIS and ERMP by Western Mining Corporation Limited (1979).

The vegetation and flora survey of the EIS and ERMP report was conducted during winter and spring 1976 and autumn 1977, after an unseasonably long dry period. This period was the driest 18 months on record from 1926 to the time of survey and only perennial species were recorded. However, it is noted that the annual rainfall received in 1975, 507 mm, was the highest rainfall record for the region. The emphasis of this report was on plant physiology and ecology, specifically drought resistant characteristics of persistent plants. The major finding of this study concluded that flora at Yeelirrie was represented by a broad range of species with a large number of species stored in the seed bank, consisting of ephemerals, grasses and other annuals, forbs and shrubs, although not usually perennials.

None of the flora taxa recorded at that time were considered rare and the majority were known to occur in similar landforms in the region. A number of the plants collected were at the time undescribed and it was not possible to determine if they were of particular botanical significance as their distribution was not understood.

Vegetation mapping was prepared, and vegetation units were related to the landform units and described using Specht's structural formation (Specht, 1970). These are listed as follows:

1 Hummock grassland;
2 Low open woodland;
2A Low open grassy woodland;
2B Low open sparse layered shrubby woodland;
2C Low open grassy woodland;
3 Low open shrubland;
4 Tall shrubland;
5 Open grassy woodland;
6 Low open forest fringing clay pan areas; and
7 Low open halophytic shrubland.

1.10. Flora and vegetation of conservation significance

The conservation status of flora is assessed under Commonwealth and State Acts, the EPBC Act 1999 and the Western Australian *Wildlife Conservation* (*WC*) *Act 1950*, respectively.

1.10.1. Flora protected under the EPBC Act 1999

At a Commonwealth level, the *EPBC Act 1999* provides a legal framework to protect and manage nationally significant flora and ecological communities. A Protected Matters Search Report, Appendix 1 of this report, provides guidance on matters of national environmental significance and other matters protected by the EPBC Act 1999 in the region of Yeelirrie. There are no Commonwealth listed Threatened Flora species or Threatened Ecological Communities known to occur in the vicinity of study area 1.

1.10.2. Flora protected under the *WC Act* 1950

Under the WC Act 1950, the Minister for the Environment may declare a species to be 'Rare Flora' if considered to be in danger of extinction, rare or otherwise in need of special protection. There are also three categories of Priority Flora defined to cover poorly known species. These are flora that are either under consideration as threatened flora but are in need of further survey to adequately determine their status, or are adequately known but require monitoring to ensure that their security does not decline. A fourth category of Priority Flora is included for those species that have been adequately surveyed and are considered to be rare but not currently threatened. Brief descriptions of the flora conservation codes and their meanings are presented in Appendix 2 of this report.

1.10.3. Declared Rare Flora and Priority Flora recorded within the region

Regional data on conservation significant species was made available by the DEC. Searches were undertaken within an area defined by the coordinates 26^0 49' - 27^0 52' S and 119^0 20' - 120^0 38' E of the following databases:

- DEC's Threatened (Declared Rare) Flora database;
- Western Australian Herbarium (WA Herbarium) Specimen database, for priority species opportunistically collected in the area of interest; and
- DEC's Declared Rare and Priority Flora List (searched using 'place names'). This may be used as a species target list, and contains species that are declared rare (Conservation Code R or X for those presumed to be extinct), poorly known (Conservation Codes 1, 2 or 3), or require monitoring (Conservation Code 4).

Thirty-seven Priority Flora taxa were listed for the regional area including Yeelirrie. These included eleven P1, twenty P3 and six P4, shown in Table 1 of Appendix 3. This list includes one Priority 3 species of lichen, *Parmeliopsis macrospora*.

1.10.4. Threatened Ecological Communities

In addition to the flora of conservation significance discussed above, communities may also be considered threatened and at risk of being destroyed. Threatened communities are assessed by a scientific committee who suggest that the DEC advise the Minister for the Environment to endorse the community as a Threatened Ecological Community (TEC). In addition to TECs there is a category called Priority Ecological Communities (PECs) defined to cover poorly known vegetation communities. Priority Ecological Communities are communities awaiting nomination for TEC status.

There were no flora related TECs as listed by the Minister or under the *EPBC Act 1999* in the vicinity of the local study area and there were no flora related PECs listed for calcrete assemblages within the vicinity of the local study area. There are fifteen Priority One PEC communities associated with Banded Ironstone Formations (BIFs) listed in the DEC Goldfields region. These are not discussed further. The DEC database for Threatened Ecological Communities also lists the *Yeelirrie calcrete groundwater assemblage type on Carey paleodrainage on Yeelirrie Station* as a Priority One PEC (unique assemblages of short-range endemic subterranean aquatic fauna have been identified in the groundwater calcretes). The locations of all PECs listed in the vicinity of the local study area are shown on Figure 1 of Appendix 3.

1.11. Regional surveys (study areas 4 to 16)

Survey of study areas 4 to 16 provides a regional context to the distribution of flora species and vegetation communities of conservation significance or interest that were recognised within study area 1. The species and communities targeted during the regional surveys were primarily associated with calcrete. These surveys also provide a guide to the regional distribution of flora and vegetation with conservation significance. Both sets of data may be used to assess the proportional impact of the proposal on flora and vegetation recorded in study area 1.

1.11.1. Targeted vegetation communities

Several vegetation communities are considered of interest within study area 1 as they are, based on current information available, of limited distribution (Table 4). Some of

these communities fall within the descriptions of ecosystems at risk described by Cowan (2001) within the East Murchison IBRA subregion, as discussed in Section 3.1.9. Distribution of these communities outside the local study area is discussed further in Section 3.8.1. CApS and CRsS are new vegetation communities described by Western Botanical (refer to Appendix 8) and are not documented outside the local study area to date. Based on current information available both communities are limited in distribution and are considered to be of high conservation significance.

Table 4. Targeted vegetation communities of interest

Vegetation community	Vegetation community description	Soil landscapes
CApS	*Atriplex* sp. Yeelirrie Station (L. Trotter and A. Douglas 25025) Shrubland on Calcrete	Calcrete
CRsS	*Rhagodia* sp. Yeelirrie Station (K. Shepherd et al. KS1396)	Calcrete
CMxS	*Melaleuca xerophila* Shrubland on Calcrete	Calcrete
CCpW	*Casuarina pauper* Woodland on Calcrete	Calcrete
CEgW	*Eucalyptus gypsophila* Woodland on Calcrete	Calcrete

1.11.2. Targeted flora species

The flora species targeted for this survey were those identified as occurring within the project footprint and having potentially high impacts from mining activities. Five flora taxa are considered to be significant or of interest and warranted regional surveys as they are, based on current information available, of limited distribution (Table 5). Further information on these taxa is provided in Section 3.3. Three are Priority species that are restricted to the calcrete communities: *Atriplex* sp. Yeelirrie Station (L. Trotter and A. Douglas LCH25025) P1, *Rhagodia* sp. Yeelirrie Station (K.A. Shepherd et al. KS1396) P1, and *Eremophila arachnoides* subsp. *arachnoides* P3. A further two species were also included as they are confined to playa and calcrete communities: *Templetonia incrassata* and *Scaevola spinescens* terete leaf form (G. Cockerton & C. Ringrose LCH14560).

Three of these species represent new taxa that were recognised as significant following the baseline survey: *Atriplex* sp. Yeelirrie Station (L. Trotter and A. Douglas LCH 25025) P1, *Rhagodia* sp. Yeelirrie Station (K. Shepherd et al. KS1396)

P1 and *Scaevola spinescens* terete leaf form (G. Cockerton & C. Ringrose LCH14560).

Table 5. Targeted flora species

Species	Reason for interest	Vegetation community	Soil landscapes
Atriplex sp. Yeelirrie Station (L. Trotter & A. Douglas LCH25025) P1	P1	CApS	Calcrete
Rhagodia sp. Yeelirrie Station (K.A. Shepherd et al. KS1396) P1	P1	CRsS	Calcrete
Eremophila arachnoides subsp. *arachnoides* P3	P3	CCpW, CAbS, CEgW	Calcrete
Templetonia incrassata	Poorly collected, range extension	CCpW, CAbS, CEgW	Calcrete, Playa
Scaevola spinescens terete leaf form (G. Cockerton & C. Ringrose LCH14560)	Possible conservation significance	various	Playa

Prior to the regional survey, *Atriplex* sp. Yeelirrie Station was known from only one location, within self-mulching clay on clay flats within the central Calcrete System of study area 1. This taxon appears to be restricted to Mileura and Cunyu land systems. These land systems are associated with calcrete on the margins of large drainage systems or lake systems. *Rhagodia* sp. Yeelirrie Station also appears to be restricted to Mileura and Cunyu land systems.

Regional representation of the Mileura, Melaleuca, Cunyu and Cosmo land systems has a high spatial association with the margins of salt lakes and occluded paleodrainage channels. These are an uncommon and geographically isolated series of land systems within the broader region of the Sandstone - Yalgoo - Paynes Find and the North-eastern Goldfields survey areas.

2. Methodology

2.1. Survey effort

Western Botanical conducted flora and vegetation surveys in the total study area from December 2008 to December 2010. A total of 39 field visits were made of the total study area over this time. Chronological lists of field surveys undertaken in the study areas are presented in Appendix 4 (Table 1, Table 2 and Table 3). A summary of the personnel and their relevant experience is also provided in Table 4 of Appendix 4 of this report.

The number of field surveys and survey effort (depth of assessment) varied for each study area, as described below.

2.1.1. Study area 1

Western Botanical conducted 26 field surveys within study area 1 during December 2008 to December 2010. The field surveys included: mapping the vegetation communities (refer to Section 2.3.1), mapping the distribution and abundance of significant flora (including the project footprint at a higher density, refer to Section 2.8.1), and establishing and assessing 182 quadrats and 180 relevés (refer to Section 2.6.1) within study area 1 to provide a numerical analysis of the variation in the floristic composition of vegetation communities.

2.1.2. Study area 2

Western Botanical conducted two field surveys within study area 2 during November 2010. The field surveys included mapping the vegetation communities (refer to Section 2.3.2), searching for and recording the extent of significant species (refer to Section 2.8.2).

2.1.3. Study area 3

As discussed below Western Botanical conducted regional surveys of 13 paleodrainage and lake systems for targeted species of interest. It was during these surveys that *Atriplex* sp. Yeelirrie Station was recorded in the north-west tip of study area 4, which included the Yeelirrie Palaeochannel and Lake Miranda. Following

these findings this section of study area 4 was investigated further and was redefined as study area 3 (see Figure 7).

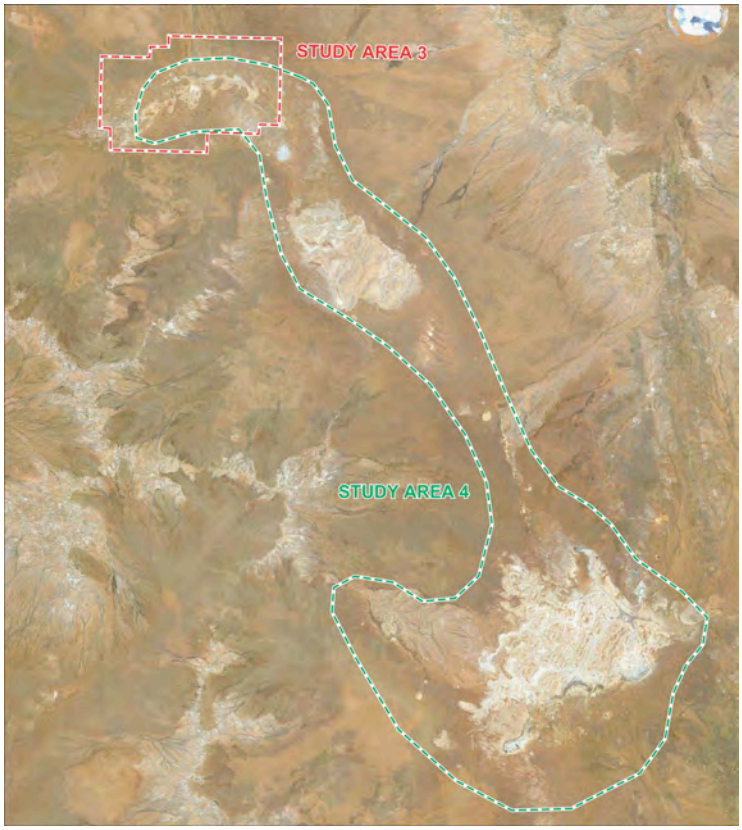

Figure 7. Location of study area 3 relative to study area 4

Western Botanical conducted a further five field surveys within study area 3 from March to December 2010. The field surveys included flora sampling, mapping the vegetation communities (refer to Section 2.3.3) and mapping the distribution and abundance of significant flora (refer to Section 2.8.3), with particular focus on *Atriplex* sp. Yeelirrie Station. Further details on the assessment of *Atriplex* sp. Yeelirrie Station numbers within study area 3 are provided in Section 2.8.5.

2.1.4. Regional surveys (study areas 4 to 16)

Western Botanical conducted regional flora and vegetation surveys from November 2009 to May 2010. A total of six surveys were conducted, two utilising a helicopter, and 13 paleodrainage and lake systems were investigated.

The field surveys included recording vegetation communities of interest (refer to Section 2.3.4), establishing and assessing quadrats in vegetation communities of interest (refer to Section 2.6.3) and recording the distribution of targeted significant and Priority Flora (refer to Section 2.8.4). Further methodology and site selection details are provided in Section 2.9.

2.2. Taxonomic identification specimen vouchering and nomenclature

Unidentified specimens found during surveys, vegetation mapping and quadrat establishment were identified either using the Western Australian reference herbarium or if that did not provide enough information the specimens were sent to a specialist taxonomist for identification. Taxonomists consulted are listed in Appendix 5 of this report. In addition, all collected samples were checked to validate the field identifications. Duplicates of each specimen were retained and the specimen of highest quality was vouchered at the WA Herbarium.

Plant nomenclature adopted for this report follows that of the Census of Vascular Plants of Western Australia administered by the DEC, WA Herbarium as at January 2011. Floristic terminology follows that of the WA Herbarium except where phrase names for undescribed species have been developed.

The WA Herbarium recently rearranged its vascular plant collections and updated its sequence and arrangement of collections to the modern APGIII phylogenetic system, which involved some family level changes. The changes to those families relevant to the Yeelirrie Project are listed below. In some cases an entire family was incorporated into another family or renamed (Table 6). In other cases, some genera were moved to another family while others were retained, and genera previously in the same family were split into different families (Table 7).

Table 6. Updates to family names relevant to the Yeelirrie Project that involved simple or entire family changes

Old family name	New family name
Adiantaceae	Pteridaceae
Asclepiadaceae	Apocynaceae

Old family name	New family name
Caesalpiniaceae	Fabaceae
Lobeliaceae	Campanulaceae
Mimosaceae	Fabaceae
Myoporaceae	Scrophulariaceae
Papilionaceae	Fabaceae
Sterculiaceae	Malvaceae

Table 7. Updates to family names relevant to the Yeelirrie Project that involved splits within families

Old Family	Genus	New family
Euphorbiaceae	*Phyllanthus*	Phyllanthaceae
Scrophulariaceae	*Peplidium*	Phrymaceae
Scrophulariaceae	*Stemodia*	Plantaginaceae

2.3. Mapping the vegetation communities

2.3.1. Study area 1

The mapping of the vegetation within the study area 1 was initiated in April 2009, and was conducted over five visits during Autumn and Winter 2009. Mapping was validated in March 2010. The total area of vegetation mapped was 48,901 ha and included the proposed 45 km access road from the Goldfields Highway (Figure 2). The proposed access road was surveyed allowing for a buffer of 250 m either side of the centre line of the existing Yeelirrie Albion Downs Road.

The seasonal conditions prior to vegetation mapping were hot and dry resulting in the mapping of predominantly perennial species with few annuals recorded. The site received 83.8 mm of rainfall over March and April 2010 enabling many perennials to flower and fruit, which assisted the identification of taxa.

Vegetation communities were mapped at the floristic community level within landform. A combination of landform, vegetation structure and dominant species in the upper and lower strata were used to differentiate and name the vegetation

communities. Where possible the vegetation unit descriptions (site type or habitat group) defined by Pringle *et al.* (1994) and Payne *et al.* (1998) in land system mapping were adopted (Section 1.8). These have been aligned and associated with the soil landscapes described by DC Blandford in *Soils and Soil Landscapes of the Study Area* (2011).

For the purposes of this study, Western Botanical devised a further series of groups, which the authors defined as vegetation communities. These are based on floristic composition and vegetation structure at the scale required for this study. Where appropriate, the authors used a similar classification method and set of terms to allow for comparisons between the vegetation communities described in study area 1 to those described in the broader region by Pringle *et al.* (1994) and Payne *et al.* (1998). Section 2.4 provides further details on the vegetation communities naming conventions.

Vegetation communities were identified by defining boundaries between polygons with homogeneous reflectance on 1:10,000 aerial photography (high resolution RGB colour and Spot satellite imagery with GDA grid overlay). Where possible polygons were verified on ground either by four-wheel drive vehicle or on foot and the vegetation community was described and polygon shapes amended as required. Inaccessible areas were extrapolated from neighbouring communities. The large area traversed during significant species searches also provided a further opportunity for ground-truthing and refinement of the mapped vegetation communities. The survey team was well equipped to identify most flora in the field and had substantial experience in flora surveys of the North-east Goldfields, particularly in the Leinster - Yakabindie - Mt Keith region some 150 km east of study area 1. A comprehensive field herbarium compiled by Western Botanical in early 2009 and was continually added to for the duration of the studies, which also facilitated flora identification.

Comprehensive species lists were made at a total of 181 relevé sites within the different vegetation communities. In addition to the vegetation structure, floristic composition and density within each defined stratum (height range) were described as well as brief descriptions of soils and landforms. The locations of all species with either conservation significance or taxonomic interest, including undescribed species, were recorded using hand held Garmin GPS (+/- 5 m accuracy) in the WGS84 datum.

Photographic records of all vegetation communities and associated flora species were taken using a digital camera. Flora that could not be identified in the field were collected for reference and later identified, as discussed in Section 2.2.

To assist with the interpretation and description of vegetation communities of study area 1, vegetation quadrats were also established and assessed (refer to Section 2.6). Vegetation quadrats provide a more formalised, repeatable and consistent means of comparing floristic composition across the survey area and within the different vegetation communities. Point sampling utilising marked quadrats is the recommended form of sampling design as set in Section 3.2.6 of Guidance No. 51 (EPA, 2004).

2.3.2. Study area 2

As per the methodology utilised in study area 1, vegetation communities in study area 2 were mapped at the floristic community level within the landform. The vegetation communities mapped, where appropriate, were aligned with those defined in study area 1. New communities were based, where appropriate, on those defined by Pringle *et al.* (1994) and Payne *et al.* (1998) in land system mapping. In contrast, to study area 1, no quadrats were established or assessed in study area 2. Species lists were made at a total of 52 relevé sites within the different vegetation communities.

In study area 2, vegetation communities were identified by defining boundaries between polygons with homogeneous reflectance on 1:20,000 aerial photography (high resolution RGB colour and Spot satellite imagery with GDA grid overlay). Where possible on ground verification, either by four-wheel drive vehicle or on foot, was undertaken. During these surveys the boundaries of the vegetation community polygons were verified or amended, as required, and the vegetation community was described. Inaccessible areas were extrapolated from neighbouring communities.

The seasonal conditions prior to vegetation mapping were hot and dry following the winter rainfall events, resulting in the mapping of predominantly perennial species with the majority of annuals desiccated to the point of being unidentifiable. The nearest weather station, Yeelirrie, recorded 19.5 mm in July, 5.8 mm in August, 35.1 mm in September and no rainfall in October, 2010 (Bureau of Meteorology, 2011). This promoted good annual growth in the months prior to this survey; however, few

late season annuals remained in a condition of sufficient quality to be positively identified. The late winter rainfall did allow for good flowering and fruiting material to be taken from perennial species, aiding in the identification of several taxa.

2.3.3. Study area 3

The vegetation communities within study area 3 where mapped at 1:10,000, and defined as per the methodology utilised in study area 1, with the exception that no quadrats were established within study area 3. Ten relevé sites were recorded in study area 3.

The seasonal conditions prior to vegetation mapping were hot and dry resulting in the mapping of predominantly perennial species with few annuals recorded. Prior to mapping, the nearest weather station, Yeelirrie, recorded 83.8 mm of rainfall over March and April, 2010 (Bureau of Meteorology, 2010) enabling a small proportion of perennials to flower and fruit, which assisted the identification of some taxa.

2.3.4. Regional (study areas 4 to 16)

No vegetation mapping was undertaken during regional surveys. Non-permanent quadrats were established to determine consistency with communities of conservation significance to study area 1 (see Section 2.6.3).

2.4. Naming convention for vegetation communities

Vegetation communities were named using a protocol based on: (i) the landform group that the community occurs on, (ii) the dominant species defining the tallest stratum of the community (where a clear dominant existed) and (iii) the vegetation structure of the dominant species based on height and density (*e.g.* Woodland, Shrubland, Thicket or Heath) adapted from B.G. Muir (1977), for example, where *Casuarina pauper* is dominant and occurs as woodland on the Calcrete System, the vegetation unit is referred to as *Casuarina pauper* Woodland on Calcrete and given the acronym CCpW. Occasionally, the structure and/or species of the lower stratum are also given in the name to provide clarification between vegetation codes, for example, PLAPoS refers to *Acacia* spp. Shrubland over *Ptilotus obovatus* within the

Playa System. Vegetation structure classifications were based on Specht (1970) as modified by Aplin (1979).

2.5. Limitations to vegetation mapping

Difficulties encountered during vegetation community mapping include:

1. Limited vehicular access due to limited, widely spaced (2 to 5 km) and often overgrown tracks in study area 1;

2. Limited vehicle access to large parts of study area 2, with large distances and high temperatures restricting the area reachable by foot;

3. Rough terrain and dense vegetative growth, inaccessible to four-wheel drive vehicle, in study area 3;

4. Numerous fire regimes and recent burn scars, making Sand Plain communities difficult to define in all three study areas;

5. Dry seasonal conditions, resulting in flora encountered being in a vegetative state and few annuals present, during the same periods of the survey of study areas 1 and 3;

6. In study areas 1 and 3, vegetation community boundaries are limited to the scale of mapping. Mapping was undertaken on at 1:10,000 aerial photographs with on ground verification. As a result each boundary is estimated to be accurate to approximately 50 m, either side of the boundary, within the vegetation communities mapped in the Calcrete and Playa Systems and approximately 100 m in the Sand Plain System (also see Section 3.1.7 on Confidence level of mapping); and

7. In study area 2, vegetation community boundaries are limited to the scale of mapping. Mapping was undertaken on at 1:20,000 aerial photographs with on ground verification. As a result each boundary is estimated to be accurate to approximately 100 metres, either side of the boundary, within the vegetation communities mapped in the Calcrete, Playa and Granite Systems and

approximately 200 metres in the Sand Plain System (also see Section 3.4.2 on Confidence level of mapping).

2.6. Vegetation quadrat establishment and assessment

2.6.1. Study area 1

Vegetation quadrats were used to conduct a numerical analysis of the variation in the floristic composition of the vegetation communities within study area 1. This is in accordance with Guidance Statement No. 51 (EPA, 2004). The analysis was used to determine to what extent the floristic assemblages were consistent with the vegetation communities mapped.

Prior to quadrat establishment, species accumulation curves were used to determine an appropriate quadrat size that would provide the best representation of species numbers within a community. Commonly 30 m by 30 m quadrats are used as the standard to adequately sample the flora of the Murchison and Goldfields regions. A series of nested quadrats representing 10 vegetation communities were established within study area 1. Starting at 10 by 10 m, and increased by 10 m increments to a maximum of 50 by 50 m. On analysis of the species accumulation curves it was decided that 50 m by 50 m quadrats would provide the best representation of species in vegetation communities across survey area 1, a reflection of the dry (non-optimal) seasonal conditions.

The majority of quadrats were assessed for a second season following sufficient spring rainfall in 2010, which resulted in a large number of ephemeral and annual species germinating. During this second survey the size of the quadrats assessed was reduced to 20 by 20 m. The smaller quadrats provided a better representation of smaller vegetation communities and reduced the effects of community ecotones or edge effects.

During the first assessment, 149 permanent vegetation quadrats, each 50 by 50 m (2500 m^2), were established in vegetation communities defined during vegetation mapping. Where possible, at least one replicate quadrat was included for each vegetation communities sampled. In cases when a 50 m by 50 m quadrat did not fit in

the associated vegetation community, for example, along drainage lines or within a narrow community, a representative shape was adjusted to better suit the community.

During the second (spring) assessment, 153, permanent vegetation quadrats, each 20 by 20 m (400 m^2), were established across the validated vegetation communities. Of these 153 quadrats, 120 were rescored from the first round of sampling, and 33 were newly established. New quadrats were established when representative quadrats of a community had been impacted, or the previous quadrat was deemed to more closely reflect an ecotone rather than a defined vegetation community.

A detailed description of each quadrat was recorded, including a listing of the plant species and the number of individuals present. The total percentage foliage cover (PFC) for each quadrat was estimated, as was the PFC for each species in each height stratum (height range). Additional information to describe site characteristics was recorded including: presence of cryptogams (lichens), slope, aspect, the surrounding landforms estimated in terms of highest/nearest point affecting water run-off, outcropping type (if present), soil and nature of surface materials, erosion and disturbance by animals or people.

Locations of quadrats were recorded at the north-west corner peg using a hand-held GPS (accurate to approximately 5 m). Coordinates were recorded in the WGS84 datum. Two photographs were taken of each quadrat from the north-west and the north-east corner looking across the quadrat using a digital camera.

Following the first assessment of quadrats, a numerical analysis for the floristic quadrat data was conducted by Western Botanical using PATN (Belbin, 2010) on 149 quadrats. Five main functions of PATN were used: Bray and Curtis association, Flexible UPGMA classification with results displayed in a dendrogram, Semi-Strong Hybrid (SSH) Multidimensional Scaling (MDS) algorithm to create a three-dimensional ordination, a Two-way Table created by classification of sites and species groups, Kruskal-Wallis values to estimate the utility of species to discriminate between a set of groups. Site and species groups were generated; however, most of the interpretation was made from the classification of sites.

The analysis provided a means of classifying the observed floristic composition variation into different levels: two levels of classification (broad), five levels, and ten levels (fine).

2.6.2. Study area 2 and 3

No permanent vegetation quadrats were established in study areas 2 or 3.

2.6.3. Regional (study areas 4 to 16)

Vegetation communities of interest identified at lake systems 4, 5, 6 and 7 were revisited for quadrat assessment. Vegetation quadrats were established and assessed to provide data for comparison with those assessed in study area 1. Quadrats were assessed in accordance with Guidance Statement No. 51 (EPA, 2004). There were no quadrats established at lake systems 8 to 16.

Non-permanent vegetation quadrats, each 50 by 50 m (2500 m^2), were established in vegetation communities of interest. When a 50 m by 50 m quadrat size did not fit in the associated vegetation community, for example, along drainage lines or within narrow communities, a representative shape was adjusted to better suit the community.

A detailed description of each quadrat was recorded as per the methodology utilised in study area 1. Vegetation codes follow those developed by Western Botanical, discussed in Section 2.4.

2.7. Vegetation condition assessment

An assessment of vegetation condition for the local study area (study areas 1, 2 and 3) were based on information collected during vegetation mapping, quadrat assessment, significant flora searches and formal weed assessments. In study area 1, during quadrat assessment the following descriptions could be used to provide a broad overview of the vegetation condition: evidence of disturbance, evidence of fire impacts, estimation of fire age, and presence of weeds. These descriptions were assessed against the Keighery (1994) ranking scale as pristine, excellent, very good, good, degraded and completely degraded (see Appendix 6 of this report for further detail).

An assessment of Dieback (*Phytophthora cinnamomi*) was not undertaken, as the disease is not known to occur in the arid regions.

Methodology for weed survey

Study area 1 was assessed for the presence of weed species from areas identified during vegetation mapping and quadrat assessment. A targeted search was undertaken for weeds in the project footprint and focused on the rehabilitated areas and high usage areas associated with the drilling program. The presence of weeds in study areas 2 and 3 were recorded during vegetation mapping and significant flora searches. The locations of weeds were recorded by handheld GPS (level of accuracy +/- 5 m).

A detailed map of the distribution of *Acetosa vesicaria* (Ruby Dock) in the project footprint area was prepared for the purpose of future weed control and weed survey works, see Figure 8. *Acetosa vesicaria* records were mapped as points or polygons (for large populations) by handheld GPS (level of accuracy +/- 5 m). The tracks walked were also recorded on each handheld GPS and downloaded into an excel worksheet. The tracks provided a visual record of survey intensity and areas covered and were used to confirm that the appropriate areas had been adequately assessed.

Figure 8. Distribution of *Acetosa vesicaria* (Ruby Dock) in the project footprint area

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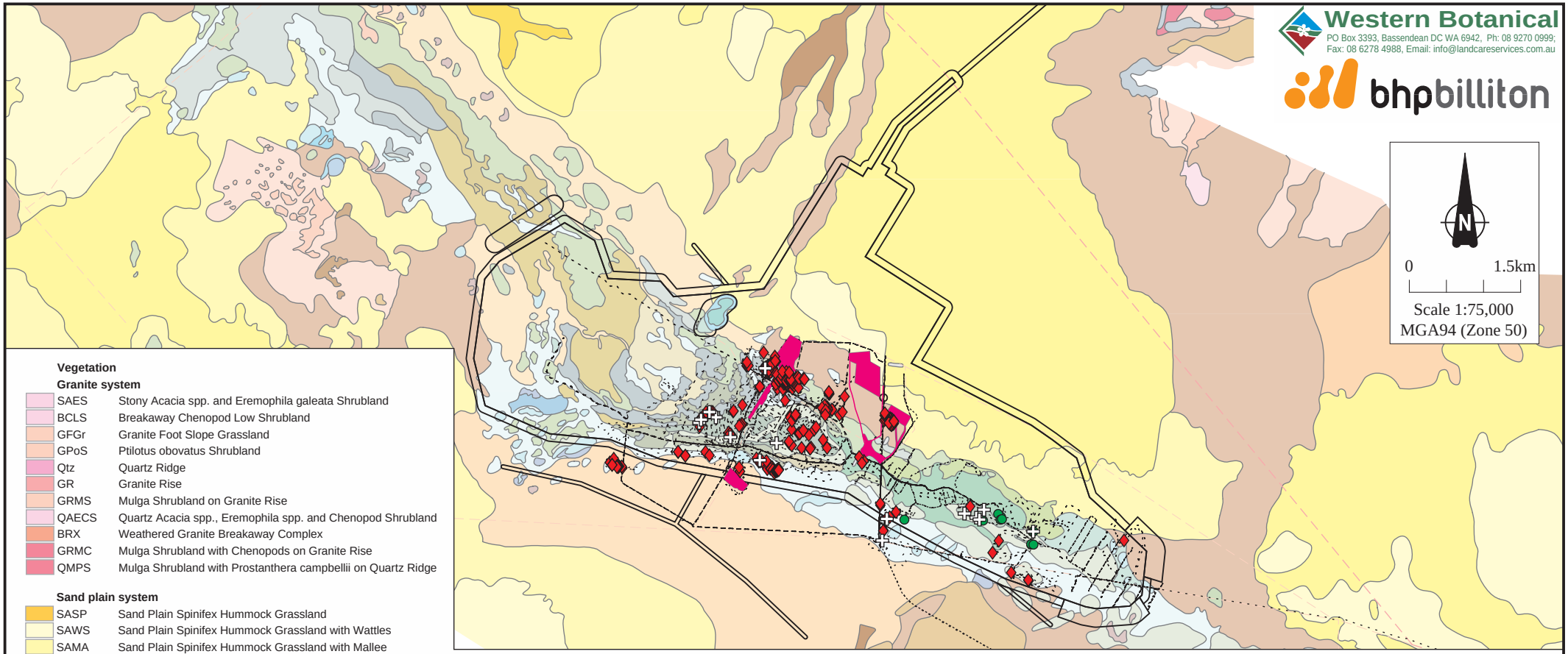

Vegetation

Granite system

SAES	Stony Acacia spp. and Eremophila galeata Shrubland
BCLS	Breakaway Chenopod Low Shrubland
GFGr	Granite Foot Slope Grassland
GPoS	Ptilotus obovatus Shrubland
Qtz	Quartz Ridge
GR	Granite Rise
GRMS	Mulga Shrubland on Granite Rise
QAECS	Quartz Acacia spp., Eremophila spp. and Chenopod Shrubland
BRX	Weathered Granite Breakaway Complex
GRMC	Mulga Shrubland with Chenopods on Granite Rise
QMPS	Mulga Shrubland with Prostanthera campbellii on Quartz Ridge

Sand plain system

SASP	Sand Plain Spinifex Hummock Grassland
SAWS	Sand Plain Spinifex Hummock Grassland with Wattles
SAMA	Sand Plain Spinifex Hummock Grassland with Mallee
SAHS	Sand Plain Spinifex Hummock Grassland with Heath
SAGS	Sand Plain Spinifex Hummock Grassland with Eucalyptus gongylocarpa
SAMU	Sandplain Mulga Spinifex Hummock Grassland
SDSH	Sand Dune Shrubland
MHHS	Mixed Chenopod Shrubland with Mulga Overstorey
SACSG	Sand plain Spinifex Hummonck Grassland with Corymbia lenziana Woodland

Playa System

PLAPoS	Acacia spp. and Ptilotus obovatus Shrubland
PLAET	Acacia spp. and Eremophila spp. Thicket
PLAMi	Acacia spp. and Melaleuca interioris Shrubland
PLMf	Muehlenbeckia florulenta Shrubland
PLCsMp	Cratystylis subspinescens and Maireana pyramidata Shrubland
PLEmc	Eremophila maculata ssp. brevifolia Shrubland
PLEml	Eremophila malacoides Shrubland
PLEsp	Eragrostis spp. Grassland on Playa
PLCh	Chenopods on Scalded Areas

Hardpan and Drainage System

DRMS	Drainage Tract Mulga Shrubland
DRMpS	Drainage Tract Maireana pyramidata shrubland
DRES	Drainage Line Eucalyptus camaldulensis Woodland
GRMU	Mulga Groves on Hardpan Plain
HPMS	Hardpan Plain Mulga Shrubland
WABS	Wanderrie Bank Grassy Shrubland

Calcrete system

CEgW	Eucalyptus gypsophila Woodland on Calcrete
CCpW	Casuarina pauper Woodland on Calcrete
CMxS	Melaleuca xerophila Shrubland on Calcrete
CAbS	Acacia burkittii Shrubland on Calcrete
CMiS	Melaleuca interioris Shrubland on Calcrete
CErG	Eragrostis sp. Yeelirrie Calcrete Grassland on Calcrete
CApS	Atriplex sp. Yeelirrie Station Shrubland on Calcrete
CRsS	Rhagodia sp. Yeelirrie Station Shrubland on Calcrete
CMpS	Maireana pyramidata Shrubland on Calcrete
CLaS	Lycium australe Shrubland on Calcrete
CMGbS	Mulga Grevillea berryana Shrubland on Calcrete

Saline Playa System

CsMp	Cratystylis subspinescens and Maireana pyramidata Shrubland
SBMMS	Sandy Bank Mulga and Maireana pyramidata Shrubland
SPAbS	Atriplex bunburyana Shrubland on Saline Playa
SPFLS	Frankenia spp. Low Shrubland on Saline Playa
SPLS	Lawrencia helmsii Shrubland on Saline Playa
SPTLS	Tecticornia spp. Low Shrubland on Saline Playa

Mosaics

- CAbS & CCpW
- CAbS & CEgW
- CErG & CAbS & CEgW
- CErG & CLaS
- HPMS & SAMU
- SAWS & SAHS
- HPMS & WABS
- HPMS & PLAPoS

Other

- Disturbed
- Bare

LEGEND

- Proposed Infrastructure
- Landcare Services' Survey Tracks

Weeds

- *Acetosa vesicaria* individual (Ruby Dock)
- *Acetosa vesicaria* population (Ruby Dock)
- *Sonchus oleraceus* (Sow Thistle)
- *Citrullus lanatus* (Afghan Melon)

Proposed Yeelirrie Development
2010 Weed Survey showing vegetation communities

Author: C. Ringrose Date: January 2011

2.8. Flora of conservation significance searches

2.8.1. Study area 1

Study area 1 was assessed for species of conservation significance either via traverses or from areas identified during vegetation mapping. Significant flora are those flora that have conservation status (Rare or Priority Flora as listed by DEC) and those that represent or may represent new species, sub-species or forms with potential conservation status.

Species of interest were also recorded. These include: species that are geographically restricted, may be poorly collected, represent significant range extensions of populations, or those requiring further taxonomic investigation.

Areas considered to have potentially high impacts from mining activities, such as the project footprint area, were surveyed intensively for significant flora. The ore body area was surveyed initially at 200 m intervals as part of the drilling programme over the ore body (and in accordance with clearing permits CPS2939/2 and CPS2965/1). The majority of the ore body area was further assessed at 50 m intervals, for additional resource confirmation, on request by BHP Billiton Yeelirrie Development Company Pty Ltd. Most of the proposed project footprint was traversed on foot by botanists at 100 m intervals. Figure 1 in Appendix 4 shows the survey intensity undertaken in study area 1.

While traversing each area, Western Botanical targeted and recorded Priority or Declared Rare Flora species, other species of conservation significance and species of interest. During these traverses botanists also recorded different vegetation communities to those already identified and potential significant ecological communities. Data on the distribution and abundance of Priority Flora elsewhere in study area 1 was collected opportunistically while conducting vegetation mapping and targeted significant species searches. The data from all surveys, including drill line and vegetation assessments over the ore body, was combined following the end of field works.

Significant species records were mapped as points or polygons (for large populations) by handheld GPS (level of accuracy +/- 5 m). The tracks walked by each botanist

were also recorded on each handheld GPS and downloaded into an excel worksheet. The tracks provided a visual record of survey intensity and areas covered and were used by botanists to confirm that the appropriate areas had been adequately assessed.

Care was taken not to duplicate counts or miss plants. Handheld two-way radios allowed communication between personnel when populations of significant species were encountered. Counts were then coordinated amongst adjacent botanists. As discussed previously, plant specimens were collected for verification and vouchering purposes for each of the significant species encountered.

Taxonomic identification, specimen vouchering and nomenclature was previously discussed in Section 2.2.

2.8.2. Study area 2

During mapping of study area 2, Western Botanical opportunistically recorded Priority or Declared Rare Flora species and other species of conservation significance. When encountered, the location of each species was recorded as per the methodology utilised in study area 1. Where a significant species was found to be a part of a larger population, the number of individuals were estimated by the methods defined in Section 2.8.7 below.

2.8.3. Study area 3

During the vegetation mapping of study area 3, Western Botanical opportunistically recorded Priority or Declared Rare Flora species and other species of conservation significance. When encountered, the location of each species was recorded as per the methodology in utilised in study area 1.

2.8.4. Regional (study areas 4 to 16)

Areas identified at each lake system were assessed for targeted species of conservation significance. The location of all significant species was recorded using a Garmin handheld GPS (accuracy +/- 5 m) and the number of plants at this point counted. Where possible specimens were collect for vouchering.

2.8.5. Population size calculations

2.8.6. Study area 1

Where necessary, the population sizes of significant flora and some flora species of interest were estimated. Where the population was considered too large to count individuals (numbers in the thousands) the perimeter of the population was recorded and the number of individuals within the population was estimated using random relevé points. At each relevé point the number of plants was counted within a 50 m diameter. When populations were extensive, in the case of *Euryomyrtus inflata* P3 and *Bossiaea eremaea* P3, an estimation of the population boundary was marked onto a series of 1:50,000 aerial photographs. A more detailed investigation was carried out for *Atriplex* sp. Yeelirrie Station P1, as discussed below.

***Atriplex* sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025) P1**

Due to the density of *Atriplex* sp. Yeelirrie Station in study area 1, a detailed estimation of the population size was undertaken. This was assessed using a combination of (i) intensive survey that counted all individual plants and (ii) estimation of individual numbers from representative quadrats within defined sub-population boundaries. The second methodology was used where the numbers were deemed too high to accurately count individual plants.

Forty vegetation quadrats, each 10 by 10 m (100 m^2), were established within areas that had very dense sub-populations of *Atriplex* sp. Yeelirrie Station. The quadrats were marked out with jarrah pegs, using a compass to get the bearing and a measuring tape to ensure the correct size. The following information was recorded within each quadrat:

- Where possible the number of plants with male and or female flowers (as suggested by Dr Kelly Shepherd WA Herbarium);
- Number of vegetative, reproductive, juvenile and aestivating/dead individuals; and
- Total Percentage Foliar Cover (PFC) of live plants and dead plants.

The quadrat data, specifically the number of live non-juvenile plants within each quadrat, and the area of occupancy of *Atriplex* sp. Yeelirrie Station was analysed and the total number of individuals was calculated using the following formula:

- Average number of live, non-juvenile, plants recorded within each 10 by 10 m quadrat. As the density of individuals was slightly higher in the west (21.62 per 100 m^2) than the east (17.36 per 100 m^2) the average number of plants within the west was calculated separately to that in the east; and

- Multiplied by the area of occupancy of *Atriplex* sp. Yeelirrie Station in the corresponding quadrated areas.

This total was added to the number of individual *Atriplex* sp. Yeelirrie Station plants counted during the intensive survey, of less dense populations, to provide the total number of *Atriplex* sp. Yeelirrie Station individuals within study area 1. Although juvenile plants were recorded, these were not included in the estimate of the total population.

The boundaries of the *Atriplex* sp. Yeelirrie Station were mapped using high resolution aerial photography and verified on ground using a handheld GPS (accuracy +/- 5 m) to record the boundary of each sub-population.

2.8.7. Study area 2

Due to the extent and density of *Euryomyrtus inflata* and *Bossiaea eremaea* populations within study area 2, an estimation of the population size of these species was undertaken, as discussed below.

Population size calculations of *Euryomyrtus inflata* P3

Surveys of *Euryomyrtus inflata* in study area 2 were carried out by walking 500 m transects, either side of the road or track, at regular intervals of one or two km spacings, dependant on the size of the population. Counts of individual plants were taken 30m either side of the transect line for a 60 m wide transect.

An estimate of the total number of *E. inflata* was calculated by multiplying the number of *E. inflata* counted against the proportion of the total area surveyed in transects. Given that each 500 m transect represented 3 ha, a total of 32 transects

were assessed and the total area surveyed was 96 ha. The total area of *E. inflata* populations covered in study area 2 was 18545 ha.

The following calculation: total area divided by area surveyed multiplied by number of plants within the area surveyed [(18545/96) x 9940], provided an estimate of 1,920,180 individuals in study area 2.

Population size calculations of *Bossiaea eremaea* P3

Where the populations *Bossiaea eremaea* were considered extensive (i.e. in the central northern area of study area 2) the number of individuals were estimated in a similar method to *Euryomyrtus inflata*, as described above. The exception being in the largest population of *Bossiaea eremaea* (301.99 ha) where a total count was carried out for approximately one eighth of the population area and then added to the estimated count of the remaining area of the population.

