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RIO TINTO
GREATER WEST ANGELAS
VEGETATION AND FLORA ASSESSMENT

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ACRONYMS

AIR	Ashburton Regional Inventory
ARRP Act	*Agriculture and Related Resources Protection Act 1976*
BIF	Banded Ironstone Formation
CALM	Department of Conservation and Land Management (now DEC)
DAFWA	Department of Agriculture and Food Western Australia
DEC	Department of Environment and Conservation
DEFL	Department of Environment and Conservation Endangered Flora Database
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
RT	Rio Tinto
Opp col	Opportunistic collection
PRI	Pilbara Regional Inventory
TEC	Threatened Ecological Community
PEC	Priority Ecological Community
UCL	Unallocated Crown Land
WAHERB	Western Australian Herbarium
WC Act	*Wildlife Conservation Act 1950*
WONS	Weeds of National Significance

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EXECUTIVE SUMMARY

Rio Tinto (RT) commisioned *ecologia* Environment (*ecologia*) to undertake a two phase assessment of the Greater West Angelas Study Area. Greater West Angelas is located approximatley 105 km north-west of Newman and comprises of three disjointed areas covering a total of 17,596 ha. Deposits C, D, D extension, G, F, H and Mt Ella were surveyed.

Methods

The vegetation and flora of the Study Area was surveyed in two phases over two separate trips totalling 60 person days. Survey timing was as follows:

- Phase 1; 9th to 18th of July 2012 (36 person days); and
- Phase 2; 21st-26th August 2021 (24 person days).

Seasonal conditions were favorable, with higher than average rainfall recorded in the months preceding the survey.

One hundred and fifty quadrats (2,500 m^2 each) were surveyed, distributed throughout the Study Area. Locations were selected using aerial photography, topographic features and field observations to represent the diversity of vegetation present. Additional opportunistic collections were made of taxa not already located within the quadrats. Locations of any introduced flora and known or potentially conservation significant taxa encountered were also recorded.

Flora

A total of 441 taxa were recorded from the West Angelas Study Area. Ten taxa could not be fully identified due to lack of reproductive material. The pattern of families and genera represented are considered typical for the Pilbara during favourable seasonal conditions. The high number of taxa within the family Scrophulariaceae and genus *Eremophila* reflects the abundance of mulga woodlands and shrublands. The relatively high representation of Asteraceae, Amaranthaceae and Goodeniaceae is a reflection of the optimal timing of the survey when many ephemeral species were flowering.

Flora sampling adequacy was estimated using species accumulation curve analysis and extrapolation of the curve to the asymptote using Michaelis-Menten modelling. Using this analysis it is estimated that between 86% and 88 % of the taxa present were recorded.

Species richness within quadrats varied from seven to 67 taxa, with a mean species richness of 35.7± 1.0 (n= 150). Vegetation units with the lowest species overall richness include *ApTssp* (*Acacia aptaneura* and *A. pruinocarpa* open woodland over *A. tetragonophylla, Senna glutinosa* subsp. *glutinosa* and *S. artemisioides* subsp. *oligophylla* isolated shrubs over *Triodia wiseana* and *T. pungens* open hummock grassland), and *Tp* (*Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia pruinocarpa* isolated trees over *Senna glutinosa* subsp. *glutinosa, A. bivenosa* and *Ptilotus rotundifolius* isolated shrubs over *Triodia pungens* or *T. basedowii* or *T.* sp. Mt Ella hummock grassland.), both of which are typical of rocky midslopes, with a mean species richness of 15.8 and 16.8, respectively. The most consistently diverse vegetation unit was *AaPoTt* (*Acacia aptaneura* open woodland over *Ptilotus obovatus* sparse shrubland over *Themeda triandra* open tussock grassland), which occurs along sandy floodplains, with mean species richness of 50.1.

Four specimens of *Lepidium catapycnon,* listed under the *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act) and the *Wildlife Conservation Act, 1950* (WC Act) (Declared Rare

Flora) were collected opportunistically from four locations within Greater West Angelas. A total of 29 individuals were recorded. Vegetation and landforms consistent with this species' habitat occur within the Study Area and it is possible that more individuals could be present given that access to some areas was limited during the survey.

Thirteen Threatened and Priority Flora taxa were recorded during the survey: one Threatened (*Lepidium catapycnon*); three Priority 1 species (*Aristida jerichoensis* var. *subspinulifera, Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662) and *Brunonia* sp. long hairs (D.E. Symon 2440); two Priority 2 species (*Aristida lazaridis* and *Eremophila forrestii* subsp. Pingandy (M.E. Trudgen 2662)); six Priority 3 species (*Acacia* aff. *subtiliformis, Indigofera* sp. Gilesii (M.E. Trudgen 15869)*, Rhagodia* sp. Hamersley (M. Trudgen 17794), *Sida* sp. Barlee Range (S. van Leeuwen 1642), *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) and *Triodia* sp. Mt Ella (M.E. Trudgen 12739) and one Priority 4 species (*Goodenia nuda*). Seven of these species have previously been recorded within the Study Area. Five of the recorded priority taxa are not represented within conservation estates (*Aristida jerichoensis* var. *subspinulifera*, *Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662), *Brunonia* sp. long hairs (D.E. Symon 2440), *Indigofera* sp. Gilesii (M.E. Trudgen 15869) and *Triodia* sp. Mt Ella (M.E. Trudgen 12739). Current advice form the Western Australian Herbarium is that *Brunonia* sp. long hairs and *Brunonia australis* are likely to be amalgamated in the future (Hislop 2012, *pers. comm.*), but as this change has not yet been adopted by the Western Australian Herbarium, *Brunonia* sp. long hairs is regarded as a priorty taxon in this report.

No Weeds of National Significance (WONS) or Declared Plants were recorded. Nine weeds were recorded within the Study Area, all of which have been assessed within the Department of Environment and Conservation (DEC) classification of Environmental Weeds within the Pilbara. Three species are ranked as a high threat; **Cenchrus ciliaris*, **Cenchrus setiger* and **Vachellia farnesiana*. **Bidens bipinnata* is by far the most abundant weed species recorded in the Study Area.

Vegetation

The West Angelas Study Area is not located within a pastoral lease and, as a result, is not actively grazed by livestock. Overall the vegetation condition was found to be excellent, with 51% and 36% assessed as being in excellent or very good condition, respectively. The disturbance most commonly observed was the presence of weed species, with a small number of areas subject to disturbance from previous exploration activities. The majority of the Study Area has not been recently burnt, with 50% of quadrats assessed as burnt more than five years ago or with no evidence of fire and 44% burnt two to five years ago. The pattern of burning appears sporadic and localised, which is typical of fires arising during the early wet season from lightning strikes that are extinguished relatively rapidly, rather than larger scale fires that burn an extensive area before being extinguished.

Based on multivariate analysis, interpretation of aerial imagery and ground truthing, 22 vegetation communities were described and mapped within the Study Area.

One Priority 1 PEC, West Angelas Cracking-Clays, occurs extensively within the Study Area. This community is further defined as open tussock grasslands of *Astrebla pectinata*, *A. elymoides*, *Aristida latifolia* in combination with *Astrebla squarrosa* and low scattered shrubs of *Sida fibulifera*, on basalt derived cracking-clay loam depressions and flowlines. Threats to this community include; clearing for further mining expansion and future infrastructure development, weed invasion and changes in fire regimes. The vegetation unit *AlAp* was determined to be equivalent to the PEC with the species compositions found to be a good match, despite the lack of *A. elymoides* which was not recorded during the current survey. It is thought that the survey timing for tussock grasses may not have been optimal with reproductive material often being absent and identifications problematic for this group.

Assessment of the significance of the vegetation of the Study Area is constrained by the lack of mapping across the state conducted at a scale comparable to the mapping conducted during the current survey. At a scale of 1: 1,000,000 the vegetation units described by Beard (1975) within the Study Area are well represented elsewhere, and extensively represented for some vegetation types.

The vegetation units mapped in the current survey were compared to those identified in the Biota (2006) survey, in which 12 vegetation types were identified and ME Trudgen & Associates (1998) in which 54 vegetation types were identified.

The mapping boundaries of the ME Trudgen & Associates survey extended beyond that of the current survey resulting in just 29 of the 54 communities defined by ME Trudgen & Associates represented within the current Study Area.

Approximately 50% of the area surveyed by Biota falls outside of the current Study Area, although, of the 12 units described by Biota, 10 identified in the current survey match well and have been interpreted to be equivalent.

Vegetation is also of conservation significance if it has "a role as a key habitat for threatened species" (EPA 2004, page 30). *Lepidium catapycnon* (T) appears to have a high specificity to the vegetation unit *SggIrTw,* rocky hillslopes, which supports 100% of all plants recorded. Although present in 10 vegetation units, *Aristida jerichoensis* var. *subspinulifera* (P1) demonstrates a higher specificity to unit *AaSlTp* (sandy undulating plains) with 40.9% of locations and 57.9% of individuals recorded within this unit. *Indigofera* sp. Gilesii (M.E. Trudgen 15869) demonstrates specificity for the vegetation unit *SggTp,* rocky midslopes, with 47.8% of all locations and 31.9% of individuals recorded within this unit.

Vegetation communities that are groundwater dependent are regionally important and also of conservation significance. Vegetation unit *AaPoTt* supports variable densities of *E. victrix* and therefore may represent a vadophytic ecosystem (i.e. supporting plants that rely on moisture in the upper soil profile) or occasionally phreatophytic (dependent on groundwater), and on this basis has been qualified as a GDE.

In a local context vegetation can be considered significant if it is locally uncommon or provides habitats of local significance. Vegetation of local significance is not legislatively protected but is of conservation value if areas are restricted and have not been identified to occur outside the Study Area, and such conservation significance is typically a consideration for environmental impact assessments. The least extensive vegetation units locally are *AaEffTp* (141.54 ha) and *AmTw* (108.7 ha), which represent 0.80 % and 0.62% of the Study Area, respectively.

Conclusions

Of the 13 threatened and priority taxa recorded, *Lepidium catapycnon*, *Aristida jerichoensis* var. *subspinulifera*, *Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662), *Brunonia* sp. long hairs (D.E. Symon 2440) and *Aristida lazaridis* appear to be the most restricted in distribution, with only 14, six, ten, three and three other West Australian Herbarium records, respectively. Only *Lepidium catapycnon* and *Aristida lazaridis* have one record each within Conservation Reserves, and therefore all of the remaining significant taxa are poorly represented within the Conservation Estate, which adds to their vulnerability.

Vegetation unit *SggIrTw* (rocky hilltops) supports *Lepidium catapycnon* (T) and is therefore of conservation significance and could be the focus of further targeted surveys.

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1 INTRODUCTION

Rio Tinto (RT) requires a series of biological surveys in order to support a strategic assessment of the Greater West Angelas Project, which includes a series of iron ore deposits in the Pilbara region of Western Australia.

RT is currently conducting preliminary feasibility studies for the development of ore deposits C, D, D extension, G, F, H and Mt Ella, collectively termed the Greater West Angelas Study Area (herein referred to as 'the Study Area') located approximately 105 km north-east of Newman (Figure 1.1). The Study Area comprises of three disjointed areas covering a total of 17,565 ha, is situated on RT exploration leases and encompasses the borefield supplying water to West Angelas Mine. The Survey Area does not support any pastoral leases.

As part of the series of biological surveys, *ecologia* was commissioned to conduct a two phase, Level 2 survey of the flora and vegetation of the Survey Area. This survey will provide baseline data which may be supplemented with additional studies, should approval to mine be sought in the future.

1.1 LEGISLATIVE FRAMEWORK

Commonwealth and State legislation applicable to the conservation of native flora and fauna in Western Australia includes, but is not limited to, the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the Western Australian *Wildlife Conservation Act 1950* (WC Act) and the*Environmental Protection Act 1986* (EP Act).

Section 4a of the EP Act requires that developments take into account the following principles applicable to native flora and fauna:

- The Precautionary Principle

  Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

- The Principles of Intergenerational Equity

  The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.

- The Principle of the Conservation of Biological Diversity and Ecological Integrity

  Conservation of biological diversity and ecological integrity should be a fundamental consideration of the project.

Furthermore, floristic surveys undertaken as part of the Environmental Impact Assessment (EIA) process are required to address the following:

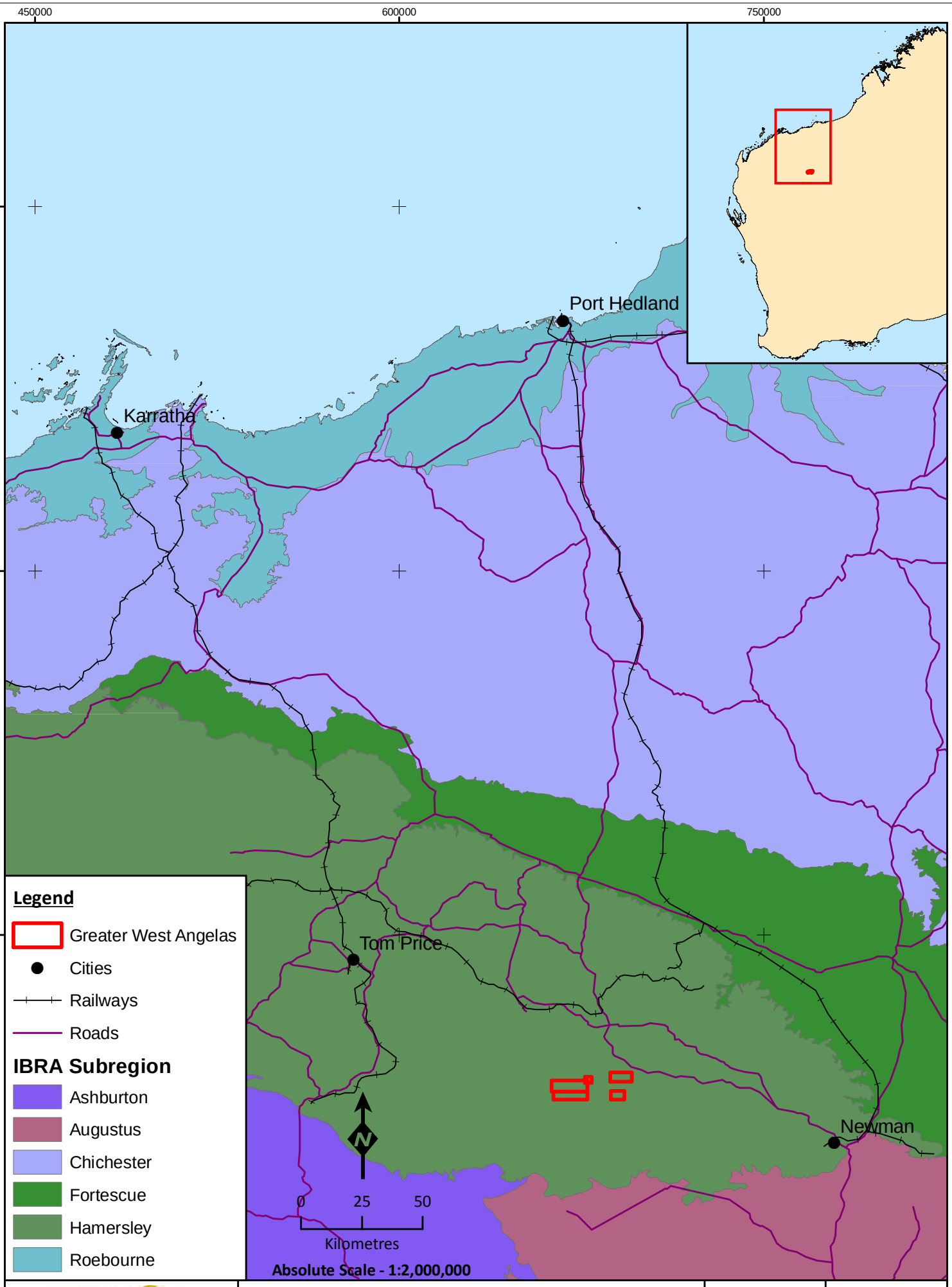
- Environmental Protection Authority's (EPA's) Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection (Environmental Protection Authority 2002); and

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

The EPBC Act was developed to provide for the protection of the environment, especially those aspects of the environment that are matters of National Environmental Significance, to promote

ecologically sustainable development through the conservation and ecologically sustainable use of natural resources; and to promote the conservation of biodiversity. The EPBC Act includes provisions to protect native species (in particular to prevent the extinction and promote the recovery of threatened species) and to ensure the conservation of migratory species. In addition to the principles outlined in Section 4a of the EP Act, Section 3a of the EPBC Act includes the principle of ecologically sustainable development; that decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equity considerations.

The WC Act was developed to provide for the conservation and protection of wildlife in Western Australia. Under Section 14 of this Act, all fauna and flora within Western Australia are protected; however, the Minister may, via a notice published in the Government Gazette, declare a list of flora taxa identified as likely to become extinct, or as rare, or otherwise in need of special protection. The current listing was gazetted on 17 February 2012.



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Location of West Angelas and IBRA Subregions

Figure: 1.1	**Drawn: CP**
Project ID: 1457	**Date:04/09/2012**

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CP098

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1.2 SURVEY OBJECTIVES

The EPA's objectives with regard to the management of native flora and vegetation are to:

- Avoid adverse impacts on biological diversity comprising the different plants and animals and the ecosystems they form, at the levels of genetic, species and ecosystem diversity.
- Maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities.
- Protect Threatened flora (formerly DRF, Declared Rare Flora) consistent with the provisions of the WC Act.
- Protect other flora species of conservation significance.

The primary objective of the surveys is to provide sufficient information to the EPA to assess the impact of the development on the vegetation, flora and fauna of the Study Area, thereby ensuring that the EPA objectives can be upheld.

Specifically, this survey was to satisfy the requirements documented in the EPA's Guidance Statement 51 and Position Statement No. 3, thus providing:

- A review of background information (including literature and database searches).
- An inventory of vegetation types and flora species occurring in the Study Area, incorporating recent published and unpublished records.
- An inventory of flora species of biological and conservation significance recorded or likely to occur within the Study Area and surrounds.
- A map and detailed description of vegetation types occurring in the Study Area.
- An appraisal of the current knowledge base for the area, including a review of previous surveys conducted in the area relevant to the current.
- A review of regional and biogeographical significance, including the conservation status of species recorded in the Study Area.
- A risk assessment to determine likely impacts of threatening processes on vegetation and flora within the Study Area.

2 EXISTING ENVIRONMENT

2.1 CLIMATE

The Study Area is located in the Pilbara region of Western Australia. The Pilbara experiences an arid-tropical climate with two distinct seasons; a hot summer from October to April and a mild winter from May to September. Temperatures are generally high, with summer temperatures frequently exceeding 40°C. Light frosts occasionally occur inland during July and August.

Rainfall is generally localised and unpredictable (some years have recorded zero rainfall), and temperatures are high, resulting in annual evaporation exceeding rainfall by as much as 500 mm per year. The majority of the Pilbara has a bimodal rainfall distribution; from December to March rains result from tropical storms producing sporadic thunderstorms. Tropical cyclones moving south also bring heavy rains. From May to June, extensive cold fronts move eastwards across the state and occasionally reach the Pilbara. These fronts usually produce only light rains. Surface water can be found in some pools and springs in the Pilbara all year round, although watercourses generally flow intermittently due to the short wet season (Beard 1975).

The nearest Bureau of Meteorology (BOM) station for which both rainfall and temperature data is available is Paraburdoo Aero (Site No. 007185), 85 km west from the western boundary of the Study Area. The location has a typical inland Pilbara climate of hot summers with sporadic summer storms and warm dry winters (Figure 2.1).

Rainfall data is available from Turee Creek Station (Site No 007083) located 45.5 km south of the southern boundary of the Study Area. Rainfall from November 2011 to March 2012 was considerably higher than the long term average at this site and occurred earlier in the season, with February the only month to record slightly below average rainfall. The rainfall received in the months preceding the first and second phases of the survey were below the monthly averages (Table 2.1). Paraburdoo received the majority of its rain later in the season (January to March 2012) with the surrounding months receiving below average rainfall (Table 2.1). Given the proximity to West Angelas, it is probable that rainfall recorded at Turee Creek is a more accurate reflection of the rainfall received by the Study Area than is rainfall at Paraburdoo. The higher than average rainfall earlier in the season and the light but continual rainfall in the months leading up to the survey determined that the survey timing was suitable.

Table 2.1 – Rainfall at Turee Creek and Paraburdoo meteorological stations

Total rainfall (mm)	Turee Creek		Paraburdoo Aero	
	Monthly total	Monthly average (1920-2012)	Monthly total	Monthly average (1974-2012)
August 2011	2	8.3	0	11.6
September 2011	0	2.9	0	3.6
October 2011	2.6	4	0	3.6
November 2011	30.2	8.5	8	8.3
December 2011	27.7	22.6	5	28.5
January 2012	126.3	41	205.2	52
February 2012	42	56.7	73.6	78.3
March 2012	72.5	34.7	77	46.4
April 2012	1.8	18.5	17.4	26.8
May 2012	0	21.6	0	16.4
June 2012	8.6	18.8	10.4	22.2
July 2012	1	10.9	1	14.6

(BOM 2011)

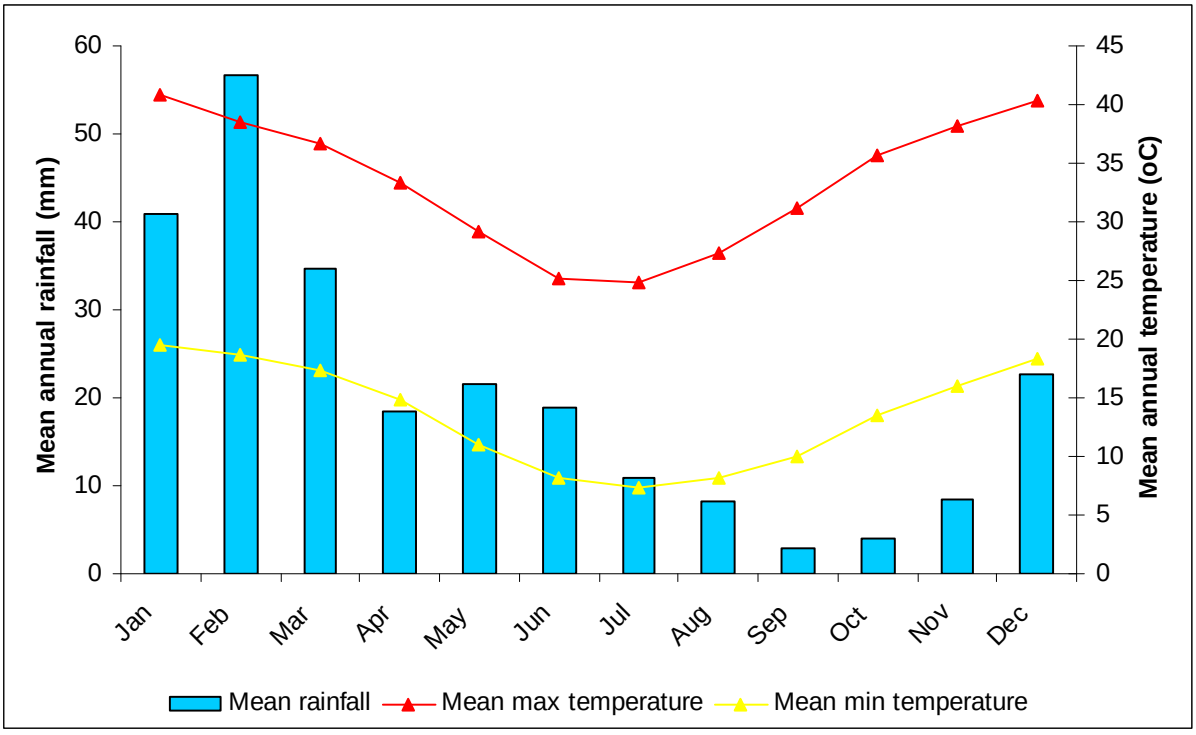


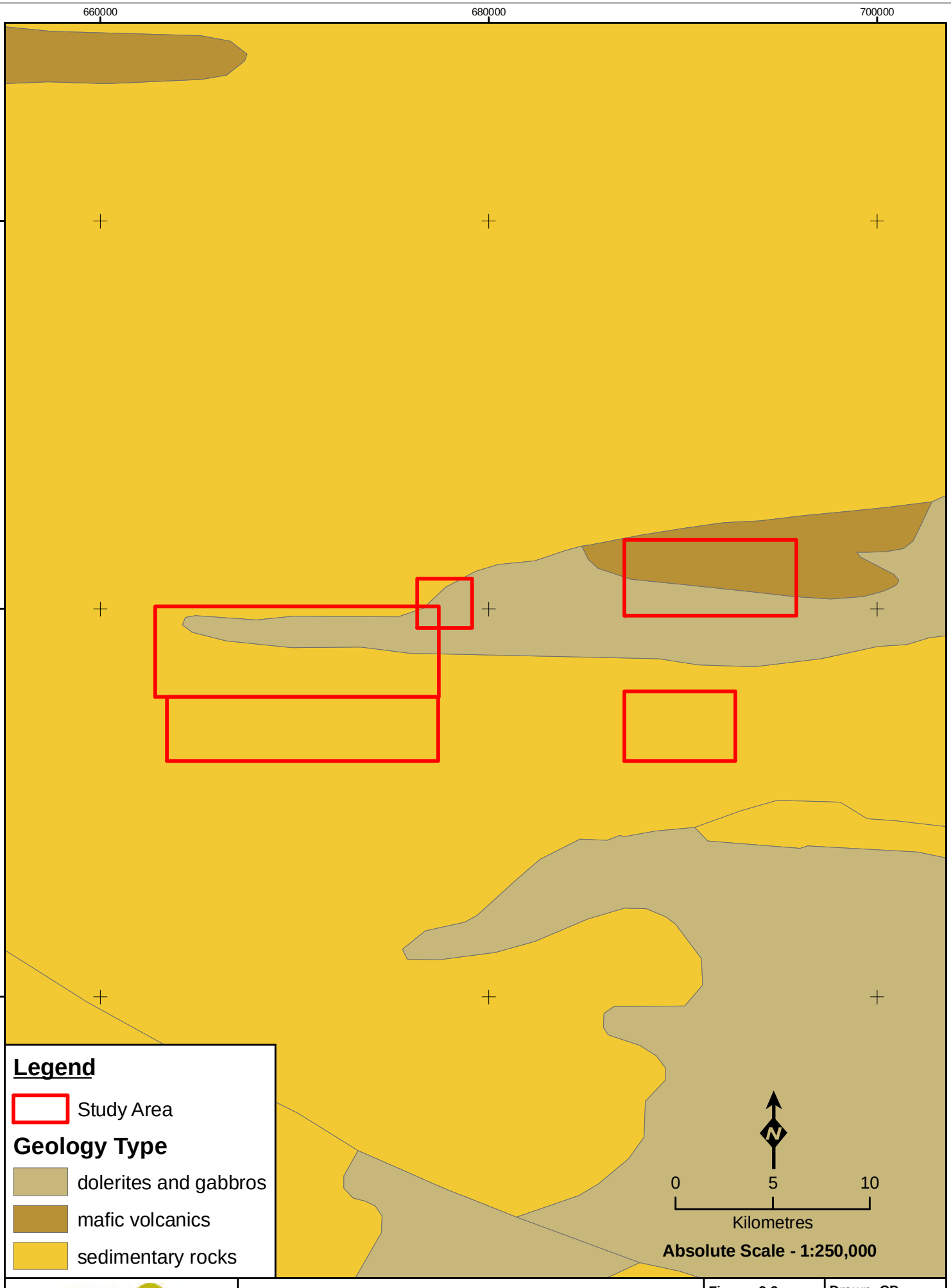
Figure 2.1 – Mean monthly climate data for Turee Creek (temperature from Paraburdoo Aero)

2.2 GEOLOGY, LAND SYSTEMS AND SOILS

2.2.1 Geology

The majority of the Pilbara is comprised of the granite terrain of the Pilbara Block in the north with the rugged sedimentary Hamersley Basin in the south and the sedimentary rocks overlain by Aeolian sands of the Canning Basin to the east. Drainage is mostly via major river catchments of the De Grey, Turner and Yule rivers in the north, and the Fortescue and Robe rivers in the west. All rivers are exoreic (i.e. flow into the ocean) with the exception of Savory Creek, which drains eastwards into Lake Disappointment (Van Vreeswyk *et al*. 2004). The geological stratigraphy in the Pilbara region is relatively continuous, with similar geological processes occurring across the region which have resulted in the enrichment of the iron deposits (Van Vreeswyk *et al.* 2004).

The main source of the magnetic mineralisation in the Pilbara is the Pincunah Formation, which is one of the prominent Banded Ironstone Formations (BIF) within the greenstone belts of the Pilbara Craton. The Study Area supports three different geological formations and these, along with the geology of the surrounding region is presented in Figure 2.2 (Hickman and Kranendonk 2008) with definitions of the geological unit codes provided in Table 2.2. The Study Area is comprised of 12.4% maffic volcanics, 66.4% sedimentary rock and 21.1% dolerites and gabbros geological units (Hickman and Kranendonk 2008).



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Geology of West Angelas Study Area

Figure: 2.2
Project ID: 1457

Drawn: CP
Date: 04/09/2012

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CP099

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Table 2.2 – Geology of West Angelas Study Area

Geological Code	Lith Association	Area within Study Area (km^2)	Definition of code
Ap	Mafic volcanics	21.7	Archaean period
Ab	Sedimentary rocks	116.9	Archaean – palaeoproterozoic period
Ad	dolerites and gabbros	37.0	Archaean period

2.2.2 Soils

Twenty-one broad soil groups have been identified by Van Vreeswyk *et al*. (2004) within their study defining land systems within the Pilbara. Soils are predominantly red and shallow with stony mantles.

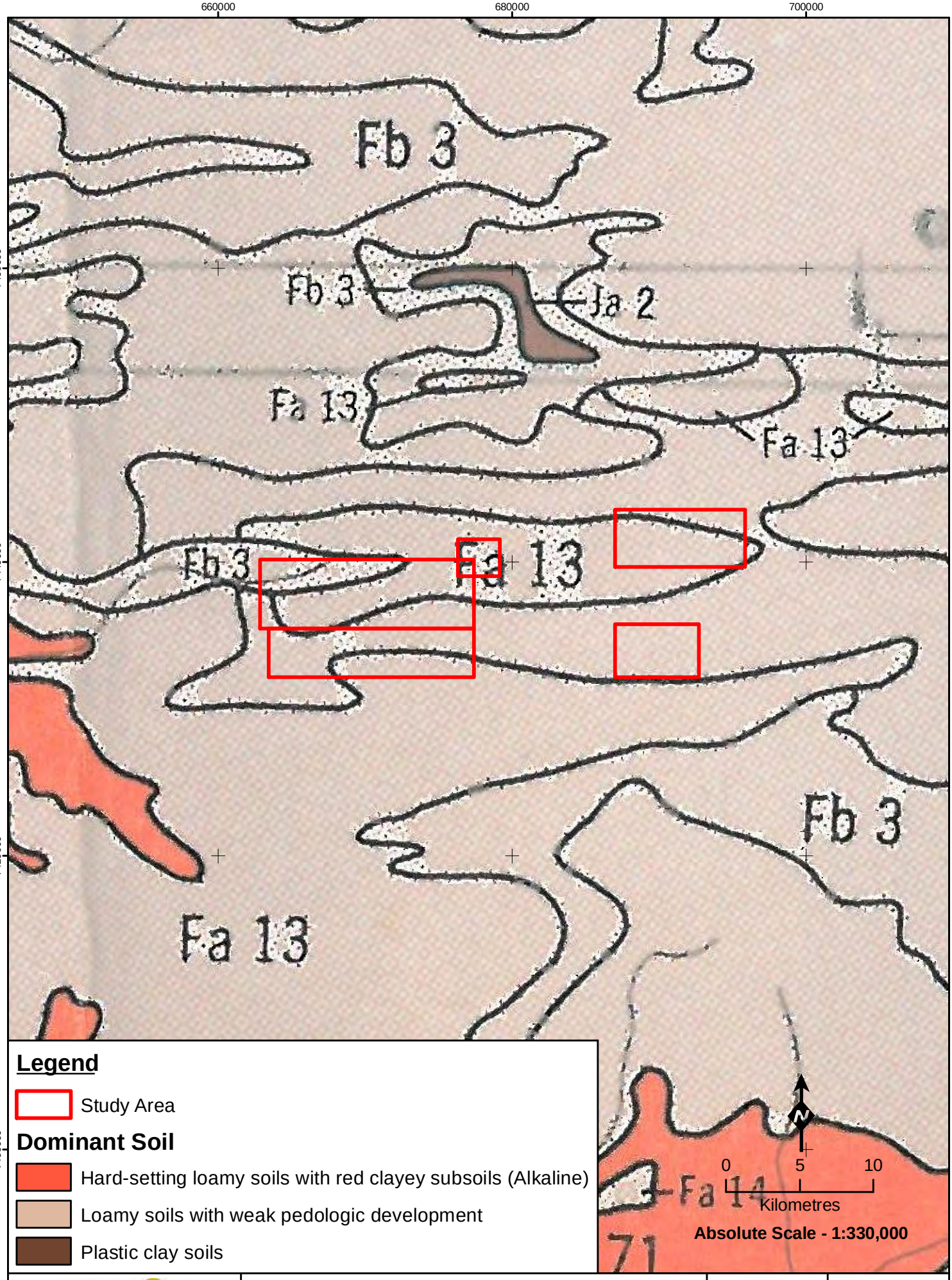
The most extensive soils in the Pilbara are shallow, stony soils on hills and ranges and sands on sandplains. In the south, the soils are predominantly red earths overlying hardpan on level to gently inclined plains. Lower flood plains have cracking and non-cracking clay soils. Duplex (texture-contrast) soils occur in localised areas on saline alluvial plains and elsewhere. These soils support the most preferentially grazed vegetation and are highly susceptible to erosion (Van Vreeswyk *et al*. 2004).

Within the Study Area, the dominant soil type is loamy soils with weak pedology (Figure 2.3) (Bettenay *et al*, 1967), which has been further classified as the following units:

Fa13: Ranges of banded jaspilite and chert along with shales, dolomites, and iron ore formations; some areas of ferruginous duricrust as well as occasional narrow winding valley plains and steeply dissected pediments. This unit is largely associated with the Hamersley and Ophthalmia Ranges. The soils are frequently stony and shallow and there are extensive areas without soil cover: chief soils are shallow stony earthy loams (Um5.51) along with some soils on the steeper slopes (Uc5.11). Associated are soils on the limited areas of dissected pediments, while (Um5.52) and (Uf6.71) soils occur on the valley plains.

Fa14: Steep hills and steeply dissected pediments on areas of banded jaspilite and chert along with shales, dolomite, and iron ore formations; some narrow winding valley plains: chief soils are shallow stony earthy loams (Um5.51) along with some (Uc5.11) soils on the steeper slopes. The (Dr2.33) and (Dr2.32) soils which occur on the pediments are more extensive than unit Fa13, while (Um5.52) and (Uf6.71) soils occur on the valley plains.

Fb3: High-level valley plains set in extensive areas of unit Fa13. There are extensive areas of pisolitic limonite deposits: ptoncipal soils are deep earthy loams (Um5.52) along with small areas of Gn2.12) soils.



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Soils of West Angelas Study Area

Figure: 2.3
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Drawn: CP
Date: 04/09/2012

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CP100

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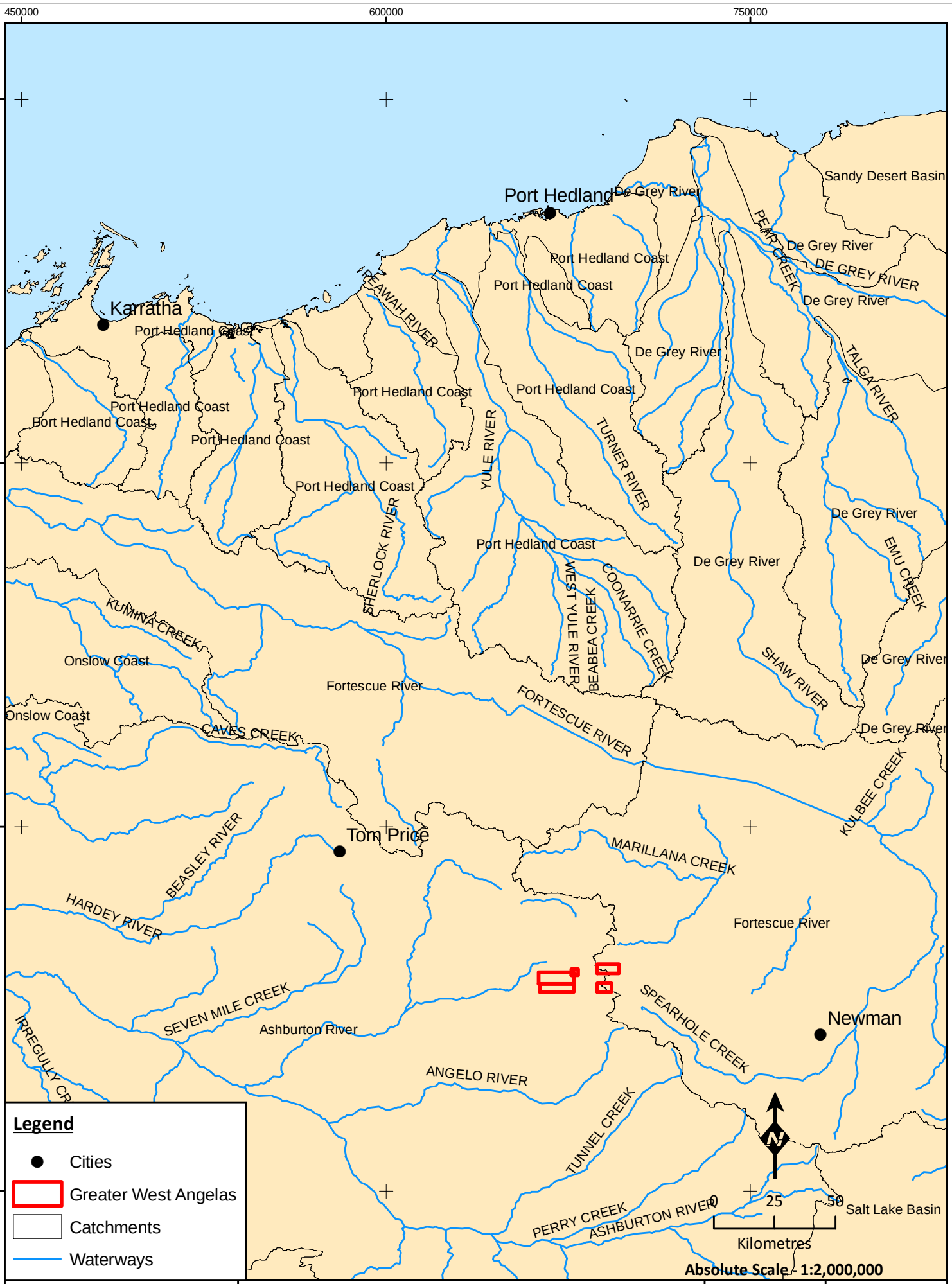
2.3 HYDROGEOLOGY

Central Pilbara groundwater occurs in the Archaean/Proterozoic basement rocks and the Cainozoic deposits. It originates from direct rainfall recharge into basement rock outcrops and indirect recharge through runoff (Johnson and Wright 2001).