Small populations were either counted or when dense populations were estimated by a single transect passing through the population. When combined, 3839 individuals of *B. eremaea* were estimated to occur within study area 2.

2.8.8. Study area 3

A population size calculation was undertaken to determine the number of *Atriplex* sp. Yeelirrie Station individuals within study area 3. This was assessed using the same methodology utilised in study area 1, described in Section 2.8.6.

2.9. Regional survey site selection of study areas 4 to 16

2.9.1. Site selection

Regional sites selected for survey were determined using Landsat Imagery, land system maps at a scale of 1:500,000 (Payne *et al.*, 1998, Pringle *et al.*, 1994) and collection records of Priority Flora and species of interest (Western Australian Herbarium, 2011).

Lake systems and associated paleodrainage systems within the East Murchison IBRA sub-region were located and assigned a priority ranking according to their spatial association with four calcrete land systems: Cosmo, Cunyu, Melaleuca and Mileura.

Landform unit maps of Sandstone-Sir Samuel (Hall *et al.*, 1994) were used to isolate the presence of calcareous plains within each lake system mapped. The WA Herbarium species collection records were examined to confirm the presence of Priority Flora and other significant species, and similar vegetation communities of interest within regional paleodrainage systems (Western Australian Herbarium, 2011).

In addition to the above, aerial imagery on Google Earth was examined to locate potential sites of self-mulching clay for investigation in order to further define possible locations of *Atriplex* sp. Yeelirrie Station populations.

Thirteen paleodrainage systems within the Murchison and Eastern Goldfields regions were considered by the authors as having the highest likelihood of having flora and vegetation representative of that present within study area 1. Figure 9 shows the paleodrainage and lake systems selected for survey utilising a helicopter, and these span a distance of 500 km east to west and 370 km north to south, encompassing a total area of 185,000 square km (1,850,000 ha).

2.9.2. Targeted flora and vegetation survey by helicopter

The most efficient, effective and economical method considered for searching over the targeted lake systems was to utilise a helicopter. Undertaking the preliminary survey with a helicopter allowed for the remoteness of the target areas, extensive size of the lake systems and the highly restricted vehicle accessibility.

Six paleodrainage systems were selected as highest priority for the first survey by helicopter (Table 8). A series of 1:25,000 maps were used to mark potential new populations of conservation significant flora and vegetation communities of interest that were to be investigated further during on-ground surveys. The survey was conducted in November 2009. The airport at Mount Keith Nickel Operation was used as the primary base to conduct the search from.

Seven additional paleodrainage systems were selected for a second survey by helicopter (Table 9). The survey was conducted in May 2010 and was to specifically search for new populations of *Atriplex* sp. Yeelirrie Station.

Figure 9. Regional paleodrainage and lake systems selected for helicopter survey

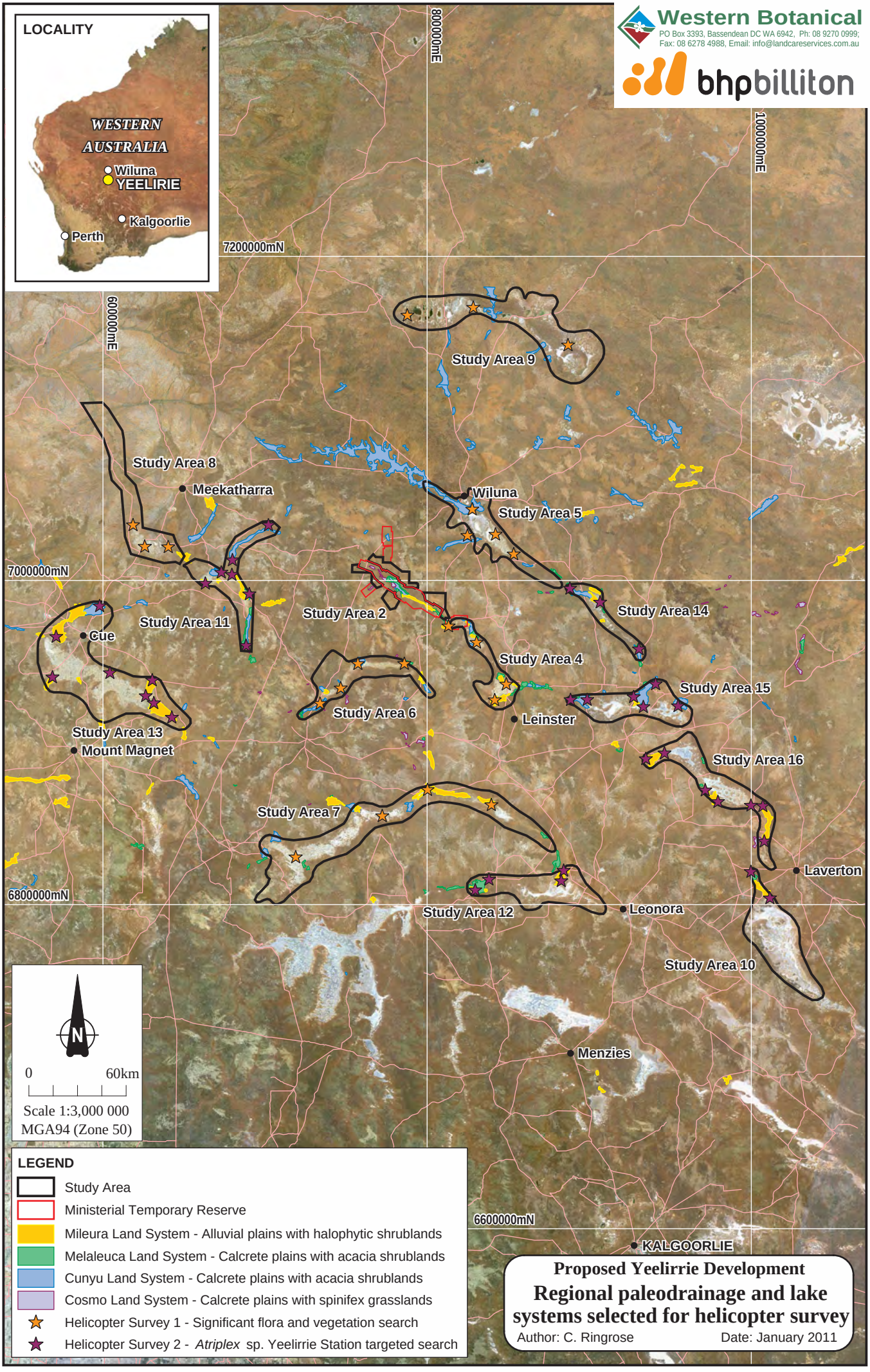

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Table 8. Paleodrainage systems targeted during the first survey by helicopter

Study Area	Site	Nearest town / Pastoral Station	Length of system	Distance (km) and direction from SA1	Land systems present	Reason for target
Study area 4	Yeelirrie Palaeochannel/ Lake Miranda	Leinster; Yakabindie and Albion Downs Stations	50 km	55 km SE	Melaleuca, Mileura, Cunyu	Regional representation of vegetation communities, *Scaevola spinescens* terete leaf form
Study area 5	Lake Way	Wiluna; Lake Way and Millbilliillie Stations	50 km	60 km NE	Melaleuca, Cosmo	Regional representation of vegetation communities, *Eremophila arachnoides* ssp. *arachnoides*, *Melaleuca xerophila*
Study area 6	Lake Mason	Sandstone; Lake Mason and Kaluwiri Reserve (DEC)	70 km	50 km SW	Melaleuca, Mileura, Cunyu, Cosmo	Regional representation of vegetation communities, *Eremophila arachnoides* ssp. *arachnoides*, *Melaleuca xerophila* PEC: Black Range South calcrete groundwater assemblage – invertebrates
Study area 7	Lake Noondie	Sandstone; Cashmere Downs, Bulga Downs, Dandaraga, Pinnacles, Yuinmery and Sturt Meadows Stations	100 km	145 km SW	Melaleuca, Mileura, Cunyu, Cosmo	Regional representation of vegetation communities
Study area 8	Lake Annean paleodrainage channel	Meekatharra; Belele, Annean, Polelle, Culcilli, Yarrabubba and Colga Downs Stations	60 km	185 km W	Mileura, Cunyu	PEC: Belele calcrete groundwater assemblage – invertebrates
Study area 9	Lake Nabberu	Wiluna; Cunyu, Neds Creek, Millrose and Granite Peak Stations	120 km	185 km N	Not mapped	*Eremophila arachnoides* ssp. *arachnoides* land systems not mapped

Table 9. Paleodrainage systems targeted for *Atriplex* sp. Yeelirrie Station during the second survey by helicopter

Study area	Lake system	Nearest town / Pastoral Station	Length of system	Distance (km) and direction from SA1	Land systems present	Reason for target
Study area 10	Lake Carey	Laverton Glenorn, Mt Weld Stations	180 km	290 km SE	Mileura, Cunyu	Self-mulching clays
Study area 11	Yarrabubba	Meekatharra Colga Downs, Hillview, Murchison Downs, Polelle, Sherwood and Yarrabubba Stations	105 km	100 km W	Mileura, Cunyu	Self-mulching clays
Study area 12	Lake Raeside	Leonora Sturt Meadows, Perrinvale Stations	90 km	200 km SSE	Mileura, Cunyu	Self-mulching clays
Study area 13	Lake Austin	Cue Austin Downs, Boogardie, Munbinia, Murrum, Nallan, Wondinong, Wyynyangoo, Yarraquin, Yoweragabbie Stations	130 km	200 km SW	Mileura, Cunyu	Self-mulching clays
Study area 14	Lake Maitland	Leinster Barwidgee and Wonganoo Stations	60 km	120 km E	Mileura, Cunyu	Self-mulching clays
Study area 15	Lake Darlot	Leinster Banjawarn, Melrose and Nambi Stations	80 km	160 km SE	Mileura, Cunyu	Self-mulching clays
Study area 16	Lake Irwin	Laverton Erlistoun, Laerton Downs, Melrose, Nambi Stations	100 km	230 km SE	Mileura, Cunyu	Self-mulching clays

2.9.3. Targeted flora and vegetation surveys on ground

These surveys were focused on areas of interest identified at each lake system following the first reconnaissance by helicopter. A series of 1:10,000 maps were used to record the locations of communities of interest, and locations of targeted flora.

3. Results and discussion

3.1. Study area 1 - vegetation

Thirty-nine vegetation communities were mapped within the 48,901 ha of study area 1; comprising 46,426 ha of the Ministerial Temporary Reserve and 2,475 ha of proposed access road. An overview of the study areas 1, 2 and 3 showing vegetation community boundaries is provided in Figure 10 and detailed vegetation maps of study area 1 are provided in Appendix 7 of this report. The communities mapped are grouped into five soil landscapes, as discussed below. The characteristics of each community is summarised in Table 10, and full descriptions are provided in Appendix 8 of this report. The area in hectares represented by each community, including those communities forming mosaics, are listed in Table 11.

3.1.1. Soil landscape association with vegetation communities

The vegetation communities of study area 1 are aligned and associated with the four soil landscapes as described in *Soils and Soil Landscapes of the Study Area* (Blandford, 2011). These soil landscapes are described below (adapted from Blandford, 2011). For the purposes of defining vegetation descriptions for study area 1, a fifth system was added, the Hardpan and Drainage System, which forms an interzone or continuum between the Sand Plain System and Playa System.

3.1.2. Communities occurring within the Sand Plain System

The sand plains are characterised by inconsistent soil profiles and have varying degrees of moisture retention according to the thickness and composition of gravels in the soil horizon. The Sand Plain System comprises the following units: plain, outwash fans, drainage lines, aeolian dunes and low relief granite rises. Surface gradients are low and there is a slight angle from the granite breakaways to the central valley. This system is underlain by weathered granites that occasionally intrude at the surface forming low relief granite rises.

Sand plain communities are characterised by Spinifex (*Triodia* spp.) hummock grasslands with a varying amount of shrub, tree and mallee components in the upper stratum. Seven vegetation communities were defined within the Sand Plain System of

study area 1: Sand Plain Spinifex Hummock Grassland (SASP), Sand Plain Spinifex Hummock Grassland with Wattles (SAWS), Sand Plain Spinifex Hummock Grassland with Mallee (SAMA), Sand Plain Spinifex Hummock Grassland with Heath (SAHS), Sand Plain Spinifex Hummock Grassland with *Eucalytpus gongylocarpa* Woodland (SAGS), Sand Plain Mulga Spinifex Hummock Grassland (SAMU) and Sand Dune Shrubland (SDSH).

Multiple fire regimes within these communities were observed. The occurence of recent fire significantly altered vegetation structure and species composition. Notably Mulga varieties are killed by fire and must regenerate from soil stored seed. Sucessful extensive regeneration occurs sporadically following high rainfall events and it can take many decades for Mulga to reassert dominance.

3.1.3. Communities occurring within the Hardpan and Drainage System

Five communities are described in the Hardpan and Drainage System which forms an interzone or continuum between the Sand Plain and Playa System. These communities are characterised by predominately bare-ground and are subject to sheet flow following rainfall and significant wind erosion.

Wanderrie Bank Grassy Shrubland (WABS) and Hardpan Plain Mulga Shrubland (HPMS) are floristically similar, and often form a mosaic. Dominant species include *Acacia ayersiana*, *A. aneura* and *A. ramulosa* var. *linophylla*. WABS is defined by the presence of Wanderrie grass (*Eragrostis eriopoda*), and HPMS is defined by an absence of a well-developed grassland understorey. Mulga Groves on Hardpan Plain (GRMU) vegetation represents dense areas of HPMS that occur in groves where soil, nutrients and water have accumulated.

Drainage Line *Eucalyptus* Woodland (DRES) and Drainage Tract Mulga Shrubland (DRMS) describe communities occurring on drainage lines. Each drainage line was floristically distinct.

3.1.4. Communities occurring within the Playa System

The Playa System is a transition zone that reflects the interaction between the sand plain and central calcrete and is the major drainage focus for surface runoff along the

valley floor. The Playa System comprises the following units: playas (shallow depressions), flats with scalds, and flats with sink holes.

Playas are circular depressions of low relief often no more than 0.5 m deep (may have a slightly raised rim) and varying in diameter from tens of metres to hundreds of metres. Flats with scalds are essentially areas devoid of vegetation where wind erosion is the major degradation factor. These flats tend to temporarily pond water. Flats with sink holes are characterised by a deranged surface where local relief may be up to 0.5 m elevation. This feature is created by the shrink-swell characteristics of the double lattice clays present.

Nine communities are described within the Playa System; however, the majority of this system is vegetated with *Acacia* - *Ptilotus obovatus* Shrubland (PLAPoS) on flats surrounding playas. PLAPoS forms a mosaic, in which eight other minor vegetation communities occur fringing or within playa depressions, scalds and sink holes. Areas with no vegetation are mapped as bare ground.

Acacia and *Melaleuca interioris* Shrubland (PLAMi) is defined by thickets of *Acacia* spp. and *Melaleuca interioris* that occur on banks fringing playas or water holding depressions.

Acacia - *Eremophila* Thicket (PLAET) is defined by thickets of tall shrubs dominated by *Acacia* spp. and *Eremophila longifolia* that occur in playas or water holding depressions, often with sink holes.

The other six minor vegetation communities are defined by the presence of one or two dominant species, these being: PLMf defined by presence of *Muehlenbeckia florulenta* shrubs, PLCh defined by presence of low chenopods, PLCsMp defined by presence of *Cratystylis subspinescens* and *Maireana pyramidata* shrubland, PLEml defined by the presence of *Eremophila malacoides* shrubland, PLEmc defined by the presence of *Eremophila maculata* subsp. *brevifolia* shrubland, and PLEsp defined by the presence of annual grasses including *Eragrostis* spp.

3.1.5. Communities occurring within the Central Calcrete System (Calcrete System)

This variable soil landscape has four recognized units: calcrete rises, depressions, flats, and clay flats. Each of these units has a distinctive soil stratigraphy. The calcrete rises are expressed as discrete areas of outcropping but weathered calcrete is generally present as scattered surface gravel. The calcrete rises are characterised by a thin veneer of residual soil overlying massive to platy calcrete.

The surface of the calcrete may still contain 'flats' where sediment is retained on the structure and where it generally forms a thin veneer of sandy loams. Elsewhere, highly distinctive clay flats are present where the clays tend to be high ranking, self-mulching, and display seasonal cracking.

The Central Calcrete System (Calcrete System) is fringed by the Playa System, excluding the north-west extent where it adjoins the Sand Plain System. There are pockets of Calcrete System vegetation communities within the Playa System and Sand Plain System. Eleven communities are described within the Calcrete System of study area 1.

Three calcrete rise shrubland/woodland communities, *Eucalyptus gypsophila* Woodland (CEgW), *Casuarina pauper* Woodland (CCpW) and *Acacia burkittii* Shrubland (CAbS) are structurally and floristically similar and defined by the dominant upper storey species, and often form mosaics. Mulga *Grevillea berryana* Shrubland (CMGbS) is structurally and floristically similar to CAbS, with the addition of Mulga and *Grevillea berryana.* In contrast to the other communities, CMGbS occurs on the outwash zone below the calcrete rise.

Maireana pyramidata Shrubland (CMpS), *Rhagodia* sp. Yeelirrie Station Shrubland (CRsS) and *Melaleuca interioris* Shrubland (CMiS) are isolated communities that are floristically similar apart from their dominant defining species. *Atriplex* sp. Yeelirrie Station Shrubland (CApS) is distinctive from all other communities and is represented and defined by one species. *Melaleuca xerophila* Shrubland (CMxS), *Lycium australe* Shrubland (CLaS) and *Eragrostis* sp. Yeelirrie Calcrete Grassland (CErG) communities are often co-occurring, however, have been described separately as they are floristically distinct.

3.1.6. Communities occurring within the Granite System

The Granite System has three key units and a highly variable transition zone to the sand plain. The system units comprise the breakaway plateau surface, the breakaway itself, and foot slopes. Breakaways are a prominent feature in the landscape, and characterised by a well-developed pallid zone, dominated by kaolinitic material. The breakaways lead into small, discontinuous areas of coarse-grained foot slope deposits, which are often incised by small surface drainage lines. Quartz dominates the mineralogy of the foot slope deposits.

There are seven communities described within the Granite System, and these are represented at the base of the granite breakaways to the north and south of the ore body, and on the proposed access road near the intersection with the Goldfields Highway. Granite rises are also present within the Sand Plain System.

The distinction between Granite Rise (GR) and Quartz Ridge (Qtz) vegetation communities is on the basis of surface features, such as the presence or absence of quartz stones or exfoliating granite outcrops, rather than floristic composition.

Stony *Acacia* and *Eremophila* Shrubland (SAES), *Ptilotus obovatus* Shrubland (GPoS), and Breakaway Chenopod Low Shrubland (BCLS) communities have overlapping floristic compositions, and the distinction between these groups is based on vegetation structure.

The remaining two communities, Granite Foot Slope Grassland (GFGr) and Mulga Shrubland on Granite Rise (GRMS), have distinctive floristic and structural compositions.

Figure 10. Overview of the vegetation communities mapped within study areas 1, 2 and 3

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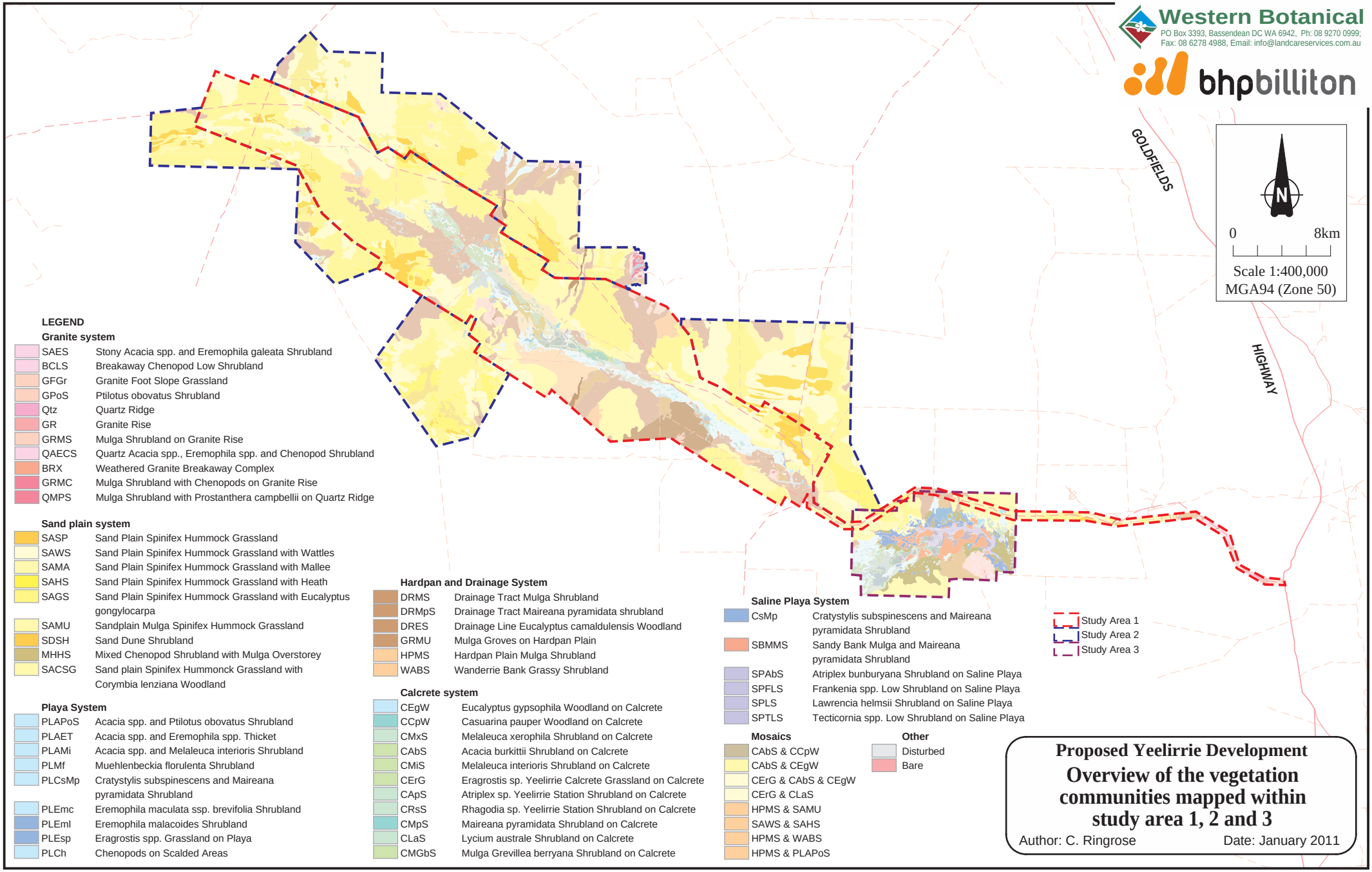

LEGEND

Granite system

SAES	Stony Acacia spp. and Eremophila galeata Shrubland
BCLS	Breakaway Chenopod Low Shrubland
GFGr	Granite Foot Slope Grassland
GPoS	Ptilotus obovatus Shrubland
Qtz	Quartz Ridge
GR	Granite Rise
GRMS	Mulga Shrubland on Granite Rise
QAECS	Quartz Acacia spp., Eremophila spp. and Chenopod Shrubland
BRX	Weathered Granite Breakaway Complex
GRMC	Mulga Shrubland with Chenopods on Granite Rise
QMPS	Mulga Shrubland with Prostanthera campbellii on Quartz Ridge

Sand plain system

SASP	Sand Plain Spinifex Hummock Grassland
SAWS	Sand Plain Spinifex Hummock Grassland with Wattles
SAMA	Sand Plain Spinifex Hummock Grassland with Mallee
SAHS	Sand Plain Spinifex Hummock Grassland with Heath
SAGS	Sand Plain Spinifex Hummock Grassland with Eucalyptus gongylocarpa
SAMU	Sandplain Mulga Spinifex Hummock Grassland
SDSH	Sand Dune Shrubland
MHHS	Mixed Chenopod Shrubland with Mulga Overstorey
SACSG	Sand plain Spinifex Hummonck Grassland with Corymbia lenziana Woodland

Playa System

PLAPoS	Acacia spp. and Ptilotus obovatus Shrubland
PLAET	Acacia spp. and Eremophila spp. Thicket
PLAMi	Acacia spp. and Melaleuca interioris Shrubland
PLMf	Muehlenbeckia florulenta Shrubland
PLCsMp	Cratystylis subspinescens and Maireana pyramidata Shrubland
PLEmc	Eremophila maculata ssp. brevifolia Shrubland
PLEml	Eremophila malacoides Shrubland
PLEsp	Eragrostis spp. Grassland on Playa
PLCh	Chenopods on Scalded Areas

Hardpan and Drainage System

DRMS	Drainage Tract Mulga Shrubland
DRMpS	Drainage Tract Maireana pyramidata shrubland
DRES	Drainage Line Eucalyptus camaldulensis Woodland
GRMU	Mulga Groves on Hardpan Plain
HPMS	Hardpan Plain Mulga Shrubland
WABS	Wanderrie Bank Grassy Shrubland

Calcrete system

CEgW	Eucalyptus gypsophila Woodland on Calcrete
CCpW	Casuarina pauper Woodland on Calcrete
CMxS	Melaleuca xerophila Shrubland on Calcrete
CAbS	Acacia burkittii Shrubland on Calcrete
CMiS	Melaleuca interioris Shrubland on Calcrete
CErG	Eragrostis sp. Yeelirrie Calcrete Grassland on Calcrete
CApS	Atriplex sp. Yeelirrie Station Shrubland on Calcrete
CRsS	Rhagodia sp. Yeelirrie Station Shrubland on Calcrete
CMpS	Maireana pyramidata Shrubland on Calcrete
CLaS	Lycium australe Shrubland on Calcrete
CMGbS	Mulga Grevillea berryana Shrubland on Calcrete

Saline Playa System

CsMp	Cratystylis subspinescens and Maireana pyramidata Shrubland
SBMMS	Sandy Bank Mulga and Maireana pyramidata Shrubland
SPAbS	Atriplex bunburyana Shrubland on Saline Playa
SPFLS	Frankenia spp. Low Shrubland on Saline Playa
SPLS	Lawrencia helmsii Shrubland on Saline Playa
SPTLS	Tecticornia spp. Low Shrubland on Saline Playa

Mosaics

CAbS & CCpW
CAbS & CEgW
CErG & CAbS & CEgW
CErG & CLaS
HPMS & SAMU
SAWS & SAHS
HPMS & WABS
HPMS & PLAPoS

Other

Disturbed
Bare

Study Area 1
Study Area 2
Study Area 3

Proposed Yeelirrie Development

Overview of the vegetation communities mapped within study area 1, 2 and 3

Author: C. Ringrose Date: January 2011

3.1.7. Confidence level of mapping

Due to the complexity of and the potential impacts a greater level of detail was used for mapping of the communities within the Calcrete and Playa Systems, and boundaries are estimated to be accurate to approximately 50 m. Less focus was placed on mapping the boundaries of those vegetation communities occurring outside the project footprint, where there is little or no proposed impact to vegetation. These are primarily vegetation communities of the Sand Plain System, and boundaries are estimated to be accurate to approximately 100 m.

Boundaries between sand plain communities were difficult to distinguish on aerial photography and at the scale that the surveys were undertaken in this area. Distinct boundaries were often absent between communities and instead there is a zone of intergrade with slight differences in species composition, for example, myrtaceous shrub layer and mallee component. In addition, differing fire regimes and the presence of fire scars often changed the appearance and composition of communities between the time the aerial imagery was captured and the time that on-ground vegetation mapping took place.

While there were challenges involved, the level of mapping in study area 1, at a scale of 1:10,000, is considered to be adequate and satisfies the purposes of an ERMP in accordance with Guidance Statement 51 (EPA, 2004).

Table 10. Summary descriptions of the vegetation communities within study area 1

Code	Vegetation Community	Landform Description	Dominant, Defining Flora
SAES	Stony *Acacia galeata* and *Eremophila* spp. Shrubland	Foot slope deposits of granite breakaway	*Eremophila galeata, Acacia aneura, A. ayersiana, A. tetragonophylla*, *Ptilotus obovatus* (typical Goldfields form), *Eremophila compacta* subsp. *compacta*, *E. latrobei* subsp. *latrobei*, *Senna artemisioides* subsp. x *sturtii*, *S. artemisioides* subsp. *helmsii*, *Sida ectogama, Eragrostis eriopoda*
BCLS	Breakaway Chenopod Low Shrubland	Foot slope deposits and undulating alluvial plains at the base of granite breakaway	*Maireana triptera, Sclerolaena diacantha, Ptilotus obovatus* (typical Goldfields form), *Cymbopogon ambiguus*
GFGr	Granite Foot Slope Grassland	Foot slope deposits of granite breakaway	*Aristida contorta, Cymbopogon ambiguus, Ptilotus obovatus* (typical Goldfields form), *Sclerolaena* spp., *Eremophila galeata, Senna artemisioides* ssp. *helmsii*
GPoS	*Ptilotus obovatus* Shrubland	Foot slope deposits of granite breakaway	*Ptilotus obovatus* (typical Goldfields form), *Maireana pyramidata*, *Eremophila compacta* subsp. *compacta*, *E. maculata* subsp. *brevifolia*, *Senna* spp., *Eragrostis* sp.
Qtz	Quartz Ridge	Hills and foot slopes associated with granite breakaway	*Acacia quadrimarginea, Acacia aneura, Callitris columellaris, Dodonaea petiolaris, Eremophila exilifolia* and *E. latrobei* subsp. *latrobei*, *Ptilotus obovatus* (typical Goldfields form), *Cymbopogon ambiguus*
GR	Granite Rise	Exfoliating granite outcrop	*Acacia quadrimarginea, Acacia aneura, Callitris columellaris, Dodonaea* spp., *Eremophila latrobei* subsp. *latrobei*, *Senna* spp., *Sida* spp., *Cymbopogon ambiguus*, various herbs
GRMS	Mulga Shrubland on Granite Rise	Plains with granite rise	*Acacia aneura, A. tetragonophylla, A. craspedocarpa, A. quadrimarginea, Ptilotus obovatus* (typical Goldfields form), *Eremophila* spp., *Sida ectogama, Senna* spp.
SASP	Sand plain Spinifex Hummock Grassland	Sand plain	*Triodia basedowii, Leptosema chambersii, Euryomyrtus inflata* P3, *Prostanthera wilkieana, Keraudrenia velutina, Acacia effusifolia, Grevillea acacioides,*
SAWS	Sand plain Spinifex Hummock Grassland with Wattles	Sand plain	*Triodia basedowii, Acacia effusifolia, A. heteroneura* var. *prolixa, A. jamesiana, A. prainii, A. pachyacra*
SAMA	Sand plain Spinifex Hummock Grassland with Mallee	Sand plain	*Triodia basedowii, Eucalyptus leptopoda* ssp. *elevata, E. kingsmillii, E. trivalva, Acacia effusifolia, A. heteroneura var. prolixa, A. prainii, A. ligulata, Leptosema chambersii*

Code	Vegetation Community	Landform Description	Dominant, Defining Flora
SAHS	Sand plain Spinifex Hummock Grassland with Heath	Sand plain	*Triodia basedowii, Enekbatus eremaeus, E. cryptandroides, Acacia effusifolia, A. heteroneura* var. *prolixa, A. jamesiana, Hakea francisiana*
SAGS	Sand plain Spinifex Hummock Grassland with *Eucalyptus gongylocarpa*	Sand plain	*Eucalyptus gongylocarpa, Acacia effusifolia, A. ligulata, A. prainii, A. heteroneura* var. *prolixa, Eremophila platythamnos* subsp. *platythamnos, Halgania cyanea* ssp. Allambi Stn (B.W. Strong 676), *Triodia basedowii*
SAMU	Sandplain Mulga Spinifex Hummock Grassland	Sand plain	*Acacia aneura, A. ayersiana, A. ramulosa* var. *linophylla, A. effusifolia, Melaleuca interioris, Triodia basedowii*
WABS	Wanderrie Bank Grassy Shrubland	Sand plain	*Acacia aneura, A. ayersiana, Grevillea berryana, A. ramulosa* var. *linophylla, A. tetragonophylla, Eremophila forrestii* ssp. *forrestii*, *Ptilotus obovatus* (typical Goldfields form), *Eragrostis eriopoda*
SDSH	Sand Dune Shrubland	Sand dunes	*Callitris columellaris, Acacia aneura, Eucalyptus leptopoda* ssp. *elevata, Bertya dimerostigma, Micromyrtus flaviflora, Hakea lorea* ssp. *lorea, Triodia basedowii*
HPMS	Hardpan Plain Mulga Shrubland	Plains	*Acacia aneura, A. ayersiana, A. ramulosa* var. *linophylla, A. tetragonophylla, Melaleuca interioris, Grevillea berryana, Eremophila* spp.
DRMS	Drainage Tract Mulga Shrubland	Drainage lines on plains	*Acacia aneura, A. ayersiana, Eremophila* spp., *Pluchea dentex,* various herbs
DRES	Drainage Line *Eucalyptus camaldulensis* Woodland	Drainage lines on plains	*Eucalyptus camaldulensis* subsp. *obtusa, Acacia aneura, A. quadrimarginea, A. tetragonophylla, A. ramulosa* var. *linophylla, Cymbopogon ambiguus, Pluchea dentex*
GRMU	Mulga Groves on Hardpan Plain	Plains	*Acacia aneura, A. ayersiana, A. craspedocarpa, A. tetragonophylla, A. ramulosa* var. *linophylla, Eremophila hygrophana, Ptilotus obovatus* (typical Goldfields form)
PLAPoS	*Acacia* spp. and *Ptilotus obovatus* Shrubland	Flats in Playa System	*Acacia aneura, A. ayersiana, A. tetragonophylla, A. ramulosa* var. *linophylla, A. burkittii, Ptilotus obovatus* (typical Goldfields form)
PLAET	*Acacia* spp. and *Eremophila* spp. Thicket	Playas with sink holes	*Acacia aneura, A. tetragonophylla, Eremophila longifolia, Hakea lorea* ssp. *lorea, Eucalyptus lucasii, Grevillea berryana, Santalum lanceolatum, Ptilotus obovatus* (typical Goldfields form), *Senna artemisioides* ssp. *filifolia, Eragrostis setifolia, Eriachne helmsii*

Code	Vegetation Community	Landform Description	Dominant, Defining Flora
PLAMi	*Acacia* spp. and *Melaleuca interioris* Shrubland	Fringes of playas in Playa System	*Acacia aneura, A. ayersiana, Melaleuca interioris, Ptilotus obovatus* (typical Goldfields form)
PLMf	*Muehlenbeckia florulenta* Shrubs	Playas	*Muehlenbeckia florulenta*
PLCsMp	*Cratystylis subspinescens* and *Maireana pyramidata* Shrubland	Playas	*Maireana pyramidata, M. georgei, Cratystylis subspinescens, Ptilotus obovatus* (typical Goldfields form), *Sclerolaena eriacantha, Solanum lasiophyllum, Frankenia laxiflora*
PLEmc	*Eremophila maculata* ssp. *brevifolia* Shrubland	Scalded areas in Playa System	*Eremophila maculata* ssp. *brevifolia*
PLEml	*Eremophila malacoides* Shrubland	Scalded areas in Playa System	*Eremophila malacoides*
PLEsp	*Eragrostis* sp. Grassland on Playa	Playas	*Eragrostis* sp. LCH26982, *Ophioglossum lusitanicum*
PLCh	Chenopods on Scalded Areas	Scalded area in Playa System	*Maireana georgei, M. carnosa, M. triptera, Sclerolaena diacantha, Dissocarpus paradoxus*
CEgW	*Eucalyptus gypsophila* Woodland on Calcrete	Calcrete rises	*Eucalyptus gypsophila, Templetonia incrassata, Eremophila arachnoides* ssp. *arachnoides* P3, *Acacia burkittii, Senna artemisioides* ssp. *filifolia*
CCpW	*Casuarina pauper* Woodland on Calcrete	Calcrete rises	*Casuarina pauper, Acacia burkittii, Templetonia incrassata, Senna artemisioides* ssp. *filifolia, Eremophila arachnoides* ssp. *arachnoides* P3, *Ptilotus obovatus* (typical Goldfields form), *Sclerolaena fusiformis*
CMxS	*Melaleuca xerophila* Shrubland on Calcrete	Flats within Calcrete System	*Melaleuca xerophila, Acacia burkittii, Senna artemisioides* ssp. *filifolia, Lycium australe, Ptilotus obovatus* (typical Goldfields form), *Sclerolaena fusiformis, Dissocarpus paradoxus, Amyema microphylla*
CAbS	*Acacia burkittii* Shrubland on Calcrete	Calcrete rises	*Acacia burkittii, Grevillea berryana, Eremophila arachnoides* ssp. *arachnoides* P3, *Senna artemisioides* ssp. *filifolia, Ptilotus obovatus* (typical Goldfields form)
CMiS	*Melaleuca interioris* Shrubland	Depressions in Calcrete System	*Melaleuca interioris, Acacia ayersiana, A. aneura* and *A. tetragonophylla, Ptilotus obovatus* (typical Goldfields form), *Sclerolaena convexula*
CErG	*Eragrostis* sp. Yeelirrie Calcrete Grassland	Flats in Calcrete System	*Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH 26770), *Lycium australe, Ptilotus obovatus* (typical Goldfields form)

Code	Vegetation Community	Landform Description	Dominant, Defining Flora
CApS	*Atriplex* sp. Yeelirrie Station Shrubland	Clay Flats in Calcrete System	*Atriplex* sp. Yeelirrie Station (L. Trotter and A. Douglas LCH25025) P1
CRsS	*Rhagodia* sp. Yeelirrie Station Shrubland	Clay Flats in Calcrete System	*Rhagodia* sp. Yeelirrie Station (K.A. Shepherd et al. KS1396) P1, *Teucrium racemosa*
CMpS	*Maireana pyramidata* Shrubland	Flats in Calcrete System	*Maireana pyramidata, M. georgei, Sclerolaena fusiformis, Ptilotus obovatus* (typical Goldfields form)
CLaS	*Lycium australe* Shrubland	Flats in Calcrete System	*Lycium australe, Eragrostis* sp. (S. Regan LCH 26770)
CMGbS	Mulga *Grevillea berryana* Shrubland	Outwash zone in Calcrete System	*Acacia aneura, Grevillea berryana, Senna artemisioides* spp. *filifolia, Acacia burkittii*

Table 11. Area (ha) represented by each vegetation community in study area 1

Vegetation Code	Study area 1 excluding proposed access road section (ha)	Proposed access road section (ha)	Study area 1 Total (ha)
SAES	14.01	184.49	198.50
DRES		4.97	4.97
BCLS		46.10	46.10
GFGr		43.37	43.37
GPoS	125.96		125.96
Qtz		0.14	0.14
GR	4.02	3.29	7.31
GRMS	388.24	147.94	536.18
SASP	1002.53	54.84	1057.37
SAWS	6513.19	268.06	6781.25
SAMA	14048.28	392.95	14441.23
SAHS	679.91		679.91
SDSH	100.62		100.62
SAGS	554.31	55.68	609.99
SAMU	6002.82	815.23	6818.05
SACSG	11.38		11.38
WABS	549.29	102.19	651.48
HPMS	7019.65	302.72	7322.37
HPMS and PLAPoS	530.25		530.25
HPMS and SAMU	752.37		752.37
HPMS and WABS	1264.68		1264.68
DRMpS	3.35		3.35
DRMS	132.52	17.30	149.82
GRMU	1393.16	0.58	1393.74
PLAPoS	1814.58	3.52	1818.10
PLAET	260.98	1.15	262.13
PLAMi	25.53	17.10	42.63
PLMf	15.24	0.02	15.26
PLCsMp	27.10		27.10
PLEmc		8.47	8.47
PLEml	15.27	2.74	18.01
PLEsp	15.18		15.18
PLCh	55.81		55.81
CEgW	178.94		178.94
CCpW	453.28		453.28
CMxS	374.95		374.95
CAbS	1119.69		1119.69
CAbS and CCpW	69.26		69.26

Vegetation Code	Study area 1 excluding proposed access road section (ha)	Proposed access road section (ha)	Study area 1 Total (ha)
CAbS and CEgW	213.92		213.92
CMiS	6.33		6.33
CErG	63.17		63.17
CErG and CAbS and CEgW	71.77		71.77
CErG and CLaS	11.77		11.77
CApS	71.48		71.48
CRsS	22.10		22.10
CMpS	147.51		147.51
CLaS	104.12		104.12
CMGbS	47.85		47.85
Bare	63.75	2.07	65.82
Disturbed area	85.16		85.16

3.1.8. Quadrats and relevés

A list of the vegetation quadrats and relevés assessed within study area 1 is presented in Table 12, and the locations of quadrats are presented in Appendix 7 of this report, on the vegetation map discussed previously in Section 3. This includes 149 vegetation quadrats from the first assessment, and 153 vegetation quadrats from the second (spring) assessment (refer to Section 2.6.1). Of these 153 quadrats, 120 were rescored from the first round of sampling, and 33 were newly established.

A description of each vegetation quadrat surveyed during the first and second assessment is provided in Appendix 9 of this report. The detailed statistical investigation of vegetation communities using data from the first assessment of quadrats in provided in Appendix 10 of this report. A table of species by vegetation community, recorded during the first and second assessment of quadrats, is provided in Table 1 and Table 2 of Appendix 11. Descriptions of relevés surveyed within study area 1 are provided in Appendix 12 of this report.

Statistical investigation of quadrats from the first assessment was undertaken using PATN. The PATN classification, for the most part, supported the expected associations and relationships between quadrats and vegetation communities described in the field.

Most of the inconsistencies between PATN classifications and the vegetation communities were due to reasons noted below.

- Errors of classification of sites in the field. Where errors in classification were clearly made, the field classifications were changed. Examples are the initial classifications of YQ019 and YQ135.

- Species defining vegetation communities in the field not having very high discrimination power between PATN classification groups and therefore not being included in further analysis.

- Placement of quadrats in locations not entirely representative of the vegetation community, for reasons such as placement on boundary or within ecotones.

- Sites floristically similar that were differentiated on the basis of the presence of one or two species.

- Sites floristically similar and differentiated on the basis of vegetation structure and cover.

- Lower intensity of survey, both in mapping and number of quadrats for areas out of the proposed project footprint - *e.g.* Sand Plain System.

It must be noted that the relationships discussed between vegetation communities defined in the field during vegetation mapping surveys, were made on the basis of the quadrats sampled, which are only a very small and selective representation of each of the vegetation communities identified in the vegetation mapping.

Table 12. Vegetation quadrats and relevés recorded in vegetation communities identified in study area 1

Vegetation Community	No. Quadrats (YQ) First assessment	No. Quadrats (YQS) Second assessment	No. Relevés (R)
SAES	2 (YQ80, YQ134)	3 (YQS80, YQS134, YQS168)	3 (R99, R102, R176)
BCLS	1 (YQ132)	2 (YQS132, YQS172)	1 (R107)
GFGr	1 (YQ128)	2 (YQS128, YQS171)	1 (R105)
GPoS	3 (YQ79, YQ83, YQ88)	3 (YQS79, YQS83, YQS88)	3 (R67, R76, R124)

Vegetation Community	No. Quadrats (YQ) First assessment	No. Quadrats (YQS) Second assessment	No. Relevés (R)
Qtz	1 (YQ133)	1 (YQS133)	1 (R106)
GR	3 (YQ126, YQ131, YQ147)	3 (YQS131, YQS147, YQS174)	3 (R33, R103, R104)
GRMS	5 (YQ82, YQ87, YQ116, YQ118, YQ135)	4 (YQS82, YQS87, YQS116, YQS118)	6 (R31, R32, R66, R74, R108, R109)
SASP	3 (YQ61, YQ62, YQ68)	4 (YQS61, YQS62, YQS68, YQS176)	2 (R96, R160)
SAWS	8 (YQ4, YQ9, YQ90, YQ91, YQ92, YQ105, YQ108, YQ109)	6 (YQS9, YQS90, YQS91, YQS92, YQS108, YQS109)	21 (R38, R45, R51, R54, R55, R56, R60, R61, R68, R78, R82, R85, R86, R87, R88, R95, R98, R114, R115, R167, R192)
SAMA	9 (YQ3, YQ48, YQ59, YQ63, YQ66, YQ85, YQ93, YQ104, YQ121)	7 (YQS3, YQS59, YQS63, YQS66, YQS85, YQS93, YQS165)	22 (R3, R4, R5, R6, R7, R24, R52, R58, R59, R110, R113, R116, R117, R152, R153, R156, R157, R159, R169, R177, R178, R179)
SAHS	5 (YQ60, YQ65, YQ67, YQ69, YQ94)	5 (YQS60, YQS65, YQS69, YQS94, YQS170)	5 (R53, R57, R166, R168, R171)
SAGS	3 (YQ51, YQ52, YQ53)	3 (YQS51, YQS52, YQS53)	3 (R89, R97, R112)
SAMU	7 (YQ1, YQ28, YQ55, YQ56, YQ57, YQ58, YQ111)	7 (YQS1, YQS28, YQS55, YQS56, YQS57, YQS58, YQS111)	15 (R2, R9, R10, R11, R12, R23, R26, R27, R39, R77, R79, R92, R94, R111, R154)
WABS	6 (YQ14, YQ71, YQ75, YQ77, YQ86, YQ107)	4 (YQS14, YQS71, YQS75, YQS86)	4 (R42, R65, R91, R121)
SDSH	3 (YQ49, YQ50, YQ54)	3 (YQS49, YQS50, YQS175)	1 (R170)
HPMS	9 (YQ2, YQ44, YQ45, YQ46, YQ47, YQ97, YQ98, YQ99, YQ112)	8 (YQS44, YQS45, YQS46, YQS47, YQS97, YQS99, YQ112, YQS166)	17 (R1, R8, R17, R20, R21, R22, R25, R34, R64, R83, R90, R122, R123, R125, R128, R139, R140)
DRMS	4 (YQ101, YQ110, YQ114, YQ115)	5 (YQS101, YQS110, YQS114, YQS115, YQS169)	1 (R101)
DRES	1 (YQ136)	2 (YQS136, YQS173)	1 (R100)
GRMU		3 (YQS135, YQS167, YQS178)	5 (R28, R29, R40, R41, R75)
PLAPoS	7 (YQ64, YQ70, YQ73, YQ74, YQ76, YQ138, YQ148)	6 (YQS64, YQS70, YQS74, YQS76, YQS138, YQS162)	8 (R35, R62, R63, R81, R119, R137, R138, R141)

Vegetation Community	No. Quadrats (YQ) First assessment	No. Quadrats (YQS) Second assessment	No. Relevés (R)
PLAET	8 (YQ12, YQ15, YQ78, YQ81, YQ84, YQ120, YQ127, YQ139)	5 (YQS15, YQS81, YQS84, YQS127, YQS139)	8 (R14, R37, R129, R134, R142, R162, R163, R172)
PLAMi	4 (YQ106, YQ113, YQ117, YQ123)	4 (YQS113, YQS117, YQS164, YQS182)	2 (R18, R93)
PLMf	2 (YQ137, YQ146)	3 (YQS137, YQS146, YQS179)	5 (R19, R48, R73, R165, R173)
PLCsMp	4 (YQ29, YQ43, YQ100, YQ149)	4 (YQS29, YQS43, YQS149, YQS155 YQS163)	1 (R175)
PLEmc	1 (YQ141)	1 (YQS141)	1 (R16)
PLEml	2 (YQ89, YQ140)	2 (YQS89, YQS140)	2 (R13, R44)
PLEsp	1 (YQ144)	1 (YQS144)	1 (R43)
PLCh	2 (YQ103, YQ142)	2 (YQS103, YQS177)	2 (R148, R149)
CEgW	6 (YQ10, YQ18, YQ20, YQ21, YQ23, YQ30)	5 (YQS10, YQS18, YQS21, YQS23, YQS30)	4 (R72, R127, R131, R136)
CCpW	7 (YQ17, YQ26, YQ39, YQ40, YQ41, YQ42, YQ72)	6 (YQS17, YQS26, YQS40, YQS41, YQS42, YQ72)	4 (R70, R71, R155, R158)
CMxS	11 (YQ8, YQ19, YQ22, YQ24, YQ32, YQ34, YQ35, YQ36, YQ37, YQ38, YQ145)	5 (YQS8, YQS24, YQS32, YQS34, YQS38)	6 (R36, R46, R49, R120, R133, R147)
CAbS	4 (YQ6, YQ11, YQ25, YQ27)	5 (YQS6, YQS11, YQS25, YQS27, YQS151)	5 (R69, R80, R126, R150, R174)
CMiS	1 (YQ129)	2 (YQS129), YQS180)	2 (R84, R118)
CErG	2 (YQ5, YQ125)	5 (YQS5, YQS125, YQS159, YQS160, YQS161)	3 (R130, R135, R143)
CApS	3 (YQ7, YQ13, YQ16)	5 (YQS7, YQS13, YQS16, YQS157, YQS158)	1 (R132)
CRsS	2 (YQ102, YQ143)	4 (YQS102, YQS143, YQS150, YQS156)	4 (R146, R151, R161, R164)
CMpS	3 (YQ31, YQ33, YQ122)	4 (YQS31, YSQ33, YQS122, YQS154)	2 (R30, R47)
CLaS	3 (YQ96, YQ119, YQ124)	5 (YQS96, YQS119, YQS124, YQS152, YQS153)	1 (R144)
CMGbS	2 (YQ95, YQ130)	3 (YQS95, YQS130, YQS181)	3 (R50, R145, 180)

3.1.9. Threatened Ecological Communities and Priority Ecological Communities

There were no flora related TECs or PECs listed for calcrete assemblages within the vicinity of the local study area. There are fifteen Priority One PEC communities associated with Banded Ironstone Formations (BIFs) listed in the DEC Goldfields region and these are not discussed further. Vegetation communities of interest within study area 1 are discussed in the next Section.

3.1.10. Vegetation communities of interest

Some vegetation communities, particularly those occurring within the Calcrete System of study area 1, are considered of interest as they are based on current information available of limited distribution. Some of these vegetation communities that are mapped in study area 1 fall within the descriptions of ecosystems at risk described by Cowan (2001) within the East Murchison IBRA subregion. These ecosystems are considered as being of limited distribution and at risk, and consequently, they are collectively considered to have conservation significance. Table 13 provides a summary of the ecosystems at risk identified by Cowan (2001) and correlates them with vegetation communities described in study area 1. While the defining species of these communities are regionally widespread, their distribution is limited and is closely associated with calcrete and/or gypsum.

Table 13. Ecosystems at risk in the East Murchison IBRA subregion which correlate with vegetation communities in study area 1.

East Murchison IBRA subregion ecosystems at risk (Cowan, 2001)	Appropriate Recovery Action recommended by Cowan (2001)	Similar Vegetation Communities in the study area 1
Melaleuca sp. nov (now *Melaleuca xerophila*) low closed to open forest strand community near Wiluna	Habitat retention and protection through reserves and fire management.	*Melaleuca xerophila* Shrubland on Calcrete (CMxS)

Calcyphytic *Casuarina* - *Acacia* woodlands / shrublands of the North-east Goldfields (Pringle *et al.*, 1994 – site type 7)	Habitat retention and protection through reserves. Fire Management.	*Casuarina pauper* Woodland on Calcrete (CCpW) and *Acacia burkittii* Shrubland on Calcrete (CAbS)
Calcrete platform woodlands / shrublands of the North-east Goldfields (Pringle *et al.*, 1994 – site type 8). NB: Eucalypt erroneously identified as *E. clelandii*, now *E. gypsophila*.	Habitat retention and protection through reserves, feral animal control and fencing.	*Casuarina pauper* Woodland on Calcrete (CCpW) and *Eucalyptus gypsophila* Woodland on Calcrete (CEgW)
Mixed chenopod shrublands with Mulga (*Acacia aneura*) overstorey of the north-east Goldfields (Pringle *et al.*, 1994 – site type 18)	Habitat retention and protection through reserves, feral animal control and fencing.	*Maireana pyramidata* Shrubland (CMpS); *Cratystylis subspinescens* and *Mairana pyramidata* Shrubland on Playa (PLCsMp)

Melaleuca xerophila shrublands or low woodlands occur on calcareous and gysiferous soils within palaeochannels and on the margins of salt lakes in the eastern Murchison biogeographic region and extends to the southern Pilbara. In study area 1, *Melaleuca xerophila* is abundant in the Calcrete System where it forms shrublands (CMxS) that have little associated understorey. It is considered a community of interest due to its (i) limited range as it is restricted to calcretes, (ii) the presence of the dominant species *Melaleuca xerophila* and (iii) the focus on these habitats in current development proposals in the North-eastern Goldfields and Murchison. While the species is not priority listed, *Melaleuca xerophila* woodlands / shrublands are recognised by Cowan (2001) as being of limited distribution and potentially under threat.

Eucalyptus gypsophila woodlands occur on red sand, calcrete and gypsum near salt or playa lakes throughout the Murchison, Yalgoo, Great Victoria Desert, Little Sandy Desert

and Coolgardie bioregions. *Casuarina pauper* is a widespread species occurring across a range of habitats including lake edges throughout the Eremaean Botanical district. Both species form woodlands (CEgW and CCpW) within study area 1 and have little associated understorey.

Acacia burkittii is a widespread species occurring across a range of habitats including lake edges, loamy hill sides and minor drainage tracts throughout the Eremaean Botanical district. It's occurrence on calcrete, in association with a limited range of understorey species (CAbS community), is an uncommon occurrence in the north-eastern Goldfields.

While the above species are regionally widespread, their association with calcrete platforms and rises is recognised by Cowan (2001) as being of limited distribution and potentially under threat. The occurrence of these landforms is geographically disjunct and associated with paleochannels.

The *Maireana pyramidata* Shrubland (CMpS) and the *Cratystylis subspinescens* and *Mairana pyramidata* Shrubland on Playa (PLCsMp) vegetation communities correlate with Mixed chenopod shrublands with Mulga (*Acacia aneura*) overstorey of the north-east Goldfields (Pringle *et al*., 1994 – site type 18). Their occurrence within the project footprint is minor, no species with conservation significance are known within these communities in study area 1 and the communities are reasonably well represented in the north-eastern Goldfields region.

Two new vegetation communities described by Western Botancial have not been documented previous to these surveys and are known from within the local study area only: (i) *Atriplex* sp. Yeelirrie Station Shrubland on Calcrete (CApS) and (ii) *Rhagodia* sp. Yeelirrie Station Shrubland on Calcrete (CRsS). The CApS community, described previously in Section 3.3.1, is dominated by *Atriplex* sp. Yeelirrie Station P1 on self-mulching clay in depressions and is confined to clay flats within the Calcrete System. The CRsS community, described previously in Section 3.3.1, is dominated by *Rhagodia* sp. Yeelirrie Station P1 on playas in the Calcrete System. Based on current information available both communities are of limited distribution.

Regional surveys, detailed in Section 5, were undertaken to determine representation of these communities elsewhere within the region.

3.1.11. Vegetation condition and weeds

The Murchison and North-eastern Goldfields regions are largely uncleared, although the ecological integrity of these regions has been degraded by the effects of grazing by sheep, cattle, goats, rabbits and elevated populations of kangaroos (Van Vreeswyk and Godden, 1998). The local study area was historically used for pastoral grazing as part of the Yeelirrie and Albion Downs pastoral leases. Over the previous forty years the area containing the Yeelirrie uranium deposit has been subject to various exploration activities, including the drilling and the excavation of bulk sampling pits, all of which resulted in land clearing.

The majority of the vegetation within the local study area (study areas 1, 2 and 3) is in 'excellent' condition (based on the ranking scale of Keighery 1994, Appendix 6 of this report). The vegetation structure is intact, with disturbance affecting individual species, with the most notable being *Atriplex* sp. Yeelirrie Station P1 in study areas 1 and 3. Grazing by native mammals and rabbits is evident on palatable species. At the time of survey, a minimal number of stock were run on the Yeelirrie pastoral lease. The stock were confined to the eastern section of the pastoral lease, located along the Yeelirrie - Albion Downs Road, west from Snake Bore to the common boundary shared with Albion Downs Station. This occurs outside study area 1 and is limited to the western section of the proposed access road. There has been more extensive livestock grazing in the past, however, this has had little long-term impact on the vegetation.

Eleven weed species were recorded in the local study area. Weeds recorded are generally non-aggressive species, however, the presence of *Acetosa vesicaria* (Ruby Dock) in areas rehabilitated in 2004 is a concern, as these areas will act as a weed seed source in future. Weeds are discussed further in Section 3.3.5.

Vegetation within the historical rehabilitated areas in the project footprint area is in 'degraded' condition based on the ranking scale of Keighery (1994).

Vegetation condition of the local study area reflects seasonal conditions. Responses to a good season with significant rainfall events include the germination of annuals, vegetative growth, flowering and fruit set of perennials. The survey of the local study area was initiated in December 2008 after a long period of poor seasonal conditions and the effects of past grazing activities were more evident. This was indicated by low fruit set, poor vegetative growth, heavily grazed plants and the absence of annual species. The vegetation within the local study area at this time was in 'very good' condition as compared to 'excellent' at the time of reporting.

3.1.12. Phreatophytic vegetation

Phreatophytic vegetation is defined as deep-rooted plants that can access groundwater, via the capillary fringe. For the purposes of this report the authors did not differentiate between obligate and facultative phreatophytic vegetation. Obligate phreatophytic vegetation only inhabits areas where they can access groundwater for at least some proportion of their environmental water requirement. Facultative phreatophytic vegetation access groundwater for at least some portion of their environmental water requirement but can also inhabit areas where their water requirements can be met by soil moisture reserves alone and are therefore groundwater dependent in some environments but not in others. These two vegetation types have been combined here as a precautionary rule, that is, ecosystems that derive a part of their water budget from groundwater must be assumed to have some degree of groundwater dependency (Hatton and Evans 1998).

For the purposes of this report, groundwater is defined as the saturated zone of the regolith and its associated capillary fringe. It is distinct from soil water, which is water held under tension in soil pore spaces and is generally not saturated. Both calcretes and palaeochannel sands are known for their groundwater availability. However, significant local variations in salinity can occur in these systems, which is often dependent on the location of the calcretes within the catchment (Pringle *et al.*, 1994).

In Australia there are a limited number of studies that have identified groundwater use by terrestrial vegetation (Dillon *et al.*, 2009). It is difficult to accurately define the

phreatophytic vegetation without significant field studies. For this preliminary assessment the authors have defined phreatophytic vegetation as the vegetation where a significant proportion of the foliage remains green and physiologically active during extended dry periods, as indicated by Earmus (2009). In addition, observations of flowering during the summer period was used as an indicator of phreatophytic species (eg *Grevillea berryana* flowering in December, *Eucalyptus gypsophila* flowering in February). Based on their observations and experience, the authors believe the vegetation communities listed in Table 14 and associated mosaics represent communities with significant phreatophytic components within study areas 1, 2 and 3. In addition to these communities, many potentially phreatophytic species occur scattered throughout large expanses of the Sand Plain System and the Hardpan and Drainage System. These species and their associated vegetation communities are listed in Table 15.

Table 14. Phreatophytic vegetation in study areas 1, 2 and 3

Phreatophytic Vegetation	Potentially Impacted species	Soil Landscapes
PLAET	*Grevillea berryana*, *Eremophila longifolia*, *Eucalyptus lucasii*, *Hakea lorea* subsp. *lorea*	Playa System
PLAMi	*Melaleuca interioris*	Playa System
CMxS	*Melaleuca xerophila*	Calcrete System
CMiS	*Melaleuca interioris*	Calcrete System
CMGbS	*Grevillea berryana*	Calcrete System
CCpW	*Casuarina pauper*	Calcrete System
CEgW	*Eucalyptus gypsophila*	Calcrete System
SAGS	*Eucalyptus gongylocarpa*	Sand Plain System
SACSG	*Corymbia lenziana*	Sand Plain System

Table 15. Phreatophytic species and associated vegetation in study areas 1, 2 and 3

Phreatophytic Species	Associated Vegetation	Soil Landscapes
Grevillea berryana	HPMS, SAGS, SAMA, SDSH, SAWS, CAbS	Sand Plain System Hardpan and Drainage System Calcrete System
Melaleuca interioris	SAWS, SAMU, HPMS, SDSH	Sand Plain System Hardpan and Drainage System
Eucalyptus kingsmillii	SASP, SAWS, SAHS, SAMU, SAMA, SAGS	Sand Plain System
Eucalyptus leptopoda		
Eucalyptus trivalva		
Eucalyptus lucasii		

3.2. Study areas 1, 2 and 3 - flora

3.2.1. Flora identified within study areas 1, 2 and 3

A total of 577 taxa from 199 genera and 62 families were recorded within study areas 1, 2 and 3 including 11 non-endemic weed species. This total includes sub species, varieties and taxa not fully determined. Families with the greatest number of representatives were Fabaceae (124 taxa), Scrophulariaceae (36 taxa), Asteraceae (53 taxa), Chenopodiaceae (39 taxa) and Poaceae (41 taxa). Genera with the greatest number of representatives were *Acacia* (91 taxa including 45 forms of *Acacia aneura* which may include some duplicates), *Eremophila* (36 taxa), *Ptilotus* (12 taxa), *Sclerolaena* (12 taxa) and *Maireana* (12 taxa). A systematic list of vascular flora for study areas 1, 2 and 3 is presented in Appendix 13 of this report. Most taxa recorded from the study areas are widespread and common in the region and occur across a range of land systems and soil types. These are not discussed further.

3.2.2. Unidentified plant specimens from study areas 1, 2 and 3

The identification of some plant specimens has not yet been validated for one of three reasons: (i) insufficient material was available due to time of survey, (ii) dry seasonal conditions meant that flowers and or fruits needed for verification were not available or (iii) specimens are still with specialist taxonomists awaiting verification.

Approximately 44 collections of plant specimens have not been not fully identified. Most of these are likely to be equivalent to named species; however, they require further collections of better material to verify accurate identification. Once these specimens are fully identified some taxa may be considered of interest.

3.3. Study area 1 - Significant flora and species of interest

Significant flora are classified within this report as being flora that: have conservation status (Declared Rare Flora and Priority species listed by DEC), or represent or may represent new species, sub-species or forms yet to be described, that possibly warrant conservation status.

No Threatened Flora, protected under the EPBC Act 1999, or Declared Rare Flora, protected under the *WC Act 1950*, were located in the survey area. Eight Priority Flora species have been confirmed to occur within study area 1, and are listed in Table 16 and described in Section 3.3.1. These are: *Atriplex* sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025) P1, *Rhagodia* sp. Yeelirrie Station (K.A. Shepherd et al. KS1396) P1, *Euryomyrtus inflata* P3, *Baeckea* sp. Sandstone (C.A. Gardner s.n. 26 Oct. 1963) P3, *Bossiaea eremaea* P3, *Eremophila arachnoides* subsp. *arachnoides* P3, *Olearia arida* P4 and *Comesperma viscidulum* P4. Of these, four occurred within the project footprint: *Atriplex* sp. Yeelirrie Station P1, *Rhagodia* sp. Yeelirrie Station P1, *Bossiaea eremaea* P3 and *Eremophila arachnoides* subsp. *arachnoides* P3. The conservation status of these flora are based on known ranges and potential threats to populations and individuals.

The eight Priority Flora recorded in study area 1 were included in the 37 Priority Flora listed by the DEC as occurring in the region including Yeelirrie (see Section 1.10.3 and Table 1 of Appendix 3). The remaining 29 Priority Flora were not recorded in study area 1 for one of two reasons: (i) there was no suitable habitat in study area 1, or (ii) the species has a limited distribution range. The nine P1 Flora listed as occurring in the region including Yeelirrie but not recorded in study area 1 are discussed further:

- *Anacampseros* sp. Eremaean (F. Hort, J. Hort & J. Shanks 3248) - There are currently six voucher collections listed on FloraBase (Western Australian Herbarium, 2011). This species is a tuberous perennial, less than 5 cm tall, and occurs in small pockets of soil on breakaway or granite outcrops. The nearest named locality is Yakabindie Station.

- *Beyeria lapidicola* - This species is restricted to banded ironstone formations, and is known only from the Murchison Biogeographic region. There are currently nine voucher collections listed on FloraBase (Western Australian Herbarium, 2011). There is no habitat suitable for this species occurring in study area 1 and the nearest named locality is Lake Way Station.

- *Dampiera plumosa* - There are currently four voucher collections listed on FloraBase (Western Australian Herbarium, 2011), and the nearest named locality

is Black Range Station near Sandstone. Suitable sand plain habitat is present in study area 1, although this species was not recorded during these surveys.

- *Eremophila congesta* - This species is restricted to banded ironstone formations and lateritic outcrops. There are currently 14 voucher collections listed on FloraBase (Western Australian Herbarium, 2011). There is no habitat suitable for this species occurring in study area 1 and the nearest named locality is Lake Way Station.

- *Neurachne lanigera* - There are currently five voucher collections listed on FloraBase (Western Australian Herbarium, 2011). The nearest named locality is Wiluna. Suitable sand plain habitat for this species occurs in study area 1, however, it was only recorded in study area 2 and is discussed further in Section 3.5.1.

- *Pityrodia canaliculata* - There are currently 20 voucher collections listed on FloraBase (Western Australian Herbarium, 2011) and the nearest named locality is Black Range Station. Suitable sand plain habitat is present in study area 1, although this species was not recorded during these surveys.

- *Stenanthemum mediale* - There are currently nine voucher collections listed on FloraBase (Western Australian Herbarium, 2011), including one from Yeelirrie Station. *Stenanthemum mediale* was recorded outside of the local study area as occasional plants on red clayey sands associated with granite breakaways. No habitat suitable for this species occurs in study area 1 and it not recorded during the survey.

- *Tecticornia* sp. Lake Way (P. Armstrong 05/961) - There are currently eight voucher collections listed on FloraBase (Western Australian Herbarium, 2011). No suitable salt lake bed habitat is present in study area 1. The nearest named locality is Lake Way Station near Wiluna.

- *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) - Known from granite breakaways on Yakabindie and Mount Keith Stations. No habitat suitable

for this species occurs in study area 1, however, it was recorded in study area 2 and is discussed in Section 3.5.1.

Three significant flora species recorded in study area 1 represent new taxa that were recognised for the first time following these surveys, and these are described in Section 3.3.2. These taxa have been confirmed as undescribed species and have had phrase names applied: *Atriplex* sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025), *Rhagodia* sp. Yeelirrie Station (K.A. Shepherd et al. KS1396) and *Scaevola spinescens* terete leaf form (G. Cockerton & C. Ringrose LCH 14560).

In addition to significant flora, a further 12 species of interest recorded in study area 1 are discussed below and a summary of all species including Priority Flora and other significant flora is presented in Table 16. Species of interest are classified within this report as being flora which either represent significant range extensions of populations, are geographically restricted, may be poorly collected, or require further taxonomic work.

Particular focus was placed on *Templetonia incrassata*, a prominently occurring species within study area 1. *Templetonia incrassata* is a newly defined taxon that was split from *T. egena* after a revision of the leafless species of *Templetonia* (Thompson, 2010). The revision was conducted independently of this survey, however, plant material collected from study area 1 was used in the assessment. *Templetonia incrassata* is poorly collected and restricted to the northern Coolgardie and Murchison Biogeographic regions. Records of *T. incrassata* within study area 1 represent a significant range extension. *Bertya dimerostigma* is known from the eastern Coolgardie Biogeographic region and is also of interest due to the population within study area 1 being a significant range extension.

In addition to the species outlined above, seven species of interest require further taxonomic work (Table 16). These are undescribed species that do not as yet appear on the Census of Vascular Flora and therefore do not appear on DEC's FloraBase website. For the purposes of reporting these taxa have been given phrase names, and it is unlikely that any warrant conservation status.

A full description of each species of interest is provided below. A discussion of the Mulga variants recorded within study area 1 is provided in Section 3.3. The variants are considered to be of taxonomic interest as Mulga show a large degree of variability and are in the process of being reviewed. There is likely duplication of Mulga varieties collected during these surveys.

Table 16. Priority Flora, other significant flora and species of interest recorded within study area 1

Species	Cons. status	Requires taxonomic investigation	Undescribed species	Geographically restricted	Range extension	Poorly collected
Atriplex sp. Yeelirrie Station (L. Trotter and A. Douglas LCH 25025)	P1					
Rhagodia sp. Yeelirrie Station (K.A. Shepherd et al. KS1396)	P1					
Euryomyrtus inflata	P3					
Baeckea sp. Sandstone (C.A. Gardner s.n. 26 Oct. 1963)	P3					
Bossiaea eremaea	P3					
Eremophila arachnoides subsp. *arachnoides*	P3					
Olearia arida	P4					
Comesperma viscidulum	P4					
Scaevola spinescens terete leaf form (G. Cockerton & C. Ringrose LCH 14560)						
Templetonia incrassata						
Acacia sp. Yakabindie (G. Cockerton & G. O'Keefe LCH14274) aff. *kempeana*						
Acacia sp. (G. Cockerton & R. Graham *Acacia* sp. (G. Cockerton & R. Graham LCH25491)						

Species	Cons. status	Requires taxonomic investigation	Undescribed species	Geographically restricted	Range extension	Poorly collected
Eremophila sp. Wiluna (G. Cockerton & K. Stratford 1983)						
Prostanthera sp. Bullimore sandplain (G. Cockerton & D. True 12813)						
Eremophila subfloccosa subsp. aff. *lanata* (G Cockerton & C Jowett 25337)						
Acacia aneura (multiple variants)						
Bertya dimerostigma						
Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH 26770)						

3.3.1. Priority Flora

Atriplex sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025) P1

Atriplex sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025) is a new species that has been recognised for the first time following these surveys. An *Atriplex* sp. was recognised in the study area considered in the EIS and ERMP flora survey (WMC, 1979), but was not confidently identified to species level. WA Herbarium staff at the time suggested that the *Atriplex* sp. was possibly a hybrid between *A. bunburyana* and *A. rhagodioides* (now *A. amnicola*). It was also noted in this document that the *Atriplex* sp. was a potential indicator species for uranium.

An initial description of *Atriplex* sp. Yeelirrie Station was provided by Paul Wilson at the WA Herbarium, a specialist for the Chenopodiaceae family. The taxon was then listed as Priority One by the Department of Environment and Conservation (DEC) in September 2009. A follow-up assessment undertaken by Dr Kelly Shepherd at the WA Herbarium in April 2010 supported the initial findings that this taxon is new and distinct from known species of *Atriplex*.

Atriplex sp. Yeelirrie Station is described as a divaricately branched dioecious perennial shrub, to 0.6 m high (Plate 1 and Plate 2). It has small ovate blue-green leaves. Flowering and fruiting were observed from March to May 2010 following significant rainfall. Male flowers are pale pink to yellow and readily observed (Plate 3), and female flowers are pale pink and difficult to observe with the naked eye (Plate 4). This taxon shows variability in fruiting bracteoles and two different morphotypes were recorded: those without appendages (Plate 5) and those with appendages (Plate 6). Both morphologies were present in all sub-populations of *Atriplex* sp. Yeelirrie Station. Reproductive strategies for this taxon are not yet understood. It was observed that both male and female plants produce fruiting bracteoles, and some plants had both male flowers and fruit.

Plate 1. *Atriplex* sp. Yeelirrie Station shrubs within the CApS vegetation community

Plate 2. *Atriplex* sp. Yeelirrie Station stem definition

Plate 3. Male flowers, *Atriplex* sp. Yeelirrie Station (Photo courtesy of Dr Kelly Shepherd)

Plate 4. Female flower, *Atriplex* sp. Yeelirrie Station (Photo courtesy of Dr Kelly Shepherd)

Plate 5. Fruiting bracteoles with no appendages, *Atriplex* sp. Yeelirrie Station (Photo courtesy of Dr Kelly Shepherd)

Plate 6. Fruiting bracteoles with appendages, *Atriplex* sp. Yeelirrie Station (Photo courtesy of Dr Kelly Shepherd)

Specimens representing various fruiting morphologies have been lodged with the WA Herbarium for further taxonomic investigation. Material was also collected for possible future molecular DNA assessment.

To date, *Atriplex* sp. Yeelirrie Station has been found at two major locations only: (i) in two sub-populations within study area 1 and (ii) in ten sub-populations south-east of study area 1, within study area 3 located in the Yeelirrie Palaeochannel (discussed in Section 3.7.1). The second location of *Atriplex* sp. Yeelirrie Station was initially recorded during the regional survey of study area 4. After the initial findings, a more detailed survey was done in the north-western section of study area 4 which was redefined as study area 3.

A survey was conducted to determine the population size within study area 1, and to date 84,510 individuals are known from this area. This number includes both sub-populations and the minor population discussed below. The distribution of *Atriplex* sp. Yeelirrie Station in the project footprint of study area 1 is shown in Figure 11). At the time of the population size survey, April 2010, no female flowers were observed. Approximately 8% of plants had fruit, 8% had male flowers only, and 15% of plants appeared to be dead or aestivating. These percentages are representative of the time of survey only and vary greatly according to seasonal rainfall trends.

Atriplex sp. Yeelirrie Station is confined to the self-mulching clay flats within the Calcrete System, which coincides with the central part of the proposed open pit mine. It was primarily recorded within the CApS vegetation community, described further in Appendix 8, with scattered plants also in surrounding CMxS and CLaS communities. The densest populations were recorded in the western end of the proposed open pit mine.

A minor population and scattered individuals were also recorded within a historical rehabilitation site at the southern end of the Central Baseline (< 50 individuals) and scattered individuals were also recorded within a rehabilitation site near the Communications Tower (Figure 11).

Figure 11. *Atriplex* sp. Yeelirrie Station populations within the project footprint

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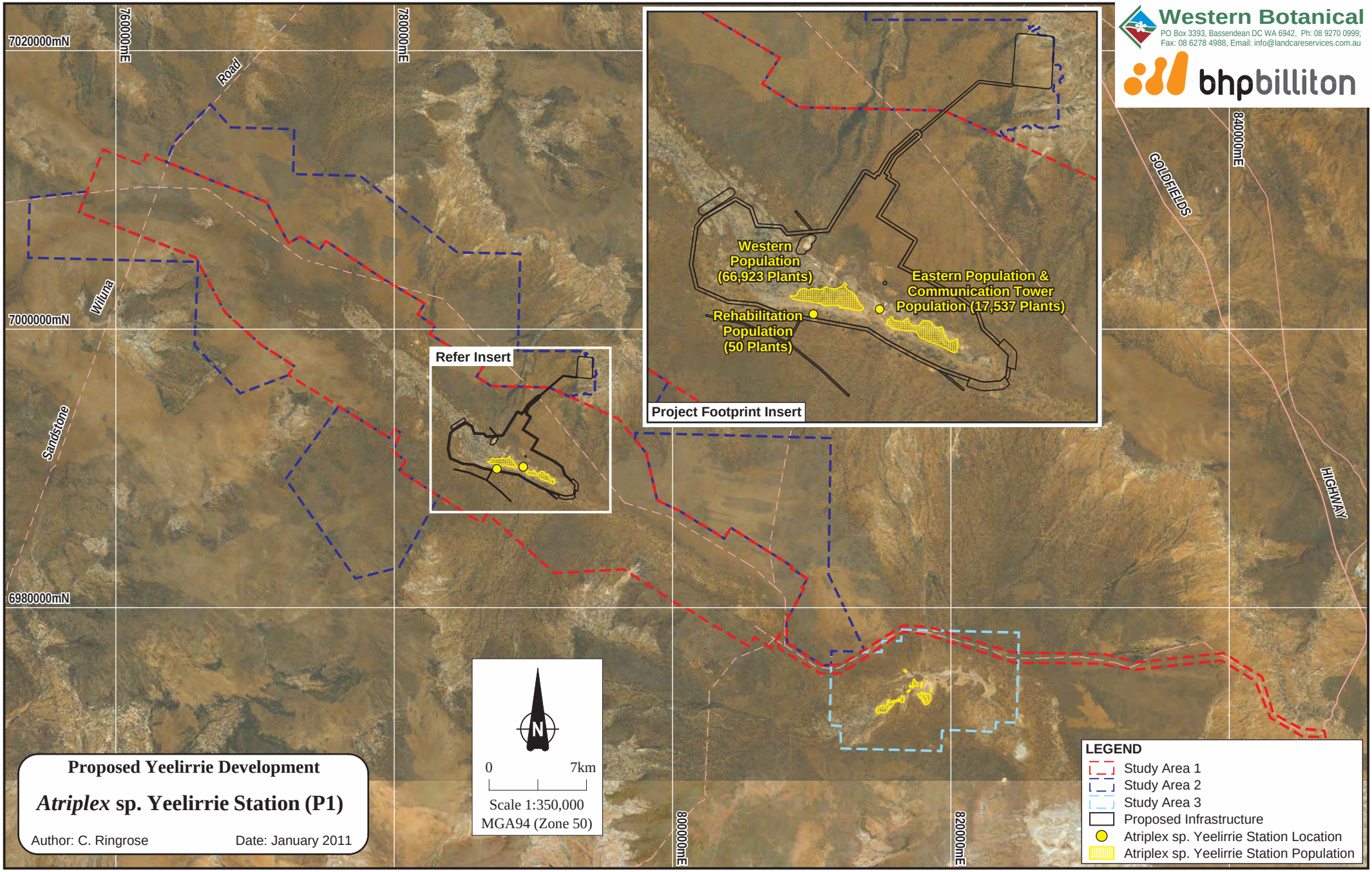

Proposed Yeelirrie Development

Atriplex sp. Yeelirrie Station (P1)

Author: C. Ringrose Date: January 2011

Rhagodia sp. Yeelirrie Station (K.A. Shepherd et al. KS1396) P1

Rhagodia sp. Yeelirrie Station (K.A. Shepherd et al. KS1396) is a new species that had originally been identified as *Rhagodia* sp. or *Crenidium spinescens* in the field due to insufficient material being available. Following further investigation of flowering material, Paul Wilson and Mike Hislop of the WA Herbarium, identified this specimen as a *Rhagodia* not matching any known species. This was later verified by Johan Hurter, a specialist in the genus *Rhagodia*. The taxon was then listed as Priority One by the DEC in August 2010. While a preliminary investigation has been undertaken, a formal description has not yet been prepared as adequate fruiting material has not yet been available. *Rhagodia* sp. Yeelirrie Station is readily recognised in the field.

Rhagodia sp. Yeelirrie Station is described as an erect, compact shrub, to 1.9 m high and 1.5 m across (Plate 7). Male and female flowers are present on the same plant and these are yellow green in colour (Plate 8).

Plate 7. *Rhagodia* sp. Yeelirrie Station (Photo courtesy of Dr Kelly Shepherd)

Plate 8. Male and female flowers, *Rhagodia* sp. Yeelirrie Station (Photo courtesy of Dr Kelly Shepherd)

This species is known from only three sites within the Coolgardie and eastern Murchison Biogeographic regions. There are currently four voucher collections listed on FloraBase (Western Australian Herbarium, 2011). Known populations include Rowles Lagoon (approximately 67 km north-west of Kalgoorlie), Pinnacles Station near Lake Noondie, and within study area 1. The Pinnacles Station population was recorded during Western Botanical's regional survey of study area 7. A distribution map is not yet available on FloraBase.

Rhagodia sp. Yeelirrie Station was recorded in five populations within study area 1 in the vegetation community described as *Rhagodia* sp. Yeelirrie Station shrubland on calcrete (CRsS). CRsS is described as scattered to open shrublands of *Rhagodia* sp. Yeelirrie Station (K.A. Shepherd et al. KS1396) on sparsely vegetated playas within the Calcrete System, and is described further in Appendix 8. These playas have a high content of fine silts on the surface and large sink holes or water accumulating depressions. Scattered individuals of *Rhagodia* sp. Yeelirrie Station also occur within *Melaleuca interioris* and *Acacia aneura* shrubland (PLAMi) vegetation, which fringes CRsS.

A location map showing its distribution in study area 1 is provided in Figure 12. Four areas of this vegetation community (CRsS) occur outside the project footprint. One area of the vegetation community occurs within the project footprint (Table 17).

Table 17. Number of *Rhagodia* sp. Yeelirrie Station (P1) individuals within study area 1

Population Number	Zone	Easting	Northing	Approximate number of Individuals
1	50J	778726	6998513	118
2	50J	782509	6996659	300
3	50J	778065	7000121	374
4	50J	777750	7000670	1,308
5*	50J	787189	6991784	100
Total number of individuals				2,200

* within project footprint

Figure 12. Distribution of *Rhagodia* sp. Yeelirrie Station in study area 1

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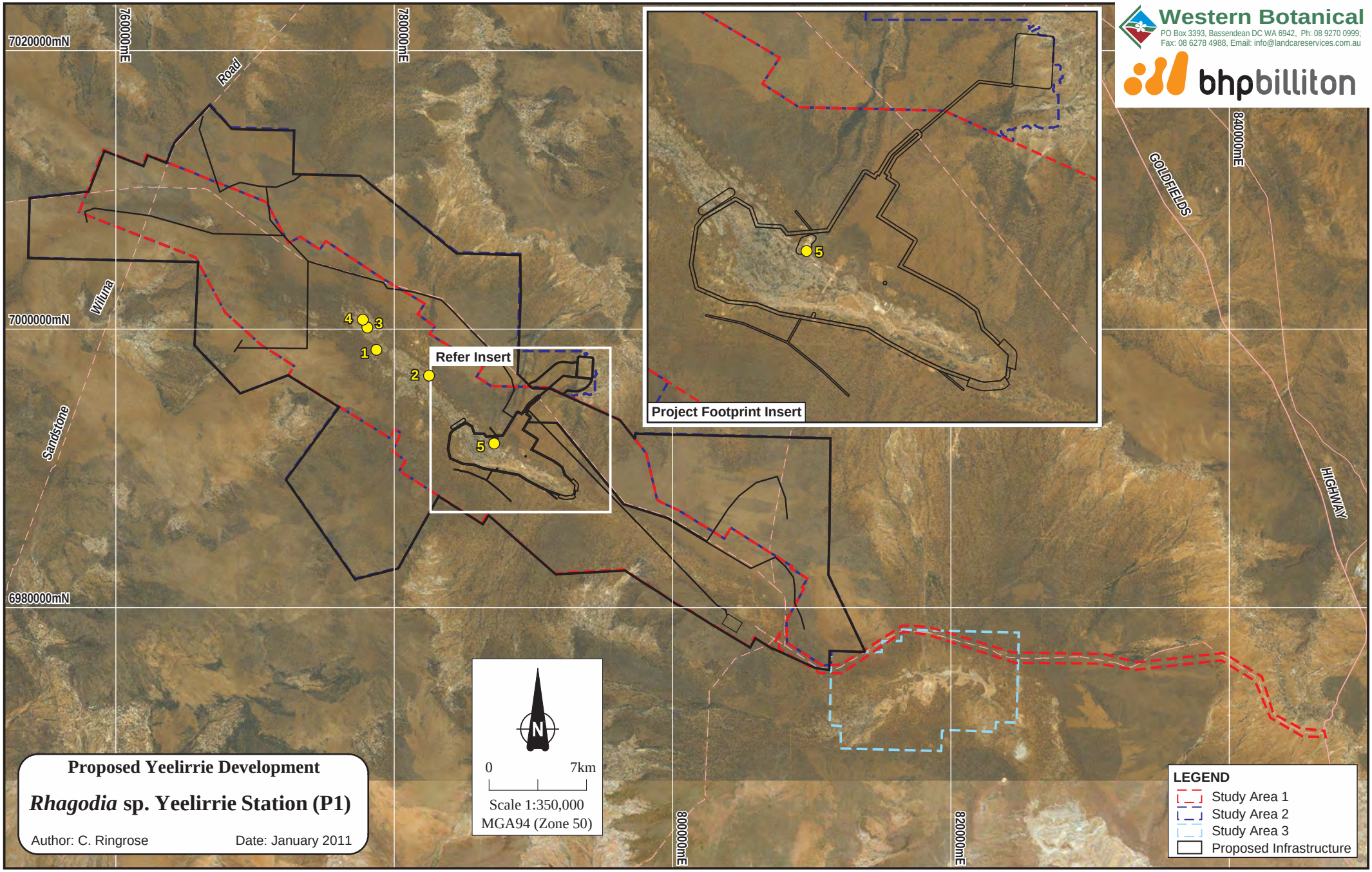

Proposed Yeelirrie Development

***Rhagodia* sp. Yeelirrie Station (P1)**

Author: C. Ringrose Date: January 2011

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Euryomyrtus inflata Trudgen P3

Euryomyrtus inflata is a small long-live shrub with a lignotuber growing to 0.7 m high with flat dull blue-green leaves that turn red during times of moisture stress (Plate 9 and Plate 10). It has erect rounded fruits with three carpels, each with a single locule. Flowers are white to pink and occur in June and July.

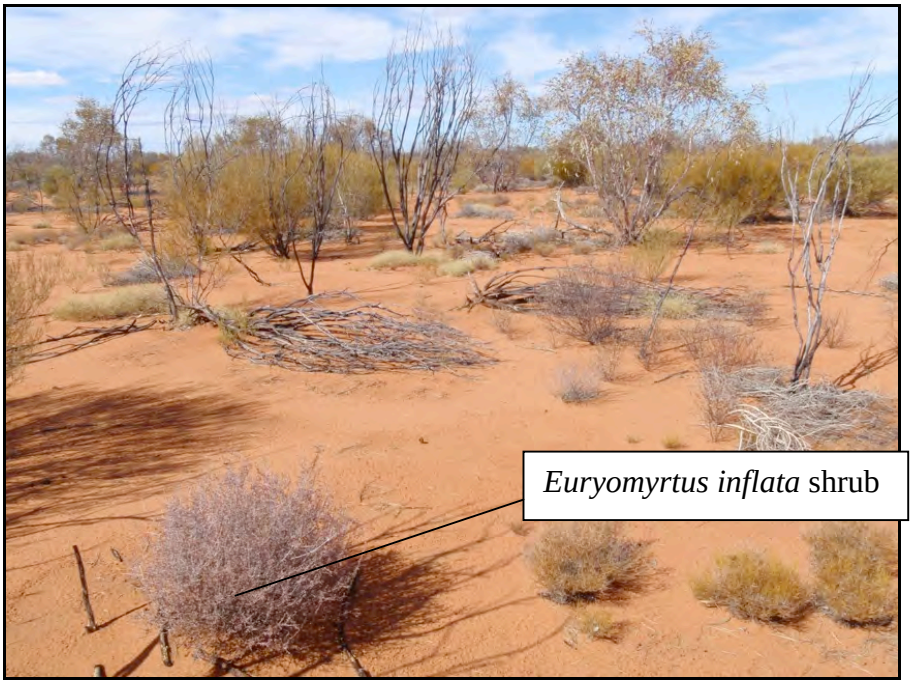

Plate 9. *Euryomyrtus inflata* within the SAMA vegetation community

Plate 10. *Euryomyrtus inflata* stem and leaf definition

Known only from the Murchison Biogeographic region, there are currently ten voucher collections listed on FloraBase (Western Australian Herbarium, 2011). Collection localities include Gidgee, Lake Mason Reserve, Kaluwiri Reserve, Yeelirrie Station, Albion Downs Station, and Youno Downs Station (Figure 13).