The Study Area is located in the Hamersley Range, and is a part of both the Ashburton and the Fortescue Catchments. The closest creek to the Study Area is Turee Creek, a sub-tributary of the Ashburton River. Turee Creek flows west along a 4 km wide valley before turning sharply to exit the Hamersley Range (Johnson and Wright 2001). The West Angelas mine and Study Area are situated in the East Turee Creek catchment (Figure 2.4). The Turee Creek East drainage is fed by a number of smaller creeks originating in the hills to the west (Johnson and Wright 2001). The creek system is ephemeral and does not support any permanent surface-water features (Johnson and Wright 2001). The main aquifer in the area is the vuggy pisolite (Robe Pisolite) which overlies fractured basement rocks of the Woongarra volcanics and Boolgeeda Iron Formations (Johnson and Wright 2001). This aquifer lies within tertiary paleochannels and the aquifer zone varies between 50 and 80 m in thickness and has an estimated permeability of 40-80 m per day (Johnson and Wright 2001).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Newman
Sandy Desert Basin
De Grey River
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PEAR CREEK
DE GREY RIVER
TALGA RIVER
YULE RIVER
TURNER RIVER
SHERLOCK RIVER
WEST YULE RIVER
BEABEA CREEK
COONARRIE CREEK
EMU CREEK
SHAW RIVER
KUMINA CREEK
Onslow Coast
Fortescue River
FORTESCUE RIVER
CAVES CREEK
KULBEE CREEK
BEASLEY RIVER
HARDEY RIVER
MARILLANA CREEK
SEVEN MILE CREEK
Ashburton River
SPEARHOLE CREEK
IRREGULLY CR
ANGELO RIVER
TUNNEL CREEK
PERRY CREEK
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Legend
Cities
Greater West Angelas
Catchments
Waterways
Absolute Scale - 1:2,000,000
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Location of West Angelas and Regional Hydrology
Figure: 2.4
Project ID: 1457
Drawn: CP
Date:13/06/2012
Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Unique Map ID: CP085
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2.4 LAND USE HISTORY

2.4.1 Overview

Pastoralism is the most extensive land use in the Pilbara bioregion with 812 different pastoral leases encompassing 109,285 km^2 (61.4%) of the region. Areas set aside for conservation account for 14,763 km^2 (8.3%), consisting of the Cane River Conservation Park, Karijini and Millstream Chichester National Parks, Mungaroona Range and an unnamed Nature Reserve (LandGate, 2012). In addition, the pastoral leases of Mt Minnie and Nanutarra (adjoining the Cane River Conservation Park), Mt Florence (adjoining Karijini NP) and Meentheena have been purchased by the DEC and destocked. Although currently of informal status, these areas will ultimately be incorporated into the conservation estate, contributing a further 1.9%.

The Aboriginal reserves of Abydos, Jigalong, Woodstock and Yandeyarra, and the special lease for Aboriginal use, Callawa, occupy 10,655 km^2 (6%) of the bioregion.

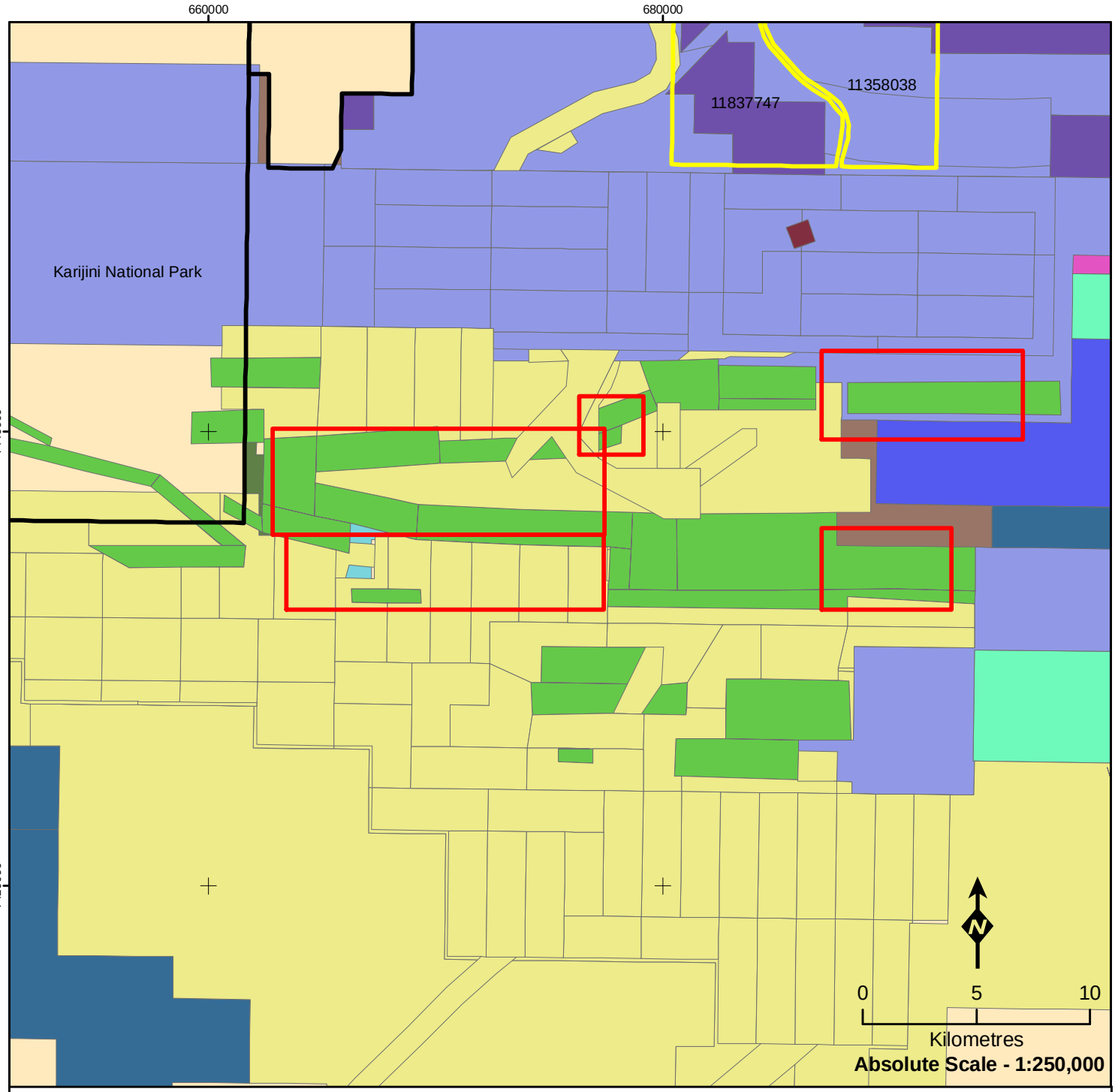
The total area of unallocated Crown land within the Pilbara bioregion is 496 km^2 (0.28%).

Mining is an important land use of ironstone ranges and greenstone belts throughout the bioregion, with development of the iron ore rich deposits accelerated in the 1960s after the Commonwealth lifted the 1938 export embargo on iron ore. Mining and exploration leases encompass 4.1% and 86% of the region, respectively. The development of the iron ore industry has resulted in activity within the Pilbara increasing from cattle and sheep stations and small coastal ports to a large mining economic base with a commensurate increase in population. In 2009, the Pilbara Development Commission reported that the Pilbara was at that time producing approximately 95% of Australia's iron ore exports, estimated at 157 Mtpa and with a value of over $5.1 billion per year (Pilbara Development Commision 2009).

Approximately 1% of the bioregion consists of town, commons and various reserves.

2.4.2 Local Land Use

The Study Area is not bound by, nor does it form part of any pastoral lease in the area. Exploration and mining leases owned by RT encompass 100% of the Study Area. As a result, the site is not subject to grazing pressure from cattle or other livestock. The Study Area (Particularly Deposit G) intersects the active West Angelas mine and infrastructure and these areas are subject to clearing and heavy vehicle traffic. All deposits in the Study Area have been subject to varying levels of clearing due to extensive resource exploration in the past during the feasibility and extent evaluation processes.



Legend

- Study Area
- Conservation Reserves
- Pastoral Lease Boundaries

Mining Tenements

- BHP BILLITON MINERALS PTY LTD
- FMG PILBARA PTY LTD
- HAMERSLEY RESOURCES LTD
- HAMERSLEY WA PTY LTD
- HOPE DOWNS IRON ORE PTY LTD
- ILMENITE RESOURCES PTY LTD
- MAMBA RESOURCE MANAGEMENT PTY LTD
- MULGA MINERALS PTY LTD
- ROBE RIVER LTD
- ROBE RIVER MINING CO. PTY LTD
- TALISMAN MINING LTD
- UNITED IRON PTY LTD
- WEST AUSTRALIAN MINISTER FOR STATE DEVELOPMENT
- WESTMAG LTD

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Local Land Use of West Angelas Study Area

Figure: 2.5
Project ID: 1457
Drawn: CP
Date: 05/09/2012

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CP101

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2.5 PILBARA BIOGEOGRAPHIC REGION

The Study Area is situated within the Pilbara Region of the Interim Biogeographic Regionalisation of Australia, IBRA 7 (Australian Government Department of Sustainability 2012). The Pilbara biogeographic region comprises four subregions: Hamersley, RT Plains, Chichester and Roebourne, and the Study Area lies within the Hamersley subregion (Figure 1.1). The Hamersley subregion encompasses 6,215,092 ha of the southern section of the Pilbara Craton. It is comprised of mountainous areas of Proterozoic sedimentary ranges and plateauxs, dissected by gorges (basalt, shale and dolerite). Mulga low woodland over bunch grasses on fine textured soils in valley floors, and *Eucalyptus leucophloia* over *Triodia brizoides* occur on the skeletal soils of the ranges. The climate is Semi-desert tropical, with an average 300 mm annual rainfall, usually in summer cyclonic or thunderstorm events, while winter rain is not uncommon. Drainage flows into either the Fortescue (to the north), the Ashburton to the south, or the Robe to the west (Kendrick and McKenzie 2001).

2.6 LAND SYSTEMS

The Study Area crosses the northern boundary of the area surveyed by Payne *et al* (1982) in the Regional Inventory of the Ashburton Rangelands and into the area surveyed by Van Vreeswyk *et al*. (2004) in the Regional Inventory of the Pilbara Rangelands. Both surveys documented the land systems present and their condition. Because the Survey Area intersects both Regional Inventory surveys, they will be discussed collectively for the purpose of the report. The Ashburton Regional Inventory (AIR) and Pilbara Regional Inventory (PIR) collectively cover an area of approximately 275,323 km^2, encompassing the Ashburton River and Rous Creek, part of the Yannarie River catchment, as well as the costal strip from and including Marrilla Station in the south, extending to Broome in the north-east.

Seven land systems mapped by Payne *et al* (1982) within the AIR and by Van Vreeswyk *et al*. (2004) in the PRI are present within the Study Area, each of which has been further classified by landform, soil, vegetation and drainage patterns (Table 2.3, Figure 2.6). The seven land systems within the Study Area include the Boolgeeda, Egerton, Elimunna, Newman, Platform, Rocklea and Wannamunna, with the Newman (71.4 km^2) and Boolgeeda (56.2 km^2) land systems being the most extensive.

The condition of vegetation of each land system within the AIR and PIR were also assessed. Regionally the majority of the area within each of these land systems was assessed to be in very good condition due to their inaccessibility and lack of palatable vegetation. The Elimunna and Wannamunna Land Systems are the exception, with only 39% and 44% assessed regionally as being in good or very good condition, respectively. The remaining percentage was assessed as either; fair, poor or very poor. The condition assessment for both Land Systems is due to the presence of vegetation that is attractive to grazing animals and prone to degradation if grazing pressure is excessive. The Wannamunna Land System is regionally restricted, comprising only 0.22% of the combined ARI and PRI areas surveyed by Payne *et al* (1982) and Van Vreeswyk *et al*. (2004). Within the Study Area it is also restricted, comprising only 0.3% of the total area. The area of each land system within the Study Area represents less than one percent of their individual regional distribution.

Given the aim of assessing the pastoral value of rangelands, the presence of the introduced grass **Cenchrus ciliaris* (Buffel grass) was not considered a negative indicator of condition, due to its perceived foraging value to pastoralists. However, this species is a serious environmental weed and the proportion of land systems in poor condition within an environmental context is therefore likely to be significantly higher, particularly for those land systems which support extensive stands of this species. Conversely the value of areas in which this species is not widespread is likely to be higher.

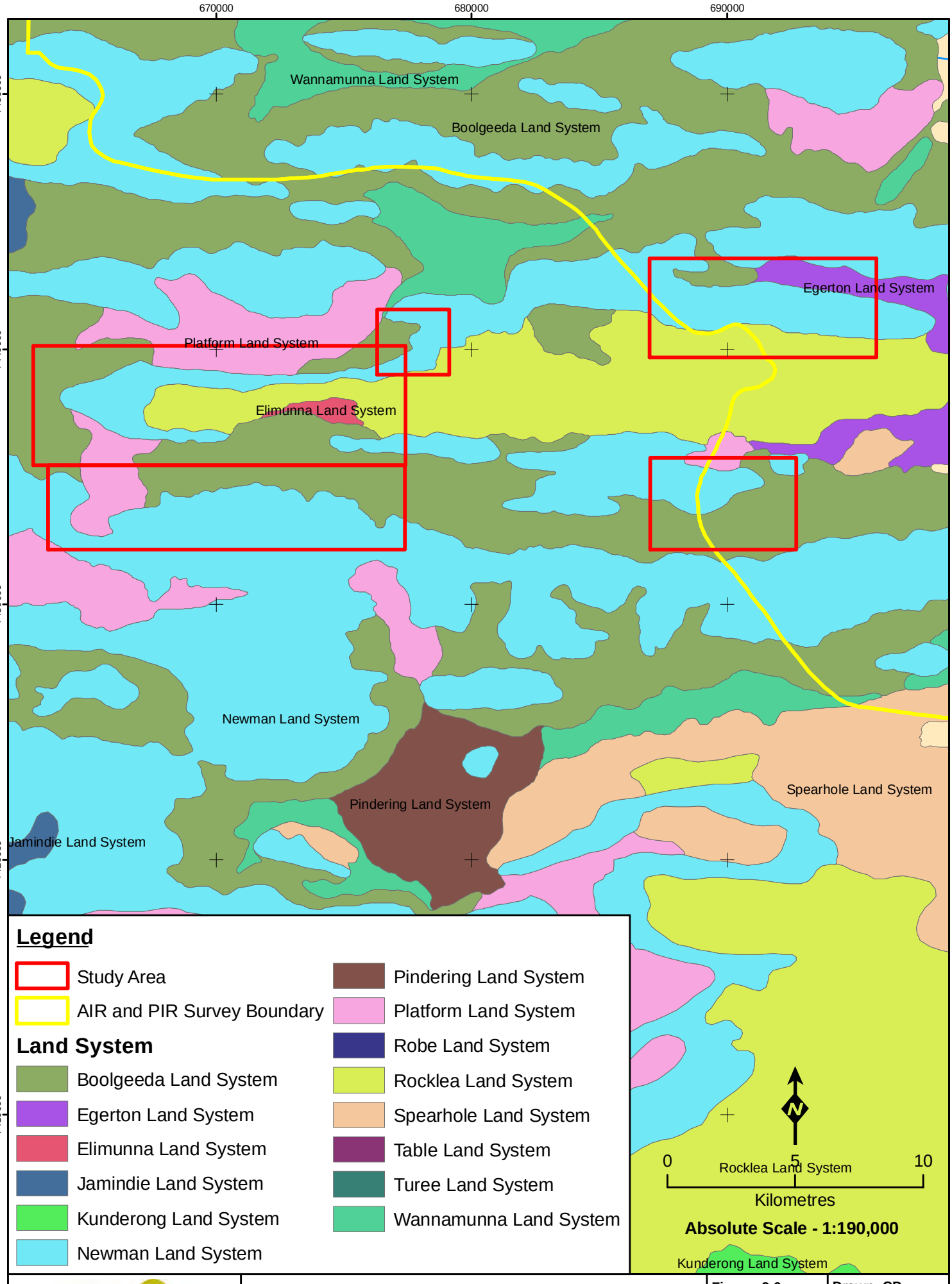
Table 2.3 – Extent of land systems present within the Study Area

Land System (% of Study Area)	Area (% of PIR and AIR combined)	Area within West Angelas Study Area (% of Land System)	Description	Vegetation Condition Assessment	Landform (and % of Land system)	Vegetation Community
Boolgeeda (32.01%)	10337 km^2 (3.8%)	56.2 km^2 (0.54%)	Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands and mulga shrublands.	Very good 82%, good 13%, fair 4%, poor 1%. Hard spinifex grasslands not preferred by livestock.	Low hill and rises (4%)	Hummock grasslands of *T. wiseana* and other *Triodia* spp. with very scattered *Acacia* spp. Shrubs.
					Stony slope and upper plain (20%)	Hummock grasslands of *T. lanigera*, *T. wiseana* or scattered tall shrublands of *A. aneura*, *A. ancistrocarpa*, *A. atkinsiana* and other *Acacia* spp., with occasional *Eucalyptus* trees.
					Stony lower plain (65%)	Hummock grasslands of *T. wiseana*, *T. lanigera* or *T. pungens*. Also scattered to moderately close tall shrublands of *A. aneura* and other *Acacia* spp. with hard and soft *Triodia* spp. ground layer.
					Grove (small drainage foci) (1%)	Moderately closed woodlands or tall shrublands of *A. aneura* with sparse low shrubs and tussock or hummock grasses.
					Narrow drainage floor and channel (10%)	Scattered to closed tall shrublands or woodlands of *A. aneura*, *A. atkinsiana* and *C. hamersleyana* with sparse low shrubs and hummock and tussock grasses. Occasionally hummock grasslands of *T. pungens*.
Egerton (2.52%)	3868 km^2 (1.40%)	4.4 km^2 (0.11%)	Dissected hardpan plains supporting mulga shrublands and hard spinifex hummock grasslands.	Very good 89%, good 11%. Vegetation not preferred by livestock.	Hardpan plains (10%)	Very scattered to scattered tall shrublands of *Acacia aneura* and other *Acacia* spp. with prominent ground layer of *Triodia* spp.
					Dissected slopes (75%)	Hummock grasslands of *Triodia brizoides*, *T. wiseana* with isolated *Acacia* shrubs and *Eucalypt*s.
					Calcrete drainage margins (6%)	Hummock grasslands of *T. wiseana* with sparse *Eucalyptus socialis* trees or mallees and isolated low shrubs.
					Drainage floors and channels (9%)	Moderately close woodlands/tall shrublands of *A. aneura* with other shrubs including *Senna* spp., *Ptilotus obovatus* and *Eremophila forrestii* with *Triodia* spp. ground layer.
Elimunna (1.15%)	656.6 km^2 (0.24%)	2.0 km^2 (0.30%)	Stony plains on basalt supporting	Very good 14%, good 25%, fair 35%, poor	Hills and low rises (10%)	Hummock grasslands of *Triodia wiseana* (hard spinifex) or very scattered shrublands of *Acacia* and *Senna* spp.