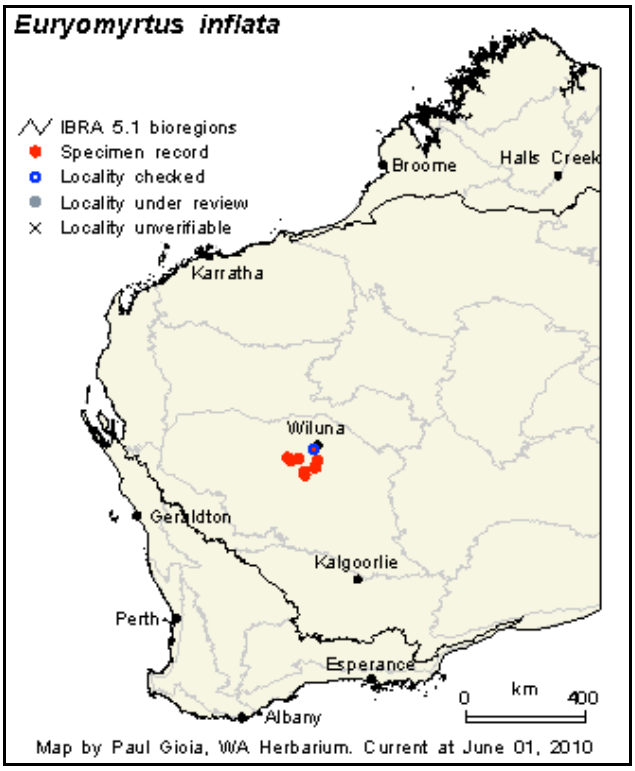

Figure 13. Distribution of *Euryomyrtus inflata* within WA

Euryomyrtus inflata occurs in extensive populations within the Sand Plain System of study area 1. A location map showing its distribution in study area 1 is provided in Figure 14. Records of individuals are shown as points, and where populations were extensive, a population boundary was inferred. The largest populations were identified in the north-west region of study area 1. These were primarily on the northern side of the Calcrete System in the more recently burnt SAWS and SAMA vegetation communities. The largest population of *E. inflata* within study area 1 extends for approximately 15 km north-west to south-east, and three km north-east to south-west along the northern side of study area 1 adjacent to the Calcrete System in the north-western part of study area 1. There was also an extensive population on the southern side of the Calcrete System in the SASP vegetation community. On the southern side of study area 1 the population extends for 10 km north-west to south-

east and two km north-east to south-west. Large populations of *E. inflata* were also present in the eastern region of study area 1, including two in the Sand Plain System. Scattered individuals were also recorded on the access road. Individual plants were present in varying densities, from approximately 10 plants per 50 m^2 (40 per ha) to 350 plants per 50 m^2 (1400 per ha). The number of plants estimated to occur within study area 1 is 134,520.

Euryomyrtus inflata is most commonly found in high numbers in areas burnt approximately five years ago. It occurs on flat sand plains and lower lying sandy areas, in SAWS, SAMA and SASP vegetation communities, and where *Triodia basedowii* has no more than 25% foliage cover. *Euryomyrtus inflata* is also present in communities that have remained unburnt for at least 15-20 years, however, plants are larger and less frequent. It is predicted that this species would also occur in the very recently burnt areas (within one to three years), given time for it to regenerate after fire.

Euryomyrtus inflata commonly occurs with *Eucalyptus kingsmillii* or *E. leptopoda* subsp. *elevata* scattered mallees over *Acacia effusifolia* (dominant), *A. jamesiana*, *Hakea francisiana*, *Enekbatus cryptandroides* and *Homalocalyx thryptomenoides* open shrubland, over *Leptosema chambersii* low open shrubland and *Triodia basedowii* (dominant) hummock grasses.

Figure 14. Distribution of *Euryomyrtus inflata* in study area 1 and 2

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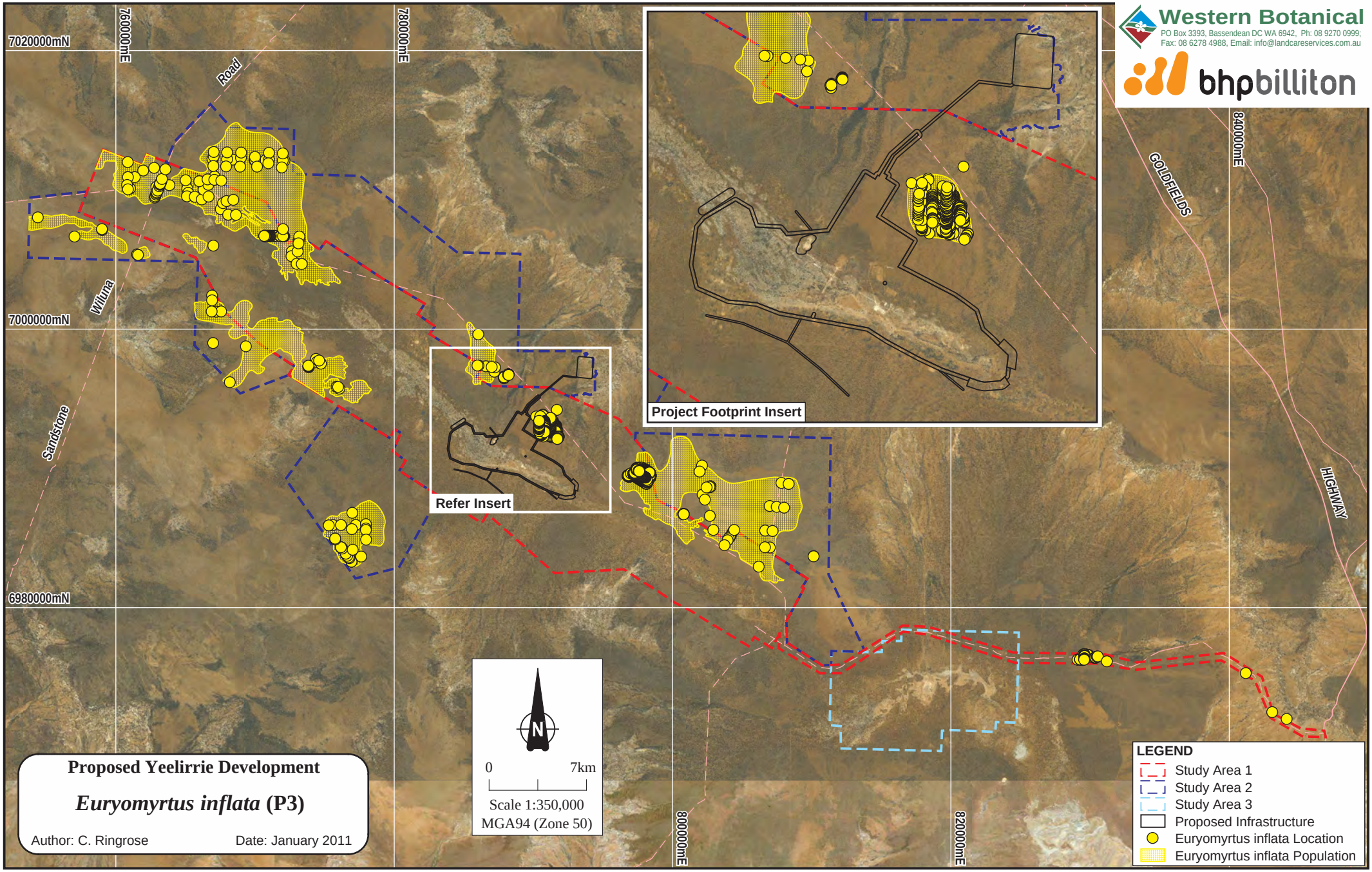

Proposed Yeelirrie Development

***Euryomyrtus inflata* (P3)**

Author: C. Ringrose Date: January 2011

Baeckea sp. Sandstone (C.A. Gardner s.n. 26 Oct. 1963) P3

Baeckea sp. Sandstone (C.A. Gardner s.n. 26 Oct. 1963) is a low upright shrub growing to 1 m. It occurs on orange sand flats and has white flowers in October (Western Australian Herbarium, 2011). Known from the Murchison and Great Victoria Desert Biogeographic regions, there are currently seven voucher collections listed by the WA Herbarium, shown in Figure 15 (Western Australian Herbarium, 2011). Collection localities in the Murchison include north and west of Sandstone, south-east of Leinster, and west of Agnew.

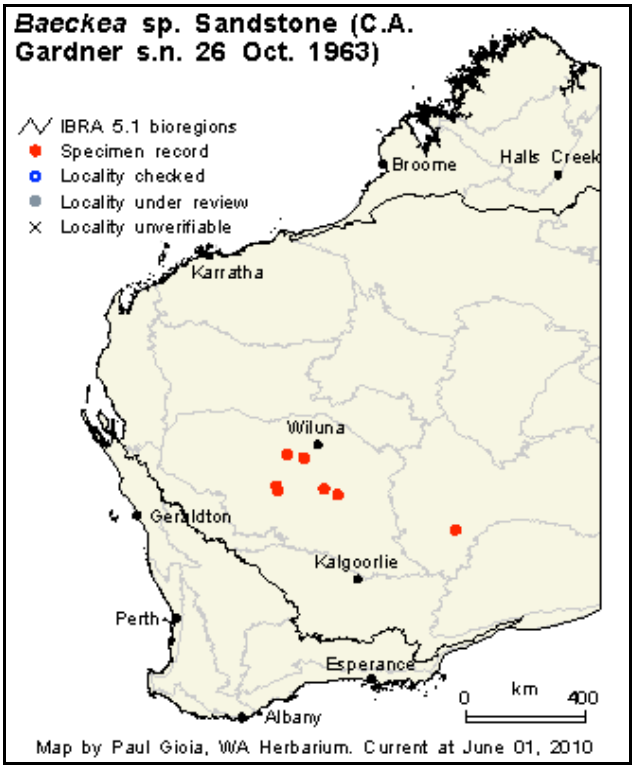

Figure 15. Distribution of *Baeckea* sp. Sandstone within WA

To date, it is known from only a single location within study area 1. This location is situated within the SAWS vegetation community at the north-western end of study area 1, and is shown Figure 16. The area appeared to have been burnt approximately 10-15 years ago. Associated species in the vicinity of *Baeckea* sp. Sandstone include *Acacia heteroneura* var. *prolixa*, *Eucalyptus leptopoda* and *Triodia basedowii*.

Baeckea sp. Sandstone was not flowering at the time of collection, which made identification in the field difficult. It is therefore possible that it occurs more

frequently than indicated in this one location. Furthermore the identification and conservation status were not known at the time of assessments and the species is likely to be more abundant within study area 1 than these data reflect.

Figure 16. Distribution of *Baeckea* sp. Sandstone in study area 1

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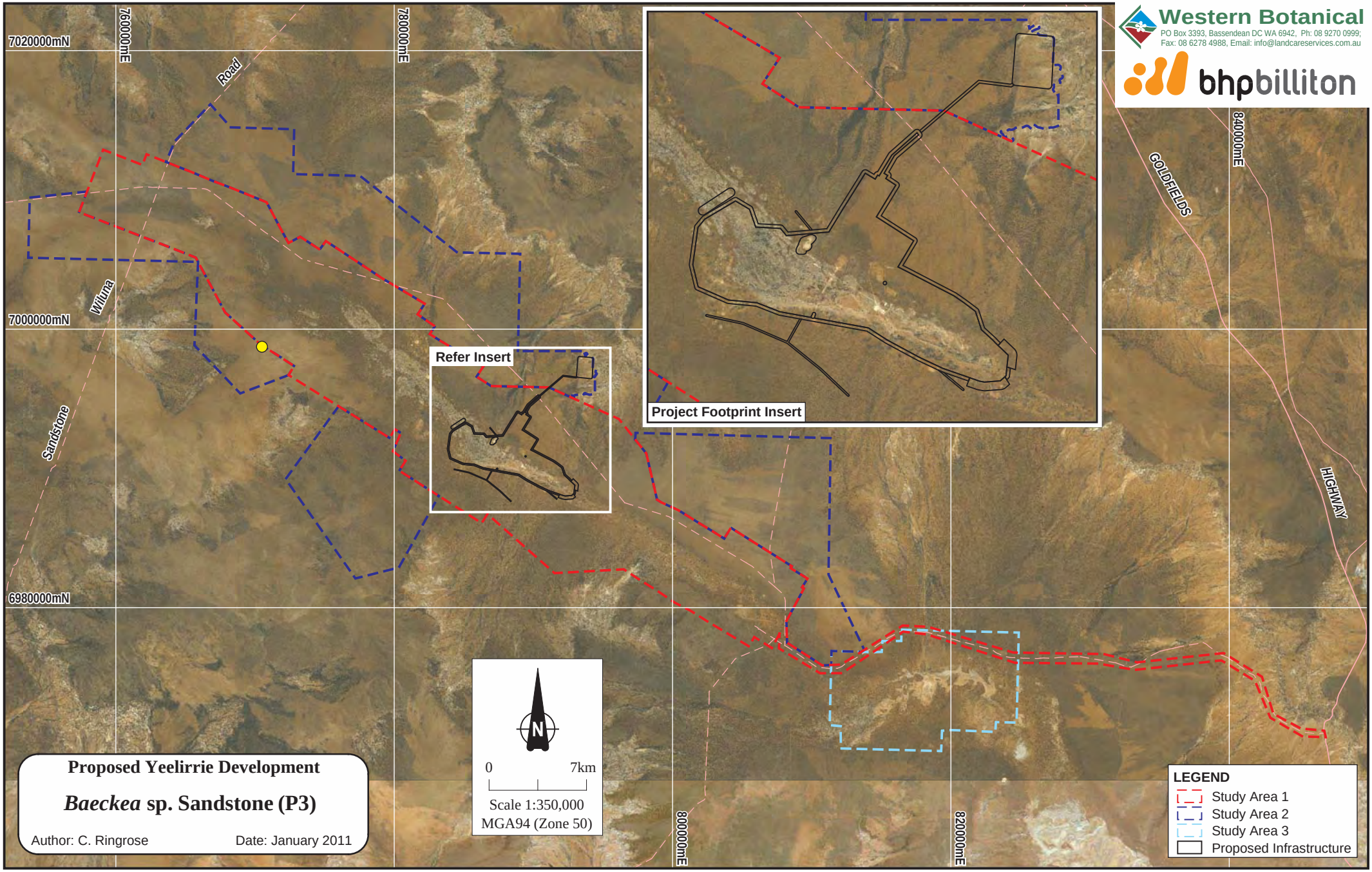

Proposed Yeelirrie Development

***Baeckea* sp. Sandstone (P3)**

Author: C. Ringrose Date: January 2011

***Bossiaea eremaea* J. H. Ross P3**

Bossiaea eremaea is a spiny, tangled, grey-green, lignotuberous spreading shrub to 1.2 m, which resprouts after fire from lignotuber (Plate 11). Flowers are red, yellow, purple or brown in colour and occur from July to September (Plate 12). There are 11 voucher specimens lodged at the WA Herbarium with a disjuncta distribution from the Murchison and Great Victoria Desert Biogeographic regions (Western Australian Herbarium, 2011) (Figure 17). Collection localities in the Murchison include west of Sandstone, Lake Mason Station, south-east of Laverton, east of Mount Magnet and Yeelirrie.

Plate 11. *Bossiaea eremaea* shrub (centre) in SAWS vegetation community

Plate 12. *Bossiaea eremaea* flower and stem detail

Extensive populations were found throughout the Sand Plain System within the survey area, and a map showing its distribution is provided Figure 18. Two large *Bossiaea eremaea* populations were recorded in study area 1 to the north of the Calcrete System. The densest population occurred within a recently burnt area on the southern side of the Yeelirrie-Meekatharra Road, in approximately the centre of study area 1. Both of these populations extended northwards into study area 2. The boundary of the largest population within study area 1 was extended by approximately 4 km to the north of its previous boundary. Other scattered populations of *B. eremaea* were also recorded on the north and south sides of the Yeelirrie - Albion Downs Road. It was found to occur within SAWS, SAGS and SAMA vegetation communities. Based on the actual count of plants in study area 1, (12,732) the total number of plants estimated to occur within study area 1 is 36,442.

Bossiaea eremaea commonly occurs with *Eucalyptus kingsmillii*, *E. leptopoda* subsp. *elevata*, *Acacia effusifolia* (dominant), *A. ligulata* (dominant), *Hakea francisiana*,

Eremophila platythamnos subsp. *platythamnos*, *Homalocalyx thryptomenoides*, *Leptosema chambersii*, *Ptilotus obovatus* (typical Goldfields form) and *Triodia basedowii* (dominant) hummock grasses.

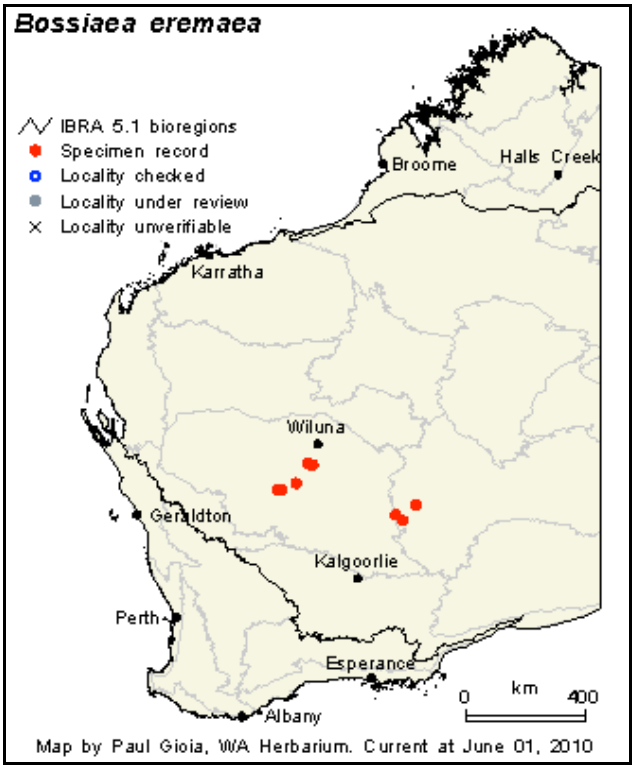

Figure 17. Distribution of *Bossiaea eremaea* within WA

Figure 18. Distribution of *Bossiaea eremaea* in study area 1 and 2

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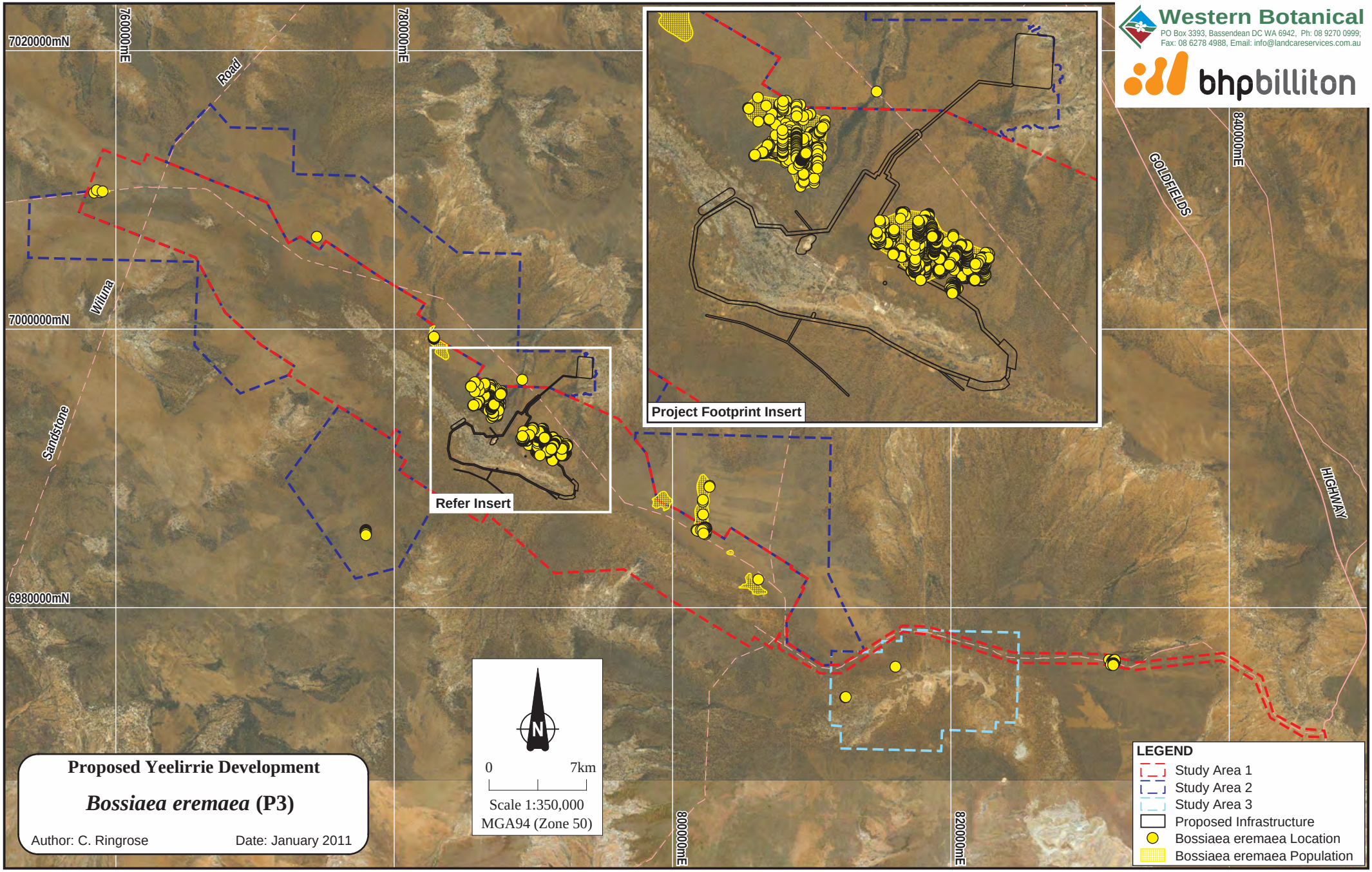

Proposed Yeelirrie Development

***Bossiaea eremaea* (P3)**

Author: C. Ringrose Date: January 2011

Eremophila arachnoides Chinnock subsp. *arachnoides* P3

Eremophila arachnoides subsp. *arachnoides* is a tall broom-like shrub growing from 1.5 to 3.5 m with small linear leaves featuring a hooked tip (Plate 13, Plate 14). Flowers are white and blue or purple and occur in September, November and December (Plate 14). There are currently ten voucher collections of the species at the WA Herbarium from the Little Sandy Desert and Murchison Biogeographic regions (Western Australian Herbarium, 2011) (Figure 19). Collection localities in the Murchison include Lake Mason, Lake Noondie, Yeelirrie and Yarrabubba Stations.

Plate 13. *Eremophila arachnoides* subsp. *arachnoides* shrub (centre)

Plate 14. *Eremophila arachnoides* subsp. *arachnoides* leaf and flower definition

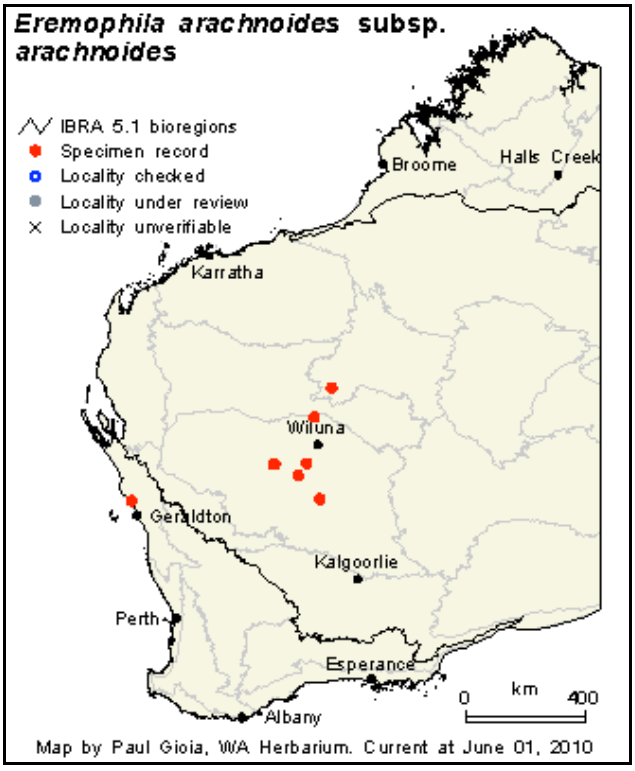

Figure 19. Distribution of *Eremophila arachnoides* subsp. *arachnoides* within WA

Eremophila arachnoides subsp. *arachnoides* almost exclusively occurs on the Calcrete System, and a map showing its distribution in study area 1 is provided in Figure 20. Scattered individuals were also recorded within the Playa and Sand Plain Systems. Intensive surveying carried out by Western Botanical has found that populations are evident on the majority of the exposed calcrete rises that occur throughout the survey area. Traverses (approximately 50 m in width) were conducted at 200 m spacings over all exposed calcrete rises within study area 1. The total population is approximated to be 43,255 plants. This is based on counts of approximately 25% of the population. The densest part of the *Eremophila arachnoides* subsp. *arachnoides* population occurred in the *Casuarina pauper* Woodland on Calcrete (CCpW) vegetation community, described in Appendix 8. Scattered individuals were recorded within CEgW, CAbS, CErG, CLaS, CMGbS, CMxS, CRsS, HPMS, PLAPoS and PLAET vegetation communities, and associated mosaics.

Eremophila arachnoides subsp. *arachnoides* commonly occurs with *Casuarina pauper* and *Eucalyptus gypsophila* scattered trees, and shrubs of *Acacia burkittii, A. tetragonophylla, Templetonia incrassata, Eremophila longifolia, Senna artemisioides* subsp. *filifolia, Ptilotus obovatus* (typical Goldfields form) and *Sclerolaena cuneata* herbs.

Figure 20. Distribution of *Eremophila arachnoides* subsp. *arachnoides* in study area 1

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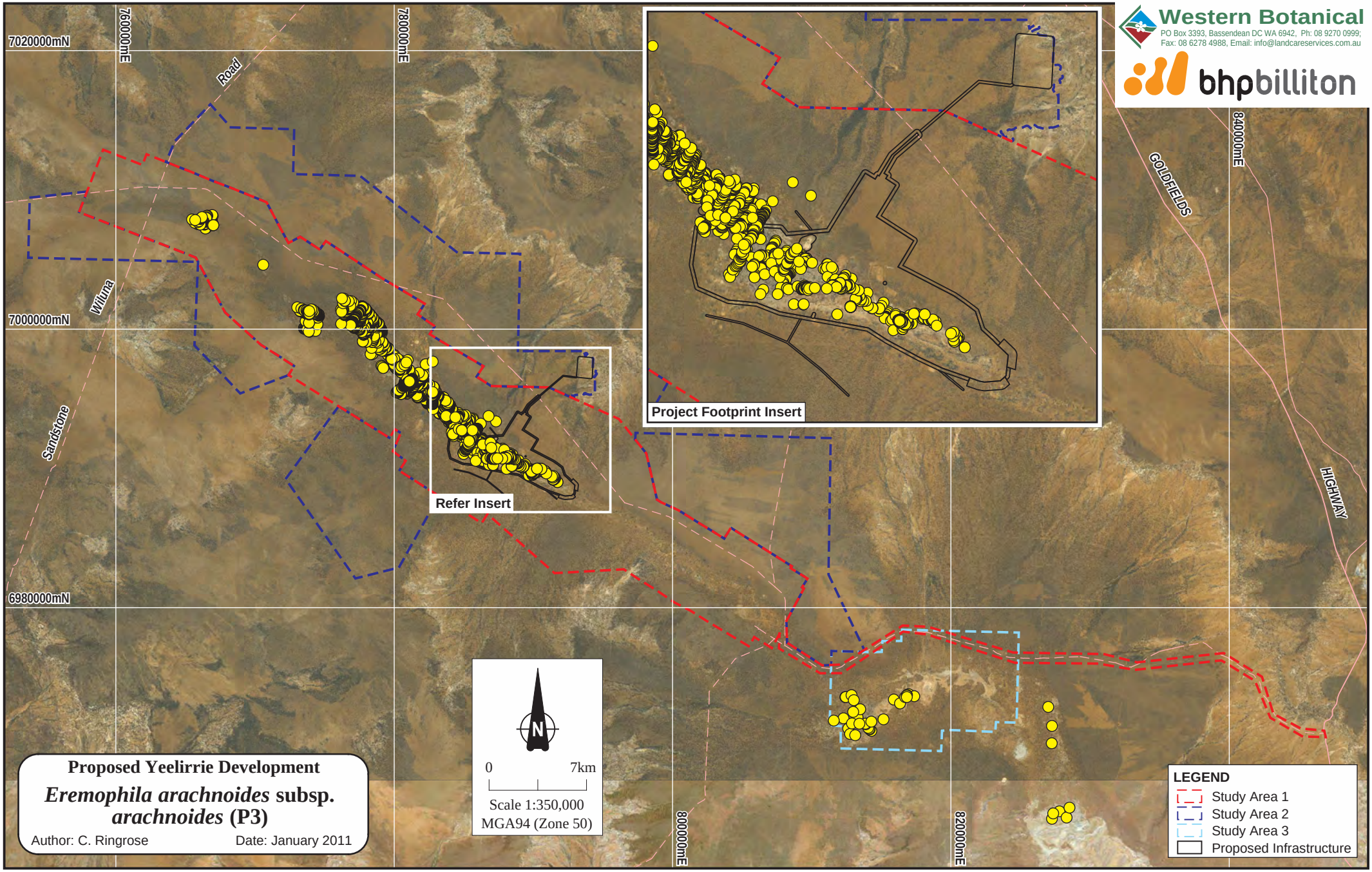

Proposed Yeelirrie Development

***Eremophila arachnoides* subsp. *arachnoides* (P3)**

Author: C. Ringrose Date: January 2011

Olearia arida E. Pritz. P4

Olearia arida is a glossy, viscid bright green glabrous erect shrub that grows to 0.5 m high (Plate 15) and has white flowers that are displayed between July and September and (Plate 16). The species occurs on red or yellow sands on low undulating rises. Known from the Great Victoria Desert Biogeographic region, there are currently 18 voucher collections listed by the WA Herbarium (Figure 21) (Western Australian Herbarium, 2011). These locations are approximately 400 km south-east of study area 1 and north-east of Kalgoorlie. The small population within study area 1 on Albion Downs stations represents a significant disjunction and range extension for this species.

Plate 15. *Olearia arida* within the SAWS vegetation community

Plate 16. *Olearia arida* flower and leaf definition

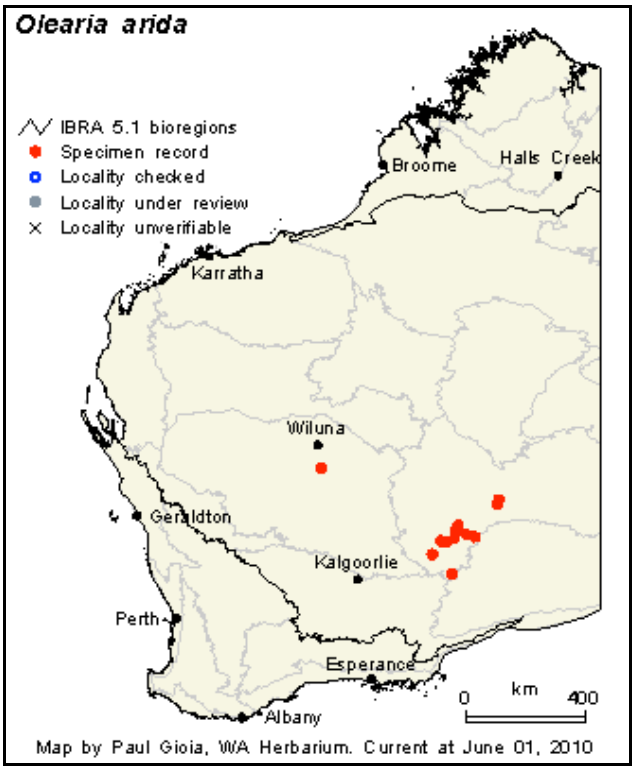

Figure 21. Distribution of *Olearia arida* within WA

Olearia arida was located on the roadside of the Yeelirrie - Albion Downs Road approximately 15 km west of its intersection with the Goldfields Highway. A single population consisting of 24 individuals in two sub-populations was recorded within SAWS and SAMA vegetation communities in the Sand Plain System. A map showing its distribution is provided in Figure 22. *Olearia arida* was not recorded in the project footprint.

Olearia arida occurs with *Acacia pachyacra, Triodia basedowii* (dominant), *Keraudrenia velutina* subsp. *velutina, Hakea francisiana, Grevillea eriostachya, Eremophila forrestii* subsp. *forrestii, E. platythamnos subsp. platythamnos,* and *Prostanthera* sp. Bullimore sandplain (G. Cockerton & D. True LCH 12813).

Figure 22. Distribution of *Olearia arida* in study area 1

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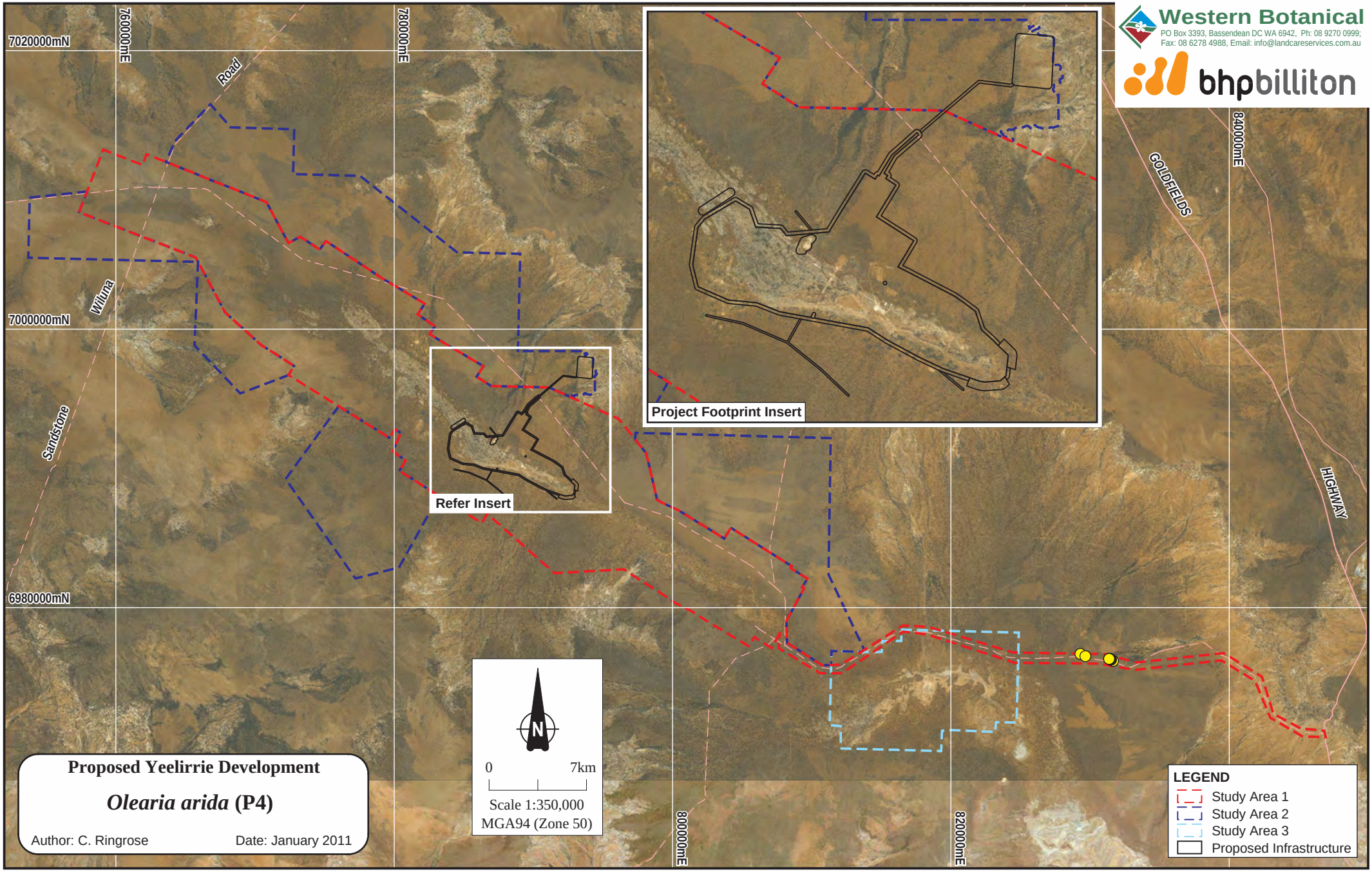

Proposed Yeelirrie Development

***Olearia arida* (P4)**

Author: C. Ringrose Date: January 2011

***Comesperma viscidulum* F. Muell P4**

Comesperma viscidulum is a low shrub growing to 0.7 m (Plate 17, Plate 18). There are currently ten voucher collections of the species at the WA Herbarium from three IBRA Biogeographic regions: Central Ranges, Great Victoria Desert and Little Sandy Desert. The closest recorded location to study area 1 is approximately 150 km to the north (Western Australian Herbarium, 2011) (Figure 23).

Plate 17. *Comesperma viscidulum*

Plate 18. *Comesperma viscidulum* leaf definition

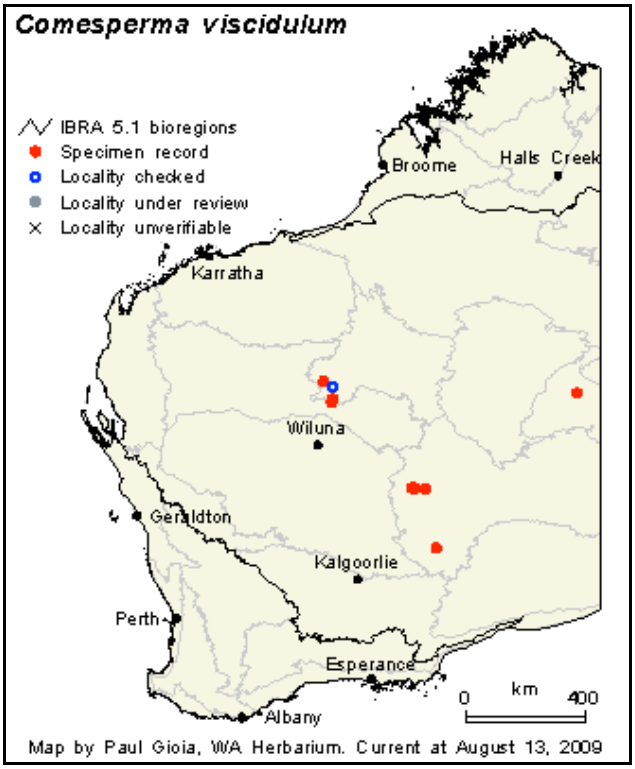

Figure 23. Distribution of *Comesperma viscidulum* within WA

Comesperma viscidulum was recorded within the Sand Plain System in the north-west region of the survey area. A map showing its distribution is provided in Figure 24. *Comesperma viscidulum* was not recorded within the project footprint.

Isolated plants were found in very low numbers, 23 in total. These were located on and near the roadside bunds near the junction of the Wiluna-Sandstone Road and Meekatharra Road, and also further west on the Meekatharra Road and further north on the Wiluna-Sandstone Road. It occurred in the SAMA vegetation community with *Eucalyptus leptopoda* subsp. *elevata* scattered mallees and shrubs of *Acacia jamesiana* (dominant), *Grevillea eriostachya*, *Eremophila platythamnos* subsp. *platythamnos*, *Prostanthera wilkieana* and *Triodia basedowii* (dominant) hummock grasses.

Figure 24. Distribution of *Comesperma viscidulum* in the study area 1

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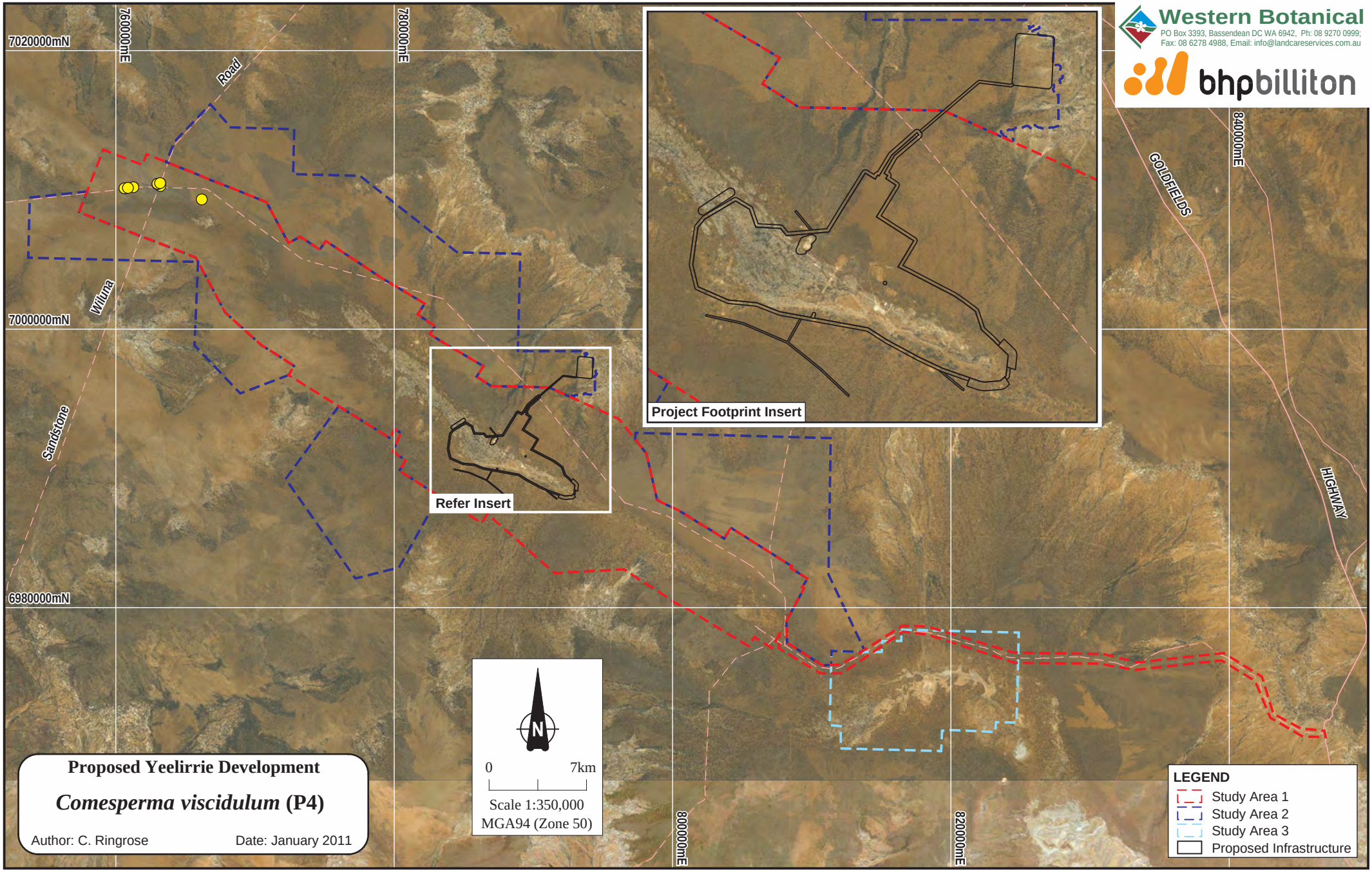

Proposed Yeelirrie Development

***Comesperma viscidulum* (P4)**

Author: C. Ringrose Date: January 2011

3.3.2. New, undescribed species with potential conservation significance

Three undescribed species recorded within study area 1, *Atriplex* sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025) P1, *Rhagodia* sp. Yeelirrie Station (K.A. Shepherd et al. KS1396) P1 and *Scaevola spinescens* terete leaf form (G. Cockerton & C. Ringrose LCH 14560) are considered to be of conservation significance. *Atriplex* sp. Yeelirrie Station and *Rhagodia* sp. Yeelirrie Station have been listed as Priority One Flora and are described in Section 3.3.1.

Scaevola spinescens terete leaf form (G. Cockerton & C. Ringrose LCH 14560)

Scaevola spinescens terete leaf form (G. Cockerton & C. Ringrose LCH 14560) is a rigid, spiny shrub to 1.8 m high and 2.5 m wide with white, cream or yellow flowers from January to December in response to rainfall (Plate 19, Plate 20). It is found infrequently on the margins of playas and scalded areas and scattered throughout a number of other vegetation communities in study area 1. It is known from three locations: (i) study area 1, (ii) an un-named lake on Yakabindie Station, downstream of study area 1, and (iii) Lake Miranda, south-east of Albion Downs Station. All three populations are within the Yeelirrie paleodrainage system.

Plate 19. *Scaevola spinescens* terete leaf form shrub

Plate 20. *Scaevola spinescens* terete leaf form flowering stem and foliage

Areas of sparse populations were found within the Sand Plain and Playa Systems of study area 1, while the densest populations were recorded north of the airstrip. In total, 782

individuals were recorded. A map showing its distribution within study area 1 is provided in Figure 25. The taxon occurs within the SAWS, SAMU, HPMS, WABS, PLAPoS, PLAET, PLAMi, PLEmc, PLEml, PLEsp, CMxS, CEgW, CErG, CLaS, CMGbS, CMiS and CMpS vegetation communities. Associated species include *Acacia aneura* (multiple varieties), *A. effusifolia*, *A. ramulosa* var. *linophylla*, *Eremophila forrestii* subsp. *forrestii, E. malacoides, E. maculata* subsp. *brevis*, *Ptilotus obovatus* (typical Goldfields form) and *Triodia basedowii.*

The group known as *Scaevola spinescens* requires further taxonomic differentiation of the several morhpologically distinct entities contained. The group known as *Scaevola spinescens* in the broad sense (sens. lat.) is widely distributed across the state, occurring in 18 Biogeographic regions, and is recognised as requiring taxonomic revision (L. Sage pers. comm., 2008). There are at least five forms of *S. spinescens* that, in the opinion of the author, could be separated at the sub-species level. These are:

- Pilbara form - little known by the author of this form;
- Broad leaf, non-spinescent form associated with granitoid, often saline landforms, salt lake margins and gypsiferous dunes;
- Narrow leaf, very spinescent form associated with limonitic landforms in the North-eastern goldfields and on the banded ironstone ranges of the Yilgarn region;
- Terete leaf, spinescent form - associated with calcrete, shallow sandsheet over calcrete and margins of claypans in the Yeelirrie – Lake Miranda paleodrainage; and
- Recurved branch form - noted at Shark Bay.

The broad leaf, non-spinescent form; narrow leaf, spinescent form; and terete leaf, spinescent forms have been found to occur on different soils and geology within study area 1. The broad leaf form (mostly non-spiny) is common in the understory of *Casuarina pauper* woodlands on calcrete. The narrow leaf, spiny form is found infrequently as scattered individuals within the Playa and Sand Plain Systems. This form

is very abundant and common on the limonitic landforms east of the survey area near Mt Keith and Leinster. Neither of these two forms have conservation significance.

Locations of these forms are only indicative at this stage and should not be taken as the full extent of occurrence. The WA Herbarium and Leigh Sage (DEC, Goodeniaceae specialist) are currently involved in conducting taxonomic investigations into the *S. spinescens* group.

Figure 25. Distribution of Species Of Interest (SOI) in the local study area

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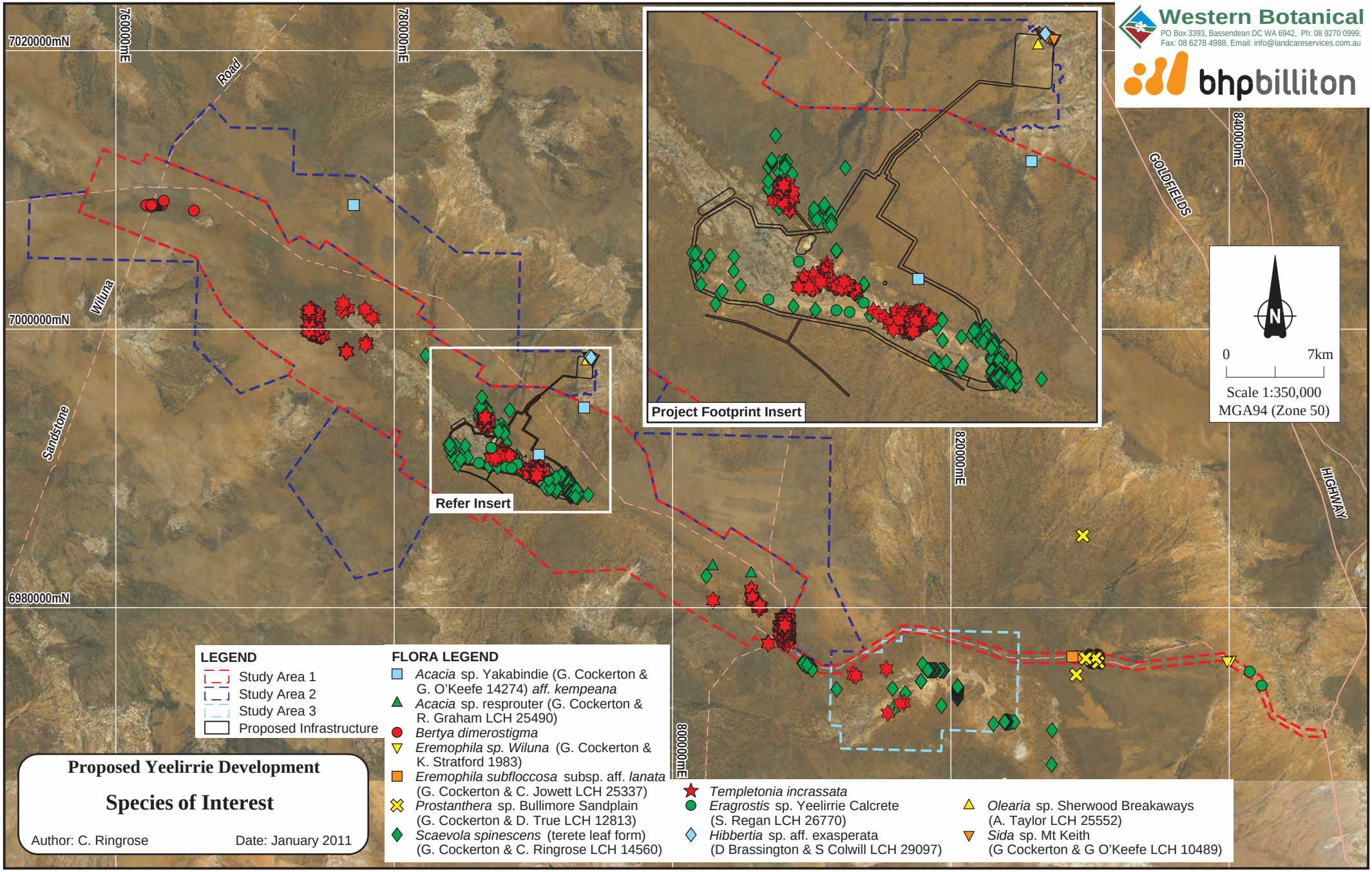

Proposed Yeelirrie Development

Species of Interest

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Date: January 2011

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3.3.3. Species of interest

***Templetonia incrassata* I. Thomps.**

Templetonia incrassata is a long lived, erect, multi-stemmed leafless shrub to 2 m high by 4 m wide with yellow and brown flowers (Plate 21, Plate 22). It flowers from August to September, and, in the survey area, occurs exclusively within the Calcrete and Playa Systems in association with *Eucalyptus gypsophila* and *Casuarina pauper*.

Plate 21. *Templetonia incrassata* shrub within the CCpW vegetation community

Plate 22. *Templetonia incrassata* stem and flower definition

Templetonia incrassata was recently differentiated as a new combination (sub-grouping) of *T. egena* (Thompson, 2010). *Templetonia incrassata* is distinguished from *T. egena* by thicker, less distinctly grooved flowering branches, which can be relatively glaucous. The revision was conducted independently of this survey; however, plant material collected from study area 1 was used in the taxonomic assessment.

The occurrence of this species in the survey area represents a northward range extension for this species, which is otherwise known from the northern Coolgardie and south-eastern Murchison Biogeographic regions (Figure 26). There are currently six voucher collections of *T. incrassata* at the WA Herbarium from Yeelirrie, Lake Raeside and Menzies. *Templetonia incrassata* is a commonly occurring species within study area 1, however, is poorly recorded in the Murchison region.

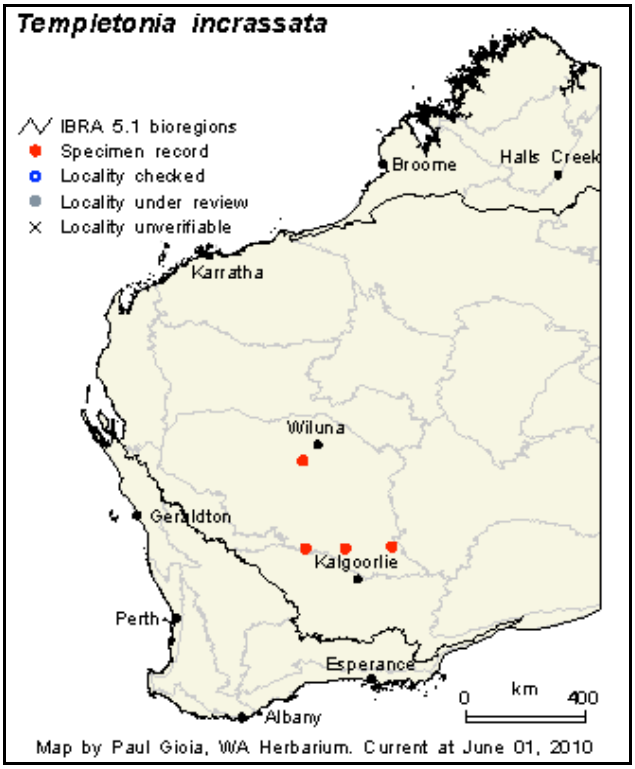

Figure 26. Distribution of *Templetonia incrassata* within WA

A total of 2,691 individuals were recorded within the CAbS, CErG, CEgW, CCpW, CLaS, CMGbS, CMxS, HPMS, PLAPoS, PLAET, PLAMi, PLEml and SAMU vegetation communities. Associated species include *Acacia aneura* (multiple varieties), *Eucalyptus gypsophila, Casurina pauper, A. ramulosa* var. *linophylla, A. burkittii, Eremophila forrestii* subsp. *forrestii, Eremophila arachnoides* subsp. *arachnoides* P3, *Lycium australe, Grevillea berryana,* and *Melaleuca xerophila.* A map showing the distribution of *T. incrassata* in study area 1 is provided in Figure 25.

Eremophila sp. Wiluna (G. Cockerton & K. Stratford 1983)

During previous surveys near Lake Way, the calcrete Palaeochannel near Wiluna and the Mt Keith mine conducted by Western Botanical from 1996 to 1997, an undescribed *Eremophila* species was recorded and collected. Identification at the time by Bob Chinnock (pers comm.) resulted in the phrase name *Eremophila* sp. Wiluna (G. Cockerton & K. Stratford 1983) being applied by the authors with recognition that it was

allied to the variable *E. margarethae* group. It remains poorly collected with insufficient material available for a formal botanical description.

Eremophila sp. Wiluna (G. Cockerton & K. Stratford 1983) is a low erect shrub growing from 0.5 to 1.2 m tall and has grey foliage and purple flowers (Plate 23, Plate 24). *Eremophila* sp. Wiluna is superficially similar to *E. margarethae* but can be distinguished by habitat preference, (*Eremophila* sp. Wiluna occurring on calcrete landforms while *E. margarethae* is associated with grantiic landforms), the absence of resin on stems and calyx, and the nature of the branched hairs on calyx lobes and corolla.

Eremophila sp. Wiluna is geographically restricted to alkaline soils with massive calcrete at or just below the surface, and occasionally metabasalt, which also has a high carbonate content. *E. margarethae*, in contrast, is often present on shallow gritty sand over granite, and was recorded in the Granite and Sand Plain Systems of study area 1. *Eremophila* sp. Wiluna has previously been recorded by the authors as occurring on palaeochannel calcrete at the western side and northern sides of Lake Way, near Wiluna, where it is locally abundant. A few plants have been noted in the Calcrete System of study area 1, although not within the project footprint (Figure 25).

Plate 23. *Eremophila* sp. Wiluna shrub

Plate 24. *Eremophila* sp. Wiluna leaf and flower definition

Prostanthera sp. Bullimore Sandplain (G. Cockerton & D. True LCH 12813)

During previous surveys of the Bullimore sand plain near Leinster and Mt Keith conducted by Western Botanical from 1996 to 2007, an undescribed *Prostanthera* species was commonly recorded and collected. Identification at the time resulted in the species being included under *Prostanthera althoferi* subsp. *althoferi.* Further investigations at the WA Herbarium has identified that there are at least two taxa curated within *Prostanthera althoferi* subsp. *althoferi* folders.

The 'Type' (true form) of *Prostanthera althoferi* subsp. *althoferi* is a low, dense, divaricately shrub to 1 m high by 1.5 m wide and grows on the rocky outcrops and banded ironstone (BIF) and chert hills and limonitic gravely plains in the Yilgarn and south-western part of the North-eastern Goldfields (Figure 27).

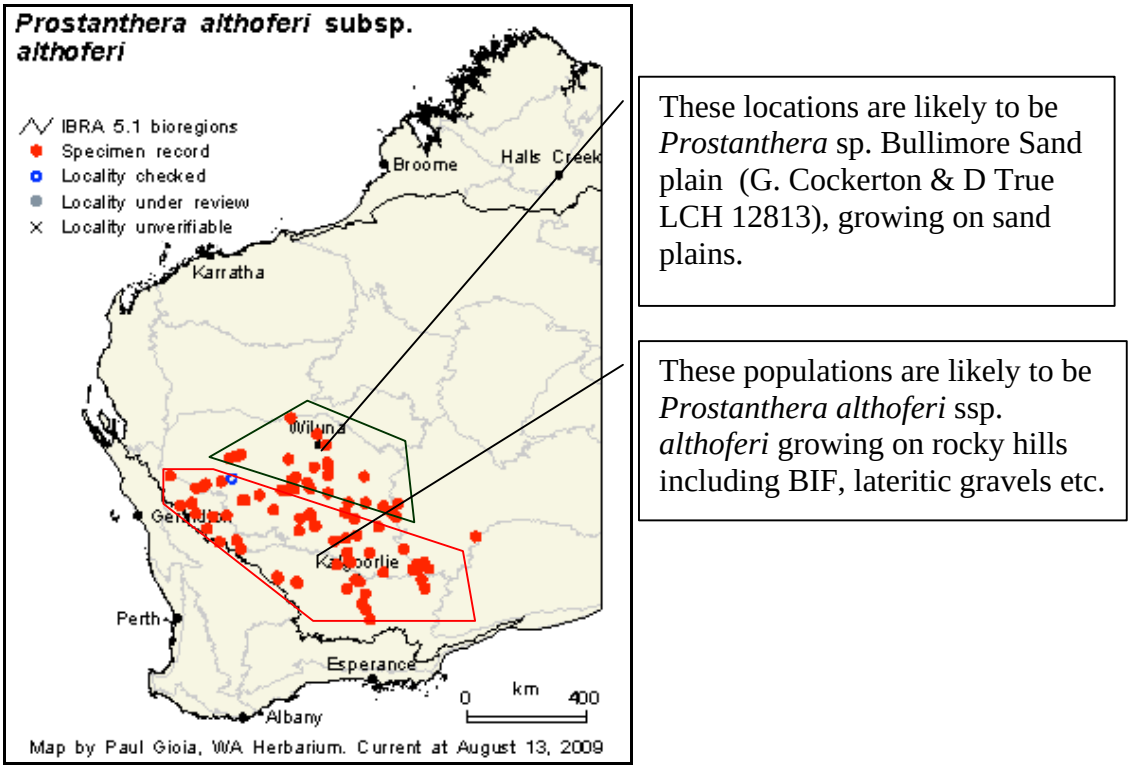

Figure 27. Distribution of *Prostanthera althoferi* subsp. *althoferi* within WA

Prostanthera sp. Bullimore sandplain (G. Cockerton & D. True LCH 12813) is a shrub to 2 m high by 2 m wide (Plate 25, Plate 26) and grows exclusively on the Aeolian yellow

sand plains of the Bullimore land system in the North-eastern Goldfields and Central Desert (Western Botanical, 2008c).

Plate 25. *Prostanthera* sp. Bullimore sandplain

Plate 26. *Prostanthera* sp. Bullimore sandplain, stem and leaf definition

The two forms differ slightly in leaf size and morphology and have major differences in growth habit and habitat preference. Western Botanical has tentatively applied the phrase name *Prostanthera* sp. Bullimore sandplain (G. Cockerton & D. True LCH 12813) to the taxon recorded in study area 1 and elsewhere on the sand plains near Yeelirrie to distinguish it from typical *P. althoferi* subsp. *althoferi* on the rocky hills further to the south-west. This phrase name has not yet been submitted to the WA Herbarium and does not appear on the Census of Vascular Flora.

Prostanthera sp. Bullimore sandplain was recorded within the Sand Plain System on the northern and southern roadsides of the Yeelirrie Albion Downs Road approximately 20 km west of the Yeelirrie Albion Downs Road and Goldfields Highway intersection. A map showing its distribution is provided in Figure 25. A total of 335 individuals were recorded within a 500 m wide buffer, 250 m either side of the current road alignment. A single individual was also recorded near the junction of the Sandstone Wiluna Road and Meekatharra Road. It occurs within the SASP, SAMA, SAGS and SAWS vegetation communities with *Acacia effusifolia, Eremophila forrestii subsp. forrestii, Leptosema chambersii* and *Triodia basedowii* (dominant).

Prostanthera althoferi subsp. *althoferi* does not have conservation significance. Both species curated under *P. althoferi* subsp. *althoferi* are considered common and widespread. It is discussed here as it is of taxonomic interest only and to recognise that a revision of this genus is required.

***Bertya dimerostigma* F. Muell**

Bertya dimerostigma is an erect dark green viscid shrub growing to 2 m (Plate 27, Plate 28). It flowers from April to July and occurs on yellow or red sands in Sand Plain Systems. There are currently 46 voucher collections of the species at the WA Herbarium from five different IBRA Biogeographic regions: Coolgardie, Great Victoria Desert, Murchison, Mallee and Avon Wheatbelt (Western Australian Herbarium, 2011) (Figure 28).

Plate 27. *Bertya dimerostigma* shrub within the SDSH vegetation community

Plate 28. *Bertya dimerostigma* stem and leaf definition

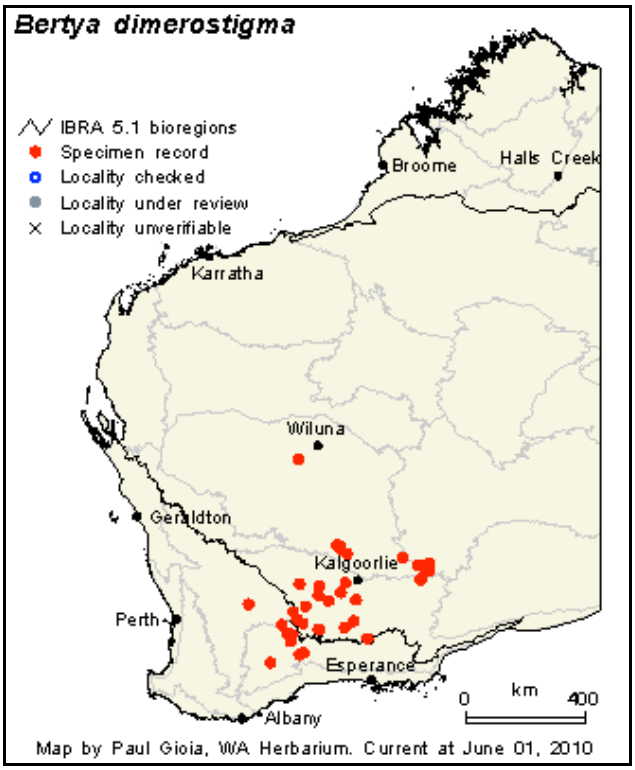

Figure 28. Distribution of *Bertya dimerostigma* within WA

Bertya dimerostigma was recorded in the north-west region of study area 1 within the Sand Plain System. A map showing its distribution in study area 1 is provided in Figure 25. A dense population (1045 individuals) was recorded on red sand dunes in the SDSH vegetation community in association with *Callitris columellaris, Acacia effusifolia, Triodia basedowii* (dominant) and *Triodia melvillei*. *Bertya dimerostigma* was also recorded in adjacent SAMA and SAWS vegetation communities.

The nearest recorded location of this species to study area 1 is approximately 200 km to the south at the Leinster townsite. Current WA Herbarium records show its present distribution is confined to the yellow and red sand plains of the greater Kalgoorlie-Boulder area extending to the south-west into the Mallee Biogeographic region. The record of *B. dimerostigma* in study area 1 represents a significant northward range extension for the species (Western Australian Herbarium, 2011).

Eremophila subfloccosa subsp. aff. *lanata* (G. Cockerton & C. Jowett 25337)

Eremophila subfloccosa subsp. aff. *lanata* (G. Cockerton & C. Jowett 25337) is a shrub to 0.7 m in height with grey felty leaves and sessile dark bottle-green flowers in the leaf axils (Plate 29, Plate 30). It has been recorded on the road shoulder of the north side of the Yeelirrie Albion Downs Road at Albion Downs Station in the SAMA vegetation community. A map showing its distribution in study area 1 is provided in Figure 25.

The differentiation from true *Eremophila subfloccosa* subsp. *lanata* has not been fully investigated as yet. It is considered a species of interest until fully investigated.

Eremophila subfloccosa subsp. *lanata* is an erect or spreading shrub, 0.25 to 0.6 m high, with light green flowers that occur in June to December. This species grows in red sandy soils on undulating plains and salt lake margins. The WA Herbarium records show that this species occurs in a wide region of southern Western Australia including the Murchison, Coolgardie, Avon Wheatbelt and Malcolm Biogeographic regions (Figure 29).

Plate 29. *Eremophila subfloccosa* subsp. aff. *lanata*

Plate 30. *Eremophila subfloccosa* subsp. aff. *lanata* stem, foliage and flower

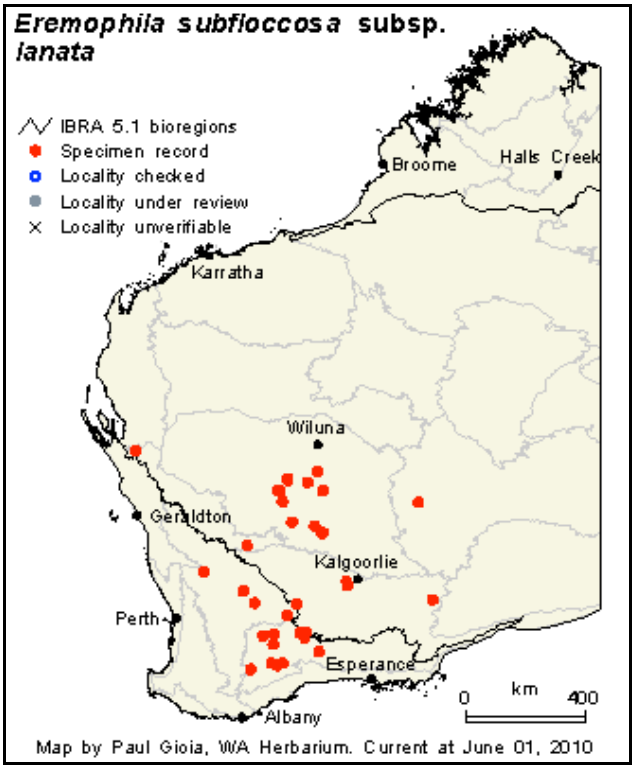

Figure 29. Distribution of *Eremophila subfloccosa* subsp. *lanata* within WA

Acacia sp. resprouter (G. Cockerton & R. Graham LCH 25490)

Acacia sp. resprouter (G. Cockerton & R. Graham LCH 25490) is a shrub to 1.7 m high, which resprouts at the base from lignotuber after fire. It was recorded as a dominant *Acacia* in one area of SAWS vegetation community north of Three Mile Well on Yeelirrie Station and is associated with *Hakea lorea* subsp. *lorea*, *Triodia basedowii* and *T. melvillei* (Plate 31 and Plate 32). It has affinities with *A. coolgardiensis* subsp. *coolgardiensis* and *A. resinosa*. Fruits were collected in November 2010. Further investigation will be carried out on this species. A small population of this *Acacia* has also been noted by authors as occurring at Lake Way Station. It is not considered to be of conservation significance. A map showing its distribution in study area 1 is provided in Figure 25.

Plate 31. *Acacia* sp. resprouter in SAWS community

Plate 32. *Acacia* sp. resprouter leaf detail

Acacia sp. Yakabindie (G. Cockerton & G. O'Keefe LCH 14274) aff. *kempeana*

Acacia sp. Yakabindie (G. Cockerton & G. O'Keefe LCH 14274) aff. *kempeana* is a shrub to 4m with striking, characteristic, yellow-green and highly fragrant foliage (Plate 33). The species has many similarities to *Acacia kempeana*, a widespread species, however, the golden-brown resins on the phyllodes and terminal stems give the plant a characteristic yellow-green colour and a strong cinnamon-honey fragrance. This strongly contrasts with *A. kempeana* which is blue-green in colour and has no noted fragrance. The phyllode shape is similar to *A. kempeana*; however, differs in veination and resin characteristics (Plate 34).

To date, approximately 447 plants in 11 populations are known, primarily on Yakabindie Station, approximately 100 km south of Wiluna. It is also known from the Pilbara region where it has been widely collected. Scattered individuals have been noted by the authors on Yakabindie Station (Dingo Creek), Albion Downs borefield (near Bore 6) and north-east of Mt Keith Operation.

One plant was recorded in study area 1 in SAMA vegetation east of proposed high grade stockpile, and a single population of approximately 30 plants in study area 2, also in the SAMA vegetation community. Another individual plant was recorded on the northern boundary of the survey area within the GPoS vegetation community.

Associated species include *Eucalyptus kingsmillii*, *Acacia effusifolia, Bossiaea eremaea* and *Triodia basedowii*. A map showing its distribution in the study areas 1 and 2 is provided in Figure 25.

Plate 33. *Acacia* sp. Yakabindie (G. Cockerton & G. O'Keefe LCH 14274) aff. *kempeana* in SAMA community

Plate 34. *Acacia* sp. Yakabindie (G. Cockerton & G. O'Keefe LCH 14274) aff. *kempeana* leaf detail

Acacia sp. (G. Cockerton & R. Graham LCH 25491)

Acacia sp. (G. Cockerton & R. Graham LCH 25491) is a tree 6-8 m high, with flat slightly curved phyllodes, 2 by 130 mm, yellow green in colour and a large amount of resin on phyllodes (Plate 35). The tree has rough grey bark and brittle branchlets, and timber has a dark centre. It doesn't key to any known *Acacia* species and fruits and flowers are required to be collected for further identification. It may fall within the broader A. *aneura* group upon revision of further collected material. It is not considered to be of conservation significance and was not recorded in the proposed project footprint. This *Acacia* was recorded in a population of 50 plants that formed a grove in SAMU vegetation, located approximately 4 km north west of the Yeelirrie Homestead. Associated species were *A. ayersiana*, *A. ramulosa* var. *linophylla* and *Triodia basedowii*.

Plate 35. *Acacia* sp. (G. Cockerton & R. Graham LCH 25491)

Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH 26770)

Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH 26770) is a commonly occurring and widespread grass of calcrete communities that has been recognised as being a new taxon for the first time following these surveys. Terry Macfarlane of the WA Herbarium initially identified collections as *Eragrostis xerophila*, although noted that the specimens did not match exactly. Further taxonomic work was later undertaken by Johan Hurter, also of the WA Herbarium, and Western Botancial. Although having floral character similarities with *Eragrostis xerophila*, it has distinct plant architecture, habitat preference and overall morphology. The taxon has been assigned the phrase name *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH 26770). A formal description is yet to be prepared and requires the collection of further flowering and seeding material. It is not considered to be of conservation significance.

Eragrostis sp. Yeelirrie Calcrete is described as a perennial, tufted grass to 0.15 m in height (Plate 36 and Plate 37), with prominent scabrid hairs within and along the edges of parallel grooves on the leaf blades and on the keel of the lemma. The scabrid hairs, smaller growth habit and obligate associated with calcrete outcrops, are notable differences to the typically occurring *Eragrostis xerophila*, which has few to no hairs, grows to 0.5 m high and is found on orange sand plains.

Eragrostis sp. Yeelirrie Calcrete was observed within study area 1 as forming very low spreading colonies to 5 cm high and up to 0.3 m in diameter. For most of the survey period, these grasses were aestivating (over-summering), heavily grazed and had inadequate material for identification purposes. Flowering occurred after rainfall in March and April 2010. This species defines the CErG community, which is characterised as a very open grassland on otherwise bare calcareous soil, and is described further in Appendix 8.

Plate 36. *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH 26770) clumping habit

Plate 37. *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH 26770) flower detail

3.3.4. *Acacia aneura* variants within study area 1

The species *Acacia aneura* is part of a core group of *Acacia* species commonly named "Mulga" and includes *Acacia aneura* and its varieties, *Acacia aptaneura, A. ayersiana, A. caesaneura, A. craspedocarpa, A. fuscaneura A. minyura, A. paraneura* and *A. pteraneura* (Miller *et al*., 2002, FloraBase, 2011). The complex contains a confusing degree of variability, especially for species found in Western Australia, and it is difficult to accommodate an orthodox taxonomic treatment (Muell, 2001). The variation and taxonomic complexity of the Mulga complex has but few rivals within Australian flora (*ibid.*). No single character uniquely defines the Mulga complex, however phyllode and pod variation have been found to covary (Miller *et al*., 2002). Additionally the variation of morphological features (growth form, phyllode shape, size and colour, and pod physiognomy) between and within populations makes the classification additionally complicated.

A guide to the identification of recognised varieties of *Acacia aneura* is presented in Flora of Australia (Muell, 2001), but this is found to be deficient for Western Australian varieties (Muell, 2001). The guide's nomenclature key categorically separates the Mulga variants via the physiognomy of the phyllodes and pods. Inflorescence attributes of the Mulga complex are defined as simple with cylindrical spikes or obloid heads, never globular (Miller *et al.*, 2002). It is this relative uniformity that encouraged the use of morphological (form and phyllode) and physiognomical (phyllode and pod) attributes in classifying the Mulga species distributed within the survey area.

During the survey of study area 1, many collections of the Mulga variants lacked pods and flowers due to dry seasonal conditions. Therefore the classification of Mulga variants was undertaken with phyllode morphological attributes and informal phrase names were applied. These collections were submitted to the WA Herbarium and some were further identified as formally recognised *Acacia* species and variants. Phyllode morphological attributes utilised for the classification of local study area Mulga species include phyllode type (flat, subterete or terete), phyllode shape (straight, slightly curved

or curved), phyllode size (length and width) and phyllode colour. Eight informally phrase named variants were recognised within study area 1 (Table 18).

At the time of reporting, Dr. Bruce Maslin of the WA Herbarium was preparing a draft electronic key that will aid the identification of Mulga variants on characteristics other than pods, such as resin type. Further classification and confirmation of variants within the survey area utilising the draft key showed a great deal of hybridisation between *Acacia* species and a high level of uncertainty remained with regard to the collections lacking quality fruit and flowers. Mulga variants recorded within the survey area are considered to be of taxonomic interest only, and are not of conservation significance.

Table 18. Description of informally phrase named Acacia aneura variants within study area 1

Species	Variant description
Acacia aneura	flat curved 40-90 x 4mm silver grey green
	flat very slightly curved 20-40 x 3mm grey green
	flat slightly curved 30-70 x 3-5mm grey green
	flat straight 30-50 x 4mm grey green
	flat straight to slightly curved 30-80 x 2mm grey green
	sub-terete slightly curved 50-70 x 1mm olive green
	sub-terete straight 20-80 x 1mm grey green
	terete straight 30-110 x 1mm grey green

3.3.5. Introduced species

Eleven introduced taxa or weeds were recorded in study area 1: *Acetosa vesicaria* (Ruby Dock), *Sonchus oleraceus* (Common Sowthistle), *Citrullus lanatus* (Afghan Melon or Pie Melon), *Tribulus terrestris* (Caltrop), *Cenchrus ciliaris* (Buffel Grass), *Lysimachia arvensis* (Pimpernel), *Cuscuta planiflora* (Dodder), *Erodium aureum*, *Portulaca oleracea* (Purslane), *Emex australis* (Doublegee), and *Opuntia* sp. (a Cactus).

Extensive populations of *Acetosa vesicaria* were recorded within the historic rehabilitation sites in the project footprint and were most prevalent after spring and summer rainfall. Isolated populations or scattered individuals were also recorded outside of these rehabilitation areas. *Acetosa vesicaria* is a common weed along roadsides and in disturbed areas and is widespread in the north eastern Goldfields and Murchison regions. *Acetosa vesicaria* is highly competitive in rehabilitation areas and needs to be controlled.

Sonchus oleraceus, *Emex australis*, *Lysimachia arvensis*, *Cuscuta planiflora*, *Erodium aureum*, *Portulaca oleracea*, *Citrullus lanatus* and *Tribulus terrestris* are widespread across Western Australia in disturbed areas and, whilst invasive, are not strongly competitive. *Sonchus oleraceus*, *Citrullus lanatus* and *Tribulus terrestris* were prevalent in the project footprint after spring and summer rainfall.

The *Opuntia* sp. Cactus was a garden escapee from the Yeelirrie Station homestead (Plate 1 in Appendix 14). Cacti commonly persist around historic settlements in the north-eastern Goldfields and Murchison regions.

A very small and isolated population of *Cenchrus ciliaris* is located adjacent to a bore on the Yeelirrie Albion Downs Road and possibly introduced via stock.

Wards Weed (*Carrichtera annua*) is also suspected to be present as dead stems were observed in the project footprint.

Most weeds appear to have been introduced via stock and seed appears to persist in the soil seed bank for several years. Coordinates of introduced taxa are listed in Appendix 14 of this report and a map showing the distribution of *Acetosa vesicaria*, *Sonchus oleraceus*

and *Citrullus lanatus* is presented in Appendix 14. Although the taxa are found throughout Western Australia, they are not listed as a 'Declared Plant' species under the *Agricultural and Related Resources Protection Act 1976* (Department of Agriculture and Food, 2009).

3.4. Study area 2 - vegetation

Twenty-seven vegetation communities and one complex of three communities were identified and mapped within the 42,027.29 ha of study area 2. These were closely related to those found within study area 1, and 20 communities were recorded in both study areas. An overview of the study area 2 showing vegetation community boundaries is provided in Figure 10 and detailed vegetation maps are provided in Appendix 7 of this report. The characteristics of each community are summarised in Table 19 and more detailed descriptions are provided in Appendix 8 of this report. The representative areas of each community in study area 1 and 2, including those communities forming mosaics and complexes, are listed in Table 20**Error! Reference source not found.**. Descriptions of relevés surveyed within study area 2 are provided in Appendix 12 of this report, and a table of species by vegetation community recorded during relevés assessment is provided in Table 3 of Appendix 11.

3.4.1. Soil landscape association with vegetation communities

The vegetation communities of study area 2 were similarly aligned with the five soil landscapes described within study area 1 in Section 3.1.1.

Communities occurring within the Sand Plain System

Sand Plain System communities are characterised by Spinifex (*Triodia* spp.) hummock grasslands with a varying amount of shrub, tree and mallee components in the upper stratum. There are eight communities described within the Sand Plain System: Sand Plain Spinifex Hummock Grassland (SASP), Sand Plain Spinifex Hummock Grassland with Wattles (SAWS), Sand Plain Spinifex Hummock Grassland with Mallee (SAMA), Sand Plain Spinifex Hummock Grassland with Heath (SAHS), Sand Plain Spinifex

Hummock Grassland with *Eucalytpus gongylocarpa* Woodland (SAGS), Sand Plain Spinifex Hummock Grassland with *Corymbia lenziana* Woodland (SACSG), Sand Plain Mulga Spinifex Hummock Grassland (SAMU) and Sand Dune Shrubland (SDSH). Several of these communities formed mosaics, or intergraded with one another, as post fire succession of species plays an integral part in vegetation community determination. Multiple fire regime mosaics within these communities were observed. The occurence of recent fire significantly altered vegetation structure and species composition. Notably Mulga varieties are killed by fire and must regenerate from soil stored seed. Sucessful extensive regeneration occurs sporadically following high rainfall events and it can take many decades for Mulga to reassert dominance.

Communities occurring within the Hardpan and Drainage System

Hardpan and Drainage System communities are characterised by a tall *Acacia aneura* (various forms) Shrubland with a highly variable understorey. There are five communities described in study area 2: Drainage Tract Mulga Shrubland (DRMS), Mulga Groves on Hardpan Plains (GRMU), Hardpan Plain Mulga Shrubland (HPMS), Wandarrie Bank Grassy Shrubland (WABS) and Drainage Tract *Maireana pyramidata* Shrubland (DRMpS). The Hardpan and Drainage System is associated with areas of surface water flow and accumulation during and following rainfall events. The soils tend to have a higher fine particle content with greater moisture retaining capacity near the surface.

Communities occurring within the Playa System

There are two communities described in the Playa System in study area 2, *Acacia* - *Ptilotus obovatus* Shrubland (PLAPoS) and *Eremophila malacoides* Shrubland (PLEml). The majority of the Playa System is vegetated with PLAPoS on flats surrounding playas. Vegetation communities of the Playa System occur interspersed within the Hardpan and Drainage System and are also associated with Granite System outwash zones.

Communities occurring within the Calcrete System

The Calcrete System of study area 2 consists of several outcropping calcrete rises that are situated on the outer margins of the ancient paleodrainage channel. The Calcrete System in study area 2 is represented by a single vegetation community, *Acacia burkittii* Shrubland on Calcrete (CAbS). Calcrete rises vegetated with CAbS are situated within, or adjacent to, the Playa, Hardpan and Drainage and Sand Plain Systems.

Communities occurring within the Granite System

The Granite System in study area 2 incorporates elements of outcropping granite masses, quartz ridgelines and weathered granite breakaways. Eleven communities were defined within the Granite System, and seven of these made up the mosaic representing the Weathered Granite Breakaway complex (BRX).

Ptilotus obovatus Shrubland (GPoS), Granite Rise (GR), Breakaway Chenopod Low Shrubland (BCLS) and Mulga Shrubland on Granite Rise (GRMS) communities are present within the BRX complex as well as elsewhere in the Granite System. In addition to these four communities, three are represented only in the BRX complex. These are the Weathered Granite Plateau (WGBP), Breakaway Mulga and *Sida ectogama* Shrubland (BMSS) and the *Acacia* spp. Shrubland in Weathered Granite Breakaway Gullies (WGAG) communities. BRX complex is mapped as one unit and the seven components listed above were not mapped separately at the scale at which this assessment was undertaken. These component units are not therefore presented in the vegetation map. In addition, WGBP, BMSS and WGAG were not mapped as vegetation communities during these surveys.

The communities defined within the Granite System that are not included in the BRX mosaic are: Quartz Ridge (Qtz), Mulga Shrubland with *Prostanthera campbellii* on Quartz Ridge (QMPS), Stony *Acacia* spp. and *Eremophila galeata* Shrubland (SAES), Mulga Shrubland with Chenopods on Granite Rise (GRMC).

3.4.2. Confidence level of mapping

The scale at which mapping was undertaken was 1:20,000, a broader mapping scale than used for study areas 1 and 3. The complex communities within the Granite System where

the majority of significant species occurred, were mapped at the finer scale, while less emphasis was placed on mapping the boundaries of vegetation communities at fine scales where there was little to no proposed impact to vegetation.

The majority of study area 2 was characterised by vegetation communities within the Sand Plain System. The boundaries of Sand Plain communities were difficult to distinguish on aerial photography at the scale these surveys were undertaken. Differing fire regimes and the presence of fire scars often changed the appearance and species composition of communities between the time the aerial imagery was captured and the time that on-ground vegetation mapping took place. Also, different densities of understorey can visually resemble one another when viewed from above, for example, myrtaceous heath (in the SAHS vegetation community) and higher densities of spinifex grasslands (in the SASP community). In addition to aerial photography limitations, during ground truthing, distinct boundaries were often absent between Sand Plain communities. Here, instead of a distinct zone of intergrade between communities, there was a wide ecotone - gradation of slight differences in species composition, for example, the myrtaceous heath stratum and the taller mallee components.