Land System (% of Study Area)	Area (% of PIR and AIR combined)	Area within West Angelas Study Area (% of Land System)	Description	Vegetation Condition Assessment	Landform (and % of Land system)	Vegetation Community
			Sparse *Acacia* and cassia shrublands and patchy tussock grasslands.	21%., very poor, 5% Vegetation attractive to grazing animals and prone to degradation if grazing pressure is excessive.	Stony plains (45%)	Very scattered to scattered mixed height shrublands with *Acacia aneura* (mulga) other *Acacia*s, *Senna* spp. (cassias) and *Eremophila* spp Occasionally with patchy *Triodia* spp. (hard spinifex) understorey.
					Gilgai plains (26%)	Patchy tussock grasslands with *Eragrostis xerophila* (Roebourne Plains grass), *E. setifolia* (neverfail), *Astrebla pectinata* (barley Mitchell grass) with isolated shrubs mainly *Eremophila* and *Senna* spp.
					Hardpan plains (6%)	Very scattered tall shrublands of *A. aneura* and other *Acacia*s.
					Groves (1%)	Moderately close to close tall shrublands of *A. aneura* with numerous other shrubs and patchy perennial grasses.
					Drainage floors (12%)	Tussock grasslands with *Astrebla* and *Eragrostis* spp. or very scattered to moderately close tall shrublands of *Acacia* spp. with various low shrubs and patchy tussock and/or hummock grasses.
Newman (40.66%)	21109 km^2 (7.7%)	71.4 km^2 (0.34%)	Rugged jaspilite plateaux, ridges and mountains supporting hard.	Very good 91%, good 7%, fair 1%, poor 1%. Inaccessible or poorly accessible and is unsuitable for pastoral purposes.	Plateaux, ridges, mountains and hills (70%)	Hummock grasslands of *Triodia wiseana*, *T. brizoides*, *T. plurinervata* with very scattered to scattered shrubs and trees including *Acacia* and *Senna* spp., *Grevillea wickhamii*, *Eucalyptus leucophloia* and other eucalypts. Occasionally hummock grass is *Triodia biflora*.
					Lower slopes (20%)	Similar to the vegetation community above.
					Stony plains (5%)	Hummock grasslands of *Triodia wiseana*, *T.* spp. (hard spinifex) with isolated to very scattered shrubs of *Acacia* and *Senna* spp. and occasional eucalypt trees. Occasionally hummock grasslands of *Triodia pungens* (soft spinifex).
					Narrow drainage floors with channels (5%)	Smaller floors support hummock grassland of *Triodia pungens* with very scattered shrubs. Larger floors and channel support tall shrublands/woodlands of *Acacia* spp. and *Eucalyptus victrix* with tussock grass or hummock grass understoreys.

Land System (% of Study Area)	Area (% of PIR and AIR combined)	Area within West Angelas Study Area (% of Land System)	Description	Vegetation Condition Assessment	Landform (and % of Land system)	Vegetation Community
Platform (9.75%)	2552 km^2 (0.9%)	17.1 km^2 (0.67%)	Dissected slopes and raised plains supporting hard spinifex grasslands.	Very good 97%, good 3%. Vegetation on this system is not preferred by livestock and is of Very little use for pastoralism. The system is not susceptible to erosion.	Stony upper plains (25%)	Hummock grasslands of *Triodia wiseana* and other *Triodia* spp. (hard spinifex) with isolated to very scattered *Acacia* spp. shrubs
					Dissected slopes (60%)	Hummock grasslands of *Triodia wiseana*, *T. plurinervata* (hard spinifex) with isolated to very scattered *Acacia* spp. shrubs or *Eucalyptus leucophloia* (snappy gum)
					Drainage floors (15%)	Scattered to close tall shrublands/woodlands with *Acacia citrinoviridis* (black mulga), *A. tumida* (pindan wattle) and other *Acacia*s, occasional eucalypt trees, numerous low shrubs including *Senna* spp. (cassias), *Ptilotus obovatus* (cotton bush), *Corchorus walcottii* (grey Corchorus) and *Triodia pungens* (soft spinifex)
Rocklea (13.89%)	31089 km^2 (11.3%)	24.4 km^2 (0.08%)	Basalt hills, plateaux, lowers slopes and minor stony plains supporting hard spinifex (and occasionally soft spinifex) grasslands.	Very good 89%, good 7%, fair 2%, poor 2% Spinifex grasslands inaccessible and not preferred by livestock.	Hills, ridges, plateaux and upper slopes (65%)	Hummock grasslands of *T. wiseana*, *Triodia* spp. or less frequently, of *T. pungens* with isolated to very scattered shrubs such as *A. inaequilatera* and *Senna* spp.
					Lower slopes (15%)	Hummock grasslands of *T. wiseana*, *Triodia* spp. Or less frequently, of *T. pungens* with isolated to very scattered shrubs such as *A. inaequilatera* and *Senna* spp.
					Stony plains and interfluves (10%)	Hummock grasslands of *T. wiseana* or less frequently *T. pungens* with isolated to very scattered shrubs such as *A. inaequilatera*. Occasionally grassy shrublands with *Acacia*, *Senna* and *Eremophila* spp.
					Gilgai plains (1%)	Tussock grasslands with *Astrebla pectinata*, *E. xerophila* and other perennial grasses.
					Upper drainage lines (4%)	Hummock grasslands of *T. wiseana* or *T. pungens* with very scattered to scattered *Acacia* shrubs and occasional *C. hamersleyana* trees.
					Drainage floors and channels (5%)	Scattered to moderately close tall shrublands or woodlands of *Acacia* and *Eucalyptus* spp. with numerous undershrubs and hummock grass understoreys or tussock grass understoreys.

Land System (% of Study Area)	Area (% of PIR and AIR combined)	Area within West Angelas Study Area (% of Land System)	Description	Vegetation Condition Assessment	Landform (and % of Land system)	Vegetation Community
Wannamunna (0.03%)	630.1 km^2 (0.22%)	0.04 km^2 (0.006%)	Hardpan plains and internal drainage tracts supporting mulga shrublands and woodlands (and occasionally eucalypt woodlands).	Very good 19%, good 25%, fair 19%, poor 21%., very poor, 16% The system supports low shrubs and tussock grasses which are highly preferred by grazing animals and are prone to degradation if grazing pressure is excessive.	Stony plains (8%	Very scattered to scattered tall shrublands of *Acacia aneura* (mulga) with sparse low shrubs and *Triodia* sp. (hard spinifex) understorey
					Hardpan plains (56%)	Very scattered tall or low shrublands of *Acacia aneura*, *Eremophila* spp., *Ptilotus obovatus* (cotton bush), *Maireana villosa*.
					Calcrete platforms (1%)	Scattered shrublands with *Acacia aneura* and other *Acacia*s, *Senna* spp. and *Triodia wiseana* (hard spinifex)
					Groves (15%)	Moderately close to closed woodlands of *Acacia aneura* with numerous undershrubs and tussock grasses such as *Chrysopogon fallax* (ribbon grass) and *Themeda triandra* (kangaroo grass).
					Internal drainage plains (20%)	Moderately close to closed woodlands of *Acacia aneura* and *Eucalyptus victrix* (coolibah) with sparse undershrubs such as *Muehlenbeckia florulenta* (lignum) and *Chenopodium auricomum* (swamp bluebush) and patchy tussock grasses. Also grasslands of *Eriachne* sp. with isolated *Eucalyptus victrix* trees and shrubs such as *M. florulenta* or grassy scattered woodlands of *E. victrix*



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Land Systems of West Angelas Study Area

Figure: 2.6	**Drawn: CP**
Project ID: 1457	**Date: 05/09/2012**

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CP103

A4

2.7 THREATENED ECOLOGICAL COMMUNITIES

2.7.1 Commonwealth Threatened Ecological Communities

Ecological communities are naturally occurring biological assemblages associated with a particular type of habitat. At a commonwealth (national) level, flora and Threatened Ecological Communities (TECs) are protected under the EPBC Act. An ecological community may be categorised into one of three sub-categories:

- Critically endangered if it is facing an extremely high risk of extinction in the wild in the immediate future.
- Endangered if it is not critically endangered and is facing a very high risk of extinction in the wild in the near future.
- Vulnerable if it is not critically endangered or endangered, and is facing a high risk of extinction in the wild in the medium-term future.

No Commonwealth listed TECs occur in the vicinity of the Study Area.

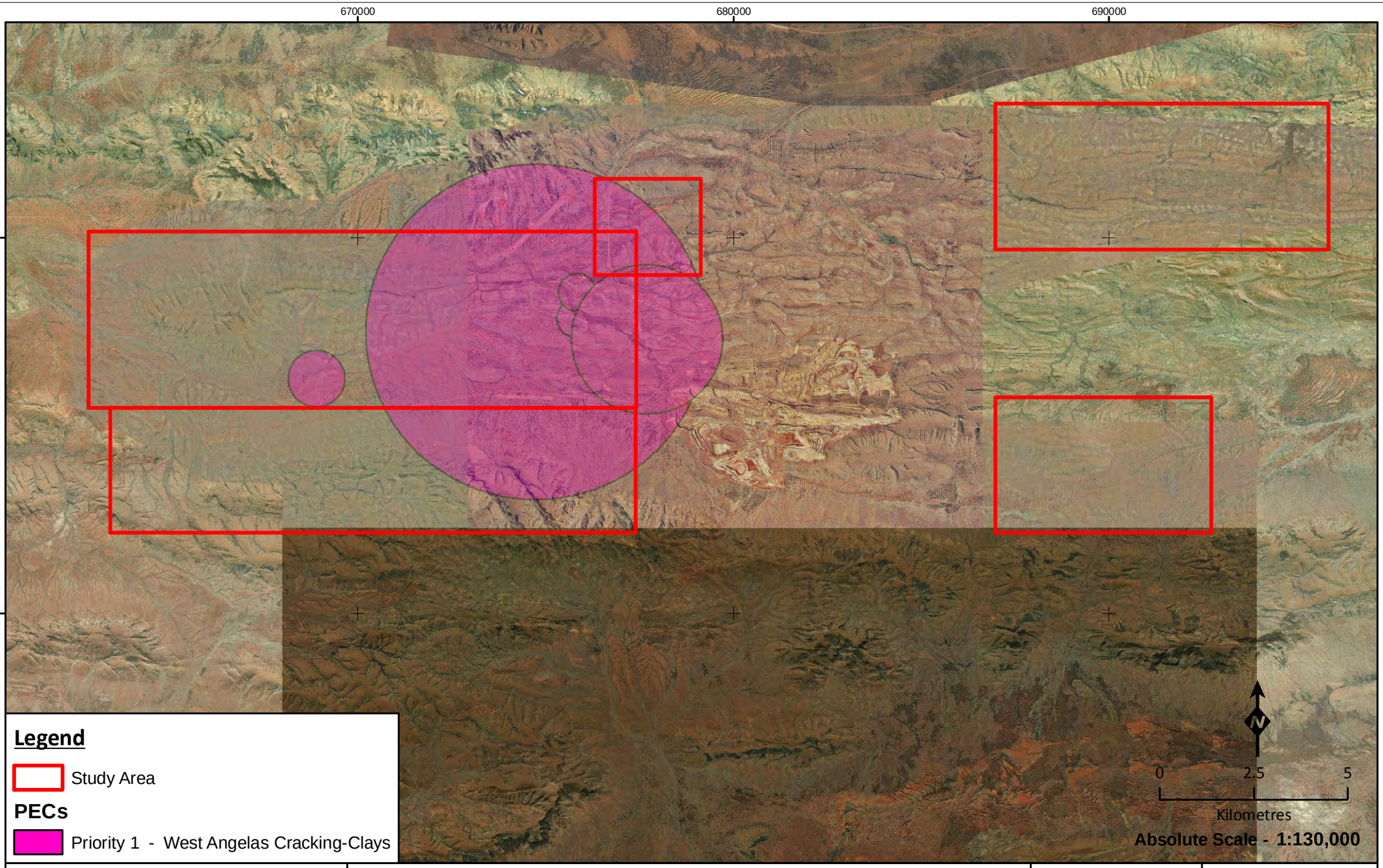
2.7.2 State Threatened Ecological Communities

The Western Australian DEC maintains a list of TECs which are further caterorised into three subcategories which replicate those of the EPBC Act, but with further definition of the threatening processes as detailed in Appendix D.

No state threatened ecological communities are located within a 40 km radius of the Study Area

2.7.3 State Priority Ecological Communities

The DEC also maintains a list of Priority Ecological Communities (PECs) which includes potential TECs that do not meet survey criteria, or that are not adequately defined. As at 13 April 2012 (Department of Environment and Conservation 2012), one Priority 1 PEC; West Angelas Cracking-Clays, has been identified to occur extensively within the Study Area (Figure 2.7). This community is further defined as open tussock grasslands of *Astrebla pectinata*, *A. elymoides*, *Aristida latifolia* in combination with *Astrebla squarrosa* and low scattered shrubs of *Sida fibulifera*, on basalt derived cracking-clay loam depressions and flowlines. Threats to this community include clearing for further mining expansion and future infrastructure development, weed invasion and changes in fire regimes.



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PECs of the West Angelas Study Area

Figure: 2.7
Project ID: 1457

Drawn: CP
Date: 20/09/2012

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CP138

A4

2.8 PREVIOUS VEGETATION SURVEYS

2.8.1 Beard Vegetation Descriptions

The Study Area lies within the area mapped by Beard (1975) within the Pilbara region of the Eremaean Botanical Province. The vegetation mapping was subsequently reinterpreted to reflect the National Vegetation Information System (NVIS) (Department of Environment and Water Resources 2012) standards, taxonomy revised where required and digitised (Shepherd *et al*. 2001). Two vegetation units have been mapped within the Study Area, the distributions and features of which are detailed in Figure 2.8 and Table 2.4, respectively.

Table 2.4 – Vegetation association codes.

Code	Structure	Vegetation Association	Species
18	Low woodland; mulga (*Acacia aneura*)	*Acacia* open shrubland / *Ptilotus* mixed open forbland	*Acacia aneura*, *Acacia pru*inocarpa, *Acacia aneura* var. *aneura Eremophila fraseri*, *Eremophila foliosissima*, *Eremophila exilifolia Senna* sp., *Solanum lasiophyllum*, *Ptilotus obovatus*.
82	Open hummock grassland	Hummock grasslands, low tree steppe; snappy gum over *Triodia wiseana*	*Eucalyptus leucophloia*, *Eucalyptus gamophylla*, *Senna artemisioides subs*p. x *sturtii*, *Dodonaea viscosa*, *Grevillea wickhamii*, *Triodia wiseana*, *Ptilotus rotundifolius*, *Acacia lycopodiifolia* and *Triodia wiseana*.

2.8.2 Finer Scale Vegetation Surveys

In recent history, strong iron ore prices have resulted in a boom in resource development projects in the Pilbara which has resulted in a significant increase in biological survey effort for the Bioregion. *ecologia* has reviewed previous survey data ranging from 1979 to the present day. During this period, the Greater West Angelas area has been subject to a series of previous vegetation, targeted flora and monitoring surveys. Infrastructure triggering previous vegetation surveys included: railway lines, gas pipelines, power stations, borefields and viable ore deposits. The most relevant spatial and temporal surveys to the current study are summarised in table Table 2.5.

Table 2.5 – Previous Vegetation Surveys at Greater West Angelas

Author	Survey	Year
ENV. Australia	Flora, Vegetation and Fauna Assessment of the Re-Aligned Gas Pipeline Corridor at West Angelas	2011
Rio Tinto	Flora and Vegetation Assessment of the West Angelas water pipeline Study Area	2011
Rio Tinto	Statement Addressing the 10 CP for West Angelas Power Station and Borrow Pits	2011
Biota Environmental Sciences	A Flora and Vegetation Survey of the Proposed West Angelas Gas-Fired Power Station and Pipeline Corridor	2010
Rio Tinto	Flora and Vegetation Assessment of the Proposed West Angelas Discharge Creekline Corridor (WADCC)	2009
ecologia Environment	West Angelas Multiple Areas Flora and Vegetation Survey & Desktop Fauna Assessment	2008
Biota Environmental Sciences	Vegetation and Flora Survey of West Angelas Deposits E and F	2006
Biota Environmental Sciences	Vegetation and Flora Survey of West Angelas Deposits E & F	2005
ME Trudgen & Associates	Flora & Vegetation Surveys of Orebody A & B in the West Angelas Hill Area	1998 (1995)

Of the surveys summarised in Table 2.5, the vegetation mapping conducted by Biota Environmental Sciences in 2006 and 2010 (Biota 2006, Biota 2010) and ME Trudgen & Associates (1998) are of particular relevance. These three are also quadrat based flora and vegetation assessments that encompass areas within and adjacent to the current Study Area.