Table 19. Summary descriptions of the vegetation communities within study area 2

Code	Vegetation Community	Landform Description	Dominant, Defining Flora
Qtz	Quartz Ridge	Hills and foot slopes associated with granite breakaway	*Acacia quadrimarginea, Acacia aneura, Callitris columellaris, Dodonaea petiolaris, Eremophila exilifolia* and *E. latrobei* subsp. *latrobei*, *Ptilotus obovatus* (typical Goldfields form), *Cymbopogon ambiguus*
QMPS	Mulga Shrubland with *Prostanthera campbellii* on Quartz Ridge	Quartz ridgeline	*Acacia aneura* (various forms), *A. quadrimarginea, Prostanthera campbellii, Eremophila latrobei* subsp. *latrobei, Eriachne mucronata* (xerophytic form)
GR	Granite Rise	Exfoliating granite outcrop	*Acacia quadrimarginea, Acacia aneura, Callitris columellaris, Dodonaea* spp., *Eremophila latrobei* subsp. *latrobei, Senna* spp., *Sida* spp., *Cymbopogon ambiguus*, various herbs
GRMS	Mulga Shrubland on Granite Rise	Plains with granite rise	*Acacia aneura, A. tetragonophylla, A. craspedocarpa, A. quadrimarginea, Ptilotus obovatus* (typical Goldfields form), *Eremophila* spp., *Sida ectogama, Senna* spp.
GRMC	Mulga Shrubland with Chenopods on Granite rise	Plains with granite rise	*Acacia aneura* (various forms), *Maireana pyramidata, Rhagodia drummondii, Eremophila latrobei* subsp. *latrobei, Senna artemisioides* subsp. *filifolia, Aristida contorta, Tripogon loliiformis*
SAES	Stony *Acacia galeata* and *Eremophila* spp. Shrubland	Foot slope deposits of granite breakaway	*Eremophila galeata, Acacia aneura, A. ayersiana, A. tetragonophylla*, *Ptilotus obovatus* (typical Goldfields form), *Eremophila compacta* subsp. *compacta, E. latrobei* subsp. *latrobei, Senna artemisioides* subsp. x *sturtii, S. artemisioides* subsp. *helmsii, Sida ectogama, Eragrostis eriopoda*
BCLS	Breakaway Chenopod Low Shrubland	Foot slope deposits and undulating alluvial plains at the base of granite breakaway	*Maireana triptera, Sclerolaena diacantha, Ptilotus obovatus* (typical Goldfields form), *Cymbopogon ambiguus*
GPoS	*Ptilotus obovatus* Shrubland	Foot slope deposits of granite breakaway	*Ptilotus obovatus* (typical Goldfields form), *Maireana pyramidata, Eremophila compacta* subsp. *compacta, E. maculata* subsp. *brevifolia, Senna* spp., *Eragrostis* sp.

Code	Vegetation Community	Landform Description	Dominant, Defining Flora
BRX	Weathered Granite Breakaway Complex	WGBP Plateaus and upper slopes of weathered granite breakaways WGAG Gullies within Weathered Granite Breakaways BMSS Alluvial plain at immediate base of weathered granite outcropping	Mosaic of GPoS, GR, BCLS, GRMS, WPBP, WGAG and BMSS communities. WGBP *Acacia quadrimarginea, A. aneura* (various forms), *A. balsamea, Mirbelia rhagodioides, Eremophila latrobei* subsp*. Latrobei, Ptilotus obovatus, Scaevola spinescens, Dodonaea petiolaris, Ptilotus schwartzii, Calytrix erosipetala, Sida sp. Mt Keith, Eremophila exilifolia, Eriachne mucronata* (xerophytic form), *Stylidium induratum, Eragrostis desertorum* and *Amphipogon strictus* WGAG *Acacia quadrimarginea, A. aneura* (various forms), *A. balsamea, A. burkittii, Dodonaea petiolaris, Eremophila latrobei* subsp*. Latrobei, Psydrax rigidula, Ptilotus obovatus, Mirbelia microphylla, Calytrix erosipetala, Eremophila exilifolia* BMSS *Acacia aneura* (various forms), *Sida ectogama*
SASP	Sand plain Spinifex Hummock Grassland	Sand plain	*Triodia basedowii, Leptosema chambersii, Euryomyrtus inflata* P3, *Prostanthera wilkieana, Keraudrenia velutina, Acacia effusifolia, Grevillea acacioides,*
SAWS	Sand plain Spinifex Hummock Grassland with Wattles	Sand plain	*Triodia basedowii, Acacia effusifolia, A. heteroneura* var. *prolixa, A. jamesiana, A. prainii, A. pachyacra*
SAMA	Sand plain Spinifex Hummock Grassland with Mallee	Sand plain	*Triodia basedowii, Eucalyptus leptopoda* ssp. *elevata, E. kingsmillii, E. trivalva, Acacia effusifolia, A. heteroneura var. prolixa, A. prainii, A. ligulata, Leptosema chambersii*
SAGS	Sand plain Spinifex Hummock Grassland with *Eucalyptus gongylocarpa*	Sand plain	*Eucalyptus gongylocarpa, Acacia effusifolia, A. ligulata, A. prainii, A. heteroneura* var. *prolixa, Eremophila platythamnos* subsp. *platythamnos, Halgania cyanea* ssp. Allambi Stn (B.W. Strong 676)*, Triodia basedowii*
SACSG	Sand plain Spinifex Hummonck Grassland with *Corymbia*	Sand plain	*Corymbia lenziana, Acacia effusifolia, A. jamesiana, A. heteroneura, Grevillea acacioides, Homalocalyx thryptomenoides, Enekbatus eremaeus, Micromyrtus flaviflora, Triodia basedowii*
SAMU	Sandplain Mulga Spinifex Hummock Grassland	Sand plain	*Acacia aneura, A. ayersiana, A. ramulosa* var. *linophylla, A. effusifolia, Melaleuca interioris, Triodia basedowii*

Code	Vegetation Community	Landform Description	Dominant, Defining Flora
SDSH	Sand Dune Shrubland	Sand dunes	*Callitris columellaris, Acacia aneura, Eucalyptus leptopoda* ssp. *elevata, Bertya dimerostigma, Micromyrtus flaviflora, Hakea lorea* ssp. *lorea, Triodia basedowii*
SAHS	Sand plain Spinifex Hummock Grassland with Heath	Sand plain	*Triodia basedowii, Enekbatus eremaeus, E. cryptandroides, Acacia effusifolia, A. heteroneura* var. *prolixa, A. jamesiana, Hakea francisiana*
WABS	Wanderrie Bank Grassy Shrubland	Sandy hardpan plain	*Acacia aneura, A. ayersiana, Grevillea berryana, A. ramulosa* var. *linophylla, A. tetragonophylla, Eremophila forrestii* ssp. *forrestii, Ptilotus obovatus* (typical Goldfields form), *Eragrostis eriopoda*
HPMS	Hardpan Plain Mulga Shrubland	Plains	*Acacia aneura, A. ayersiana, A. ramulosa* var. *linophylla, A. tetragonophylla, Melaleuca interioris, Grevillea berryana, Eremophila* spp.
DRMS	Drainage Tract Mulga Shrubland	Drainage lines on plains	*Acacia aneura, A. ayersiana, Eremophila* spp., *Pluchea dentex,* various herbs
GRMU	Mulga Groves on Hardpan Plain	Plains	*Acacia aneura, A. ayersiana, A. craspedocarpa, A. tetragonophylla, A. ramulosa* var. *linophylla, Eremophila hygrophana, Ptilotus obovatus* (typical Goldfields form)
PLAPoS	*Acacia* spp. and *Ptilotus obovatus* Shrubland	Flats in Playa System	*Acacia aneura, A. ayersiana, A. tetragonophylla, A. ramulosa* var. *linophylla, A. burkittii, Ptilotus obovatus* (typical Goldfields form)
PLEml	*Eremophila malacoides* Shrubland	Scalded areas in Playa System	*Eremophila malacoides*
DRMpS	Drainage Tract Maireana pyramidata shrubland	Sheet wash plains in the granite system	*Maireana pyramidata, Frankenia setosa, Maireana georgei, M. tomentosa, Sclerolaena densifolia, Ptilotus obovatus*
CAbS	*Acacia burkittii* Shrubland on Calcrete	Calcrete rises	*Acacia burkittii, Grevillea berryana, Eremophila arachnoides* ssp. *arachnoides* P3, *Senna artemisioides* ssp. *filifolia, Ptilotus obovatus* (typical Goldfields form)

Table 20. Representation of vegetation communities within study areas 1 and 2

Vegetation community code	Area mapped Study area 2 (ha)	Area mapped Study area 1 (ha)
Bare	1.29	65.82
BRX	9.76	-
BCLS	8.34	46.10
CAbS	25.50	1119.69
DRMS	133.52	149.82
GPoS	7.81	125.96
GR	40.41	7.31
GRMC	79.23	-
GRMS	299.56	536.18
GRMU	5.24	1393.74
HPMS	3583.07	7322.37
HPMS and SAMU	60.68	752.37
PLAPoS	387.80	1818.10
PLEml	1.66	18.01
DRMpS	74.10	3.35
QMPS	2.42	-
Qtz	6.03	0.14
SACSG	989.48	11.38
SAES	30.83	198.50
SAGS	2253.93	609.99
SAHS	1578.63	679.91
SAMA	15338.75	14441.23
SAMU	5574.31	6818.05
SASP	994.74	1057.37
SAWS	9456.72	6781.25
SAWS and SAHS	479.98	-
SDSH	63.39	100.62
WABS	541.42	651.48

3.5. Study area 2 – Flora

Most taxa recorded from within study area 2 are widespread and common in the region and occur across a range of land systems and soil types. These are not discussed further. A table of species by vegetation community is provided in Appendix 11, and a systematic list of vascular flora for study areas 1, 2 and 3 is presented in Appendix 13. Significant flora and species of interest recorded in study area 2 are summarised in Table 21 and discussed in the next Section.

Table 21. Priority Flora, other significant flora and species of interest recorded within study area 2

Species	Cons. status	Requires taxonomic investigation	Undescribed species	Geographically restricted	Range extension	Poorly collected
Thryptomene sp. Leinster (B.J. Lepschi & L.A. Craven 4362)	P1					
Neurachne lanigera S.T.Blake	P1					
**Euryomyrtus inflata* Trudgen	P3					
**Bossiaea eremaea* J.H.Ross	P3					
Calytrix erosipetala Craven	P3					
Calytrix uncinata Craven	P3					
Sauropus ramosissimus (F.Muell.) Airy Shaw	P3					
Sida sp. Mt Keith (G Cockerton & G O'Keefe LCH 10489)						
Olearia sp. Sherwood Breakaways (A. Taylor LCH 25552)						
Hibbertia sp. aff. *exasperata* (D. Brassington & S. Colwill LCH29097)						
**Acacia* sp. Yakabindie (G. Cockerton & G. O'Keefe 14274) aff. *kempeana*						
**Acacia aneura* (multiple variants)						

*These species were also present in study area 1

3.5.1. Priority flora

Seven priority species were recorded from study area 2, including two Priority One flora: *Thryptomene* sp. Leinster and *Neurachne lanigera*, and five Priority Three flora: *Sauropus ramosissimus*, *Bossiaea eremaea*, *Euryomyrtus inflata*, *Calytrix erosipetala* and *Calytrix uncinata*. *Calytrix erosipetala* occurs in the proposed quarry of the project footprint.

Thryptomene sp. Leinster (B.J. Lepschi & L.A. Craven 4362) P1

Priority one species, *Thryptomene* sp. Leinster is an upright to sprawling shrub up to 2.5 m in height, producing white to pink flowers from October to December (Plate 38 and Plate 39). It is known to occur on rocky Archaean granite breakaways, stony rises and rocky granite outcroppings, in association with *Acacia aneura*.

Known only from a narrow distribution in the eastern Murchison Biogeographic region, there are currently 13 voucher collections listed on FloraBase (Western Australian Herbarium, 2011) (Figure 30). *Thryptomene* sp. Leinster is associated with the Barr-Smith Range, which extends from the south of Wiluna to approximately 60 km south of Leinster.

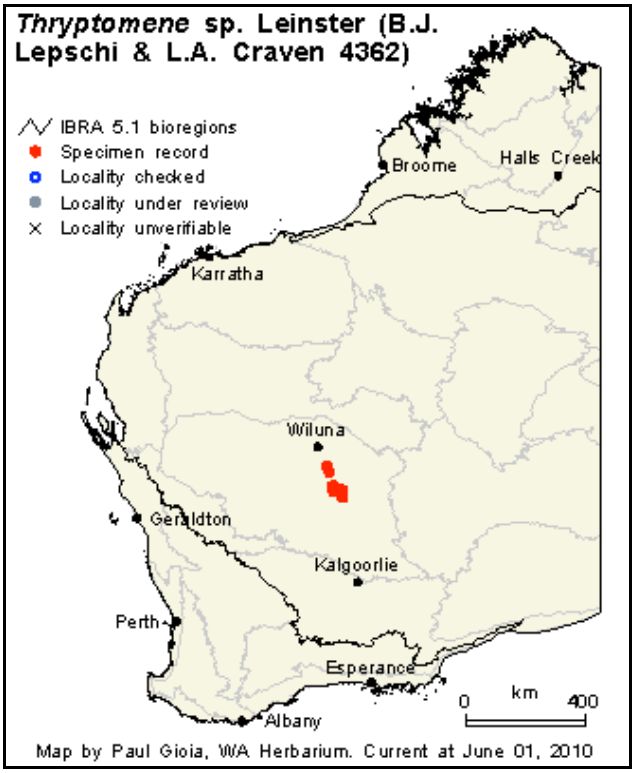

Figure 30. Distribution of _Thryptomene_ sp. Leinster within WA

Thryptomene sp. Leinster has previously been referred to as the closely related species, *T. decussata,* but differs in morphology with the following attributes:

- Leaves are smaller and of a different shape – leaves are very broad ovate to sub-orbicular in shape with a truncate base,
- Oil glands on the leaves are more closely packed, and
- Difference in anther arrangement.

Plate 38. *Thryptomene* sp. Leinster (B.J. Lepschi and L.A. Craven 4362)

Plate 39. *Thryptomene* sp. Leinster stem and flower detail

A single population of 168 plants was recorded in study area 2. This population occurred on a Quartz ridge in the central north-western part of the study area 2 (Figure 31). The vegetation community Qtz (Quartz ridge), consists of *Acacia aneura* tall shrubland with occasional *Callitris columellaris*. *Thryptomene* sp. Leinster forms a mid shrub level over *Ptilotus obovatus* (typical Goldfields form) Other associated species include *Acacia quadrimarginea, Callitris columellaris, Dodonaea petiolaris, Eremophila exilifolia, E. latrobei* subsp. *latrobei*, and *Cymbopogon ambiguus.* Similar quartz ridges in the study area 2 did not support *T.* sp. Leinster.

Figure 31. *Thryptomene* sp. Leinster population within study area 2

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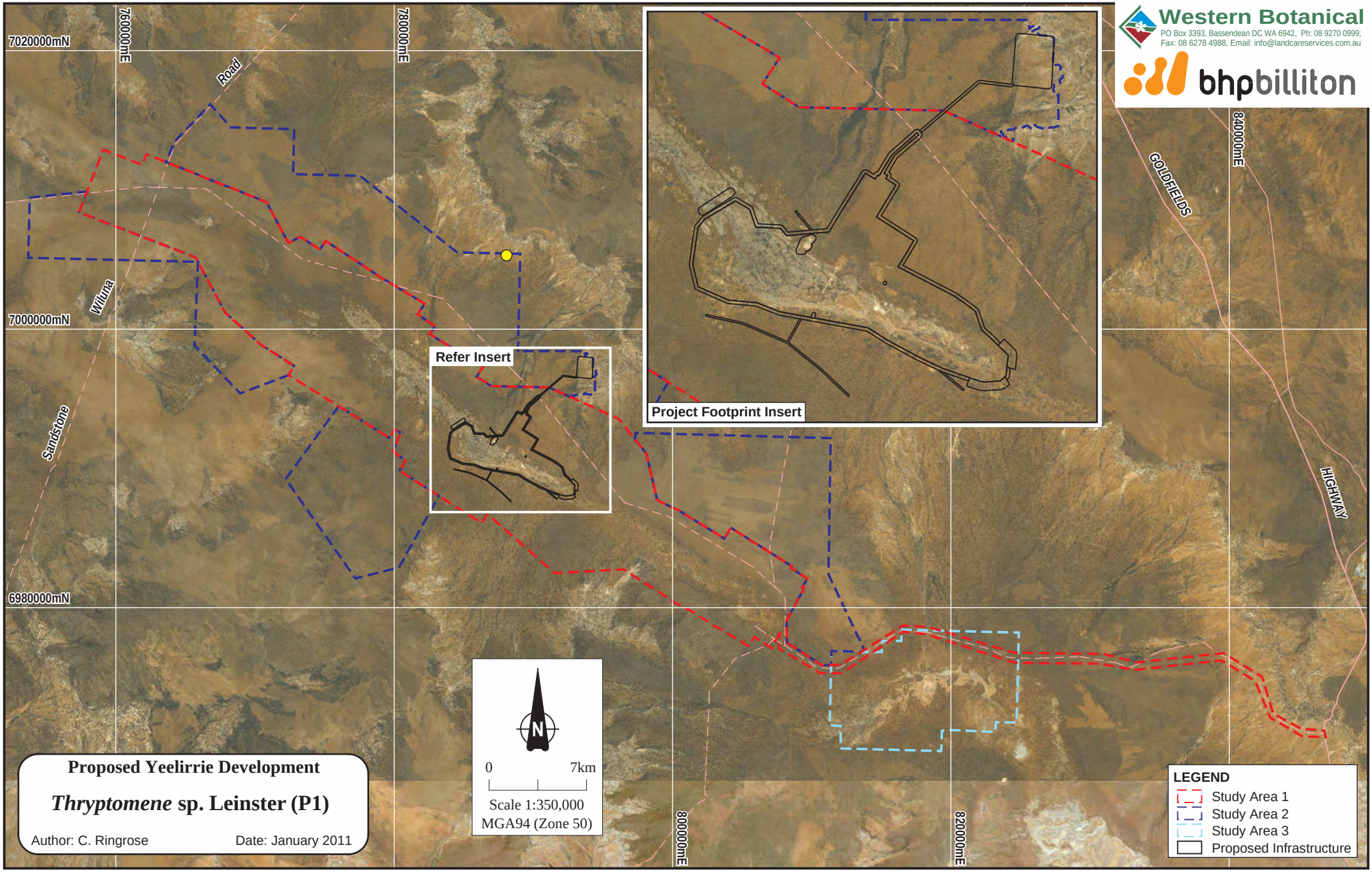

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***Thryptomene* sp. Leinster (P1)**

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Neurachne lanigera S.T.Blake P1

Neurachne lanigera is a tufted, shortly rhizomatous perennial grass with a woolly base growing to about 0.3 m in height (Plate 40, Plate 41 and Plate 42). The inflorescence is a whitish grey oblong spike-like panicle or raceme 1.5 – 3.5 cm in length (Plate 43) (Jessop *et al*., 2006). There are currently five voucher collections of the species lodged with the WA Herbarium from the Gibson Desert, Central Ranges and Murchison Biogeographic regions. Collection localities include Warburton, Wiluna, Cunyu and Winduldarra Rockhole (Figure 32) (Western Australian Herbarium, 2011).

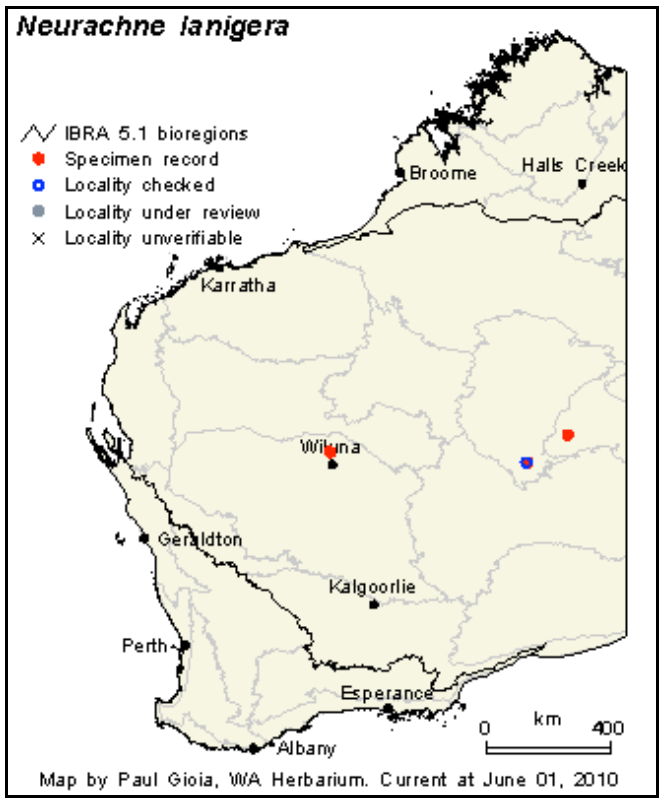

Figure 32. Distribution of *Neurachne lanigera* in WA

Neurachne lanigera occurs across a range of vegetation types and landscapes, including rocky hills and outcroppings, lateritic breakaways, and sandplains with Spinifex. Associated vegetation includes open *Acacia* shrublands and Spinifex grasslands (Western Australian Herbarium, 2011).

Plate 40. ***Neurachne lanigera***

Plate 41. ***Neurachne lanigera*** **leaves**

Plate 42. *Neurachne lanigera* woolly base

Plate 43. *Neurachne lanigera* spikelet from the inflorescence

In study area 2, *Neurachne lanigera* was recorded at a single location in the SACSG (*Corymbia lenziana* Woodland over Spinifex hummock grassland on Sandplains) vegetation community. Scattered individuals also co-occurred with *Triodia basedowii* hummock grasses. An assessment of population size was not undertaken, as this species was not identified until after all field surveys had been completed. Figure 33 shows were the identified specimen was collected.

Figure 33. *Neurachne lanigera* populations within study area 2

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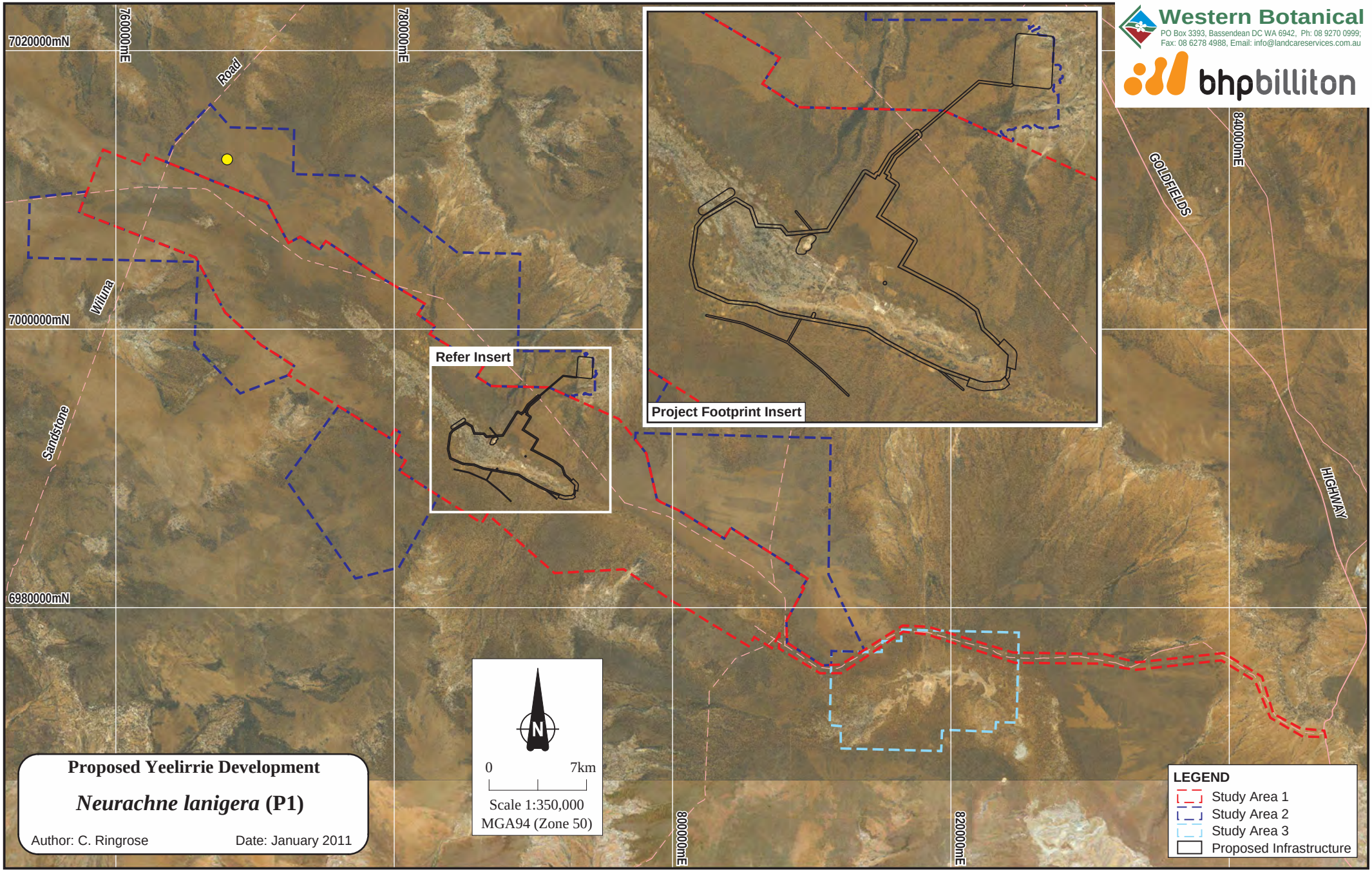

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***Neurachne lanigera* (P1)**

Author: C. Ringrose Date: January 2011

Sauropus ramosissimus (F.Muell.) Airy Shaw P3

Sauropus ramosissimus is a spreading, much-branched shrub, to 0.3 m in height (Plate 44 and Plate 45). Flowers are small and green in colour and occur following spring rainfall. This species is often subject to high grazing pressure, particularly where goat populations are high, such as around the township of Leinster. There are currently 11 voucher collections of this species lodged with the WA Herbarium from four IBRA Biogeographic Regions: Gascoyne, Gibson Desert, Great Victorian Desert and Murchison (Figure 34) (Western Australian Herbarium, 2011).

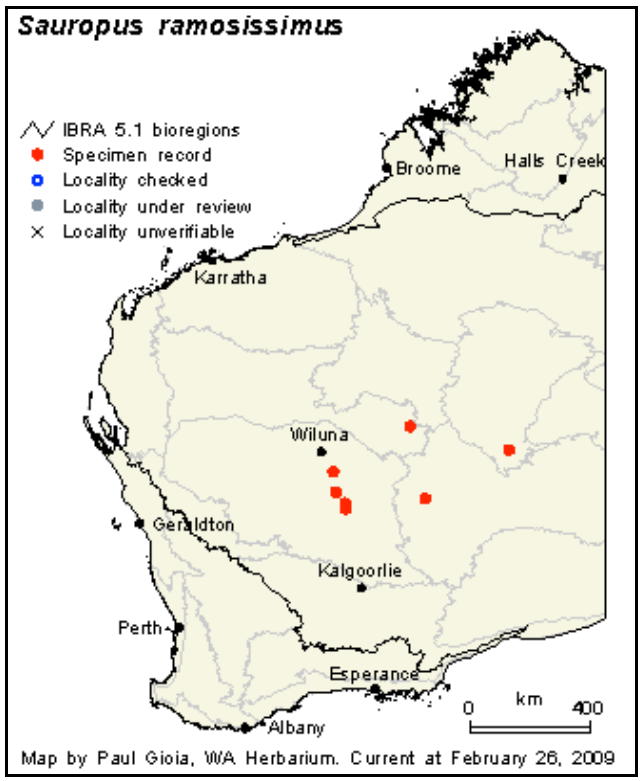

Figure 34. Distribution of *Sauropus ramosissimus* in WA

Two populations of *S. ramosissimus* were recorded within study area 2 (Figure 35). One population of 10 plants was recorded on low granite outcrops in the central-northern margins of study area 2, in the GRMS community; and a second collection was made on top of a small weathered granite breakaway plateau in the WGBP community (within the BRX complex).

Plate 44. *Sauropus ramosissimus* within the GRMS vegetation community

Plate 45. *Sauropus ramosissimus* stem and leaf detail

Figure 35. *Sauropus ramosissimus* populations within study area 2

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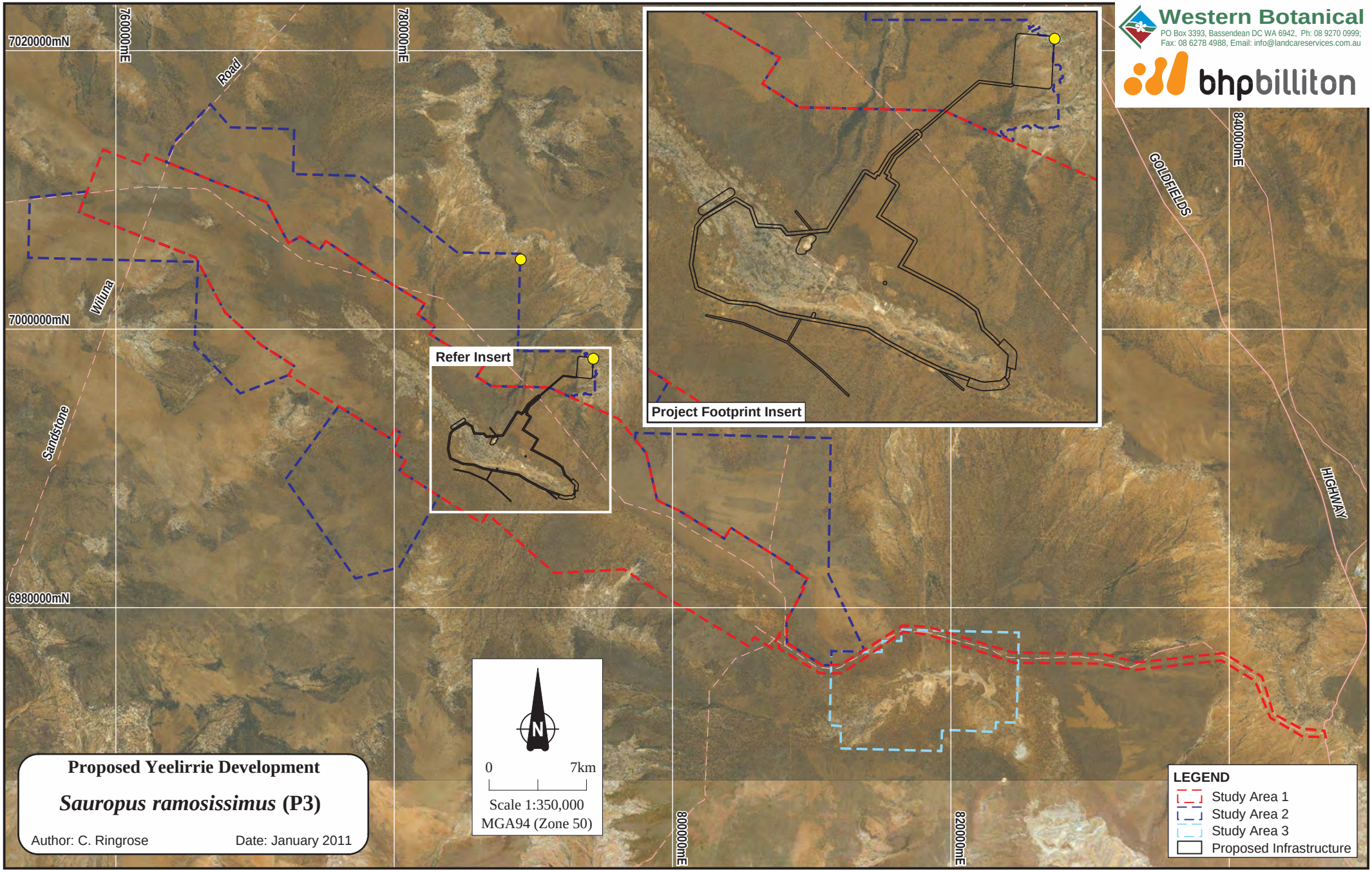

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***Sauropus ramosissimus* (P3)**

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***Bossiaea eremaea* J. H. Ross P3**

A description of *Bossiaea eremaea* is provided in Section 3.3.1.

Extensive populations of *Bossiaea eremaea* were recorded throughout the Sand Plain System within study area 1. Two of these populations extended northwards into study area 2. The boundary of the largest population within study area 1 was extended by approximately 4 km to the north of its previous boundary. This population occurred in a mix of burnt and unburnt SAWS and SAMA vegetation communities.

An additional population of *Bossiaea eremaea* was recorded in the south-west corner of study area 2 in a SAGS community on a slight sandy rise. A total of 1,391 *B. eremaea* individual plants were counted, with an overall estimation of 3,839 individuals of *B. eremaea* within the study area 2.

Eight populations were recorded throughout study areas 1 and 2 and a map showing its distribution is provided in Figure 18, Section 3.3.1.

Bossiaea eremaea commonly occurs with *Eucalyptus kingsmillii*, *E. leptopoda* subsp. *elevata*, *Acacia effusifolia* (dominant), *A. ligulata* (dominant), *Hakea francisiana*, *Eremophila platythamnos* subsp. *platythamnos*, *Homalocalyx thryptomenoides*, *Leptosema chambersii*, *Ptilotus obovatus* (typical Goldfields form) and *Triodia basedowii* (dominant) hummock grasses.

***Euryomyrtus inflata* Trudgen P3**

A description of *Euryomyrtus inflata* is provided in Section 3.3.1. *Euryomyrtus inflata* was recorded in extensive populations within the Sand Plain System of study area 1. Five additional populations and several sub-populations were recorded within study area 2, which cover a total area of 18,545 ha. The greater portion of these populations were located on the northern side of Meekatharra Road, however, *E. inflata* was recorded in all but the south-west section of study area 2.

The largest population of *E. inflata* extends approximately 16 km west to east and six km north to south in the northern section of study area 2. The second largest population extends approximately 13 km west to east and six kilometers north to

south in the north-eastern section of study area 2. The other large populations of *E. inflata* were recorded in the western and south-western sections of study area 2. An overview location map showing its distribution in study area 2 is provided in Figure 14, Section 3.3.1.

Individual plants were present in varying densities, from approximately 10 plants per 50 m^2 (40 per ha) to 350 plants per 50 m^2 (1,400 per ha). A total of 2432 plants were recorded, with an estimated total of 1,920,180 individuals within study area 2.

Euryomyrtus inflata is most commonly found in high numbers in areas burnt approximately five years ago. It occurs on flat sand plains and lower lying sandy areas, in SAWS, SAMA, and SAHS vegetation communities and where *Triodia basedowii* has no more than 25 % projected foliage cover (PFC).

***Calytrix erosipetala* Craven P3**

Calytrix erosipetala is a small shrub, growing from 0.3 to 0.7 m in height, with white to pink flowers produced from September to October (Plate 46 and Plate 47). It occurs on rocky sandstone or granite breakaways.

Calytrix erosipetala is known from the Murchison and Yalgoo Biogeographic regions and there are currently 40 voucher collections listed on FloraBase (Western Australian Herbarium, 2011). The majority of the populations are located between Leonora, Wiluna and Mt Magnet on the Archaean granite breakaways of the Sherwood Land System (Figure 36) (Western Australian Herbarium, 2011). This land system is widespread in the North-eastern Goldfields on the extensive Barr-Smith Range that extends from north of Leonora to south of Wiluna.

Plate 46. *Calytrix erosipetala*

Plate 47. *Calytrix erosipetala* stem and leaf detail

A single population of *Calytrix erosipetala* was recorded in study area 2 on the Weathered Granite Breakaway system, in the BRX complex, north of Meekatharra Road (Figure 37). A total of 419 plants were counted within study area 2, however, the population appeared to continue to the north and east in association with the breakaways. This population may represent a small proportion of the total number of plants in the region.

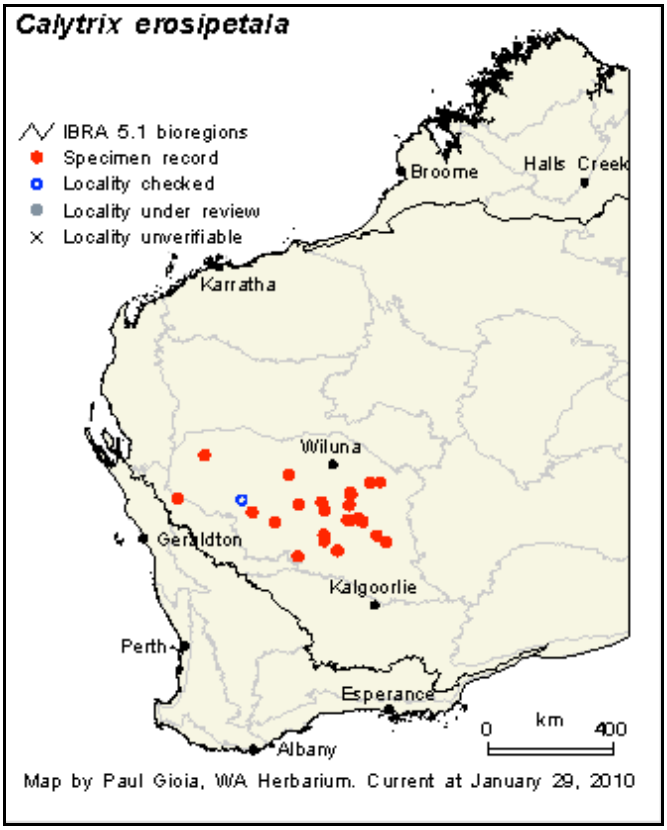

Figure 36. Distribution of *Calytrix erosipetala* within WA

Figure 37. *Calytrix erosipetala* populations within study area 2

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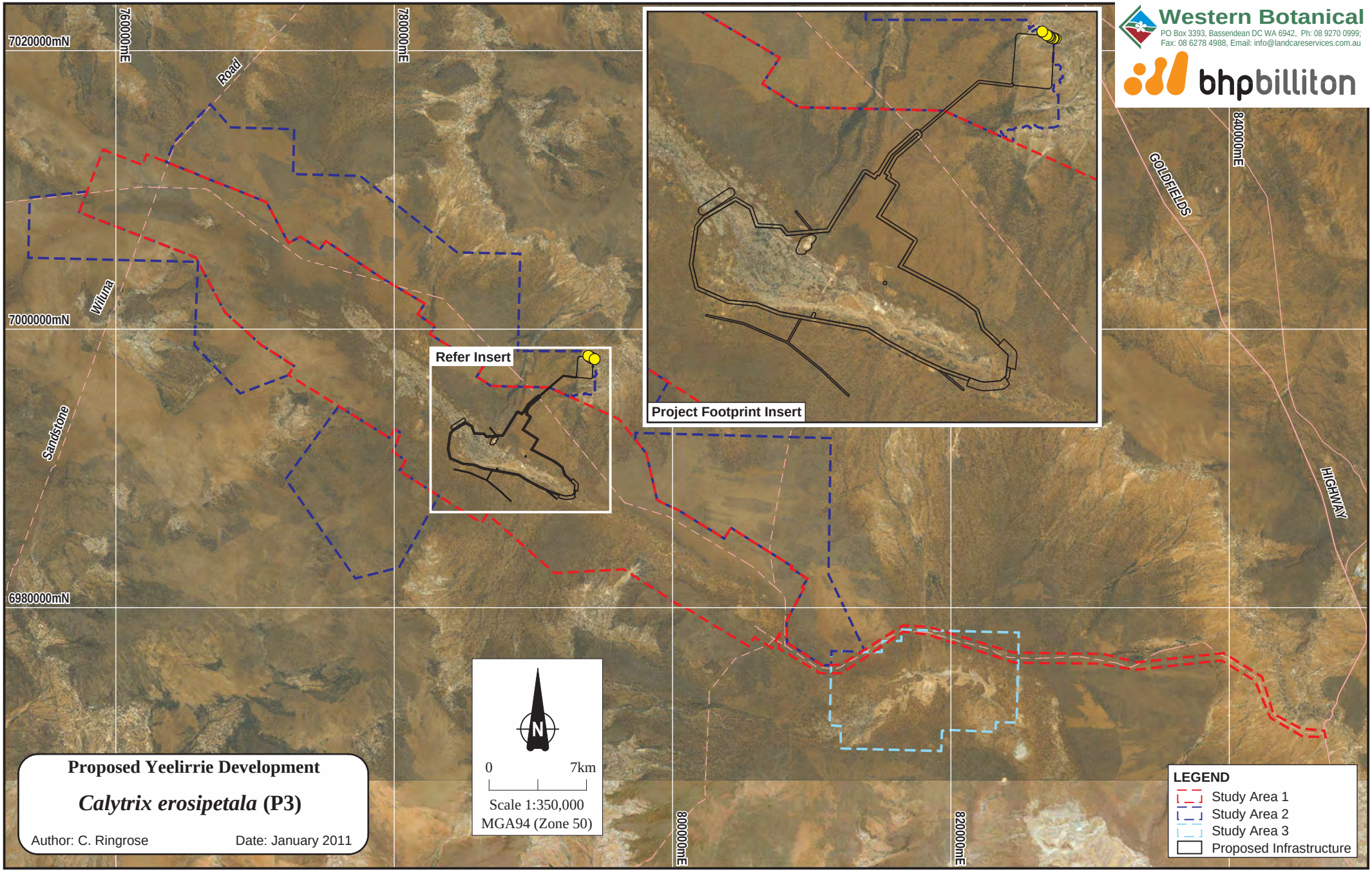

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***Calytrix erosipetala* (P3)**

Author: C. Ringrose Date: January 2011

Calytrix uncinata Craven P3

Calytrix uncinata is a glabrous shrub to 1 m high with distinctive uncinate or hooked-tipped leaves (Plate 48). White flowers are usually produced between the months of August and November (Plate 49). It has been found growing in shallow pockets of sandy soil on granite breakaways and rocky rises.

Calytrix uncinata is know from the Murchison and Yalgoo IBRA Biogeographic regions and is represented by 44 voucher collections at the Western Australian Herbarium (FloraBase, 2011). The known range of *Calytrix uncinata* extends from Meekatharra and Paynes Find in the west to Leonora in the east and Mt Keith in the north (Figure 38).

Plate 48. *Calytrix uncinata* at Mt Keith

Plate 49. *Calytrix uncinata* flowers at Mt Keith

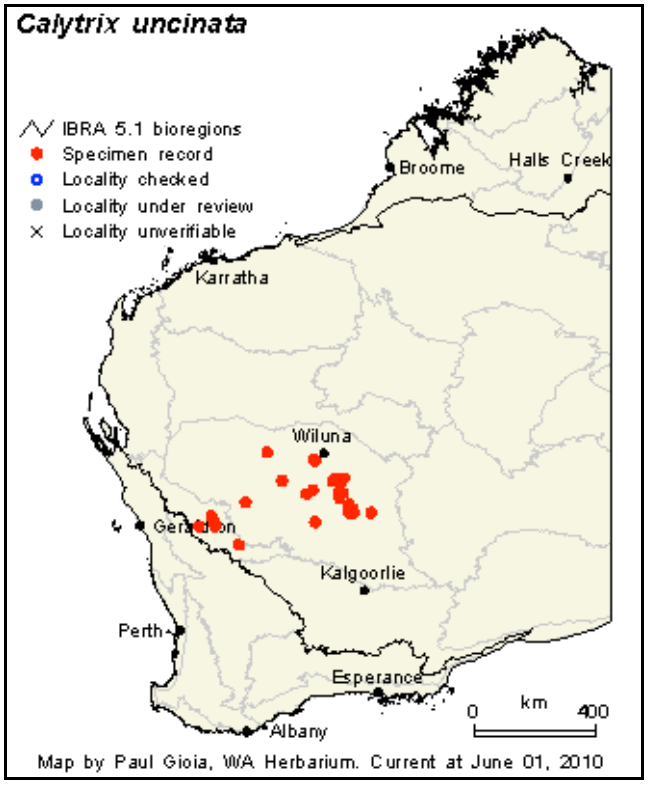

Figure 38. Distribution of *Calytrix uncinata* in WA

There is one record of *C. uncinata* in study area 2. A single site with 18 individuals was found in the Breakaway Complex (BRX) in the Weathered Granite Breakaway Plateau (WGBP) community (Figure 39).

Figure 39. *Calytrix uncinata* population within study area 2

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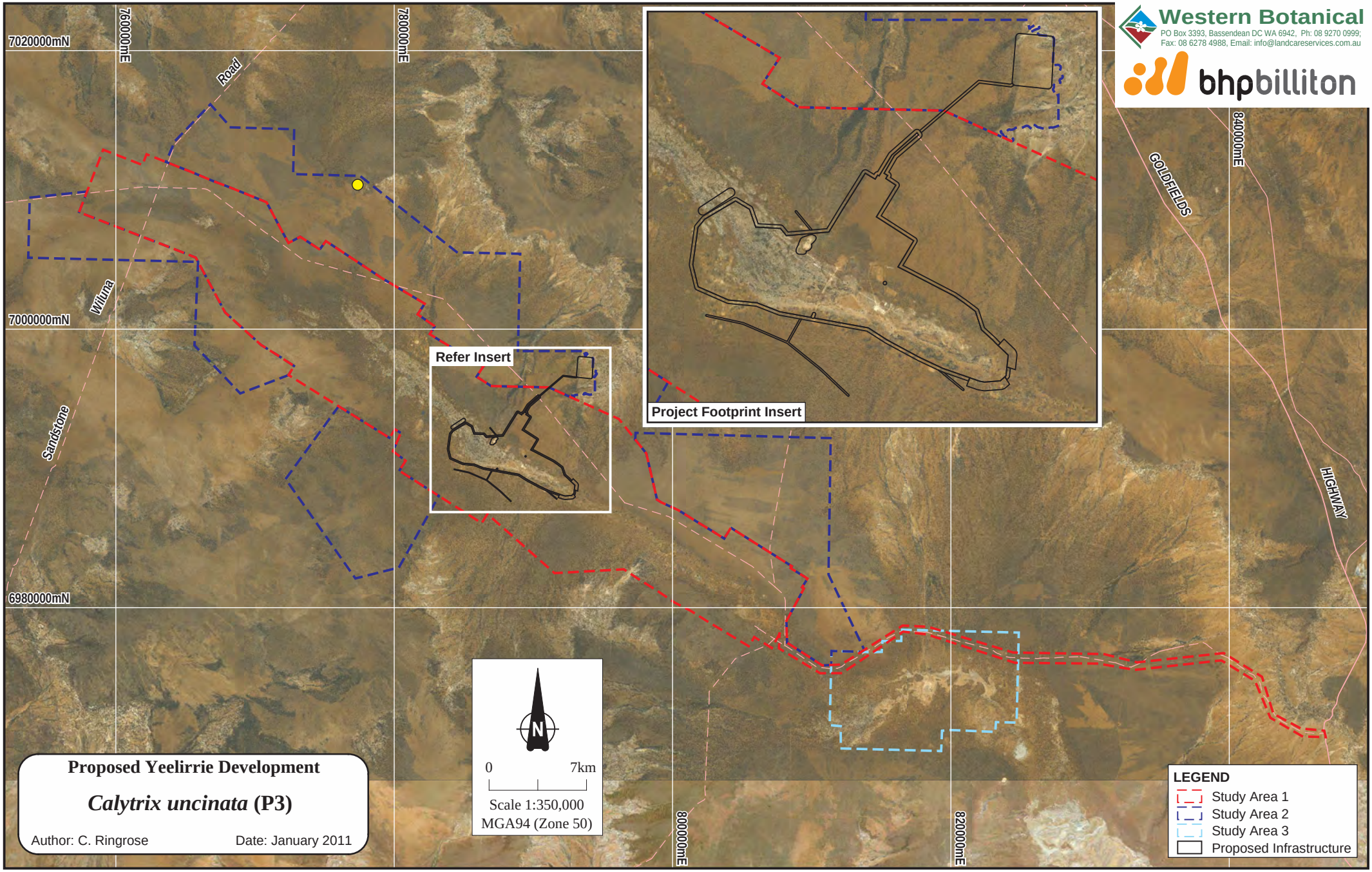

Proposed Yeelirrie Development

***Calytrix uncinata* (P3)**

Author: C. Ringrose Date: January 2011

3.5.2. New, undescribed species with potential conservation significance

Three undescribed species were recorded within study area 2: *Sida* sp. Mt Keith (G Cockerton & G O'Keefe LCH 10489), *Olearia* sp. Sherwood Breakaways (A. Taylor LCH25552) and *Hibbertia* sp. aff. *exasperata* (D. Brassington & S. Colwill LCH29097).

Sida sp. Mt Keith (G Cockerton & G O'Keefe LCH 10489)

Sida sp. Mt Keith (G Cockerton & G O'Keefe LCH 10489) is a tangled divaricately branched dioecious shrub 0.3 to 0.5 m high x 0.3 to 1 m wide. The leaves are ovate, margin crenulate, 0.6 to 1.2 mm long x 0.4 to 0.7 mm wide (Plate 50). Plants are dioecious, that is male and female flowers of *Sida* sp. Mt Keith are borne on separate plants, (Plate 51 and Plate 52). Fruits have five carpels (Plate 53).

The species is unusual in that it represents a new taxon within the sub-genus of *Sida* with small unadorned fruits. Following investigations at the WA Herbarium, the undescribed species was given the phrase name *Sida* sp. Mt Keith (G Cockerton & G O'Keefe LCH 10489). The new species status has been verified by taxonomic experts K. R. Thiele (WA Herbarium) and R. Barker (Adelaide Herbarium) and is the subject of investigation by the WA Herbarium and Adelaide Herbarium.

Sida sp. Mt Keith has only been recorded from two other locations regionally, both in the proximity of the Mt Keith minesite. It occurs in small, scattered and disjunct populations on the weathered Archaean granite breakaway plateaux and upper footslopes of the Barr-Smith Range.

Plate 50. *Sida* sp. Mt Keith

Plate 51. *Sida* sp. Mt Keith male flower

Plate 52. *Sida* sp. Mt Keith female flower

Plate 53. *Sida* sp. Mt Keith fruit showing four of the five carpels filled

Sida sp. Mt Keith was recorded from a single population of 397 individuals within study area 2 (Figure 25). It was found growing along both the slopes and plateaux on

the edge of the weathered granite breakaway, which lies within the Sherwood Breakaway and Plateaux land system. *Sida* sp. Mt Keith was found in association with two vegetation communities, the Weathered Granite Breakaway Plateau (WGBP) community (apart of the BRX complex), and the *Acacia* Shrubland in Weathered Granite Breakaway Gullies (WGAG) community.

The conservation status of *Sida* sp. Mt Keith has not yet been assessed. However, the species is very restricted in it's habitat preference and occurs in small, disjunct populations on the breakaways of the Barr-Smith Range. Should the DEC review the conservation status of this species, based on the known numbers of individuals and distribution of populations, the species would potentially qualify as a priority species (see flora conservation codes and their meanings, presented in Appendix 2 of this report).

Olearia sp. Sherwood Breakaways (A. Taylor LCH 25552)

Olearia sp. Sherwood Breakaways (A. Taylor LCH 25552) is a small sparse highly fragrant shrub to 0.6 m high. It has an upright habit with few branches, producing white flowers with yellow centres following spring rainfall (Plate 54, Plate 55 and Plate 56). This species has affinities to *O. stuartii* but has some distinct differences which are noted below:

- *Olearia* sp. Sherwood Breakaways is highly fragrant whereas *O. stuartii* has no fragrance;
- The capillary bristles of *Olearia* sp. Sherwood Breakaways are larger than the bracts, whereas the capillary bristles *of O. stuartii* are the same length as the bracts;
- The petals of *Olearia* sp. Sherwood Breakaways curl under, whereas the petals of *O. stuartii* do not curl under;
- The leaves of *Olearia* sp. Sherwood Breakaways are not as long or as broad as the leaves of *O. stuartii*;
- *Olearia* sp. Sherwood Breakaways have noticeably more glandular hairs on its foliage than that of *O. stuartii*; and
- *Olearia* sp. Sherwood Breakaways leaves are lobed at the ends, whereas *O. stuartii* leaves have lobed sides.

A detailed taxonomic investigation of this taxon has not yet been undertaken, however, following a preliminary investigation and in consultation with WA Herbarium botanists Kevin Thiele and Nicholas Lander, it has been suggested as a novel species and the phrase name *Olearia* sp. Sherwood Breakaways (A. Taylor LCH 25552) was applied.

Plate 54. *Olearia* sp. Sherwood Breakaways (A. Taylor LCH 25552)

Plate 55. *Olearia* sp. Sherwood Breakaways (A. Taylor LCH 25552) stem and leaf detail

Plate 56. *Olearia* sp. Sherwood Breakaways (A. Taylor LCH 25552) flower detail

Olearia sp. Sherwood Breakaways was first collected on the Archaean breakaway of the Sherwood Land System within the Bar-Smith Range, to the west of the Mt Keith Nickel minesite. This species has been collected previously at Yakabindie (by the authors) and at the Brooking Hills, west of Menzies.

A population (70 individuals) of *Olearia* sp. Sherwood Breakaways was found on a small plateau in the Weathered Granite Plateau (WGBP) community of the BRX complex (Figure 25).

The conservation status of *Olearia* sp. Sherwood Breakaways has not yet been assessed. However, the species is very restricted in it's habitat preference and occurs in small, disjunct populations on the breakaways of the Barr-Smith Range in the local region, with one population noted on Banded Ironstones at the Brooking Hills.

Should the DEC review the conservation status of this species, based on the known numbers of individuals and distribution of populations, the species would potentially qualify as a priority species (see flora conservation codes and their meanings, presented in Appendix 2 of this report).

Hibbertia sp. aff. *exasperata* (D. Brassington & S. Colwill LCH29097)

Hibbertia sp. aff. *exasperata* (D. Brassington & S. Colwill LCH29097) is an erect shrub to 1.2 m high with pungent, green leaves (Plate 57 and Plate 58). This species is restricted to the Archaean granite breakaway system, which is a part of the Sherwood Land System.

Hibbertia sp aff. *exasperata* is currently considered to be a part of the *H. exasperata* group, which is a group of at least four to five closely related species (Wheeler, 2004). Further collections of reproductive material and a review of the *H. exasperata* sens. lat. group are required to determine it's taxonomic status.

Plate 57. *Hibbertia* sp. aff. *exasperata* (D. Brassington & S. Colwill LCH29097)

Plate 58. *Hibbertia* sp. aff. *exasperata* (D. Brassington & S. Colwill LCH29097) stem and leaves

One population, of 71 individuals, was recorded within the BRX complex on the breakaways in the central northern section of study area 2 (Figure 25). This population may extend beyond the boundary of study area 2 in association with the breakaway system. This species is also known by the authors from the same landform some 20 km south-east of this site on Yakabindie Station.

3.5.3. Species of interest

Acacia sp. Yakabindie (G. Cockerton & G. O'Keefe LCH 14274) aff. _kempeana_

A description of *Acacia* sp. Yakabindie (G. Cockerton & G. O'Keefe LCH 14274) aff. *kempeana* is provided in Section 3.3.3.

A single population of approximately 30 plants was recorded in the SAMA vegetation community in study area 2 (Figure 25). In study area 1, one plant was recorded in the SAMA vegetation east of proposed high grade stockpile, and a second plant was recorded on the northern boundary of the survey area within the GPoS vegetation community.

To date, approximately 447 plants in 11 populations are known in the local area, primarily on Yakabindie, Yeelirrie and Leinster Downs stations, approximately 100 km south of Wiluna. It is also known from the Pilbara region where it has been widely collected. It is not considered to have conservation significance other than populations in the Yeelirrie – Yakabindie – Leinster region likely representing the southern limit of it's range.

Associated species include *Eucalyptus kingsmillii*, *Acacia effusifolia*, *Bossiaea eremaea* (P3) and *Triodia basedowii*.

3.5.4. *Acacia aneura* variants within study area 2

As discussed in Section 3.3.4, the *Acacia aneura* group is extremely variable and current taxonomic literature does not adequately describe the breadth of variability within the taxon. The *A. aneura* group in study area 2 was identified utilising phyllode morphological attributes and informal phrase names were applied to describe variants. A total of 30 informally morphologically described variants were recognised in study area 2 (Table 22), however there is likely considerable duplication or overlap in taxa. Mulga collections from study area 2 will be submitted to the WA Herbarium at a later date for further identification.

Table 22. Description of phrase named *Acacia aneura* variants within study area 2

Species	Variant description
Acacia aneura	flat blue grey 5mm x 50mm
	flat blue grey curved 3x60mm
	flat blue grey falcate 4x30mm
	flat blue grey straight 5x50mm
	flat blue grey straight to falcate 2x20mm
	flat blue grey straight to slightly curved 2x55mm
	flat blue grey straight to slightly curved 2x80mm
	flat blue grey straight to slightly curved 3x20mm
	flat blue grey straight to slightly curved 3x50mm
	flat blue grey straight to slightly curved 3x65mm
	flat blue grey straight to slightly curved 4.5x40mm
	flat blue grey straight to slightly curved 4x65mm
	flat blue grey straight to slightly falcate anastomosing nerves 6x30mm
	flat green slightly curved 3x60mm
	flat green straight 1.5x60mm
	flat green straight to falcate 4x40mm
	flat green straight to falcate 4x50mm
	flat green straight to slightly curved 1.5x35mm
	flat green straight to slightly curved 4.5x70mm
	flat grey green slightly curved 1x25mm
	flat grey green slightly curved 2x40mm
	flat grey green slightly curved 8x80mm
	flat grey green straight 8x60mm
	flat grey green straight to curved 2x50mm
	flat grey green straight to slightly curved 2x60mm
	sub-terete blue grey strait to slightly curved 1x30mm
	sub-terete green straight 1x60mm
	sub-terete green straight to slightly curved 1x60mm
	sub-terete grey green straight to curved 1x50mm
	terete green straight 1x60mm

3.6. Study area 3 - vegetation

A total of 9,843 hectares was surveyed and 31 vegetation communities identified and mapped in study area 3. These were closely related to those found within study area 1, and 23 communities were recorded in both. A summary of the vegetation communities is listed in Table 23 and more detailed descriptions in Appendix 8 of this report. Figure 40 provides an overview of the vegetation communities mapped in study area 3. Note that "1" and "2" marked on Figure 40 refer to the two vegetation community map sheets provided in Appendix 7 of this report. Table 24 provides a summary of the representative area of each community in hectares. Descriptions of the 10 relevés surveyed within study area 3 are provided in Appendix 12 of this report.

3.6.1. Soil landscape association with vegetation communities

The vegetation communities of study area 3 were similarly aligned with the five soil landscapes described within study area 1 in Section 3.1.1.

A sixth soil landscape is the Saline Playa System, described below, which occurs within study area 3 but is not represented within study area 1. The western extents of Lake Miranda make up the Saline Playa System in study area 3. It is orientated roughly west to east in a broad inverted 'U' and is characterised by broad seasonally inundated low flats with saline clays. The area represents a large Playa System with high salinity levels.

Figure 40. Overview of vegetation communities mapped in study area 3

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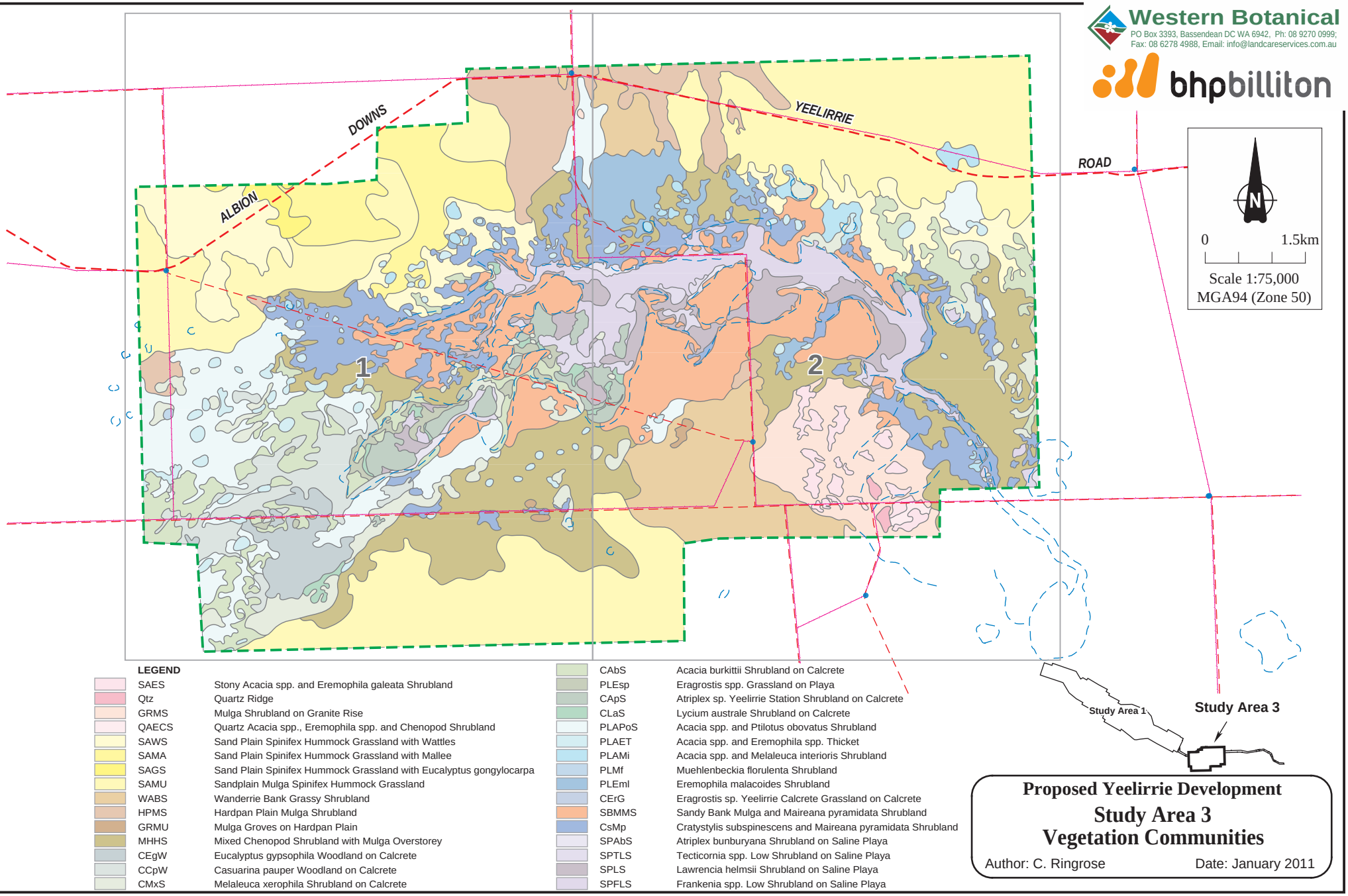

LEGEND

	SAES	Stony Acacia spp. and Eremophila galeata Shrubland
	Qtz	Quartz Ridge
	GRMS	Mulga Shrubland on Granite Rise
	QAECS	Quartz Acacia spp., Eremophila spp. and Chenopod Shrubland
	SAWS	Sand Plain Spinifex Hummock Grassland with Wattles
	SAMA	Sand Plain Spinifex Hummock Grassland with Mallee
	SAGS	Sand Plain Spinifex Hummock Grassland with Eucalyptus gongylocarpa
	SAMU	Sandplain Mulga Spinifex Hummock Grassland
	WABS	Wanderrie Bank Grassy Shrubland
	HPMS	Hardpan Plain Mulga Shrubland
	GRMU	Mulga Groves on Hardpan Plain
	MHHS	Mixed Chenopod Shrubland with Mulga Overstorey
	CEgW	Eucalyptus gypsophila Woodland on Calcrete
	CCpW	Casuarina pauper Woodland on Calcrete
	CMxS	Melaleuca xerophila Shrubland on Calcrete
	CAbS	Acacia burkittii Shrubland on Calcrete
	PLEsp	Eragrostis spp. Grassland on Playa
	CApS	Atriplex sp. Yeelirrie Station Shrubland on Calcrete
	CLaS	Lycium australe Shrubland on Calcrete
	PLAPoS	Acacia spp. and Ptilotus obovatus Shrubland
	PLAET	Acacia spp. and Eremophila spp. Thicket
	PLAMi	Acacia spp. and Melaleuca interioris Shrubland
	PLMf	Muehlenbeckia florulenta Shrubland
	PLEml	Eremophila malacoides Shrubland
	CErG	Eragrostis sp. Yeelirrie Calcrete Grassland on Calcrete
	SBMMS	Sandy Bank Mulga and Maireana pyramidata Shrubland
	CsMp	Cratystylis subspinescens and Maireana pyramidata Shrubland
	SPAbS	Atriplex bunburyana Shrubland on Saline Playa
	SPTLS	Tecticornia spp. Low Shrubland on Saline Playa
	SPLS	Lawrencia helmsii Shrubland on Saline Playa
	SPFLS	Frankenia spp. Low Shrubland on Saline Playa

Proposed Yeelirrie Development
Study Area 3
Vegetation Communities

Author: C. Ringrose Date: January 2011

Communities occurring within the Granite System

There are four vegetation communities described within the Granite System, and these are represented in the south-eastern area of study area 3. A low quartz and granite hill is the predominant feature in this area and represent predominately with Stoney *Acacia Eremophila* Shrubland (SAES) and Mulga Shrubland on Granite Rise (GRMS) communities. The other two communities present are Quartz Ridge (Qtz) and Quartz *Acacia* spp., *Eremophila* spp. and Chenopod Shrubland (QAECS).

Communities occurring within the Sand Plain System

Sand Plain System communities are characterised by Spinifex (*Triodia* spp.) hummock grasslands with a varying amount of shrub, tree and mallee components in the upper stratum. There are four communities described within the Sand Plain System: Sand Plain Spinifex Hummock Grassland with Wattles (SAWS), Sand Plain Spinifex Hummock Grassland with Mallee (SAMA), Sand Plain Spinifex Hummock Grassland with *Eucalytpus gongylocarpa* Woodland (SAGS) and Sand Plain Mulga Spinifex Hummock Grassland (SAMU).

Multiple fire regimes within these communities were observed. The occurence of recent fire significantly altered vegetation structure and species composition. Notably Mulga varieties are killed by fire and must regenerate from soil stored seed. Sucessful extensive regeneration occurs sporadically following high rainfall events and it can take many decades for Mulga to reassert dominance.

Communities occurring within the Hardpan and Drainage System

Four communities are described in an interzone or continuum between the Sand Plain system and Playa System. These communities are characterised by predominately bare ground, and are subject to sheet flow following rainfall and significant wind erosion.

Wanderrie Bank Grassy Shrubland (WABS) and Hardpan Plain Mulga Shrubland (HPMS) are floristically similar and often form a mosaic. Dominant species include *Acacia ayersiana, A. aneura* and *A. ramulosa* var. *linophylla*. WABS is defined by the presence of Wanderrie Grass (*Eragrostis eriopoda*) and HPMS is defined by an absence of a well-developed grassland understorey. Mulga Groves on Hardpan Plain

(GRMU) vegetation represents dense areas of HPMS that occur in groves where soil, nutrients and water have accumulated. Mixed Chenopod Shrublands with Mulga Overstorey (MHHS) vegetation occurs on the broad plains between the Lake System and Sand Plain communities.

Communities occurring within the Playa System

Six communities are described within the Playa System, however, the majority of this system is vegetated with *Acacia - Ptilotus obovatus* Shrubland (PLAPoS) on flats surrounding playas. PLAPoS forms a mosaic in which five other minor vegetation communities occur fringing or within playa depressions, scalds and sink holes.

Acacia and *Melaleuca interioris* Shrubland (PLAMi) is defined by thickets of *Acacia* spp. and *Melaleuca interioris* that occur on banks fringing playas or water holding depressions.

Acacia - Eremophila Thicket (PLAET) is defined by thickets of tall shrubs dominated by *Acacia* spp. and *Eremophila longifolia* that occur in playas or water holding depressions, often with sink holes.

The other three minor vegetation communities are defined by the presence of one or two dominant species, these being: PLMf defined by presence of *Muehlenbeckia florulenta* shrubs, PLEml defined by the presence of *Eremophila malacoides* shrubland and PLEsp defined by the presence of annual grasses including *Eragrostis* spp.

Communities occurring within the Calcrete System

The Calcrete System of study area 3 is characterised by outcropping calcrete rises and a series of flats and clay flats which run along the trunk of an ancient paleodrainage channel. The Calcrete System is fringed by the Playa System. There are pockets of Calcrete System vegetation communities within the Playa System and Sand Plain System. Seven communities are described within the Calcrete System of study area 3.

Three calcrete rise shrubland/woodland communities, *Eucalyptus gypsophila* Woodland (CEgW), *Casuarina pauper* Woodland (CCpW) and *Acacia burkittii* Shrubland (CAbS) are defined by the dominant upper storey species, and often form mosaics.

Atriplex sp. Yeelirrie Station Shrubland (CApS) is distinctive from all other communities and is represented and defined by one species. *Melaleuca xerophila* Shrubland (CMxS), *Lycium australe* Shrubland (CLaS) and *Eragrostis* sp. Yeelirrie Calcrete Grassland (CErG) communities are often co-occurring in mosaics, however, have been described separately as they are structurally and floristically distinct.

Communities occurring within the Saline Playa System

The Saline Playa System supports a complex of vegetation communities which appear to be well adapted to highly variable moisture and salinity conditions. Salinity levels have not been measured but the vegetation present is highly indicative of high salinity levels. This is especially evident where the *Frankenia* species are heavily crusted with sodium chloride crystals. The presence of gypsum crystals on the soil surface indicates that the Calcrete System retains an influence on the soil chemistry in the area.

Six communities are described within the Saline Playa System. The lake bed is vegetated with three communities: *Frankenia* Low Shrubland (SPFLS), *Lawrencia helmsii* Shrubland (SPLS), and *Tecticornia* Low Shrubland (SPTLS). The *Atriplex bunburyana* Shrubland (SPAbS) community occurs as a narrow band between the lake bed and surrounding sandy banks.

The salt lake is fringed by sandy banks and extensive gently sloping clay flats, somewhat resembling the Playa System, and is characterised by expanses of Sandy Bank Mulga and *Maireana pyramidata* shrubland (SBMMS) and *Cratystylis subspinescens* and *Maireana pyramidata* Shrubland (CsMp). This grades into the Sand Plain System away from the lake system.

3.6.2. Confidence level of mapping

A high level of effort and therefore detail was placed on the Calcrete and Saline Playa Systems in study area 3 as the majority of significant species occurred on these soil landscapes. Less focus was placed on mapping the boundaries of the vegetation communities occurring where either (i) there was little to no access due to limited tracks and dense vegetation or (ii) the requirement for increased survey effort fell beyond the scope of this study. These are primarily vegetation communities of the Sand Plain System, which integrade with broad ecotones and are difficult to

distinguish on aerial photography and therefore are difficult to distinguish with clear boundaries. Fire regimes and fire scars may change the appearance and composition of communities between the time the aerial imagery was taken and field works for vegetation mapping.

Table 23. Summary descriptions of the vegetation communities within study area 3

Code	Vegetation Community	Landform Description	Dominant, Defining Flora
SAES	Stony *Acacia* spp. and *Eremophila galeata* Shrubland	Foot slope deposits of granite breakaway	*Eremophila galeata, Acacia aneura, A. ayersiana, A. tetragonophylla, Ptilotus obovatus* (typical Goldfields form), *Eremophila compacta* subsp. *compacta, E. latrobei* subsp. *latrobei, Senna artemisioides* subsp. x *sturtii, S. artemisioides* subsp. *helmsii, Sida ectogama, Eragrostis eriopoda*
Qtz	Quartz Ridge	Hills and foot slopes associated with granite breakaway	*Acacia quadrimarginea, Acacia aneura, Callitris columellaris, Dodonaea petiolaris, Eremophila exilifolia* and *E. latrobei* subsp. *latrobei, Ptilotus obovatus* (typical Goldfields form), *Cymbopogon ambiguous*
GRMS	Mulga Shrubland on Granite Rise	Plains with granite rise	*Acacia aneura, A. tetragonophylla, A. craspedocarpa, A. quadrimarginea, Ptilotus obovatus* (typical Goldfields form), *Eremophila* spp., *Sida ectogama, Senna* spp.
QAECS	Quartz *Acacia* spp., *Eremophila* spp. and Chenopod Shrubland	Stony low quartz hill	*Acacia aneura* (various forms), *Acacia ayersiana, Acacia quadrimarginea, Acacia tetragonaphylla, Hakea preissii, Maireana georgii, M. glomulifera, M. triptera, M. convexa, M. pyramidata, Eremophila alternifolia, E, falcata, E. malacoides, Enchylaena tomentosa, Sida calyxhymenia, Ptilotus obovatus* and *Solanum lasiophyllum*
SAWS	Sand plain Spinifex Hummock Grassland with Wattles	Sand plain	*Triodia basedowii, Acacia effusifolia, A. heteroneura* var. *prolixa, A. jamesiana, A. prainii, A. pachyacra*
SAMA	Sand plain Spinifex Hummock Grassland with Mallee	Sand plain	*Triodia basedowii, Eucalyptus leptopoda* ssp. *elevata, E. kingsmillii, E. trivalva, Acacia effusifolia, A. heteroneura var. prolixa, A. prainii, A. ligulata, Leptosema chambersii*
SAGS	Sand plain Spinifex Hummock Grassland with *Eucalyptus gongylocarpa*	Sand plain	*Eucalyptus gongylocarpa, Acacia effusifolia, A. ligulata, A. prainii, A. heteroneura* var. *prolixa, Eremophila platythamnos* subsp. *platythamnos, Halgania cyanea* ssp. Allambi Stn (B.W. Strong 676), *Triodia basedowii*
SAMU	Sandplain Mulga Spinifex Hummock Grassland	Sand plain	*Acacia aneura, A. ayersiana, A. ramulosa* var. *linophylla, A. effusifolia, Melaleuca interioris, Triodia basedowii*
WABS	Wanderrie Bank Grassy Shrubland	Sand plain	*Acacia aneura, A. ayersiana, Grevillea berryana, A. ramulosa* var. *linophylla, A. tetragonophylla, Eremophila forrestii* ssp. *forrestii, Ptilotus obovatus* (typical Goldfields form), *Eragrostis eriopoda*
HPMS	Hardpan Plain Mulga Shrubland	Plains	*Acacia aneura, A. ayersiana, A. ramulosa* var. *linophylla, A. tetragonophylla, Melalaeuca interioris, Grevillea berryana, Eremophila* spp.
GRMU	Mulga Groves on Hardpan Plain	Plains	*Acacia aneura, A. ayersiana, A. craspedocarpa, A. tetragonophylla, A. ramulosa* var. *linophylla, Eremophila hygrophana, Ptilotus obovatus* (typical Goldfields form)

Code	Vegetation Community	Landform Description	Dominant, Defining Flora
MHHS	Mixed Chenopod Shrubland with Mulga Overstorey	Plains	*Acacia aneura* (various forms), *Acacia ayersiana*, *Maireana pyramidata*, *Cratystylis subspinescens*
PLAPoS	*Acacia* spp. and *Ptilotus obovatus* Shrubland	Flats in Playa System	*Acacia aneura*, *A. ayersiana*, *A. tetragonophylla*, *A. ramulosa* var. *linophylla*, *A. burkittii*, *Ptilotus obovatus* (typical Goldfields form)
PLAET	*Acacia* spp. and *Eremophila* spp. Thicket	Playas with sink holes	*Acacia aneura*, *A. tetragonophylla*, *Eremophila longifolia*, *Hakea lorea* ssp. *lorea*, *Eucalytpus lucasii*, *Grevillea berryana*, *Santalum lanceolatum*, *Ptilotus obovatus* (typical Goldfields form), *Senna artemisioides* ssp. *filifolia*, *Eragrostis setifolia*, *Eriachne helmsii*
PLAMi	*Acacia* spp. and *Melaleuca interioris* Shrubland	Fringes of playas in Playa System	*Acacia aneura*, *A. ayersiana*, *Melaleuca interioris*, *Ptilotus obovatus* (typical Goldfields form)
PLMf	*Muehlenbeckia florulenta* Shrubs	Playas	*Muehlenbeckia florulenta*
PLEml	*Eremophila malacoides* Shrubland	Scalded areas in Playa System	*Eremophila malacoides*
PLEsp	*Eragrostis* sp. Grassland on Playa	Playas	*Eragrostis* sp. LCH26982, *Ophioglossum lusitanicum*
CEgW	*Eucalyptus gypsophila* Woodland on Calcrete	Calcrete rises	*Eucalyptus gypsophila*, *Templetonia incrassata*, *Eremophila arachnoides* ssp. *arachnoides* P3, *Acacia burkittii*, *Senna artemisioides* ssp. *filifolia*
CCpW	*Casuarina pauper* Woodland on Calcrete	Calcrete rises	*Casuarina pauper*, *Acacia burkittii*, *Templetonia incrassata*, *Senna artemisioides* ssp. *filifolia*, *Eremophila arachnoides* ssp. *arachnoides* P3, *Ptilotus obovatus* (typical Goldfields form), *Sclerolaena fusiformis*
CMxS	*Melaleuca xerophila* Shrubland on Calcrete	Flats within Calcrete System	*Melaleuca xerophila*, *Acacia burkittii*, *Senna artemisioides* ssp. *filifolia*, *Lycium australe*, *Ptilotus obovatus* (typical Goldfields form), *Sclerolaena fusiformis*, *Dissocarpus paradoxus*, *Amyema microphylla*
CAbS	*Acacia burkittii* Shrubland on Calcrete	Calcrete rises	*Acacia burkittii*, *Grevillea berryana*, *Eremophila arachnoides* ssp. *arachnoides* P3, *Senna artemisioides* ssp. *filifolia*, *Ptilotus obovatus* (typical Goldfields form)
CErG	*Eragrostis* sp. Yeelirrie Calcrete Grassland	Flats in Calcrete System	*Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH 26770), *Lycium australe*, *Ptilotus obovatus* (typical Goldfields form)
CApS	*Atriplex* sp. Yeelirrie Station Shrubland	Clay Flats in Calcrete System	*Atriplex* sp. Yeelirrie Station (L. Trotter and A. Douglas LCH25025) P1
CLaS	*Lycium australe* Shrubland	Flats in Calcrete System	*Lycium australe*, *Eragrostis* sp. (LCH25340)

Code	Vegetation Community	Landform Description	Dominant, Defining Flora
SBMMS	Sandy Bank Mulga and *Maireana pyramidata* Shrubland	Sandy banks surrounding Saline playas	*Acacia aneura* (various forms), *Acacia ayersiana*, *Maireana pyramidata*, *Cratystylis subspinescens*
CsMp	*Cratystylis subspinescens* and *Maireana pyramidata* Shrubland	Playas and Plains surrounding Saline playas	*Maireana pyramidata*, *M. georgei*, *Cratystylis subspinescens*, *Ptilotus obovatus* (typical Goldfields form), *Sclerolaena eriacantha*, *Solanum lasiophyllum*, *Frankenia laxiflora*
SPAbS	*Atriplex bunburyana* shrubland on Saline playa	Saline playa	*Atriplex bunburyana*
SPTLS	*Tecticornia* spp. low shrubland on Saline playa	Saline playa	*Tecticornia undulata*, *Tecticornia pterygosperma* subsp. *pterygosperma*
SPLS	*Lawrencia helmsii* shrubland on Saline playa	Saline playa	*Lawrencia helmsii*
SPFLS	*Frankenia* spp. low shrubland on Saline playa	Saline playa	*Frankenia pauciflora*, *F. cinerea*, *F. laxiflora*

Table 24. Representation of vegetation communities within study area 3

Vegetation community code	Total area mapped (ha)
SAES	81.73
Qtz	9.66
GRMS	323.62
QAECS	9.24
SAWS	528.58
SAMA	335.81
SAGS	37.44
SAMU	2136.56
WABS	507.80
HPMS	400.39
GRMU	10.69
MHHS	1206.59
PLAPoS	596.17
PLAET	122.18
PLAMi	75.68
PLMf	2.45
PLEml	178.17
CEgW	130.95
CCpW	228.99
CMxS	287.63
CAbS	398.05
CErG	56.44
CApS	120.73
CLaS	36.49
SBMMS	780.42
CsMp	610.41
SPAbS	25.42
SPFLS	68.50
SPLS	209.99
SPTLS	325.91

3.7. Study area 3 - flora

Most taxa recorded from within study area 3 are widespread and common in the region and occur across a range of land systems and soil types. These are not discussed further. A systematic list of vascular flora for study areas 1, 2 and 3 is presented in Appendix 13 of this report. Significant flora and species of interest recorded in study area 3 are discussed in the following Sections.

3.7.1. Priority Flora

Three Priority Flora species were recorded within study area 3. These were, *Atriplex* sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025) P1, *Bossiaea eremaea* P3 and *Eremophila arachnoides* subsp. *arachnoides* P3. The locations of taxa of conservation significance recorded in study area 3 are presented in Appendix 15 of this report. These records do not include locations of significant flora recorded during the regional survey of study area 4 of which study area 3 is a subset.

***Atriplex* sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025) P1**

A description of *Atriplex* sp. Yeelirrie Station is provided in Section 3.3.1.

Atriplex sp. Yeelirrie Station was first recorded in the north-western section of study area 4 during the regional survey, and this area was redefined as study area 3 for a more detailed survey. These records comprise the second known location of *Atriplex* sp. Yeelirrie Station.

Atriplex sp. Yeelirrie Station was recorded primarily within the CApS vegetation community, as described in Appendix 8. It was also recorded as scattered individuals within the CLaS, SPFLS, SPTLS and SPLS communities.

Western Botanical has estimated that there are a total of 190,656 *Atriplex* sp. Yeelirrie Station individuals in study area 3. These occurred within ten sub-populations and five scattered clumps of between one and five individuals. The population boundaries are shown in Figure 41 and the locations of the 36 quadrats used in population size calculations are shown in Appendix 16 of this report. At the time of the population size survey, May 2010, no female flowers were observed. Approximately 5% of plants had fruit, 3% had male flowers only, 1% of plants had fruit and male flowers, and 10% of plants appeared to be dead or aestivating. These percentages are representative of the time of survey only and vary greatly according to seasonal rainfall trends.

***Bossiaea eremaea* P3**

A description of *Bossiaea eremaea* is provided in Section 3.3.1.

Two populations of *Bossiaea eremaea* were recorded in study area 3, approximately 4 km apart, with a total of five plants. Locations are shown in Figure 18 (Section 3.3.1). Population 1, with three plants, was recorded in SAMA vegetation. Population 2, with two plants, was recorded in PLAPoS vegetation. It is possible that additional small populations of *Bossiaea eremaea* are scattered throughout the tenement. Individual points and counts are listed in Appendix 15 of this report.

***Eremophila arachnoides* subsp. *arachnoides* P3**

A description of *Eremophila arachnoides* subsp. *arachnoides* is provided in Section 3.3.1.

Eremophila arachnoides subsp. *arachnoides* was found to be widespread in low numbers throughout the calcrete vegetation communities at study area 3.

Western Botanical recorded 97 individuals while traversing the area. Locations are shown in Figure 20 (Section 3.3.1). The majority of these occurred in CAbS, CEgW and CCpW communities, while a few occurred in PLAPoS adjacent to the calcrete rises. The survey effort is estimated to have covered 30% of the calcrete rises in study area 3, and it was extrapolated that the population consists of approximately 320 plants. Individual points and counts are listed in Appendix 15 of this report.

Figure 41. *Atriplex* sp. Yeelirrie Station populations within study area 3

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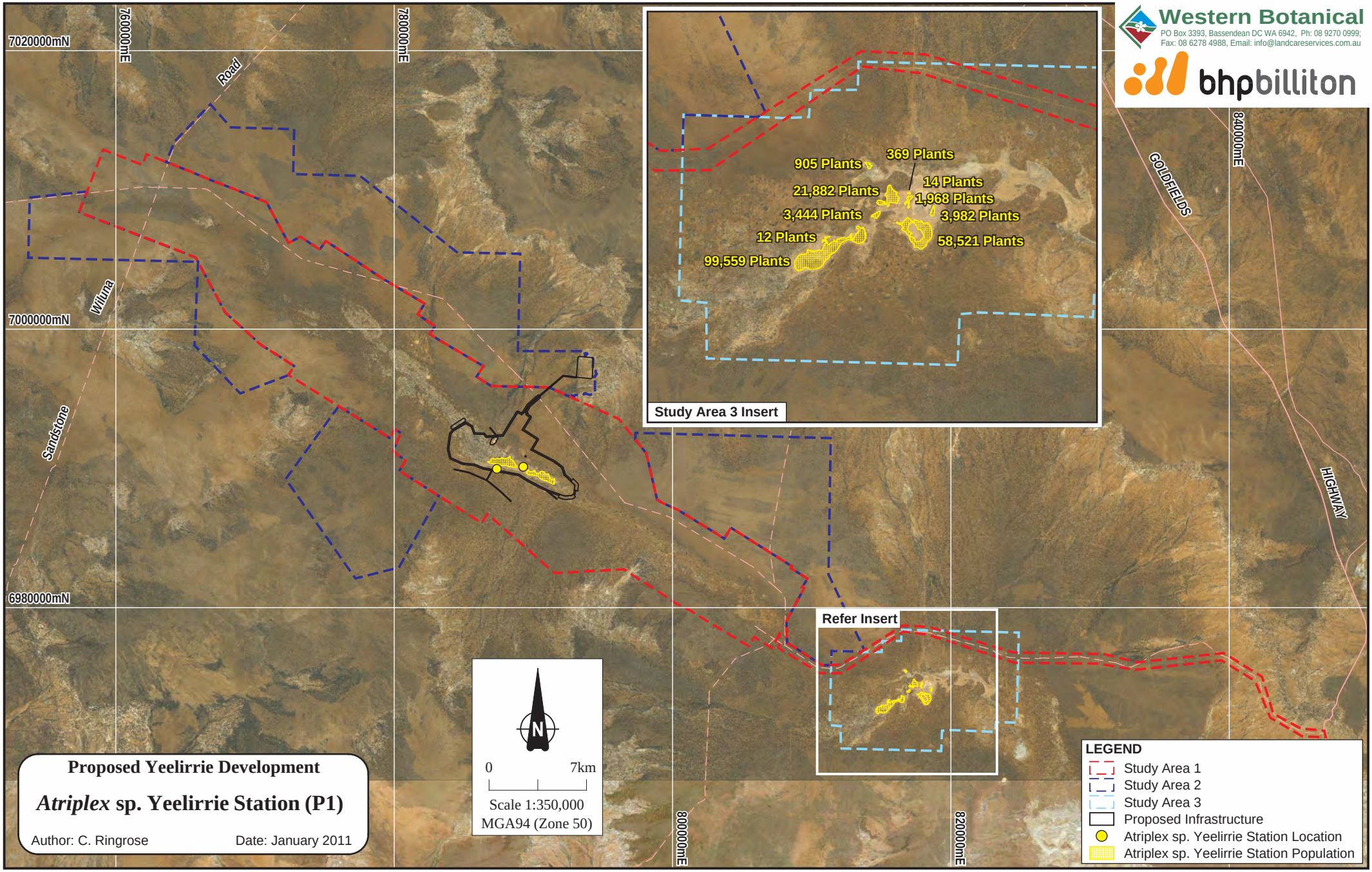

Proposed Yeelirrie Development

***Atriplex* sp. Yeelirrie Station (P1)**

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3.7.2. Other significant species and species of interest

One species that may warrant conservation status was found in study area 3: *Scaevola spinescens* terete leaf form (G. Cockerton & C. Ringrose LCH 14560). A further species of interest, *Templetonia incrassata,* was also recorded in study area 3. The locations of these taxa are presented in Appendix 15 of this report.