The Biota survey, "Flora and Vegetation Survey of the Proposed West Angelas Gas-Fired Power Station" (Biota 2010), was a single phase Level Two flora and vegetation survey. A total of 262 taxa from 93 genera and 35 families were recorded from a combination of 37, 50 x 50 m bound quadrats and targeted searches.

Earlier, in 2006 Biota completed; "Flora Survey of West Angelas Deposits E and F" (Biota 2006), where 24 detailed flora quadrats and 17 releves, as well as observations in the field were used to record a total of 429 taxa of native vascular flora from 143 genera belonging to 53 families.

ME Trudgen & Associates (1998) mapped a large proportion of the current Study Area in "Flora & Vegetation Surveys of Orebody A & B in the West Angelas Hill Area" where 635 taxa were recorded.

Table 2.6 summarises the vegetation units of the three surveys mapped within the current Study Area. The most abundant unit from the ME Trudgen & Associates (1998) survey was vegetation unti *5edb,* covering 2,536.25 ha of the Study Area. In the 2006 survey conducted by Biota the most abundant vegetation unit was *H1*, *Eucalyptus leucophloia* low open woodland over *Acacia maitlandii*, *A*. *hamersleyensis* shrubland over *Triodia pungens* (*T*. *wiseana*) mid-dense hummock grassland, covering an area of 206.08 ha.

The most restricted vegetation units within the Study Area were units *6adb212* (0.06 ha) and *6adb213* (0.35 ha) from the ME Trudgen & Associates (1998) survey and unit *CdAanAprTsTp* (0.91 ha), *Corymbia deserticola*, *Acacia aneura*, *A. pruinocarpa* low open woodland over *Triodia sch*inz*ii*, *T. pungens* hummock grassland, from the Biota (2010) survey.

Table 2.6 – Summary of Vegetation Units of Previous Studies Within the Study Area

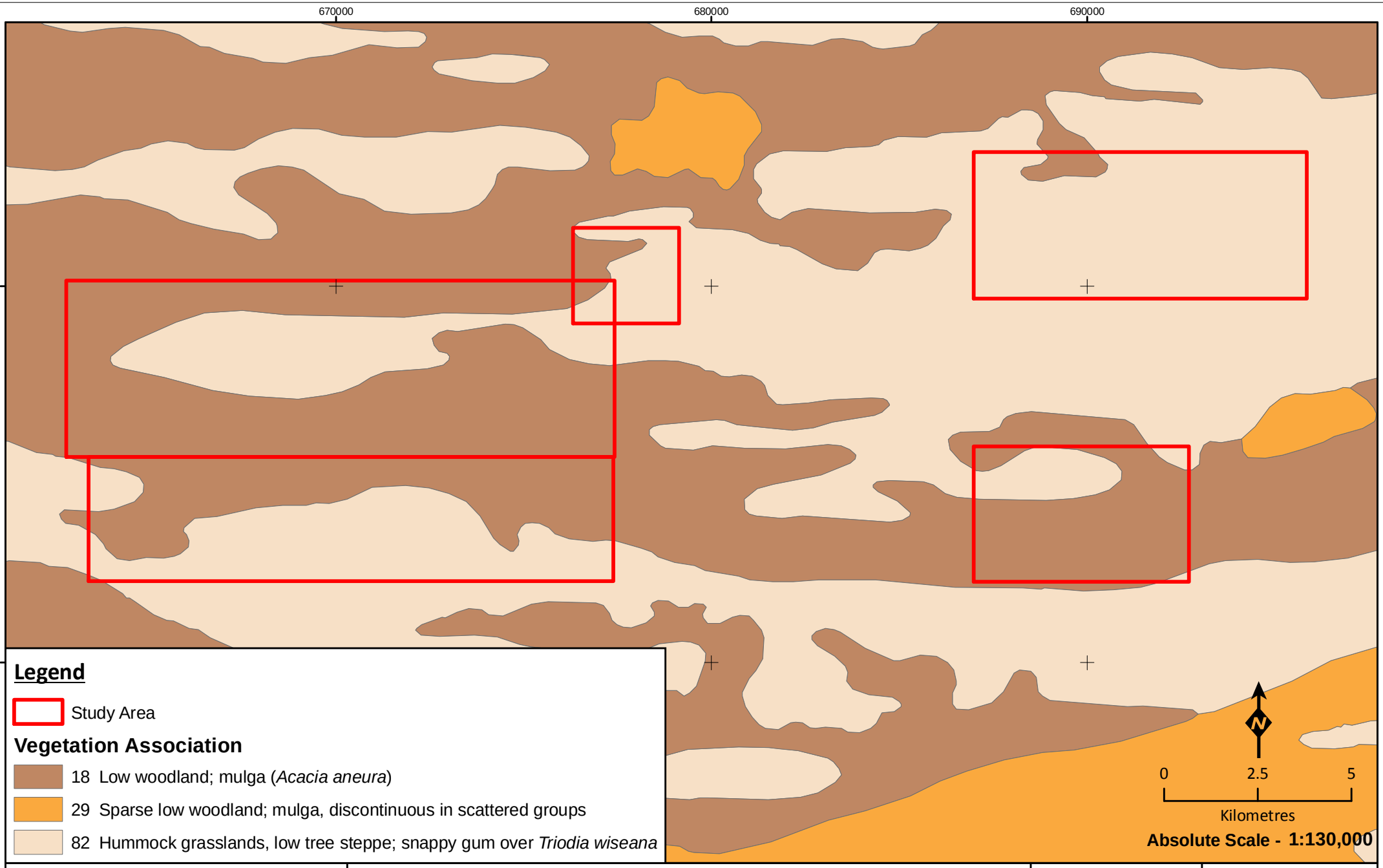
Biota (2010)			Biota (2006)			ME Trudgen & Associates(1998)		
Unit	**Description**	**Area (ha)**	**Unit**	**Description**	**Area (ha)**	**Unit**	**Description**	**Area (ha)**
AanAprRHeE RfoTHtTlo	*Acacia aneura*, *A. pruinocarpa* low woodland over *Rhagodia eremaea*, *Eremophila forrestii* open shrubland over *Themeda triandra* open *tussock* grassland, *Triodia longiceps* scattered hummock grasses	34.28	*C1*	*Eucalyptus* spp. scattered low trees over *Acacia maitlandii*, *Gossypium robinsonii*, *Petalostylis labicheoides* shrubland over *Triodia pungens* open hummock grassland *and Eriachne mucronata*, *Themeda triandra* open *tussock* grassland	40.38	*2cab*	*Eucalyptus xerothermica* low open woodland over *Acacia pruinocarpa* scattered tall shrubs over *Maireana* spp. Scattered low shrubs over *Triodia pungens* open hummock grassland with *Themeda triandra* scattered tussock grass	576.73
AanAprTbrTp	*Acacia aneura*, *A. pruinocarpa* tall open shrubland over *Triodia brizoides*, *T. pungens* hummock grassland	32.48	*C2*	*Eucalyptus xerothermica* low open woodland over *Acacia maitlandii*, *Petalostylis labicheoides*, *Rulingia luteiflora* shrubland to tall shrubland over *Triodia pungens* open hummock grassland	10.09	*2cac*	*Eucalyptus xerothermica* scattered low trees over *Acacia aneura* var. *longicarpa* and *Acacia* aff. *aneura* high shrubland over *Themeda triandra* and *Chrysopogon fallax* very open tussock grassland with *Triodia pungens* and *Triodia wiseana* scattered hummock grass	272.04
AanAprTp/A anTp	*Acacia aneura*, *A. pruinocarpa* tall open *scrub* over *Triodia pungens very* open hummock grassland; occurring in mosaic with groves of *Acacia aneura* low open *forest* over *Triodia pungens* hummock grassland	10.79	*H1*	*Eucalyptus leucophloia* low open woodland over *Acacia maitlandii*, *A. hamersleyensis* shrubland over *Triodia pungens (T. wiseana)* mid-dense hummock grassland	206.08	*5eda*	*Corymbia deserticola* scattered low trees over *Acacia bivenosa*, *Acacia pruinocarpa* and *Hakea chordophylla* scattered tall shrubs over *Cassia prunosa* scattered shrubs over *Triodia* aff. *basedowii* and *Triodia pungens* open hummock grassland	1,798.74
AanApyTHt	*Acacia aneura* low open woodland over *A. pyrifolia* scattered tall *shrubs* over *Themeda triandra tussock* grassland	21.88	*H2*	*Acacia catenulata* low woodland over *Triodia pungens* mid-dense hummock grassland	4.54	*5edac*	*Eucalyptus gamophylla* scattered low trees over *Acacia bivenosa*, A. pyrifolia scattered tall shrubs over *Triodia pungens* open hummock grassland	132.06
AanArERfoTp	*Acacia aneura* low woodland over *A. rhodophloia*, *Eremophila forrestii*, open shrubland over *Triodia pungens* open hummock grassland	8.23	*H3*	*Corymbia ferriticola*, *Eucalyptus leucophloia* low open woodland over *Triodia* sp. *Mt Ella*, *T. pungens* hummock grassland *and Eriachne mucronata* open *tussock* grassland	45.18	*5edacl*	*Eucalyptus gamophylla* scattered low trees over *Acacia bivenosa* scattered tall shrubs over *Triodia pungens* and *Triodia longiceps* open hummock grassland.	47.95

Biota (2010)			Biota (2006)			ME Trudgen & Associates(1998)		
Unit	**Description**	**Area (ha)**	**Unit**	**Description**	**Area (ha)**	**Unit**	**Description**	**Area (ha)**
AanArGbERf oERpCAsTp	*Acacia aneura* low woodland over *A. rhodophloia*, *Grevillea berryana* scattered tall *shrubs* over *Eremophila phyllopoda*, *E.* sp., *Cassia stricta* low open shrubland over *Triodia pungens very* open hummock grassland	21.31	*H4*	*Eucalyptus leucophloia* low open woodland over *Triodia wiseana* mid-dense hummock grassland *and Themeda triandra tussock* grassland	1.09	*5edad*	*Eucalyptus gamophylla* scattered low trees over *Acacia bivenosa* and *Acacia pyrifolia* scattered tall shrubs over *Triodia pungens* and *Triodia longiceps* open hummock grassland	665.01
AbApyTp	*Acacia bivenosa*, *A. pyrifolia* shrubland over *Triodia pungens* hummock grassland	1.50	*H5*	*Eucalyptus gamophylla* low woodland over *Triodia* aff. *basedowii (T. pungens)* mid-dense hummock grassland	111.44	*5edae*	*Scaervola acacioides* open shrubland over *Triodia pungens* open hummock grassland	296.24
AciTHtTp	*Acacia citrinoviridis* tall shrubland over *Themeda triandra* open *tussock* grassland over *Triodia pungens* scattered hummock grasses	38.86	*M1*	*Acacia aneura* low open woodland over *Acacia bivenosa*, *Gossypium robinsonii*, *Sida* aff. *cardiophylla*, *Scaevola parvifolia* shrubland to low open shrubland over *Triodia pungens*, *T. schinzii* mid-dense hummock grassland	184.02	*5edaf*	*Acacia aneura* var. *longicarpa* and *Acacia rhondophloia* high shrubland over *Eremophila fraseri* ssp. *fraseri*, *Eremophila lachnocalyx* and *Eremophila exilifolia* shrubland over *Triodia pungens* open hummock grassland	194.01
AiTbrTw	*Acacia* in*aequilatera* tall shrubland over *Triodia brizoides*, *T. wiseana* hummock grassland	60.56	*M2*	*Acacia aneura* low open woodland over *Triodia pungens*, *T.* aff. *basedowii* mid-dense hummock grassland	22.81	*5edag*	*Corymbia ferriticola* ssp. *ferriticola* low open woodland over *Acacia pruinocarpa* and *Acacia aneura* var. *aneura/ intermedia* high open shrubland over *Harneria kempeana* ssp. *muelleri* and *Ptilotus obovatus* shrubland over *Triodia pungens* and *Plectrachne melvillei* very open hummock grassland with *Themeda triandra* scattered tussock grassland.	24.22
AprAanAwTp	*Acacia pru*inocarpa, *A. aneura* tall open *scrub* over *A. wanyu* scattered *shrubs* over *Triodia pungens* hummock grassland	47.20	*M3*	*Acacia aneura* woodland over *Maireana villosa*, *Ptilotus obovatus*, *Rhagodia* sp. *Hamersley* open to low open shrubland over *Triodia* sp. *Mt Ella* open hummock grassland	129.84	*5edb*	*Acacia ayersiana*, *Acacia* aff. *aneura* (narrow green), *Acacia* Aff. *catenulata*, *Acacia* aff. *aneura* (grey, bushy form) and *Acacia* aff. *aneura* (scythe-shaped) high open shrubland over *Maireana* spp. low scattered shrubs over *Triodia pungens* very open hummock grassland	2,536.25
AprAciApyTp	*Acacia pru*inocarpa, *A. citrinoviridis*, *A.*	17.64	*M4*	*Acacia aneura*, *A. pruinocarpa* low *closed forest*	66.28	*5edbw*	*Eucalyptus leucophloia, Corymbia*	913.81

Biota (2010)			Biota (2006)			ME Trudgen & Associates(1998)		
Unit	**Description**	**Area (ha)**	**Unit**	**Description**	**Area (ha)**	**Unit**	**Description**	**Area (ha)**
	pyrifolia open shrubland over *Triodia pungens* hummock grassland			to low woodland over *Eremophila forrestii*, *E. longifolia*, *Ptilotus obovatus*, *Rhagodia* sp. *Hamersley* low open shrubland to open shrubland over *Triodia pungens* open hummock grassland			*hamersleyana* and *Eucalyptus pilbarensis* scattered low trees over *Acacia pruinocarpa* and *Acacia rhodophloia* scattered tall shrubs over *Ptilotus obovatus* scattered shrubs over *Triodia wiseana* and *Triodia pungens* hummock grassland	
AprAiTw	*Acacia pruinocarpa*, *A.* in*aequilatera* open shrubland over *Triodia wiseana* hummock grassland	50.13	*M5*	*Acacia aneura* low *closed forest* over *Triodia pungens* mid-dense hummock grassland	32.32	*5kd3r*	*Eucalyptus leucophloia* low open woodland over *Acacia pruinocarpa* scattered tall shrubs over *Triodia pungens* open hummock grassland.	885.70
ApyAciTp	*Acacia pyrifolia*, *A. citrinoviridis* tall shrubland over *Triodia pungens* open hummock grassland	2.46				*5kd3w*	*Eucalyptus leucophloia* low open woodland over *Triodia wiseana* open hummock grassland with *Eriachne mucronata* scattered tussock grass	15.50
AteTbr	*Acacia tenuissima* scattered *shrubs* over *Triodia brizoides* hummock grassland	17.78				*5kdm1*	*Eucalyptus leucophloia* scattered low trees over *Triodia* aff. *basedowii* and *Triodia pungens* open hummock grassland	687.41
CdAanAprTsTp	*Corymbia deserticola*, *Acacia aneura*, *A. pruinocarpa* low open woodland over *Triodia schinzii*, *T. pungens* hummock grassland	0.91				*5kdm2*	*Eucalyptus leucophloia* and *Corymbia hamersleyana* low open woodland over *Acacia maitlandii* scattered shrubs over *Triodia wiseana* open hummock grassland	1.16
ChAciGwRUlTp	*Corymbia hamersleyana*, *Acacia citrinoviridis* low woodland over *Grevillea wickhamii*, *Rulingia luteifolia* shrubland over *Triodia pungens* hummock grassland	23.19				*5kdm3*	*Eucalyptus leucophloia* scattered low trees over *Acacia pruinocarpa* scattered tall shrubs over *Triodia pungens* open hummock grassland	36.71
Disturbed	Cleared of native vegetation	4.53				*5kdmaf*	*Eucalyptus leucophloia* and *Corymbia ferriticola* low woodland over *Acacia pruinocarpa* and *Acacia anuran* var. *longicarpa* high open shrubland over *Ptilotus obovatus* and *Olearia stuartii* low open shrubland over *Triodia pungens* open hummock grassland	30.84

Biota (2010)			Biota (2006)			ME Trudgen & Associates(1998)		
Unit	**Description**	**Area (ha)**	**Unit**	**Description**	**Area (ha)**	**Unit**	**Description**	**Area (ha)**
EgAiAprAbTp	*Eucalyptus gamophylla*, *Acacia* in*aequilatera*, *A. pruinocarpa*, *A. bivenosa* open shrubland over *Triodia pungens* hummock grassland	19.26				*6/2ef*	*Eucalyptus victrix* open woodland over *Acacia aneura* var. *longicarpa* scattered tall shrubs over *Enneapogon* sp. and *Eriachne benthamii* tussock grassland over *Eragrostis pergracilis* and *Aristida contorta*	508.84
ElCdAiTbrTp	*Eucalyptus leucophloia*, *Corymbia deserticola* scattered trees over *Acacia* in*aequilatera* open shrubland over *Triodia brizoides*, *T. pungens* hummock grassland	8.00				*6adb212*	*Acacia* aff. *aneura* (narrow, green; M.E.T. 15,850), *Acacia* aff. *catenulata, Acacia* aff. *ayersiana* (narrow form; M.E.T. 15,786) and *Acacia ayersiana* high shrubland over *Plectrachne melvillei* and *Triodia pungens* scattered hummock grassland	0.06
EvAciTHtEUaCYaTp	*Eucalyptus victrix*, *Acacia citr*inoviridis low woodland over *Themeda triandra*, *Eulalia aurea*, *Cymbopogon ambiguus* open *tussock* grassland, *Triodia pungens* hummock grassland	3.76				*6adb213*	*Acacia* aff. *aneura* (scythe-shaped; MET 15,743), *A. pruinocarpa*, A. aff. *aneura* (grey, bushy form; MET 15,732 high shrubland over *Eremophila forrestii* subsp. *forrestii* scattered shrubs over *Triodia pungens* very open hummock grassland	0.35
						6adb215	*Aristida contorta* open annual tussock grassland	13.17
						6adb231	*Acacia* aff. *aneura* (grey, bushy form; M.E.T. 15,732) and *Acacia aneura* var. *longicarpa* high open shrub land over *Triodia pungens* very open hummock grassland	627.79
						6adb232	*Acacia aneura* var. *longicarpa* high shrubland over *Rhagodia* sp. Hamersley, *Ptilotus obovatus* open shrubland over *Digitaria brownii* scattered tussock grassland	1.09
						6adb26	*Acacia* aff. *aneura* and *Acacia pruinocarpa* scattered tall trees over *Maireana* spp. scattered low shrubs	167.00

Biota (2010)			Biota (2006)			ME Trudgen & Associates(1998)		
Unit	**Description**	**Area (ha)**	**Unit**	**Description**	**Area (ha)**	**Unit**	**Description**	**Area (ha)**
							over *Triodia pungens* open hummock grassland with *Themeda triandra* scattered tussock grass	
						8bj	*Acacia aneura* var. *longicarpa* and *Acacia pruinocarpa* high open shrubland over *Acacia pyrifolia* and cassia *oligophylla* scattered shrubs over *Triodia wiseana* and *Triodia pungens* open hummock grassland	947.73
						8bja	*Eremophila fraseri spp. fraseri* and *Acacia pyrifolia* scattered shrubs over *Triodia wiseana* open hummock grassland	3.12
						8db/8dc	*Astrebla pectinata*, *Astrebla elymoides* and *Aristida latifolia* open tussock grassland	239.13
						8dd	*Sida fibulifera* low scattered shrubs over *Astrebla squarrosa* tussock grassland	11.12
						11kb	*Acacia* sp., *Acacia pyrifolia* and *Acacia bivenosa* scattered shrubs over *Triodia wiseana* open hummock grassland	139.81



ecologia ENVIRONMENT

Shepherd *et al.* (2001) Vegetation Units of West Angelas Study Area

Figure: 2.8
Project ID: 1457

Drawn: CP
Date: 16/10/2012

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CP104

A4

2.8.3 Previous Records of Priority Flora at West Angelas

Searches of the DEC database, the Department's Threatened Flora Database (DEFL) and the Western Australian Herbarium's specimen database were conducted for all records within a polygon encompassing the West Angelas Study Area and a 40 km buffer zone. In addition, the published Threatened and Priority Taxa listing was searched for records for which the named location is within the search area. The latter search is less precise as no coordinates are provided for records retrieved.