Scaevola spinescens terete leaf form (G. Cockerton & C. Ringrose LCH 14560)

A description of *Scaevola spinescens* terete leaf form (G. Cockerton & C. Ringrose LCH 14560) is provided in Section 3.3.2.

Twelve individuals of *Scaevola spinescens* terete leaf form (G. Cockerton & C. Ringrose LCH 14560) were recorded, scattered throughout the CsMp, SBMMS and MHHS vegetation communities. A targeted search is likely to find a greater number of individuals of this taxon. Locations are shown in Figure 25 (Section 3.3.2), and individual points and counts are listed in Appendix 15 of this report.

Templetonia incrassata

A description of *Templetonia incrassata* is provided in Section 3.3.3.

Western Botanical recorded six small populations of *Templetonia incrassata* in study area 3, with a total of 31 plants. Four of these populations were found near the edge of the SAMU and SAMA communities and two in the MHHS community on the southern bank of the Saline Playa system. It is expected that *Templetonia incrassata* would occur in small populations throughout the area. Locations are shown in Figure 25 (Section 3.3.3) and individual points and counts are listed in Appendix 15 of this report. Given the limited area surveyed due to accessibility issues in some areas, the actual population may be as high as 200 individuals.

Acacia aneura variants

In contrast to study area 1 and 2, only one form of *Acacia aneura* was recorded in study area 3 and separation into phyllode morphological forms was not warranted (refer to Section 3.3.4).

3.7.3. Introduced species

Two introduced taxa, *Tribulus terrestris* (Caltrop) and *Citrullus lanatus* (Afghan or Pie melon) were noted during the survey of study area 3. Although these are found throughout Western Australia, they are not listed as a 'Declared Plant' species under the *Agricultural and Related Resources Protection Act 1976* (Department of Agriculture and Food, 2009). Both taxa were observed as commonly occurring and widespread throughout study area 3 and their distribution was not mapped. No declared weeds were noted.

3.8. Regional survey (study areas 4 to 16) – vegetation

Regional surves were planned and conducted to give regional context for significant species and vegetation communities which were present witin study area 1 and, based on information at that time, were of restricted distribution. A total 13 paleodrainage and lake systems were investigated during the regional surveys. The regional survey area spanned a distance of 500 km east to west and 370 km north to south, encompassing a total area of 185,000 square km (1,850,000 ha).

Six paleodrainage systems were selected as highest priority for the first survey by helicopter (see Section 2.9, Table 8). Four of these: study areas 4 to 9, were targeted for ground survey. A further seven paleodrainage systems: study areas 10 to 16, were selected for a second survey by helicopter (see Section 2.9, Table 9). These latter surveys primarily focused on searching for further populations of *Atriplex* sp. Yeelirrie Station.

3.8.1. Vegetation communities of interest

Vegetation communities of interest were identified at four lake systems following the first survey by helicopter, these were: study area 4 (Lake Miranda and the southern end of the Yeelirrie Palaeochannel), study area 5 (Lake Mason), study area 6 (Lake Way), and study area 7 (Lake Noondie) (Table 25). These lake systems were further surveyed on ground.

No vegetation communities of interest were recorded in study area 9 (Lake Nabberu). Although study area 8 (Lake Annean) had extensive areas of *Melaleuca xerophila*,

Casuarina pauper and *Acacia burkittii* Shrubland on calcrete, it was decided to be unsuitable for further survey, as the vegetation communities were not representative of those recorded in the study area 1.

Table 25. Lake systems visited during ground surveys

Study area	Lake system	Dates of assessment
Study area 4	Lake Miranda and Yeelirrie Palaeochannel	3rd to 9th December 2009
Study area 5	Lake Way (northern shoreline, central western shoreline and southern palaeochannel)	25th to 29th January, 2010
Study area 6	Lake Mason (western and northern shorelines)	10th to 11th and 16th February, 2010
Study area 7	Lake Noondie (western shoreline, northern shoreline and central eastern palaeochannel)	12th to 15th February, 2010

At each lake system it was observed that the majority of vegetation occurred on gypsum rather than calcrete. Although gypsum did not support the same vegetation communities that were recorded in study area 1, pockets of the same species were observed. Bordering the gypsum were smaller areas of calcrete that supported the same or similar vegetation communities to those recorded in study area 1.

In each vegetation community of interest up to three temporary quadrats were assessed to allow for statistical comparison and vegetation community clarifications. The locations of quadrats assessed at each lake system are shown in Figure 42 and coordinates and data recorded are provided in Appendix 17 of this report.

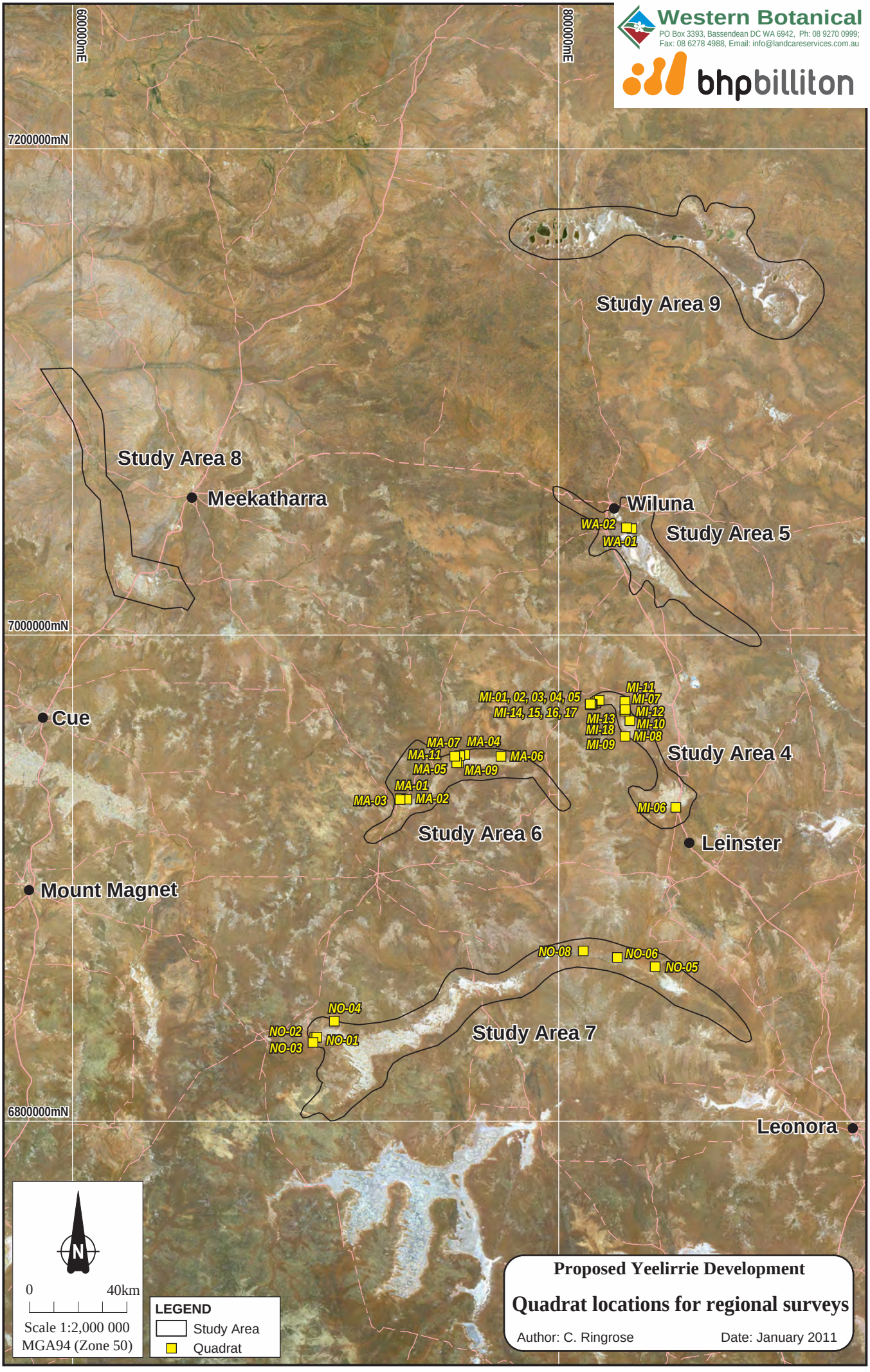
The findings for each lake system are summarised in Table 26 and described below.

Table 26. Vegetation communities of interest recorded at the four study areas visited during ground surveys

Vegetation Community	Study area 4	Study area 5	Study area 6	Study area 7
CEgW				
CMxS				
CCpW				
CApS				
CRsS				

Green shaded cell indicates presence in that study area

Figure 42. Quadrat locations for regional study areas (4 to 7)



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Study area 4

This paleodrainage system was the most representative of the vegetation communities recorded within study area 1. Four vegetation communities of interest were recorded during the survey at the southern end of the Yeelirrie Palaeochannel: CCpW, CApS, CMxS and CEgW.

Study area 3 is located within the southern end of the Yeelirrie Palaeochannel and vegetation communities occurring within this study area have been mapped and are discussed in Section 3.5.2.

Study area 5

Two vegetation communities of interest were recorded on calcrete occurring on the northern shoreline of Lake Way: CMxS and CEgW. Four small areas with CEgW (*Eucalyptus gypsophila* woodland on calcrete) were recorded. Of these, only one had an understorey comparable with those communities in study area 1: one small area of CMxS (*Melaleuca xerophila* shrubland on calcrete) was recorded. Extensive shrublands or woodlands of *M. xerophila* were observed bordering drainage lines and the shoreline of Lake Way. These occurred on gypsum, sand plain and cracking clay soils. *Casuarina pauper* was observed occasionally on the northern shoreline of Lake Way as scattered individuals within calcrete communities and did not form a woodland community.

Study area 6

Three vegetation communities of interest were recorded within study area 6: CCpW, CMxS, and CEgW. *Melaleuca xerophila* occurred in groves and large areas of shrubland bordering drainage lines and the shoreline of Lake Mason. Two communities similar to those recorded within study area 1 were *Melaleuca xerophila* and *Acacia burkittii* shrubland on calcrete with a high cryptogam cover, and *Casuarina pauper* woodland on calcrete.

Study area 7

Six areas with vegetation communities of interest were recorded at Lake Noondie along the western shoreline, northern shoreline and the central eastern palaeochannel.

Three vegetation communities of interest were recorded within these areas, CRsS, CCpW and CEgW.

Vegetation communities were not investigated in study areas 10 to 16.

3.9. Regional survey (study areas 4 to 16) - flora

3.9.1. Flora recorded during regional survey

A total of 143 species from 70 genera and 29 families were recorded during the regional surveys of study areas 4 to 16. Families with the greatest number of representatives were Chenopodiaceae (28 species), Fabaceae (24 species), Poaceae (20 species) and Scrophulariaceae (15 species). Genera with the greatest number of representatives were *Acacia* (17 species), *Eremophila* (15 species), *Maireana* (6 species) and *Sclerolaena* (5 species). Most species recorded are widespread and common in the region, and occur across a range of land systems and soil types. A systematic species list recorded during regional surveys is provided in Appendix 18 of this report.

The identification of some plant specimens has not yet been validated for one of three reasons: (i) insufficient material was available due to time of survey, (ii) dry seasonal conditions meant that flowers and or fruits needed for verification were not available or (iii) specimens are still with specialist taxonomists awaiting verification.

Approximately 40 collections of plant specimens have not been not fully identified. The identifications of these specimens will provide contextual regional information, however, were not targeted species of interest for these surveys.

3.9.2. Flora of conservation significance

Priority Flora and species of conservation interest were recorded at six lake systems during helicopter and ground surveys (Table 27). The coordinates of these records are presented in Appendix 19 of this report and locations are shown in Figure 43. Records represent population occurrences, or number of individuals observed. It was noted that often species of interest were recorded in different vegetation communities to those in study area 1.

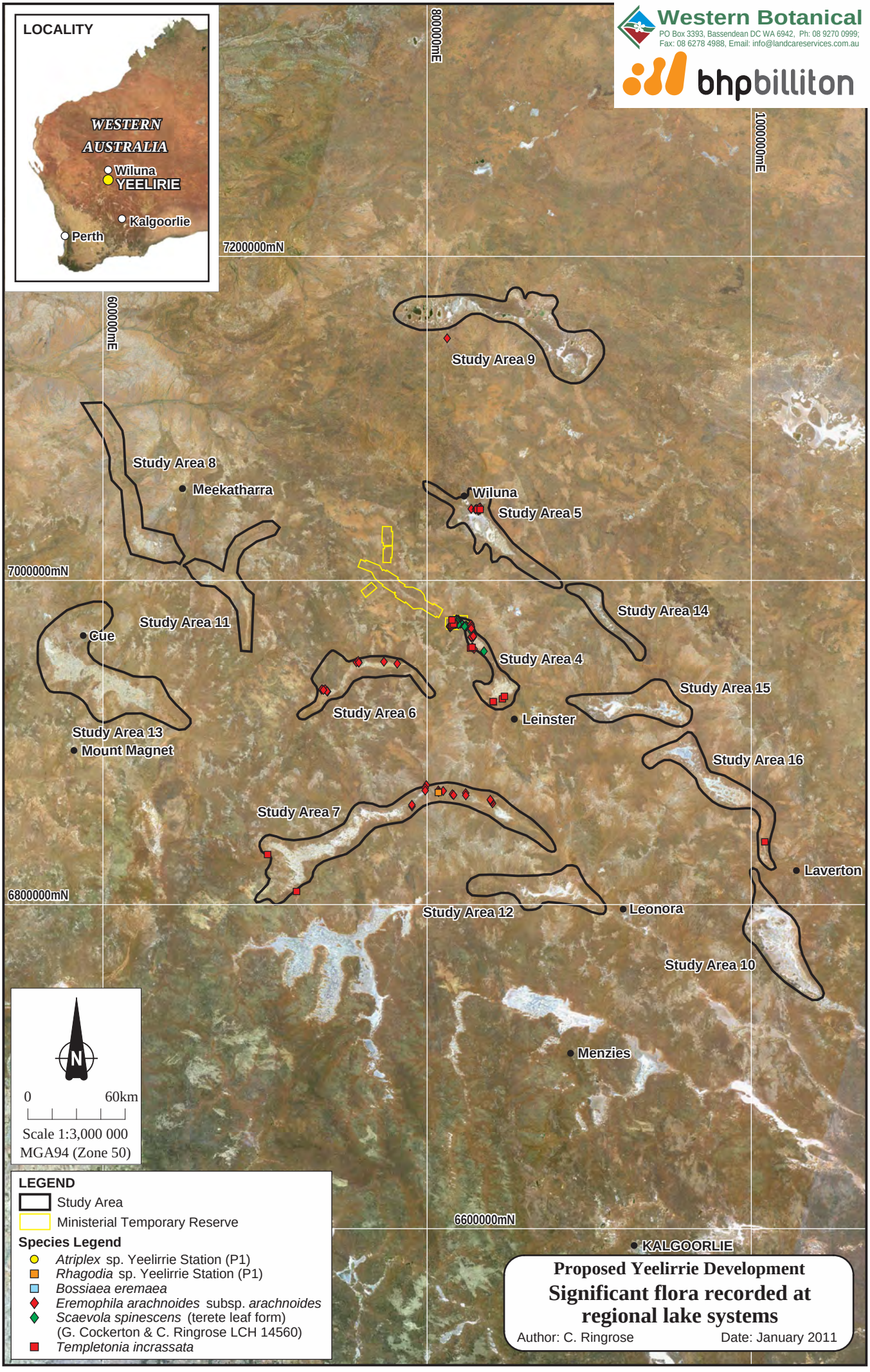
The second survey of study areas 10 to 16 by helicopter did not identify additional populations of *Atriplex* sp. Yeelirrie Station. Similar self-mulching clay habitats to those supporting *Atriplex* sp. Yeelirrie Station within the Yeelirrie palaeochannel occurred at most of the lake systems visited, however, different species were recorded growing in these habitats. Generally these were *Tecticornia* spp. (samphires) and other *Atriplex* species. All *Atriplex* species encountered were collected for identification verification and further taxonomic investigation at the WA Herbarium.

Table 27. Significant flora recorded in study area 4 to 16

Species	Study area 4	Study area 5	Study area 6	Study area 7	Study area 9	Study area 16
Atriplex sp. Yeelirrie Station P1						
Rhagodia sp. Yeelirrie Station P1						
Eremophila arachnoides subsp. *arachnoides* P3						
Bossiaea eremaea P3						
Templetonia incrassata						
Scaevola spinescens terete leaf form						

Green shaded cell indicates presence in that study area

Figure 43. Significant flora recorded in study areas 4 to 16



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Proposed Yeelirrie Development

Significant flora recorded at regional lake systems

Author: C. Ringrose Date: January 2011

Compiled: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ A4 ~ Rev: A ~ CAD Ref g1697_Rep1101_F011.dgn

Study area 4

Three species of Priority Flora were recorded within the southern end of the Yeelirrie palaeochannel, *Atriplex* sp. Yeelirrie Station (L. Trotter and A. Douglas LCH 25025) P1, *Bossiaea eremaea* P3 and *Eremophila arachnoides* subsp. *arachnoides* P3. A further two species of interest, *Scaevola spinescens* terete leaf form (G. Cockerton & C. Ringrose LCH 14560), and *Templetonia incrassata* were also recorded.

Atriplex sp. Yeelirrie Station was found in large numbers, and these were confined to self-mulching clays within study area 3. Details of population size estimates are discussed in Section 3.7.1. *Eremophila arachnoides* subsp. *arachnoides* and *Templetonia incrassata* was recorded in small and scattered populations within *Acacia burkittii* shrubland, *Lycium australe* shrubland and *Casuarina pauper* woodland. Individuals of *Scaevola spinescens* terete leaf form (G. Cockerton & C. Ringrose LCH 14560) and *Bossiaea eremaea* were recorded in low numbers during the survey.

Study area 5

One Priority Flora species was recorded on the northern shoreline of Lake Way, *Eremophila arachnoides* subsp. *arachnoides* P3. A further species of interest, *Templetonia incrassata* was also recorded.

Scattered populations of *Eremophila arachnoides* subsp. *arachnoides* were recorded in calcrete communities in study area 5 spanning an area of approximately five by four kilometres across. *Eremophila arachnoides* subsp. *arachnoides* was recorded in the following calcrete communities: *Eucalyptus gypsophila* woodland, *Acacia burkittii* shrubland, *Casuarina pauper* woodland and *Acacia aneura* shrubland. Several small, scattered populations of *Templetonia incrassata* were recorded co-occurring with *Eremophila arachnoides* subsp. *arachnoides* in *Acacia burkittii* and *A. aneura* shrubland.

Subsequent to these surveys, populations of *Scaevola spinescens* terete leaf form (G. Cockerton & C. Ringrose LCH 14560) have also been recorded by the authors on the south-eastern margins of Lake Way.

Study area 6

One Priority Flora species, *Eremophila arachnoides* subsp. *arachnoides* P3, was recorded within *Casuarina pauper* woodland and *Melaleuca xerophila* shrubland in study area 6 (Lake Mason).

Study area 7

Two Priority Flora species were recorded in study area 7 (Lake Noondie): *Rhagodia* sp. Yeelirrie Station (K.A. Shepherd et al. KS1396) P1 and *Eremophila arachnoides* subsp. *arachnoides* P3.

Rhagodia sp. Yeelirrie Station was recorded in a population of between 100 - 200 plants on a clay flat within the calcrete land system.

Eremophila arachnoides subsp. *arachnoides* was recorded in large numbers within *Eucalyptus gypsophila* woodland, *Acacia burkittii* shrubland and *Casuarina pauper* woodland. A further species of interest, *Templetonia incrassata,* was also recorded as scattered individuals at two locations.

Study area 9

One Priority Flora species, *Eremophila arachnoides* ssp. *arachnoides* P3,was recorded in study area 9 (Lake Nabberu).

Study area 16

One species of interest, *Templetonia incrassata,* was recorded during the second survey by helicopter in study area 16 (Lake Irwin). Three individual plants were recorded adjacent to *Tecticornia* spp. shrubland on self-mulching clay.

3.9.3. Regional summary of significant flora

To provide a regional context for significant flora recorded in the proposed project footprint, Western Botanical examined FloraBase records and undertook prioritised surveys of regional paleochannels and lake systems. A summary of significant flora recorded to from the project footprint (in study areas 1 and 2) and regional lake systems (study areas 3 to 16) is presented in Table 28. An interpreted summary of FloraBase (WA Herbarium) records of these species is also provided in Table 28 to indicate the known number of individuals recorded elsewhere within Western

Australia. The interpreted summary of FloraBase records was prepared using a conversion table to convert qualitative data associated with population descriptions of vouchered specimens listed on FloraBase into quantitative values. FloraBase records and the conversion table are provided in Appendix 20 of this report.

Table 28. Summary of significant flora records from the project area (study areas 1 and 2), regional surveys (study areas 3 to 16) and interpreted population sizes of specimens vouchered at the WA Herbarium

Species	Cons Status	Project Area (Study areas 1 and 2) Western Botanical		Study areas 3 to 16 Western Botanical ¤		WA records (FloraBase, WA Herbarium) *
		Populations recorded	Individuals recorded	Populations recorded	Individuals recorded	Number of individuals interpreted
Atriplex sp. Yeelirrie Station	P1	1	84,510[b]	1	190,656[b]	-
Rhagodia sp. Yeelirrie Station	P1	5	2200	1	100-200	100-200
Baeckea sp. Sandstone	P3	1	1			69
Bossiaea eremaea	P3	9	12,732	1	5	154
Eremophila arachnoides subsp. *arachnoides*	P3	4	43,255[a]	5	1059	303
Euryomyrtus inflata	P3	6	10,229			166
Comesperma viscidulum	P4	1	23			217
Olearia arida	P4	1	24			183
Scaevola spinescens terete leaf form		6	1047		50	-
Templetonia incrassata		3	2985		140	13

a. extrapolated counts based on plants per unit area of calcrete soil landscape system
b. refer to Section 2.8.5 for calculations of *Atriplex* sp. Yeelirrie Station population size
¤ duplicate records of flora surveyed in study areas 3 and 4 were not counted twice
*quantitative data of individuals interpreted from FloraBase records, excluding Western Botanical records

Both Priority One species that were recorded in the project footprint are poorly represented in the region. *Atriplex* sp. Yeelirrie Station (L. Trotter & A. Douglas LCH 25025) is known from two locations only: (i) the project footprint (within the pit boundary) and (ii) study area 3. *Rhagodia* sp. Yeelirrie Station (K.A. Shepherd et al. KS 1396) is known from three locations only: (i) within and outside the project footprint in study area 1, (ii) study area 7, Lake Noondie and (iii) Rowles Lagoon near Coolgardie (J Hurter pers. comm., FloraBase, 2011).

Euryomyrtus inflata P3 occurs in extensive populations on the Sand Plain System, outside the pit and to the west of the proposed infrastructure development areas. This taxon is reasonably abundant where it occurs and numerous populations were noted.

Baeckea sp. Sandstone (C.A. Gardner s.n. 26 Oct. 1963) P3 occurs on the Sand Plain System outside the project footprint. Regional data on abundance is deficient.

Bossiaea eremaea P3 is relatively abundant in patches on the north side of study areas 1 and 2, particularly within the project footprint, although none occurs within the pit. The species has a strongly disjunct distribution with the Yeelirrie populations being some 300 km north-west of the populations near Laverton. Regional data on abundance is deficient.

Eremophila arachnoides subsp. *arachnoides* P3 is abundant and restricted to the Calcrete System within the project footprint. Of the 43,255 individuals recorded in the study area 1, 45% occur within the project footprint. During regional surveys, *Eremophila arachnoides* subsp. *arachnoides* was recorded at five lake systems; study areas 4, 5, 6, 7 and 9. The populations in study area 6, Lake Mason, occur within a proposed DEC Reserve. The largest populations noted during regional surveys was recorded on Pinnacles Station within study area 7.

Olearia arida P4 was recorded in one population (24 individuals in total) in study area 1. The population was located on the roadside of the Yeelirrie - Albion Downs access road approximately fifteen kilometres west of the Yeelirrie - Albion Downs and Goldfields Highway intersection. This is the first record in the Murchison Region, representing a range extension of more than 500 km. Road widening activities on the Yeelirrie - Albion Downs Road may impact on the extant population of this species.

Comesperma viscidulum (P4) was recorded as isolated plants (23 in total) within the Sand Plain System in the north-west region of study area 1. This species is known from five widely disjunct populations in central and eastern Western Australia with the population in the study area 1 being a new record and slight range extension to the south-west. Any road widening activities on the Yeelirrie – Meekatharra Rd or the Sandstone – Wiluna Rd (in the vicinity of that intersection) will impact on the extant population of this species.

Scaevola spinescens terete leaf form (G. Cockerton & C. Ringrose 14560) is associated with the Calcrete and Playa Systems within study areas 1 and 2. Of the 782 individuals recorded, 81% were recorded within the project footprint. A small population (~50) was recorded in study areas 3 and 4; however, the lack of information on the regional distribution of this species is noted. However, it is known by the authors at Lake Way (study area 5) and one specimen lodged at the WA Herbarium was collected at Lake Austin, south of Cue.

Templetonia incrassata was recently described as a new species after being distinguished from *Templetonia egena* (I.R. Thompson, 2010). Populations have been recorded in the northern Coolgardie Biogeographic region and the southern Murchison Biogeographic region. The population in the local study area occurs at the northern limit of its range. Of the 2,691 individuals recorded in the study area 1, 29% were recorded within the project footprint. This taxon was also recorded during regional surveys in study areas 4, 5 and 7, but in very low numbers. A lack of information on the regional populations of this species is noted. The largest known population of *Templetonia incrassata* (to date) occurs within the Yeelirrie paleochannel.

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5. Glossary

Assemblage (compare with community, which is similar): A collection of co-occurring populations (Lewis, 1977).

Biodiversity: is the variety of all life forms - the different plants, animals and microorganisms, the genes they contain, and the ecosystems of which they form a part. It is not static, but constantly changing; it is increased by genetic change and evolutionary processes and reduced by processes such as habitat degradation, population decline, and extinction (Commonwealth of Australia, 1996).

Biodiversity has two key aspects:

- its intrinsic value at the genetic, individual species, and species assemblages levels; and
- its functional value at the ecosystem level.

Two different species assemblages may have different intrinsic values but may still have the same functional value in terms of the part they play in maintaining ecosystem processes.

Genetic diversity: is the variety of genetic information contained in all of the individual plants, animals and microorganisms that inhabit the earth (Commonwealth of Australia, 1996). In any given area it is the variety of genetic material contained in all organisms.

Genetic diversity occurs within and between the populations of organisms that comprise individual species as well as among species (Commonwealth of Australia, 1996). Due to a lack of research regarding the genetic range of endemic species, there has been, and will continue to be, difficulty in addressing protection of biodiversity specifically at the genetic level.

However for many species some information is available on the phenotypic expression of genetic variation through the recognition of different taxa at the subspecies or variety level. These may be significant in terms of exhibiting varying distribution and levels of rarity. The protection of species throughout their range and

on the variety of sites may therefore serve as a surrogate for protection of genetic diversity in the absence of specific information. This issue needs to be considered in the design/collection and interpretation of data obtained in flora and vegetation surveys.

Species diversity: the variety of species on the earth (Commonwealth of Australia, 1996). In any given area it is the variety of species, or a measure of that variety (Lewis 1977, Jones *et al.,* 1990). While diversity can be measured in many ways, Most simply it is measured as the species richness of ... an area, though it provides a more useful measure ... when it is combined with an assessment of the relative abundance of species present.

Diversity within ecosystems has been equated classically with stability and climax communities (Allaby, 1992). Species diversity is conceptually different from genetic diversity because:

- in general, the recognition of species is based on physical features (a taxonomic approach of recognising, describing, naming and classifying);
- a species is a concept, rather than a clear unit in nature. This can mean that the amount of genetic variation within one species may be markedly different from another species. To accommodate such inconsistencies, sub-divisions such as sub-species, varieties and hybrids may be recognised.

Species diversity is usually the default in biodiversity assessment, which means it becomes a surrogate for the underlying genetic diversity. Species diversity becomes a progressively better estimate of the full range of genetic diversity when it considers the range of variation within a species (including sub-species, varieties, and hybrids), a species' entire range, and the range of habitat in which a species occurs.

Declared Rare and Priority Flora are only one subset of species diversity. The scope of formal listings is limited by the extent and intensity of sampling in any area, by how well a surveyor recognises all different organisms in an area, by whether all known occurrences are registered (*i.e.* whether specimens were submitted), and by the current progress in naming species groups. Since these processes are ongoing, it is clear that survey for environmental impact assessment has a role in extending

knowledge. Consequently, consultants are encouraged to check specimens that have no known match, or appear anomalous, and which may be new.

In natural systems, species diversity varies from area to area and so is not a complete measure of the significance of a vegetation unit. Many communities with relatively few species, such as estuaries and mangrove forests, are highly productive and have an abundance of life but not a great variety of species.

Similarly, for any species, its significance may come from values other than scarcity, or because it may be under threat. For example, a prolific species may be a key part of an ecosystem (*e.g.* in terms of bulk, productivity, or the provision of resources such as nest sites or nectar).

Ecosystem diversity: in any given area, the variety of habitats, biotic communities and ecological processes (Commonwealth of Australia, 1996). Ecosystems are the basic functional ecological units. They comprise the diversity of all-living organisms and non-living components and their relationships within a given area. They can be defined at almost any nominated scale. Ecosystems include abiotic components, which include physical factors such as radiation, gases, the water cycle, geology, land and soil forming processes, and climate.

Ecological processes are the interactions, and changes or development processes, of the ecosystem over time. Ecosystem diversity is harder to measure than species or genetic diversity because the boundaries of ecosystems (or component habitats and communities) are a matter of definition within a matrix. Provided a consistent set of criteria is used to define ecosystems, their number and distribution can be measured. It is therefore essential that scale/s and the basis for differentiation are defined and understood in any treatment of ecosystem diversity.

Other expressions of biodiversity - Other expressions of biodiversity can be important. These include the relative abundance of species, the age structure of populations, the pattern of communities in a region, changes in community composition and structure over time, and ecological processes such as predation, parasitism and mutualism. It is often important to examine diversity in ecosystem structure and function as well as compositional diversity of genes, species and ecosystems (Environmental Protection Authority, 2002a).

Botanical Province: botanical regions within Western Australia described by Beard; Eremaean, South-west and Northern Provinces. These are further divided into botanical districts; *e.g.* Austin.

Calcrete: the term given to a calcium carbonate rich deposit, generally indurated to varying degrees, often commonly occurring in valley deposits where it has been formed as a precipitate from calcium carbonate rich groundwater.

Community (compare with assemblage and ecological community and vegetation community): A general term applied to any grouping of populations of different organisms found living together in a particular environment (Allaby, 1992). Plant community is an assemblage of plants at any given locality Beard (1990). The term 'community' has been applied at a range of scales in general use (as have ecosystem, habitat and vegetation). In this document 'community' is usually used to refer to all populations of all plant species at a locality. This is a detailed approach to plant diversity, with good resolution of the make-up of vegetation. Beard's regional vegetation mapping was several levels coarser than this.

Conservation Interest/Significance: poorly represented and poorly known taxa likely to be listed as Priority Flora in the future, pending review by the DEC.

Declared Rare Flora (DRF): Species specially protected under the *Wildlife Conservation* (*WC*) *Act 1950*, as identified in the current listing. At time of printing the listing is Wildlife Conservation (Rare Flora) Notice 2003 (Government of Western Australia, 2003b).

Ecological community: Naturally occurring biological assemblage that occurs in a particular type of habitat. Note that the scale at which ecological communities are defined will often depend on the level of detail in the information source. Therefore no particular scale is specified (English and Blyth, 1999). An assemblage of native species that: a) inhabits a particular natural area; and b) meets the additional criteria specified in the regulations, made for the purposes of this definition (*EPBC Act*, 1999).

Ecosystem: A dynamic complex of plant, animal, fungal, and microorganism communities and the associated non-living environment interacting as an ecological

unit (Commonwealth of Australia, 1996). (That is, all living and non-living parts of a system and their interaction. Non-living factors include climate, atmosphere, and the geosphere.)

Ecosystem function/processes (compare to threatening processes): Interconnected processes that sustain the biodiversity typical of a given ecosystem and drive the self-directed development of that ecosystem. Such processes involve all components of ecosystems, living and non-living. One-off biological survey tends to reveal little about ecosystem processes without complementary investigations over time.

Ephemerals: species that grow, flower and set seed within one season before dying off.

Factor: This word has two meanings in the contexts of EPA and ecology:

environmental factor - [EPA definition] Usually broad working divisions used to compartmentalise the environment for administrative purposes. Some of these definitions may have broad similarities with the ecological definitions at higher levels. Since these factors arise from an administrative need to compartmentalise, they are imposed *a priori* (before study). At lower levels, they may more closely approach environmental factors, such as within proposal-specific guidelines or approved scoping documents; and

environmental factor - [ecological definition] Any component or aspect of the environment that may influence the observed state. Since these factors arise from the environment, they are revealed by impartial observation. They are not imposed. Rather, they are labelled as they manifest themselves. (In ecology, multi-variate analysis is employed in order to account for the influence of all factors other than the one in question, so that its influence clearly stands out).

Flora (compare with vegetation): All the vascular plant taxa (including species, subspecies, varieties, hybrids, and ecotypes) in a given area or epoch (*after* Collocott and Dobson, 1975, Onions, 1978, Lewis, 1977, Delbridge, 1987 and Mueller-Dombois and Ellenberg, 1974).

GDE: Groundwater Dependent Ecosystem

Geographically restricted species: a species that is known to occur in a small geographical range, *i.e.* in one or two Biogeographic Regions, or within a 200 km diameter. May be restricted to small refuges (*i.e.* rocky outcrops), locally abundant or sparse in specific habitats.

Glabrous: lacking hairs or scales

Habitat: The natural environment of an organism or a community, including all biotic and abiotic elements; a suitable place for it to live (*after* Gilpin, 1996, Jones *et al.*, 1990, Lewis, 1977, Onions, 1978 and Commonwealth of Australia, 1996). The term 'habitat' has been applied at a range of scales in general use (as have community and vegetation). Vegetation can become a reasonable surrogate for outlining habitat when its main components, structure and the associated landform are also described.

Herbarium: a collection of dried plants or parts of plants usually flattened and mounted on paper or stored in packets.

Inflorescence: the flower-bearing parts of a plant, in particular those parts that are separated from one another by vegetative portions.

Land system: a recurring pattern of geology-landform-soils-vegetation and surface hydrology.

Landform: the term applied to the multitude of surface features that make up the surface of the earth and includes large-scale features such as mountain ranges, as well as small-scale features such debris slopes.

Landscape: a concept encompassing physical, biological, and social components. In the context of my reports, it comprises a collection of landforms, (hence landform elements) which have been formed within a geo-tectonic framework as modified by climate over time, and on which drainage systems and vegetation patterns have become established.

Midrib: the central vein of a leaf.

Morphology: the study of structure, form and development of plants.

ms: manuscript. Unpublished manuscript name.

Mucro: a short sharp point.

Mucronate: tipped with a short sharp point.

Palaeo drainage channel: an ancient drainage line that has been active in the past during periods of a wetter climate, and has been subsequently buried by modern sediments. Contemporary drainage systems often reflect the location of palaeo drainage lines. The depth below the surface of palaeo systems reflects the degree of erosion and sedimentation that has occurred during the onset of aridity.

Priority Ecological Community (PEC): Vegetation communities not initially categorized as a TEC and waiting nomination for TEC status.

Precautionary Principle: Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason to postpone measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by:

- careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and

- an assessment of the risk-weighted consequences of various options. (Intergovernmental Agreement on the Environment, 1992).

This provides an approach for considering the environmental impacts of a proposal on biodiversity values where there is a lack of knowledge and lack of scientific certainty. A useful methodology for applying the precautionary principle is that of Deville and Harding (1997).

Priority Flora: Lists of plant taxa, maintained by the Department of Conservation and Land Management (Atkins, 2003), that are either under consideration as threatened flora but are in need of further survey to adequately determine their status, or are adequately known but require monitoring to ensure that their security does not decline.

Pubescent: bearing hairs of any type.

Pungent: ending in a sharp point.

Quadrat: an in depth vegetation survey of a set area (in this survey 2500 m^2). Marked by permanent pegs to allow for ongoing monitoring.

Range extension: a species recorded outside its known distribution.

Relevés: a high level vegetation survey of a small area. Similar to a quadrat, but with no permanent pegs and not used for ongoing monitoring.

Significant Flora: Species, subspecies, varieties, hybrids, and ecotypes may be significant for a range of reasons, other than as Declared Rare Flora or Priority Flora, and may include the following:

- a keystone role in a particular habitat for threatened species, or supporting large populations representing a significant proportion of the local regional population of a species;
- relic status;
- anomalous features that indicate a potential new discovery;
- being representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- the presence of restricted subspecies, varieties, or naturally occurring hybrids;
- local endemism/a restricted distribution; and
- being poorly reserved.

Significant Vegetation: Vegetation may be significant for a range of reasons, other than a statutory listing as Threatened Ecological Communities or because the extent is below a threshold level, which may include the following:

- scarcity;
- unusual species;
- novel combinations of species;

- a role as a refuge;
- a role as a key habitat for threatened species or large populations representing a significant proportion of the local to regional total population of a species;
- being representative of the range of a unit (particularly, a good local and/or regional example of a unit in 'prime' habitat, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range); and
- a restricted distribution.

This may apply at a number of levels, so the unit may be significant when considered at the fine-scale (~intra-locality), intermediate-scale (~locality or inter-locality) or broad-scale (~local to region).

Soil landscapes: those landform elements making up the local landscape that comprise a suite of soils with similar characteristics. Any given soil landscape may contain up to 20 definable soils, all with similar characteristics, but which may vary in profile or horizon morphology.

sp.: species.

sp. aff.: species with affinity to …, or close to …

Species: a taxon consisting of individuals or populations that share certain common features and freely interbreed and produce fertile offspring.

Species of Interest or significance: species other than DRF or Priority listed flora with some value of interest, whether that is of taxonomic interest, a new taxa or have a range extension.

Spinescent: ending in a sharp point

sp. nov.: new species.

spp.: species (plural).

subsp.: subspecies.

Subspecies: taxon that are characterised by minor morphological differences from other species, such as the size or shape of parts, usually as a result of being geographically isolated or other ecological barriers.

subsp. nov.: new subspecies.

Taxa: A taxonomic group. Depending on context, this may be a species or their subdivisions (subspecies, varieties, forms), genus or higher group.

Taxonomic Interest: Poorly known or undescribed taxa that require taxonomic revision. May represent morphological or regional variation of known species; that is a possible new species, subspecies or variety e.g. *Scaevola spinescens* terete leaf form (G. Cockerton & C. Ringrose LCH 14560). Requires the acquisition of flowering and fruiting material to fully identify taxa.

Threatened Ecological Community (TEC): Ecological communities that have been assessed through a procedure (coordinated by DEC) and assigned to one of the following categories related to the status of the threat to the community. These categories are:

- Presumed Totally Destroyed;
- Critically Endangered: <10% of pre-European extent remains in an intact condition in the bioregion;
- Endangered: 10 to 30% of pre-European extent remains; and
- Vulnerable: declining and/or has declined in distribution and/or condition, and whose ultimate security is not yet assured (it could move into a category of higher threat in the near future if threatening processes continue) (English and Blyth 1997, 1999).

One of the criteria used to determine the categories of threatened ecological community is an estimate of the geographic range and/or the total area occupied and/or the number of discrete occurrences reduced since European settlement.

Threatening Processes (compare ecosystem function/processes): Any process or activity that threatens to destroy or significantly modify the ecological community

and/or effect the continuing evolutionary processes within any ecological community (English and Blyth, 1999). A process that threatens, or may threaten, the survival, abundance or evolutionary development of a native species or ecological community (ANZECC, 2000).

var.: variant

Variant: similar to subspecies, although after identification, the taxa are not regarded to fit into a recognised taxon.

Vegetation (compare with flora; and see significant vegetation): The various combinations that all populations of all vascular plant species form within a given area, and the nature and extent of each combination (*after* Mueller-Dombois and Ellenberg, 1974, Collocott and Dobson, 1975, Lewis, 1977, Onions, 1978, and Delbridge, 1987). Note that this is a biodiversity approach, and that other approaches may be based on structure or appearance - approaches that describe lesser subsets of plant diversity. The term vegetation has been applied at a range of scales in general use (as have community and habitat). The joint influence of different approaches and levels that can be applied to vegetation has led to a range of terms that describe vegetation, with resulting confusion.

Vegetation community: An association of vascular flora species characterized by key dominant species within observed strata which co-occur in a repeating pattern and consistently occupy a recognizable landscape position with unique soil and hydrological characteristics across the landscape, often strongly contrasting with those adjacent. Vegetation Communities defined here are broadly similar to Land Units defined by Pringle *et al* (1994). However, many have been described at finer scale and detail to enable definition and depiction of the distribution of key dominant species within the intricately variable landscapes associated with the Calcrete and Playa Soil Landscape Systems.

Vegetation unit: A general purpose term to apply to vegetation categories regardless of level, and with no level implied. This is required because the most variable area of terminology is to do with vegetation and its categorisation at various levels of meaning. If practitioners have any doubt about the application of vegetation terms, it is recommended that they:

- refer to absolute scales, densities, and extent of vegetation as much as possible; and

- use only the generic term “vegetation unit” and qualify whether each unit is fine-scale (~intra-locality), intermediate-scale (~locality or inter-locality) or broad-scale (~local to region).