Two EPBC listed, Threatened Flora (Declared Rare Flora) have previously been recorded within the search area: *Thrypt*o*mene wittweri* from the location-based search of the Threatened and Priority listing and *Lepidium catapycnon* from the spatial DEFL and Western Australian Herbarium searches. Twenty nine other Priority flora were also recoded in the location based search and 37 additional records resulted within the 40 km spatial database search area. Thirteen locations of *Lepidium catapycnon* are present within the 40 km search area, with the closest falling within 4 km of the Study Area boundary (Figure 2.9).

A review of RT spatial data and the DEC database revealed that 11 species of Priority flora were observed to occur within the Study Area; *Aristida lazaridis*, *Dampiera me*tall*orum Eremophila forrestii sub*sp. Pingandy (M.E. Trudgen 2662), *Goodenia* sp. East Pilbara (A.A. Mitchell PRP 727), *Indigofera* sp. Gilesii (M.E. Trudgen 15869), *Oldenlandia* sp. Hamersley Station (A.A. Mitchell PRP 1479), *Rhagodia* sp. *Hamersley* (M. Trudgen 17794), *Sida* sp. *Barlee Range* (S. van Leeuwen 1642), *Tetratheca fordiana*, *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) and *Triodia* sp. Mt Ella (M.E. Trudgen 12739).

The likelihood of occurrence of each taxon within the Study Area was assessed based on distribution and known habitat preference (Table 2.8), using the following rankings:

Table 2.7 – Criteria used to Assess Likelihood of Occurrence of Significant Flora at West Angelas.

Likelihood of Occurrence	Criteria
Certain	The taxon has already been recorded within the Study Area.
Probable	Due to the proximity of previous records (<2 km) and the presence of suitable habitat, the taxon is considered highly likely to occur.
Likely	Given the presence of suitable habitat and moderate proximity (2-10 km) of previous records, the taxon is considered likely to occur.
Possible	The habitat specificity of the taxon is only broadly defined, or is not defined and/or there are no current records within 10 km. However there is insufficient information available to exclude the possibility of occurrence.
Unlikely	The habitat specificity of the taxon is well defined from previous records and the habitat is considered unlikely to be present within the Study Area.

Table 2.8 – Priority Flora Previously Recorded in the Vicinity of the West Angelas.

Conservation Status	Taxon	Family	Source	Bio-region	Habitat (WA Herbarium 2012)	Nearest Localities or Towns	Flowering Period	Likelihood of Occurrence
4	*Acacia bromilowiana*	Fabaceae	WAHERB, DRF, DEC	PILB	High in landscape, summit of hill and on steep slope, skeletal red gritty soil over massive basalt type rock	Tom Price, Balfour Downs Stn, West Angelas, Hope Downs, Hamersley Ranges, Marillana Stn, Ophthalmia Range	Jul-Aug	Probable
3	*Acacia daweana*	Fabaceae	DEC	PILB	Very stony red loam, gentle slope	Hamersley Range, Karijini N.P.	Jul	Possible
3	*Acacia effusa*	Fabaceae	WAHERB, DRF, DEC	PILB	Stony red loam. Scree slopes of low ranges	Mt Bruce, Hamersley Ra., Karijini N.P., Juna Downs	May to Aug	Likely
3	*Acacia* aff. *subtiliformis*	Fabaceae	WAHERB, DRF, DEC	PILB	On rocky calcrete plateaus	Hamersley Ranges, Hancock Range, Ophthalmia Range, Hope Down North, Marillana Stn	Jul, Aug	Likely
2	*Adiantum capillus-veneris*	Pteridaceae	DEC	PILB, SWAN	Moist, sheltered sites in gorges and on cliff walls	Hamersley Range, Karijini N.P., Peppermint Grove	-	Unlikely
1	*Aluta quadrata*	Myrtaceae	RT	PILB	Edge of creek beds, base of cliffs, rocky crevices, near crest of ridge	Mt Channar, Paraburdoo	May-Jun	Unlikely
3	*Ampelopteris prolifera*	Thelypteridaceae	DEC	KIMB, PILB	Near water or in wet ground	Barlee Range N.R., Doongan Stn, Karijini N.P., Prince Regent River	-	Unlikely
2	*Aristida calycina* var. *calycina*	Poaceae	DEC	PILB	Red earths, sands, alluvial soils	Karijini N.P., Eastern States	-	Unlikely
2	*Aristida lazaridis*	Poaceae	DEC, RT	PILB	Sand or loam	Karijini N.P., Queensland	Apr	Certain
1	*Barbula ehrenbergii*	Pottiaceae	DEC	PILB	Gorge wall, restricted to a small area where water trickles down the wall. On rock iron rich, weathered conglomerate	Dale's Gorge, Hamersley Range	-	Unlikely
1	*Bothriochloa decipiens* var. *cloncurrensis*	Poaceae	DEC	PILB	On a stony clay plain. Red-brown clay loam with a sparse surface mantle of ironstone	Hamersley Range, Queensland	-	Unlikely

Conservation Status	Taxon	Family	Source	Bio-region	Habitat (WA Herbarium 2012)	Nearest Localities or Towns	Flowering Period	Likelihood of Occurrence
1	*Brachyscome* sp. Wanna Munna Flats (S. van Leeuwen 4662)	Asteraceae	WAHERB	PILB	Plain; deep clay loam with very fine buckshot gravel along with a clay crust on the surface	Tom Price, Newman	July, Sep	Possible
1	*Brunonia* sp. Long hairs (D.E. Symon 2440)	Goodeniaceae	WAHERB	CR, PILB	Along creeklines and floodplains in clay or sandy clay	West Angelas, Newman	Ma	Likely
3	*Calotis latiuscula*	Asteraceae	DEC	GOLD, PILB	Sand, loam. Rocky hillsides, floodplains, rocky creeks or river beds	Giles, Warburton, Blackstone Range, Rawlinson Range, Hamersley Range	Jun to Oct	Possible
1	*Calotis squamigera*	Asteraceae	DEC	PILB	Plain with pebbly red-brown loam with loam surface.	Wittenoom, Hamersley Range	-	Possible
2	*Cladium procerum*	Cyperaceae	DEC	PILB	Perennial pools	Karijini N.P., Millstream-Chichester N.P.	Nov	Unlikely
3	*Dampiera anonyma*	Goodeniaceae	DEC	PILB	High in landscape, summit of hill and on steep slope, skeletal red gritty soil over massive basalt type rock (Jerrinah formation)	Mt Bruce, Mt Nameless, Hamersley Ranges, Mt Sheila, Karijini NP	Jun-Aug	Unlikely
3	*Dampiera metallorum*	Goodeniaceae	WAHERB, DRF, DEC	PILB	Rocky ledges and breakaways with loose scree material in lower section of plot.	Hamersley Range, Mt Meharry, West Angelas, Karijini NP	Sep	Certain
1	*Dicrastylis mitchellii*	Laminaceae	WAHERB, DEC	MWST, PILB	Sand or clay soils around dunes	Killara Stn, Turee Creek	Oct	Possible
1	*Eragrostis* sp. Mt Robinson (S. van Leeuwen 4109)	Poaceae	WAHERB, DRF, DEC	PILB	Red-brown skeletal soils, ironstone. Steep slopes, summits	Hamersley Range	Sep	Likely
2	*Eremophila forrestii* subsp. Pingandy (M.E. Trudgen 2662)	Scrophulariaceae	WAHERB, DRF, DEC, RT	PILB	Flat terrain, low in landscape, base of broad valley, stony gibber plain above shallow drainage line, red clay-loam	Karijini NP, Hamersley Range NP, Turee Creek Stn	May-Jul	Certain
3	*Eremophila forrestii* subsp. *viridis*	Scrophulariaceae	DEC	PILB	Dune. Red [sand]	Hamersley Range, Onslow, Canning Stock Route	Aug	Unlikely
4	*Eremophila magnifica* subsp. *magnifica*	Scrophulariaceae	WAHERB, DEC	PILB	High in landscape, summit of hill, skeletal red brown soil over massive ironstone, Brockam Iron Formation.	Hamersley Ranges, Tom Price, Marandoo, Wittenoom	Jul-Sep	Possible

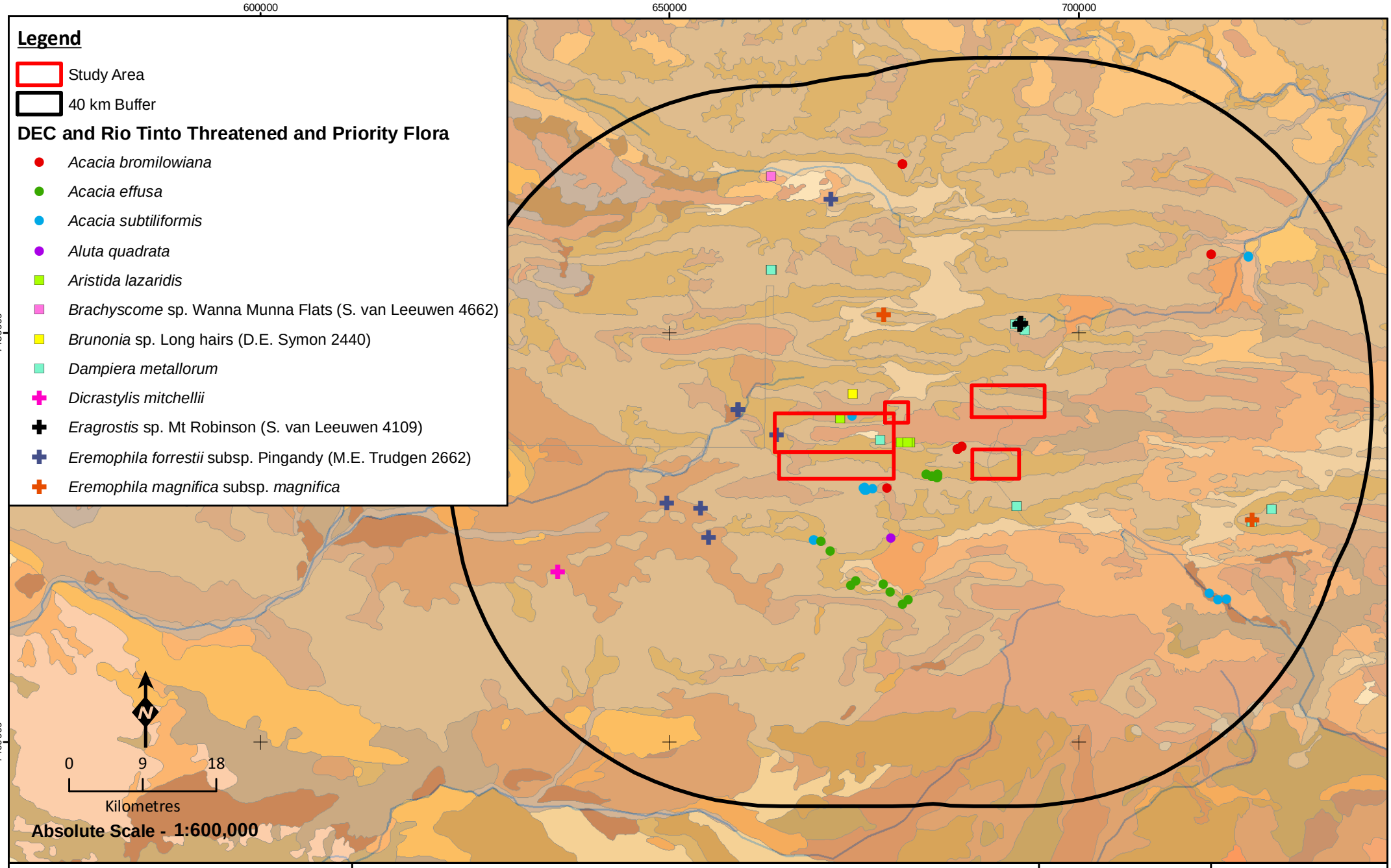
Conservation Status	Taxon	Family	Source	Bio-region	Habitat (WA Herbarium 2012)	Nearest Localities or Towns	Flowering Period	Likelihood of Occurrence
3	*Eremophila magnifica* subsp. *velutina*	Scrophulariaceae	WAHERB, DRF, DEC	PILB	Skeletal soils over ironstone. Summits	Hamersley Ranges, Newman, Marandoo	Jul-Sep	Possible
1	*Eremophila* sp. Hamersley Range (K. Walker KW 136) PN	Scrophulariaceae	DEC	PILB	Summit of hill, high in landscape, steep rock slopes and scree, skeletal brown-red soil over massive banded ironstone of the Brockman Iron Formation	Newman, Hamersley Range	Aug	Likely
1	*Eremophila* sp. Snowy Mountain (S. van Leeuwen 3737)	Scrophulariaceae	DEC	PILB	Summit of hill, high in landscape, skeletal red gritty soil over massive ironstone of the Brockman Iron Formation	Hamersley Range	-	Unlikely
1	*Eremophila* sp. West Angelas (S. van Leeuwen 4068)	Scrophulariaceae	WAHERB, DEC	PILB	High in landscape, summit of hill, gently undulating to steep terrain, skeletal red gritty soil over massive banded iron of the Brockman Iron Formation	West Angela Hill, Opthalmia, Hamersley Range	Sep-Oct	Likely
3	*Eriachne* sp. Dampier Peninsula (K.F. Kenneally 5946)	Poaceae	DEC	KIMB	Plain. Red-brown sandy loam	Karijini N.P., Dampier Peninsula, King Hall Is.	Mar-Apr	Possible
1	*Eucalyptus lucens*	Myrtaceae	DEC	PILB	Rocky mountain top; ironstone.	Hamersley Range	-	Unlikely
2	*Euphorbia clementii*	Euphorbiaceae	DRF	PILB	Sandplains, gravelly hillsides, stony grounds	Ashburton and Yule River	-	Likely
2	*Euphorbia* sp. *Mt Bruce flats (S. van Leeuwen 3861)*	Euphorbiaceae	DEC	PILB	Sump, low in landscape, alluvial cracking clay loamy soil, gritty with ironstone fragments, some sinkholes	Karijini NP	-	Possible
3	*Euphorbia stevenii*	Euphorbiaceae	DEC	KIMB, PILB	Bedrock rise with thin proximal colluvium. Gently inclined slope, cracking black clay plain	Karijini N.P., Kununurra	-	Possible
3	*Fimbristylis sieberiana*	Cyperaceae	DEC	KIMB, PILB	Mud, skeletal soil pockets. Pool edges, sandstone cliffs	Hamersley Range, Millstream, Fitzroy Crossing, King Leopold Range, Halls Creek, Little Sandy Desert	May to Jun	Unlikely

Conservation Status	Taxon	Family	Source	Bio-region	Habitat (WA Herbarium 2012)	Nearest Localities or Towns	Flowering Period	Likelihood of Occurrence
3	*Geijera salicifolia*	Rutaceae	DEC	PILB	Red skeletal sand in massive rock scree, high in landscape.	Mt Samson, Mt Howieson, Tom Price, Hamersley Ranges, Qld, NT	-	Unlikely
1	*Genus* sp. Hamersley Range hilltops (S. van Leeuwen 4345)	Asteraceae	DEC	PILB	Skeletal, brown gritty soil over ironstone. Hill summit	Hamersley Range	-	Unlikely
3	*Goodenia lyrata*	Goodeniaceae	WAHERB, DRF	PILB, GIB, MUR	Red sandy loam. Near claypan	Newman, Gibson Desert Nature Reserve, Coodewonna Flats	Aug	Possible
4	*Goodenia nuda*	Goodeniaceae	RT	PILB	Wide alluvial plain or creek beds. Red-brown clay loam, ironstone.	Dry brown-red sand – loam occasionally in areas of recent burns	Apr to Aug	Likely
3	*Goodenia* sp. East Pilbara (A.A. Mitchell PRP 727)	Goodeniaceae	DRF, RT	PILB, GAS	Red-brown clay soil, calcrete pebbles. Low undulating plain, swampy plains	Tom Price, Newman	Mar, Apr	Certain
1	*Grevillea* sp. Turee (J. Bull & G. Hopkinson ONS JJ 01.01) PN	Proteaceae	DEC	PILB	Breakaways and scree slopes, orange-brown loam soils	Paraburdoo, Tom Price, Karijini, Newman	Feb-Mar	Likely
2	*Hibiscus* sp. Gurinbiddy Range (M.E. Trudgen MET 15708) PN	Malvaceae	DEC	PILB	Near summit of hill, high in landscape, skeletal red-brown stony soil over massive ironstone of the Brockman Iron Formation	Hamersley Range, Karijini N.P.	May, Jul	Probable
1	*Hibiscus* sp. Mt Brockman (E. Thoma ET 1354) PN	Malvaceae	DEC	PILB	Rocky Places and Gorges	Hamersley Range, Tom Price	Aug	Unlikely
3	*Indigofera* sp. Gilesii (M.E. Trudgen 15869)	Fabaceae	WAHERB, DRF, DEC, RT	GOLD, KIMB, PILB	Pebbly loam amongst boulders & outcrops. Hills	Hamersley Range, Meekatharra, West Angelas, Rawlinson Range, Tanami Desert	May, Aug	Certain
2	*Indigofera ixocarpa*	Fabaceae	DEC	PILB	High in landscape, summit of hill, skeletal red brown soil over massive ironstone, Brockam Iron Formation.	Marandoo, Tom Price, Nullagine, Karijini NP	Mar, May	Possible
3	*Indigofera* sp. Bungaroo Creek (S. van Leeuwen 4301)	Fabaceae	DEC	PILB	Cracking loam flat with some flow channels. Soil: red-brown loam, pebbly.	Hamersley Range, Tom Price	Jul	Unlikely
3	*Iotasperma sessilifolium*	Asteraceae	DEC	PILB	Cracking clay, black loam. Edges of waterholes, plains	Ethel Creek Stn, Coolawanya Stn, Juna Downs Stn, Hamersley Range	Jul-Sep	Possible

Conservation Status	Taxon	Family	Source	Bio-region	Habitat (WA Herbarium 2012)	Nearest Localities or Towns	Flowering Period	Likelihood of Occurrence
2	*Isotropis parviflora*	Fabaceae	DEC	KIMB, PILB	Valley slope of ironstone plateau.	East Angelas, Karijini N.P., Tanami Desert	Feb-Mar, May	Possible
1	*Josephinia* sp. Marandoo (M.E. Trudgen 1554)	Pedaliaceae	WAHERB, DRF, DEC	PILB	Outer edge of creek vegetation. Soil: Orange-brown (terracotta) coloured clay-loam	Marandoo, West Angelas	-	Likely
T	*Lepidium catapycnon*	Brassicaceae	WAHERB, DRF, DEC	PILB	Skeletal soils. Hillsides	Wittenoom Gorge, Hamersley Range, Weeli Wolli, Newman	Oct-Jan?	Likely
3	*Nicotiana umbratica*	Solanaceae	DEC	PILB	Shallow soils. Rocky outcrops	Newman, Karijini N.P., Marble Bar, Woodstock, Abydos	Apr, Jun, Sept	Possible
3	*Oldenlandia* sp. Hamersley Station (A.A. Mitchell PRP 1479)	Rubiaceae	WAHERB, DEC	PILB	Cracking clay, basalt. Gently undulating plain with large surface rocks, flat crabholed plain	Millstream-Chichester N.P., Hamersley Range, Caoolawanyah Stn	Mar-May, Jul	Certain
3	*Olearia mucronata*	Asteraceae	WAHERB, DRF, DEC	GOLD, PILB	Schistose hills, along drainage channels	Hamersley and Chichester Range area, West Angelas, Paraburdoo, Mt Margaret, Mt Keith, Wiluna	Aug-Jan	Likely
2	*Oxalis* sp. Pilbara (M.E. Trudgen 12725)	Oxalidaceae	WAHERB, DEC	PILB	Gully. Brown-red loam, cobbles and pebbles	Karijini N.P., Hamersley Range	May	Likely
3	*Phyllanthus aridus*	Phyllanthaceae	DEC	KIMB, PILB	Sandstone, gravel, red sand.	West Kimberley, Chichester Range, West Angelas, Pardoo, Shay Gap, Doongan Homestead, Durack River	May-Jun	Possible
2	*Pilbara trudgenii*	Asteraceae	WAHERB, DRF, DEC	PILB	Skeletal, red stony soil over ironstone. Hill summits, steep slopes, screes, cliff faces	Hamersley Range	Sep-Oct	Likely
4	*Ptilotus mollis*	Amaranthaceae	RT	LSD, PILB	Stony hills and screes	Tom Price, Paraburdoo, Marble Bar, Hamersley Range National Park	May or Sep	Unlikely
3	*Rhagodia* sp. Hamersley (M. Trudgen 17794)	Chenopodiaceae	WAHERB, DRF, DEC, RT	PILB	Broad plain at the base of hills (enclosed on all sides). Red brown clay/ loam. Ironstone pebbles	Hamersley Ranges	May	Certain
1	*Rhodanthe ascendens*	Asteraceae	WAHERB, DRF, DEC	MWST, PILB	Clay	Gascoyne Junction, Middalya Station, Karijini N.P.	Aug	Likely

Conservation Status	Taxon	Family	Source	Bio-region	Habitat (WA Herbarium 2012)	Nearest Localities or Towns	Flowering Period	Likelihood of Occurrence
4	*Rhynchosia bungarensis*	Fabaceae	DEC	MWST, PILB	Pebbly, shingly coarse sand amongst boulders. Banks of flow line in the mouth of a gully in a valley wall.	Hamersley Ranges, Chichester Ranges, Yardie Creek, Robe River, Tom Price, Ashburton, East Lewis Island, Burrup Peninsula, Dampier Archipelago	May-Dec	Unlikely
3	*Rostellularia adscendens* var. *latifolia*	Acanthaceae	WAHERB, DEC	PILB	Ironstone soils. Near creeks, rocky hills	Hamersley Ranges	Apr to May	Likely
2	*Scaevola* sp. Hamersley Range basalts (S. van Leeuwen 3675)	Goodeniaceae	DEC	PILB	Skeletal, brown gritty soil over basalt. Summits of hills, steep hills	Hamersley Range	Jul to Aug	Unlikely
3	*Sida* sp. Barlee Range (S. van Leeuwen 1642)	Malvaceae	WAHERB, DEC, RT	PILB	Skeletal red soils pockets. Steep slope.	Barlee Range, Turee Creek, Paraburdoo, Hamersley Range	Aug	Certain
1	*Sida* sp. Hamersley Range (K. Newbey 10692)	Malvaceae	DEC	PILB	High in landscape, summit of hill, skeletal red stony soil over massive Brockman Iron Formation bedrock	Hamersley Range, Lawloit Range	-	Unlikely
2	*Spartothamnella puberula*	Lamiaceae	WAHERB, DRF, DEC	PILB	Rocky loam, sandy or skeletal soils, clay. Sandplains, hills	Mt Bruce, Hamersley Range, West Angelas, NT	Sep to Nov	Likely
1	*Tetratheca fordiana*	Elaeocarpaceae	WAHERB, DRF, DEC, RT	PILB	Shale pocket amongst ironstone	West Angelas, Hamersley Range	Sep	Certain
1	*Teucrium pilbaranum*	Lamiaceae	WAHERB	PILB	Crab hole plain in a river floodplain, margin of calcrete table	Millstream National Park, Wittenoom	May or Sep	Likely
3	*Themeda* sp. Hamersley Station (M.E. Trudgen 11431)	Poaceae	WAHERB, DEC, RT	PILB	Red clay. Clay pan, grass plain	Karratha, Millstream, Hamersley Stn, West Angelas, Coondewanna Flats	Aug	Certain
T	*Thryptomene wittweri*	Myrtaceae	WAHERB, DRF, DEC	GOLD, MWST, PILB	Skeletal red stony soils. Breakaways, stony creek beds	Hamersley Range, Mt Augustus, Carnarvon Range, White Cliffs Stn, NT	Aug-Oct	Possible
3	*Triodia* sp. Mt Ella (M.E. Trudgen 12739)	Poaceae	WAHERB, DEC, RT	PILB	Light orange-brown, pebbly loam. Amongst rocks & outcrops, gully slopes	Hamersley Range, Mt Ella	-	Certain
3	*Triodia* sp. *Robe River* (M.E. Trudgen et al. MET 12367)	Poaceae	DEC	PILB	Rangeland. Hillside and hill top. Brown/red ironstone gravel	Yarraloola Stn, Yalleen Stn., Red Hill Stn., Mt Stuart Stn., Hamersley Range	-	Unlikely

Conservation Status	Taxon	Family	Source	Bio-region	Habitat (WA Herbarium 2012)	Nearest Localities or Towns	Flowering Period	Likelihood of Occurrence
2	*Vigna* sp. *central* (M.E. Trudgen 1626)	Fabaceae	DEC	PILB	Plain with thin sheet of sand (light orange / brown) over compacted hardpan and limestone rock	Karijini N.P., Nyang Stn, Warrawagine Stn	May-Jun, Oct	Possible
1	*Vittadinia* sp. Coondewanna Flats (S. van Leeuwen 4684)	Asteraceae	WAHERB, DEC	PILB	Flat plain. Red sandy clay-loam.	Hamersley Range	Jul	Probable



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Regional Threatened and Priority Flora of Greater West Angelas - Map A

Figure: 2.9
Project ID: 1457

Drawn: CP
Date: 19/09/2012

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CPXXX

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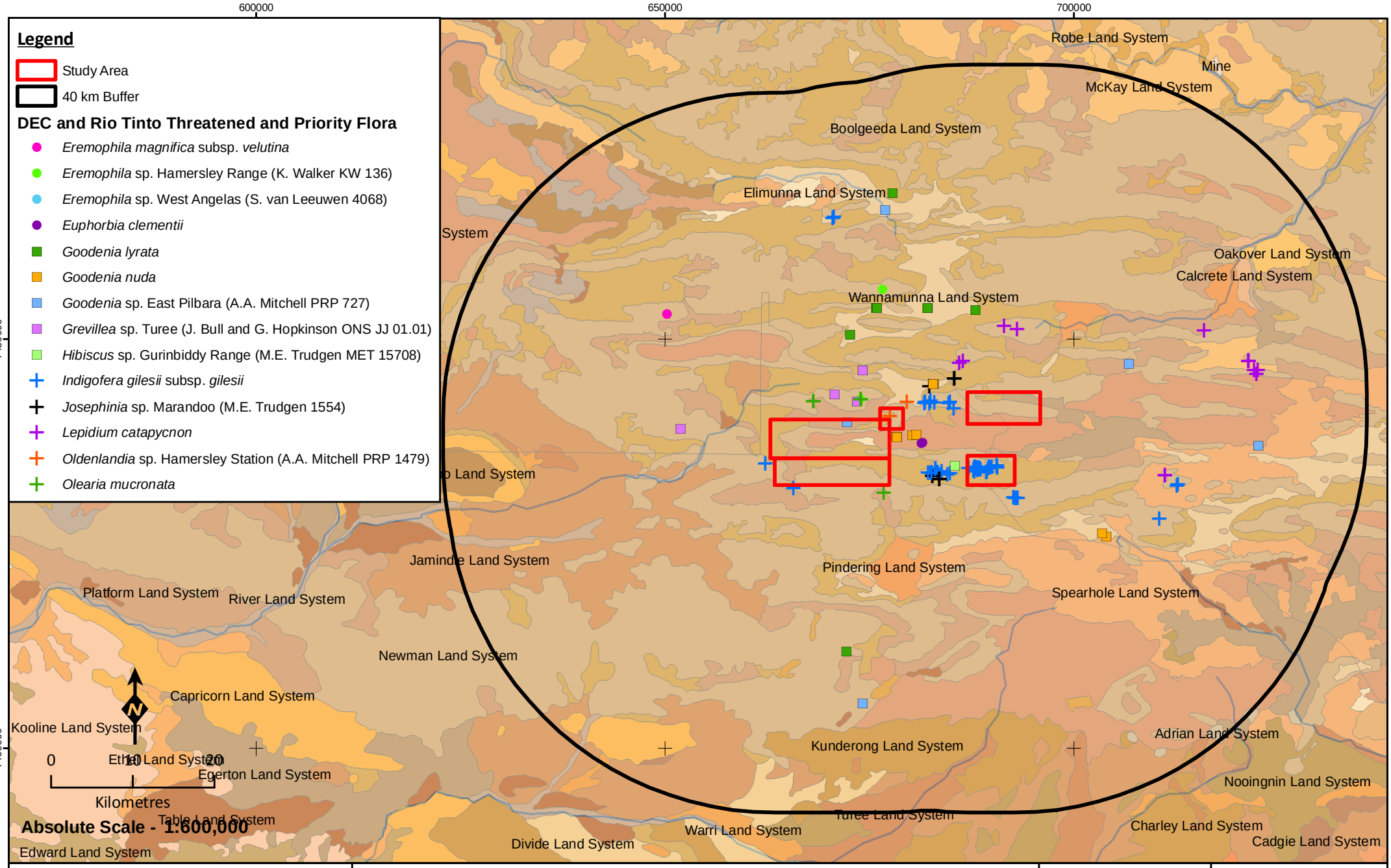

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Regional Threatened and Priority Flora of Greater West Angelas - Map B

Figure: 2.10
Project ID: 1457

Drawn: CP
Date: 19/09/2012

Coordinate System
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Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CP170

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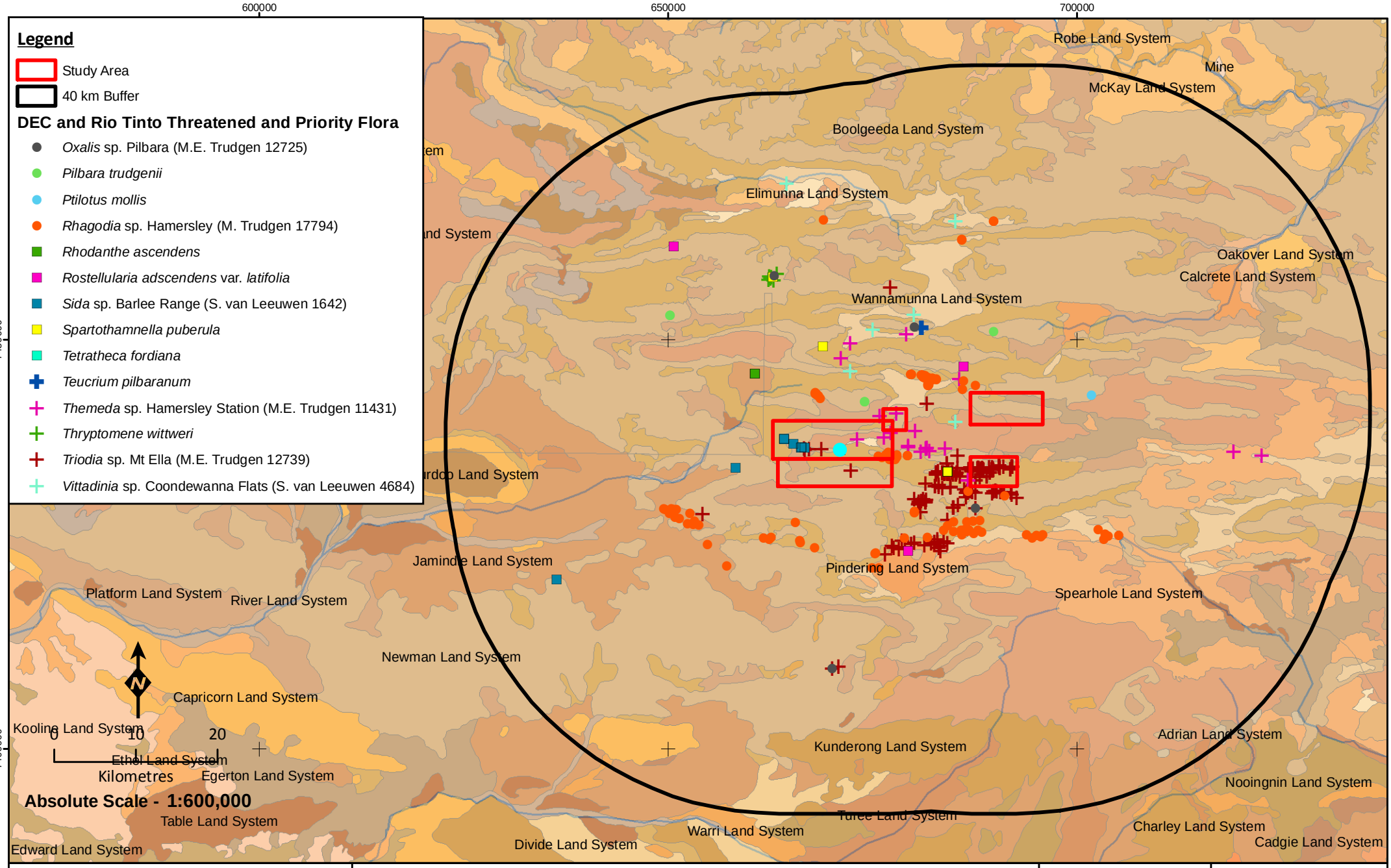

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Regional Threatened and Priority Flora of Greater West Angelas - Map C

Figure: 2.11
Project ID: 1457

Drawn: CP
Date: 19/09/2012

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CP172

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3 SURVEY METHODOLOGY

3.1 GUIDING PRINCIPLES

The survey methods adopted by *ecologia* were formulated using:

- Position Statement 3 (Environmental Protection Authority 2002), Terrestrial Biological Surveys as an Element of Biodiversity Protection;
- Guidance Statement 51 (Environmental Protection Authority 2004) Terrestrial Flora and Vegetation Surveys for nvEironmental Impact Assessment;
- Consultation with DEC personnel;
- Background research to gather background information on the footprint or target area (i.e. search of literature, data and map-based information); and
- A reconnaissance survey, conducted in February 2011, to verify the accuracy of the background information, broadly characterise the flora and range of vegetation units present in the footprint and to identify logistical constraints to survey.

Guidance Statement 51 recommends the following characteristics for a Level 2 surveys which were incorporated into the survey and reporting design:

- One or more visits to the target area in the main flowering season and visits in other seasons;
- Replication of plots in each vegetation unit to thoroughly sample the flora and characterise the vegetation units over their full extent in the target area;
- Multivariate analysis of the vegetation using, at a minimum, presence/absence data and perennial species;
- Mapping of vegetation at an appropriate scale; and
- Tabulation of the area of each vegetation unit mapped and an assessment of the environmental values including such factors as extent, condition and presence or significant flora.

3.2 DATABASE SEARCHES

A search of the following databases were undertaken in May 2012 prior to the field survey, to determine flora species and ecological communities of conservation significance previously recorded in the vicinity of the Study Area:

- DEC Threatened (Declared Rare) Flora Database (DEFL);
- DEC Declared Rare and Priority Flora List;
- DEC Western Australian Herbarium Specimen Database (WAHERB);

- DEC Threatened Ecological Community Database; and
- Department of the Sustainability, Environment, Water, Populations and Communities (DSEPaC) Protected Matters search.

3.3 VEGETATION AND FLORA ASSESSMENT

The two-phase survey involved a combination of sampling within bounded quadrats of 2,500 m^2 in area, in accordance with Guidance Statement 51, supplemented by a series of linked field traverses. Linked traverses assisted in maximising the floristic inventory and thus increasing the probability of locating flora of potential significance. Standardised quadrats allow the vegetation to be consistently characterised and facilitate multivariate analysis. Both methods contributed to the delineation of vegetation units and a comprehensive floristic inventory of the Study Area.

3.3.1 Survey Timing

The vegetation and flora of the Study Area was surveyed in two phases over two separate trips totalling 60 person days. Survey timing was as follows:

- Phase 1; 9 to 18 July 2012 (36 person days); and
- Phase 2; 21 to 26 August 2011 (24 person days).

The objectives of these surveys were to provide:

- Inventory of vascular plant species;
- Description and mapping of plant communities, including an update (Deposits C, D extension and G) and extension (Deposits C, D, F and H) of historical vegetation mapping;
- Review of plant species considered to be rare and endangered, or geographically restricted, which are known to, or may occur, within the Study Area;
- Inventory of exotic plants, including Declared Plantss; and
- Review of the significance of the plant communities within a local, regional, and state context.

3.3.2 Quadrat-Based and Transect Sampling

One hundred and fifty quadrats, distributed throughout the Study Area as detailed in Figure 3.1 were surveyed. Locations were selected using aerial photography, topographic features and field observations to represent the diversity of vegetation present. The majority of quadrats were 50 x 50 m, however the dimensions were modified where necessary to ensure that sampling occurred in homogeneous vegetation. For example, 25 x 100 m quadrats were frequently used for vegetation along drainage lines and other linear features.

Coordinates for all quadrats are detailed in Appendix A.

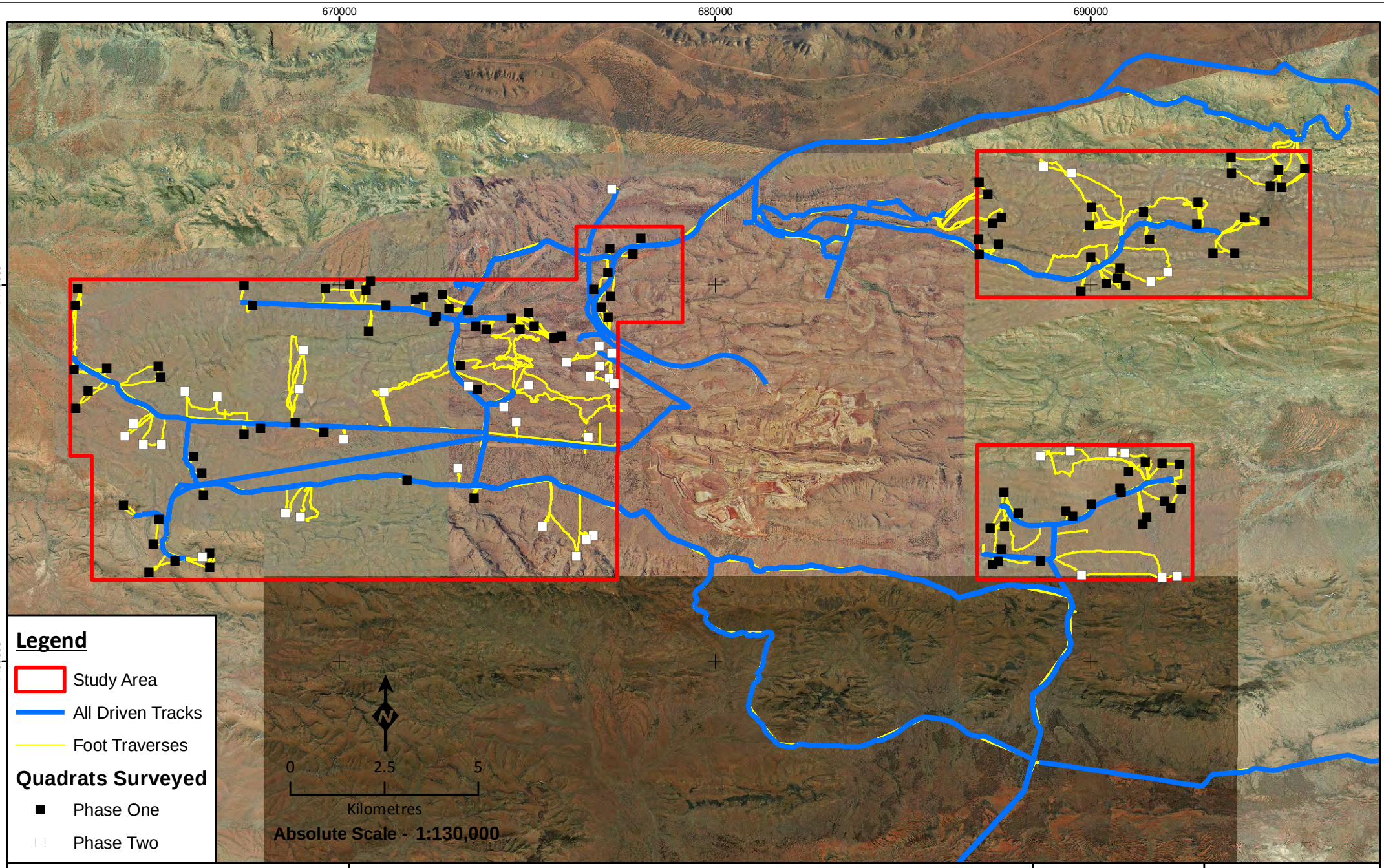
For each quadrat, the following was recorded:

- Coordinates of each corner of the quadrat;
- Site features such as topography, soil and lithology;

- Structure of the vegetation, including the height, cover, habit and dominant species within each stratum;
- Height range and percentage foliage cover for each species within the site (including introduced species);
- Vegetation condition (degree of disturbance); and
- Estimated time since fire.

At least one specimen of all taxa recorded was collected for subsequent verification. Nomenclature and taxonomy follow the conventions currently adopted by the Western Australian Herbarium (Western Australian Herbarium 1998-2013).

While walking between quadrats (Figure 3.1), opportunistic collections were made of taxa not recorded within the quadrats. Locations of any introduced flora, known or potentially conservation significant taxa encountered were also recorded, and notes were made on the boundaries of the vegetation communities to facilitate with the mapping of the vegetation communities.



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Quadrat Locations and Foot Traverses of the Greater West Angelas Study Area

Figure: 3.1
Project ID: 1457

Drawn: CP
Date: 27/09/2012

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CP147

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3.3.3 Vegetation Condition

Vegetation condition was assessed at each quadrat using the condition scale based on Trudgen (1991) based on the criteria described in Table 3.1.

Table 3.1 – Vegetation Condition Scale

Vegetation Condition	Criteria
Excellent	Pristine or nearly so, no obvious sign of damage caused by European man
Very good	Some relatively slight signs of damage caused by the activities of European man. E.g. damage to tree trunks by repeated fires, the presence of some relatively non-aggressive weeds or occasional vehicle tracks.
Good	More obvious signs of damage caused by the activities of European man, including some obvious impact to vegetation structure such as caused by low levels of grazing or by selective logging. Weeds as above, possibly plus some more aggressive ones
Poor	Still retains basic vegetation structure or ability to regenerate it after very obvious impacts of European man such as grazing or partial clearing or very frequent fires. Presence of some more aggressive weeds.
Very poor	Severely impacted by grazing, fire, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weeds species including aggressive species.
Completely Degraded	Areas that are completely or almost completely without native vegetation e.g. areas that are cleared or parkland cleared with their flora comprising weed or crop species with isolated native trees or shrubs.

3.3.4 Vegetation Mapping

Vegetation mapping is the delineation of plant communities based on distinctive characteristics of these communities such as the vegetation structure, dominant species, species composition, soil types and position in the landscape.

A combination of multivariate analysis of species composition of quadrats and ground truthing was employed to define communities. Multivariate analysis was conducted using the species matrix data from quadrats completed during both field trips. Cluster analysis was performed on the cover weighted site by species matrix using an association matrix of the Bray-Curtis coefficient with the multivariate program SYSTAT™. The resultant dendrogram was used in the definition of hierarchy of vegetation assemblages. This method provides an objective means of defining vegetation communities and provides insight into the hierarchical relationship between communities based on the degree of similarity in species composition and abundance.

The communities were described to Association level (NVIS level V). The boundaries of communities were then extrapolated to the entire Study Area based on their appearance in aerial imagery.

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4 FLORA RESULTS

A total of 441 taxa were recorded from the West Angelas Study Area in this study. Ten taxa could not be fully identified due to lack of reproductive material, nine of which are likely to be recollections of fully identified taxa. Only the 431 fully identified records were included in the diversity and multivariate analyses, but all 441 taxa are presented in the species list (Appendix C).

The summary of the composition of the fully identified species inventory is summarised in Table 4.1 .

Table 4.1 – Diversity of the Flora of Survey Area

Number of Quadrats Surveyed	Number of Taxa Recorded	Number of Families	Number of Genera	Number of Families Represented by a Single Taxon	Number of Genera Represented by a Single Taxon
149	431	48	163	13	94

The families and genera represented by the greatest number of taxa and the most frequently recorded species in the Study Area are listed in Table 4.2. This pattern of representation is typical of surveys within the Pilbara. The large number of taxa within the family Scrophulariaceae and genus *Eremophila* reflects the abundance of mulga woodlands and shrublands, within which most of these taxa occur. The relatively high representation of Asteraceae, Amaranthaceae and Goodeniaceae is a reflection of the optimal timing of the survey when many ephemeral species were flowering.

Table 4.2 – Most Frequently Recorded Families, Genera and Taxa in the Current Survey

Most Common Families	Most Common Genera	Most Frequently Recorded Taxa
Poaceae (76 taxa)	*Acacia* (33 taxa)	*Triodia pungens* (99 quadrats, 66 %)
Fabaceae (72 taxa)	*Eremophila* (17 taxa)	*Acacia pruinocarpa* (94 quadrats, 63 %)
Malvaceae (46 taxa)	*Ptilotus* (15 taxa)	*Ptilotus nobilis* subsp. *nobilis* (92 quadrats, 61 %)
Asteraceae (27 taxa)	*Senna* (15 taxa)	*Aristida contorta* (85 quadrats, 57 %)
Amaranthaceae (23 taxa)	*Sida* (15 taxa)	*Enneapogon polyphyllus* (85 quadrats, 57 %)
Chenopodiaceae (20 taxa)	*Abutilon* (11 taxa)	*Acacia bivenosa* (74 quadrats, 49 %)
Scrophulariaceae (17 taxa)	*Eragrostis* (9 taxa)	*Pterocaulon sphacelatum* (73 quadrats, 49 %)
Goodeniaceae (14 taxa)	*Aristida* (8 taxa)	*Ptilotus obovatus* (73 quadrats, 49 %)
Myrtaceae (14 taxa)	*Eucalyptus* (8 taxa)	*Themeda triandra* (72 quadrats, 48 %)
	Goodenia (8 taxa)	*Solanum lasiophyllum* (68 quadrats, 45%)

Species richness within quadrats varied from seven to 67 taxa, with a mean species richness of 35.7± 1.0 (n= 150). Vegetation units with the lowest overall species richness include *ApTssp* (*Acacia aptaneura* and *A. pruinocarpa* open woodland over *A. tetragonophylla, Senna glutinosa* subsp. *glutinosa* and *S. artemisioides* subsp. *oligophylla* isolated shrubs over *Triodia wiseana* and *T. pungens* open hummock grassland.), and *Tp* (*Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia pruinocarpa* isolated trees over *Senna glutinosa* subsp. *glutinosa, A. bivenosa* and *Ptilotus rotundifolius* isolated shrubs over *Triodia pungens* or *T. basedowii* or *T.* sp. Mt Ella hummock grassland.), both of which are typical of rocky midslopes, with a mean species richness of 15.8 and 16.8 respectively. The most consistently diverse vegetation unit was *AaPoTt* (*Acacia aptaneura* open woodland over *Ptilotus obovatus* sparse shrubland over *Themeda triandra* open tussock grassland), which occurs along sandy floodplains, with mean species richness of 50.1.

4.1.1 Sampling Adequacy for the Study Area

Species accumulation curves (SAC) provide a theoretical basis for understanding the relationship between sampling effort and the accumulation of species, and therefore provide a means of estimating the survey adequacy. As sampling effort increases, the rate at which new species are recorded is reduced until ultimately the curve representing the number of species recorded becomes asymptotic. At the point where there is a negligible increase in species inventory with continued sampling effort, the survey effort is deemed sufficient.

Flora sampling adequacy was estimated using SAC analysis (Colwell 2009) and extrapolation of the curve to the asymptote using Michaelis-Menten modelling (Figure 4.1). The incidence-based coverage estimators of species richness; ICE Mean, Chao 2 Mean were determined as 462 and 470, respectively. The total number of taxa collected in the study was 441 if all potential duplicates not fully identified to subspecies level (and therefore possibly repeats of other taxa) are excluded. Thus, it is estimated that between 86% and 88 % of the taxa present were recorded.

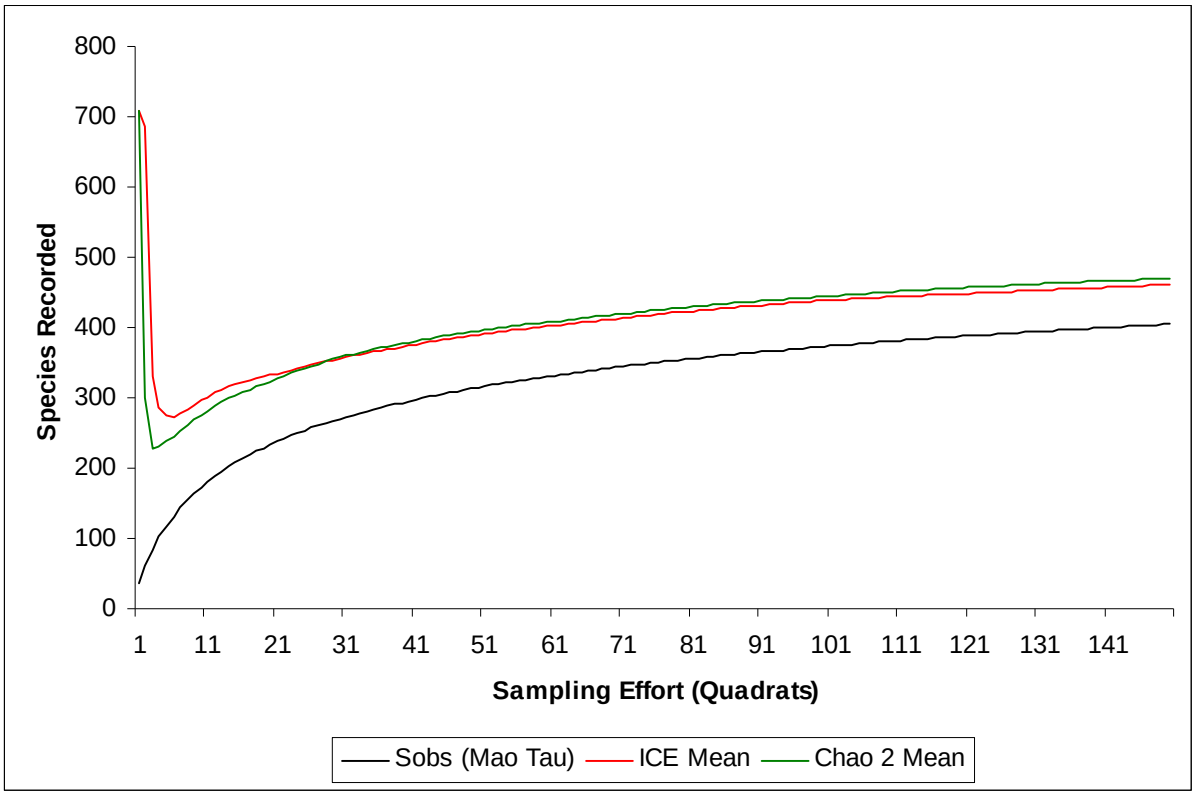

Figure 4.1 – Average Randomised Species Accumulation Curve for Greater West Angelas

4.2 FLORA OF CONSERVATION SIGNIFICANCE

4.2.1 EPCB Act

At a Commonwealth level, flora are protected under the EPBC Act, which lists species that are considered Critically Endangered, Endangered, Conservation Dependant, Extinct, or Extinct in the Wild (Appendix D). Two taxa occurring within the Pilbara bioregion are listed: *Lepidium catapycnon* and *Thryptomene wittweri* (both Vulnerable).

Four specimens of *Lepidium catapycnon* were collected opportunistically from four locations within Greater West Angelas, all within the northern portion of Deposit H. A total of 29 individuals were recorded. Vegetation and landforms consistent with this species habitat occur within the Study Area (Table 4.3) and it is possible that more individuals could be present given that access to some areas was limited during the survey.

The GPS coordinates of each location at which *Lepidium catapycnon* was observed are provided in Appendix E, and the Priority Flora Report Forms for these are presented in Appendix F. The general characteristics of the species and maps showing the locations of all recorded priority taxa are presented in Section 4.2.3.

The nearest record of *Thryptomene wittweri* lies 17 km to the north of the Study Area boundary and this species was not recorded during the survey. However, due to the presence of suitable habitat and its proximity to the Study Area, it is considered possible that this species may occur.

4.2.2 WC Act

Taxa which have been adequately searched for and are deemed to be either rare, in danger of extinction, or otherwise in need of special protection, are gazetted as such (Schedule 1, *WC Act* 1950). Threatened Flora (Schedule 1, December 2010) taxa are further categorised by the Department according to their level of threat using IUCN Red List criteria:

- CR: Critically Endangered – considered to be facing an extremely high risk of extinction in the wild;
- EN: Endangered – considered to be facing a very high risk of extinction in the wild; and
- VU: Vulnerable – considered to be facing a high risk of extinction in the wild.

These taxa are legally protected and their removal or impact to their surroundings cannot be conducted without Ministerial approval, obtained specifically on each occasion for each population (refer to Appendix D for category definitions).

There are two State Listed Threatened taxa known to occur within the Pilbara, *Lepidium catapycnon* and *Thryptomene wittweri* (both Vulnerable). As discussed above, 29 individuals of *Lepidium catapycnon* was collected from four locations within the Study Area, and further results are presented in Section 4.2.3 (species characteristics and distribution maps) and in Appendices E (GPS coordinates of collections) and F (Priority Flora Report Forms).

4.2.3 Priority Flora

The DEC maintains a list of Priority Flora taxa, which are considered poorly known, uncommon or under threat but for which there is insufficient justification, based on known distribution and

population sizes, for inclusion in Schedule 1 of the *WC Act*. A Priority Flora taxon is assigned to one of four priority categories (Appendix D).

Currently, 163 Priority Flora taxa are listed as occurring in the Pilbara region, including 60 Priority 1, 24 Priority 2, 68 Priority 3, and nine Priority 4 taxa (Western Australian Herbarium 1998-2013).

Thirteen Priority taxa were recorded in the Study Area during the current survey (Table 4.3). The distribution of records within the Study Area are illustrated in Figure 4.2 and coordinates of records and Rare Flora Report Forms are provided in Appendices E and F, respectively.

Table 4.3 – Priority Flora Recorded Within the West Angelas Study Area

Conservation Status	Taxon	Family	No. of records in Study Area	Habitat (WA Herbarium 2012)	Distribution	Flower Period	Picture
T	*Lepidium catapycnon* A papilose perennial herb or shrub. Leaves small, linear, ascending, terete succulent - on characteristically zigzag branch tips.	Brassicaceae	4 locations (29 plants)	Outer edge of creek vegetation and on rocky screes. Soil: Orange-brown (terracotta) coloured clay-loam	Marandoo, West Angelas, Tom Price	Oct-Jan	 (*ecologia* 2012)
P1	*Aristida jerichoensis* var. *subspinulifera* A tufted annual grass. Leaf-blade wire-like, round in cross section, surface scabrous.	Poaceae	44 locations (1,948 plants)	Plains with brown-red loam, clay	East Angelas, Sylvania Station, Newman		 (*ecologia* 2012)